NATIONAL SEMINAR

ON

DEVELOPMENTS IN SOIL SCIENCE – 2013

ABSTRACTS

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Abstracts

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ABSTRACTS: NATIONAL SEMINAR ON DEVELOPMENTS IN SOIL SCIENCE – 2013

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Morphology and Pore Size of Commercial Zeolites of India

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Zeolite is a crystalline, hydrated aluminosilicate having nanopores and has importance with very broad applications in agriculture. Understanding and control of matter at the nanoscale, at dimensions of 1–100 nm, where unique phenomena such as improved physical, chemical, biological properties enable novel applications is an exploratory field of research. Interesting structural feature of zeolites, is the existence of orderly arrangement of channels and/or cavities linked through channels besides, a variety of pore-sizes (<100 nm) and shapes. Studying of the morphology of zeolites is an essential element in the characterization. Commercial zeolite samples were collected from different parts of the country. The crystal morphology was studied using a JEOL JS 6701F Field Emission Scanning Electron Microscope (FE-SEM). Each sample was examined at $1\times10^3 – 1\times10^5$ magnifications to determine the dispersion and visibility of crystals and to select an appropriate field and magnification for morphology. A representative central field with adequate dispersion of fibers was selected and photomicrographs were taken. The length and width of particles were measured. The maximum width was recorded for particles with regular surfaces. Conditions of the microscope used in the study were as follows. Parameters: 1) The working distance was 8-8.3 mm except 1000 magnification, 15.2 mm; 2) The accelerating voltage was 3 kilovolts; 3) Probe current was 9.63×10^{-5}A; 4) Emission current 10 µA; 5) Extraction voltage 6.96 Kv and 6) SIP (Spectra Ion Pump) - 1: 2.4×10^{-8} P and SIP-2: 4.3×10^{-7} P. Different morphologies identified were, tubular/columnar, linear/ pentagon/ octagon/ irregular, cubical besides irregular structure too.

Nitrogen gas absorption has been useful to measure porosity distribution of powdery samples. Before the measurements, samples were degassed overnight at 77° K. The relation between relative pressure P/Po (where P and Po denote the equilibrium and saturation pressures of nitrogen, respectively) and size of the relative pores were derived and the isotherms were transformed into a relation between the volume adsorbed of N_2 and pore-size. The pore sizes varied from 15.64 nm – 16.72 nm, 17.52 nm – 19.71 nm, 7.08 nm – 10.49 nm and 19.2 nm – 22.13 nm for natural zeolites of India, through various calculation methods like Brunauer, Emmet and Teller by 4V/A (BET), Barret, Joyner and Halenda (Adsorption and desorption), Dollimore-Heal (Adsorption and desorption) while for synthetic zeolites it was 10.5 nm – 15.5 and 30.28 nm – 76.83 nm. Their utilization in agriculture is being investigated.

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Delineation of Management Zones in Rice-Wheat Cropping System for Site-specific Fertilizer Application using GIS and Remote Sensing

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Rice-wheat is an important cropping system in India covering an area of about 12 Mha. Temporal and spatial variability of soil and climate is a common consequence which accounts largely for variation in crop yield in this cropping system. For attaining uniform higher yield over larger areas, production inputs like seeds, fertilizers, pesticides *etc.* are to be applied as per site specific need rather than applying recommended blanket doses. Creation of management zones using remote sensing data and GIS is being applied in larger areas for assessing and managing soil variability to achieve higher yield uniformly over the entire area in various cropping systems. But its application is limited to small fields around one ha, the average land holding size for small farmers in India. In the present study, an attempt was made to delineate management zones based using remote sensing data and GIS to formulate site specific nutrient management strategies for attaining specific yield target on an experimental field less than one hectare in rice-wheat cropping system on an Ustochrept of Indo Gangetic Plain in India.

Management zones were created on the basis of false color composite (FCC) using LISS-III data for the month of April 2010 and January 2011. The data was superimposed on an area 6050 m^2 in the 29^0 04' 59.88" N and 77^0 41' 38.91" E coordinate having history of continuous rice-wheat cropping system located at P.D.F.S.R, research farm Modipuram, Meerut, U.P. Using this data and visual image interpretation keys, FCC was generated and three management zones were delineated with Arc. GIS software as low, medium and high productivity with estimated area being 2000, 2900 and 1150 m^2 during *rabi* 2010 and employing the same technique and using LISS-III (January-2011) data low, medium and high productivity zones were delineated having estimated areas 1820, 1280 and 2950 m^2 during *rabi* 2011. On the basis of management zones created in the respective years, site specific N, P, K management was carried for *kharif* rice 2011 and 2012 which correspond to N_{107} P_0 K_{26} and N_{101} P_0 K_{22} for low fertility zone while for medium and high fertility zones the fertilizer doses were N_{77} P_0 K_{10} and N_{78} P_0 K_{14}; N_{50} P_0 K_0 and N_{51} P_0 K_0 respectively. Likewise, site specific N, P and K recommendations for low, medium and high fertility zones were N_{139} P_{55} K_{48} and N_{133} P_{45} K_{62} for low fertility zone while for medium and high fertility zones the fertilizer doses were N_{100} P_{12} K_{20} and N_{101} P_{20} K_{28}; N_{98} P_0 K_0 and N_{68} P_0 K_0 respectively. Mean rice equivalent yield (REY) during 2010-11 and 2011-12 were 12.81, 13.40 and 13.44 t ha^{-1} under low, medium and high fertility zones. Thus the present study clearly demonstrate that remote sensing data and GIS can be used for delineating management zones in small holding size in rice-wheat cropping system. Site specific nutrient management packages for various management zones also helps in attaining higher yield levels than target.

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Identification of Soil Fertility Constraints by GIS Technique for Site Specific Nutrients Management in a Micro-Watershed of Northern Transition Zone of Karnataka

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A survey was undertaken in Kotur micro-watershed in Dharwad district, Northern transition zone of Karnataka with an objective of identifying soil fertility constraints of a by GIS technique for site specific nutrients management. Surface soil samples at 10 (second) grid interval were collected from the study area for the assessmenet of soil fertility constraints. The sampling location was recorded by using GPS. After processing, the samples were analyzed for pH, EC, OC, N, P, K, S, Ca, Mg, Zn, Fe, Cu, Mn and B. Soil fertility maps were prepared for each of the nutrients by GIS technique using Arc GIS 10.0 software.

Available nitrogen content of the entire micro-watershed was low (870.6 ha) which ranged from 62 to 264 kg ha^{-1}. Available phosphorous in the soil ranged from 1.0 to 56.0 kg ha^{-1} with 355.3 ha in low and 513.3 ha in medium category available phosphorus. The lowest value of available potassium recorded was 200 kg ha^{-1} and the highest 520 kg ha^{-1}. Available K_2O was medium in 191.4 ha area and high in 679.2 ha. Available sulphur ranged from 4.9 to 19.6 mg kg^{-1} with 669.0 ha low and 201.6 ha medium category. Available zinc content in soil ranged from 0.32 mg kg^{-1} to 1.41 mg kg^{-1}. Zinc was deficient in 454.3 ha and sufficient 416.3 ha. Available iron content in soil ranged from 0.9 mg kg^{-1} to 28.9 mg kg^{-1}. In the study area iron was deficient in 242.6 ha, while 628.0 ha area was sufficient in iron. The entire watershed was found to be sufficient in available copper and manganese. Available boron content in the micro-watershed ranged from 0.12 mg kg^{-1} to 1.19 mg kg^{-1} with 501.5 ha deficient in boron, while 369.1 ha area sufficient in boron. Mapping of nutrients by GIS techniques revealed that major portion of the study area was deficient in available N, P, S, Zn and B.

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Assessing Wardha Soils for Land Productivity Potential for Cotton: A Remote Sensing and GIS Approach

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Land Productivity Potential (LPP) study is a preliminary step for assessing whether the land is suitable and sustainable for intended crop or not. These studies are generally practiced following traditional land evaluation methods using soil resource inventory datasets. In the present study, assessment of LPP for cotton in Wardha district has been carried out through close examination of the indicators of land suitability for cotton. Based on suitability criteria for cotton, four main factors (texture, drainage, depth and pH) readily available in soil survey reports and terrain parameters *viz*. slope and topographic wetness index have been selected. In the present case, the soil productivity factors has been replaced with principal component (PC) of MODIS 16 day's composite time series NDVI data for 10 years (from 2000 to 2009). Multi-year time series NDVI reflects growth of vegetation for different seasons and thus indirectly reflect soil productivity. The first PC was found to be capturing major variations of NDVI during *kharif* season in all ten years. Based on these seven parameters, the culturable areas of the district were categorized as very good, good, moderate, poor, and very poor covering 8.7, 47.4, 35.0, 8.0 and 1.0 per cent, respectively, of culturable area of Wardha district by adopting the logical criteria. These categories were arrived at by integrating the various layers with corresponding weights in GIS using multi-criteria analysis. The model provides a better insight to the suitability of land parcels for specific crop production. The suitability classes are quantified and evaluated on pixel basis and found to be more precise. This modeling technique provides better understanding on the crop suitability at larger scale and will be a new approach in crop planning, over the traditional crop suitability assessment.

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Characterization of Soils along a Toposequence in Chhattisgarh Basin

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Four pedons along a typical toposequence in Chhota Urla village, district Raipur, Chhattisgarh representing Bhata, Matasi, Dorsa and Kanhar soils were characterized for their morphological, physical and chemical properties. The pedon occurring on plateau Bhata (P1) is characterized by very shallow, brown, clay soil on laterite mass (Typic Haplustepts). Matasi soil, a Lithic Haplustalf (P2) had shallow solum with light yellowish brown colour with mottles over laterite mass. The solum of Dorsa (P3) represents deep very dark greyish brown clay soil (Typic Haplustert). Kanhar, Typic Haplustert (P4) is deep, dominantly clay, very dark greyish brown. All soils were under bunded rice except Bhata. Geology of the study area comprises of quartzite/granite/limestone with capping of metabasic rock away from site. The sand in pedons varied from 4.8% (P3 and P4) to 45.0% (P1), clay 28.1% (P1) to 61.5% (P3), bulk density 1.47 Mg m^{-3} (P3) to 1.85 (P1) Mg m^{-3}), pH 5.3 (P1) to 8.3 (P3 and P4), pH^{KCl} 4.4 (P1) to 6.9 (P4), organic carbon 0.36% (P4) to 1.17% (P2), calcium carbonate 1.16% (P1) to 3.74% (P4), CEC 9.54 cmol(p^+)kg^{-1} (P1) to 32.54 cmol(p^+) kg^{-1}) (P4) and base saturation 82.0 (P1) to 134.6% (P4) respectively. Moisture retention and COLE values seems to be dependent on clay and smectite content (23.7% in P1 to 76.9% in P4) that reflect in success of bunded rice.

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Geo-referenced Soil Fertility Status for Soil Health Management through Optimized Fertilizer Use in Amravati District of Maharashtra

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The georeferenced soil fertility status of Amravati district was studied under the project "Management of Soil Health and Fertility for GPS-GIS Based Model Soil Fertility Maps" at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The surface soil samples were collected in 128 villages from fourteen tehsils of Amravati district during October, 2011. Six farmers were selected based on land holdings and two soil samples were collected from fields of these small (less than 1 ha), medium (1-3 ha) and large (above 3 ha) group of land holdings. The geo-referenced soil samples (768) were collected using Geographical Position System (GPS) in Amravati district.

The soil pH ranged from 6.00 to 9.15. The electrical conductivity of soil varied from 0.101 to 0.510 dS m^{-1}. The $CaCO_3$ content found to vary from 1.62 to 12.12 per cent. It was found in high category in Achalpur (95.46%), Anjangaon (89.59%) and Bhatkuli (88.89%) tehsils. Organic carbon content in the soil ranged from 1.00 to 9.88 g kg^{-1} which was higher in Dharni tehsil (1.09 - 9.88 g kg^{-1}).

The available nitrogen varied from 101.7 to 296.5 kg ha^{-1} out of which 97 per cent samples were found deficient. The available phosphorus ranged from 2.21- 46.80 kg ha^{-1} in which 34.4 per cent samples were found deficient. The available potassium ranged between 134.4 to 1019.2 kg ha^{-1} where in 79.8 per cent samples were found high while 17 per cent samples were found medium. The available sulphur ranged from 8.83 to 47.93 mg kg^{-1} in which 17.2 per cent samples were deficient and 63.2 per cent samples were found medium. The available zinc ranged from 0.11 – 5.31 mg kg^{-1} where in 43.3 per cent samples were deficient and 44.7 per cent samples were in medium category. The available iron ranged from 2.49 – 49.62 mg kg^{-1} out of which 47.8 per cent samples were deficient. The available Mn and Cu were found sufficient in most of soils. The nutrient indices of N, P, K and S were found to be 1.03, 1.87, 2.76 and 2.02, respectively. The nutrient index of nitrogen was low, phosphorus and sulphur were medium whereas the nutrient index of K was found high. The nutrient indices of micronutrients *viz.,* Zn, Fe, Mn and Cu were found to be 1.68, 1.71, 2.99 and 2.68, respectively. The nutrient index of zinc was found low while that of iron was medium. In Amravti district out of 768 soil samples 100 samples were collected from citrus growing tehsils in which 52 per cent samples were found high in $CaCO_3$ content which resulted in 27 and 52 per cent deficiency of zinc and iron, respectively. It could be inferred that, fertility of soils in Amravati district of Maharashtra was low in nitrogen and, medium in phosphorus, sulphur, iron and zinc while high in potassium, copper and manganese.

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Environmental Influence on Physicochemical Characteristics of Soils in Bolangir District of Odisha

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Influence of physiography and landuse on soil properties in Bolangir subdivision of Bolangir district of Odisha covering 2002.78 sq.km and constituting Balangir Sadar, Deogaon, Puintola, Loisingha and Agalpur blocks were investigated. The whole area falls under AESR 12.1 *i.e.* hot moist subhumid ESR with medium AWC and LGP of 180-210 days in Mahanadi basin area and represents moist sub-humid climate with mean annual rainfall of 1627mm. The area forms a part of Eastern Ghat Super group of rocks comprising of Khondalite Granite gneiss, Calc Granulite, Anorthside, Quartz vein and Pegmatite.

Based on reconnaisance soil survey of the area on 1:50,000 scale using IRS P6-LISS III satellite imageries and SOI toposheets, thirteen representative profiles were studied under forest, degraded pasture land ,monocropped paddy,paddy plus redgram and paddy plus khesari landuse. The landform units identified are gently and moderately sloping dissected plains,very gently and gently sloping undulating plains and very gently sloping recent alluvial plains. Soils were analysed for different soil hydrophysical and chemical properties, viz moisture content at 0.33 bar and 15 bar, available water capacity, soil texture, O.C, pH (water and KCl), exchangeable bases etc using standard methods. Perusal of the data reveals clay loam soils under paddy plus redgram cultivation in the gently sloping undulating plains recorded the highest mean organic carbon (0.54%) and AWC values (15.7%) while the sandy loam soils under monocropped paddy showed the lowest OC (0.13%) and AWC values (4.47%), respectively. The mean clay content and CEC content of the soils shows an increasing trend from the upper to the lower plains and varies from 13.8-40.9% and 10.1-17.6 cmol(p+)kg^{-1} soils, respectively. All the soils are moderately acidic to slightly alkaline with the surface soils (0-20 cms) showing mean values ranging from 4.9-7.8 while the subsurface values ranged from 5.7-8.4. The correlations study reveals that moisture content of the soils at 1/3 bar and 15 bar suctions are positively correlated with the finer clay(r=0.55** and 0.59**), silt (r=0.0.63** and 0.57**) fractions and CEC (0.62** and 0.72**) content of the soils.However the AWC values show only significant correlation with the base saturation content of the surface soils (r=0.67**) while the corresponding subsurface values are not significant in influencing the available water capacity.

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Pedospheric Distribution of DTPA-extractable Zinc in Soils from Long-term Experiments in Inceptisols under Different Agro-ecological Zones of India

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Presence of micronutrients in optimum concentration is essential for the plants to complete their life cycle which ends with maturity and harvesting of the economic produce. Zinc in particular is considered to be a very important micronutrient when it comes to plant and human nutrition through its role in promotion of enzymatic activity. Soil micronutrients are strongly affected by cropping patterns and management practices. Long-term experiments provide genuine information on the impact of long-term nutrient management system with varying sources, types and combinations of plant nutrient inputs on soil fertility as well as productivity. The present investigation was conducted with soils collected from a few certified long-term experiments in India with varying cropping systems *viz.,* Rice-Lentil (Varanasi, U.P.), Rice-Wheat (RSpura, J&K), Pearl millet-Wheat-Cowpea (Anand, Gujarat) and Rice-Wheat (Mohanpur, West Bengal) and management practices, to find out their effects on depth-wise distribution of DTPA-extractable Zn. From the field experiments of each site, four common treatments were taken into consideration *viz.,* Fallow, Control, 100% NPK and 50% NPK+50% N(FYM) along three different soil depths i.e., 0-0.15 m, 0.15-0.30m and 0.30-0.45m. The range of DTPA-extractable Zn for all treatments on surface soil was found to be 3.51-8.67 mg kg^{-1}, 2.52-5.61 mg kg^{-1}, 2.21-5.35 mg kg^{-1} and 2.42-6.71 mg kg^{-1} for RSpura, Varanasi, Anand and Mohanpur respectively which continued to decrease with increasing soil depth, in all the treatments in all the four sites. The incorporation of FYM along with NPK resulted in highest concentrations of Zn in all four sites with values ranging from 4.21-8.67 mg kg^{-1}, 3.74-5.61 mg kg^{-1}, 2.48-5.35 mg kg^{-1} and 3.42-6.71 mg kg^{-1} for RSpura, Varanasi, Anand and Mohanpur respectively across all soil depths. The lowest values of Zn were recorded in the fallow strip at all the soil depths. Results of the present study indicated that integrated use of nutrient (NPK + FYM) can cater to the micronutrient requirement of crops for quite long time by mobilizing from the native source.

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Cultivated Land Conversion and Potential Agricultural Productivity: A Geoinformatics Study in Western Uttar Pradesh

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The study demonstrates the effect of rapid urbanization with increasing population on shrinkage of agricultural land in western Uttar Pradesh. Spatial pattern of cultivated land conversion over a decade was captured through satellite remote sensing. Regional soil and water resources and constraints were characterized through generation of homogeneous agro-ecological units. The region recorded a net change (-4.41%) of cultivated land from agricultural to non-agricultural uses in which 2.89% accounted for conversion to built-up areas. Potential agricultural productivity of major crops in the agro-ecological units was computed through crop simulation modelling and the yield gaps at different production technology level were quantified. Yield gaps (potential-current) ranged at 3.87-6.64, 2.85-4.89, 4.09-6.02 and 30 t ha in rice, wheat, maize and sugarcane for a majority of land units. Fertilizer and irrigation inputs for these crops were tested at selected agri-technology levels. Irrigation requirement for a crop was mostly similar among the units, but fertilizer requirements significantly varied. Although conversion of agricultural land was less, rapid urbanization has significant impact on agricultural production. Regional assessment of bio-physical potential through geoinformatics coupled with simulation modeling can help in great way in augmenting agricultural food production to ensure food security and sustainability of the region.

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Contribution of Edaphic Factors to the Crop Stress as Identified by NDVI – An Analysis

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Monitoring of crop abiotic stresses at a regional scale helps in identifying and recommending suitable management options for their resilience and remote sensing tools have proved their utility in such activities. Using normalised difference vegetation index (NDVI), groundnut area and productivity were found to be determined by rainfall in Anantapur district, Andhra Pradesh. The contribution of edaphic factors was further assessed in areas with normal and excess rainfall. Eight-day composite image acquired by MODIS-Terra on 29 Sep 2005, coinciding with the withdrawal of Southwest monsoon was used for deriving NDVI image of Anantapur district. Classes of stress namely high, moderate and low stress with <0.33, 0.33-0.67 and >0.67 of NDVI, respectively were identified and six mandals with high stress are selected. Selection was based on the area under stress and prominent edaphic stressors.

Large extent of Gummagatta (53%) and Anantapur (43%) have shallow soil depth indicating lower effective soil volume (ESV) and effective foraging space (EFS) causing stress to plants. Although, 81% area in Kalyandurg has moderately deep soils, the ESV was reduced as of 96% of the area is gravelly. Such diluent of soil volume was observed in Kanaganapalle (73%), Kambadur (72%), Anantapur (69%) and Beluguppa (69%). Combined influence of lower soil depth and high gravel content on available water content (AWC) exists in Kalyandurg mandal (almost 100%) followed by anaganapalle (81%), Kambadur (74%), Beluguppa (73%), Anantapur (72%) and Gummagatta (64%). Salinity afflicted area ranged from 1% (in Kalyandurg) to 21% (in Kambadur) while the area ranged between 7 to 20% in Kanaganapalle, Beluguppa and Anantapur. Similarly, Gummagatta was the most afflicted by sodicity (21%). Soil erosion was severe in Kalyandurg (77%) followed by Anantapur (71%), Gummagatta (64%), Kanaganapalle (60%), Kambadur (54%). 89% of area in Gummagatta is of Aridisols and further 50% in Anantapur 20% in Beluguppa (20%). Thus the relation between NDVI and edaphic factors can act as a model to establish a protocol for mapping adverse impact of edaphic stresses at regional scale.

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Soil Resources Information for Sustainable Land Use Planning with Particular Reference to Petroleum Exploration and Refinery Setup in Barmer District of Rajasthan

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Management of soil resources on scientific principles is essential to maintain present level of productivity and conservation of natural resources. This calls for comprehensive information of soil resources in terms of their characteristics, spatial extent and their capabilities. The Barmer district, located at the western fringe of Rajasthan along the international border with Pakistan, one of the driest district, covered with vast stretches of sand dunes/ sandy plain came to lime light because of discovery of largest onshore petroleum reserves, the Mangala area, consists of over 16 separate oil and gas fields of which Mangala, Bhagyam and Aishwariya fields have oil reserves of approximately one billion barrels and currently contributes more than 23% of India's domestic production. With these oil production activities the entire area is bound to undergo unprecedented land use changes and adversely affect soil resources. Present study reports characteristics and capability of soils of Barmer district and their vulnerability to techno-genic pressure exerted due to oil production and refinery activities so that while harvesting the benefits, eco-tecno-friendly land use be adopted. Physiography soil series relationship has been adopted for soil mapping of Barmer district. Geocoded IRS P6 LISS III 1:50, 000 scale images were visually interpreted for physigraphic units. Soil units were delineated based on interpretation key developed based on image elements namely tone, texture, shape, size and pattern. Extensive and intensive field work by digging augar holes and profile examination was carried out and soil series mapped after following standard methodology (FAO, 1988). Detailed studies were carried out in Petroleum exploring areas and proposed sites for petroleum refineries. The Barmer district (28501.61 sq. km) experiences extreme arid climate with mean annual rain fall of 250 mm at the eastern fringe and less than 100 mm at the western fringe and highest wind speed of 30-45 km per hour during May and June. Sand dune are dominant formation in western and southern part of the district (7940 sq. km 27.9%) with Dune and Dhanana series (Typic Torripsamments) associated with undulating eolian plain (5530sq. km 19.4%) with Baytu (Typic Torripsamments) and Modasar (Coarse loamy Typic Haplocambids) and eolian plain (8828 sq. km 30.9%) with soil series Chirai, Bhimra, Kalyanpur (Coarse loamy Typic Haplocambids/Calcids), Chohtan (Typic Torripsamments). All oil production and exploration activities are centered on the Dune complex and undulating sandy plain. The oil fields Mangala and Bhagyam are already operational, oil production in Aishwariya, Saraswati and Raageshwari fields operational recently. Oil from all these fields processed at Mangala Processing Terminal and sold through pipeline. Oil refinery is likely to setup in this soil zone. Impact of these activities on soil resources and technologies for their sustainable management involving sand dune stabilization, sivipasture in sandy plain, cropping through sprinkler/drip irrigation etc. discussed. Buried pediments (2952 sq.km 10.4%) include Mokalsar (Coarse Loamy Typic Haplocambids), Jamsar (Coarse loamy Typic Haplogypsids) and Jajiwal (Coarse Loamy, Lithic Haplocambids) soil series. The alluvium (2078 q. km, 7.29%) along Luni river includes Samdari and Tilwara (Coarse loamy Typic Torrifluvent), Borabas and Asotra (Fine loamy Fluventic Haplocambids) soil series are irrigated productive soils. Playa near Pachpadra (262 sq. km, 0.9%) and hills and rocky out crops (912 sq. km, 3.2%) occur scattered in the districts.

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Soil Fertility Constraint Assessment using GPS based Nutrient Map at Different Villages of Coastal Sundarbans

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We have studied soil fertility constraint in coastal degraded soil at Sandeshkhali block-II, North-24 Parganas, West Bengal as a representative site of coastal Sundarbans. To identify the fertility constrains of the studied area, georeferenced soil samples from three representative villages i.e. Tushkhali, Duchnikhali and Korakati were collected and analysed. The GPS based soil reaction, salinity and nutrient maps were prepared by Inverse Distance Weighted (IDW) interpolation method using ArcGIS Ver. 10 software. Results revealed that soils were mostly heavy in texture with high clay content generally more than 50%. Bulk density of the soil varied from 1.26 to 1.36, 1.22-1.36 and 1.23-1.31 Mg m^{-3} under Tushkhali, Duchnikhali and Korakati village. The soil reaction was highly acidic to neutral in nature. The pH of the soil samples at the surface soil under Tushkhali, Duchnikhali and Korakati village ranged from 4.36 to 7.53, 5.16-7.15 and 4.85-7.58 respectively. The extreme acidity (< 4.8) was observed in some of the soil samples irrespective of studied villages, might be due to the occurrence of acid sulphate soils at such particular sites. The soils were marginally saline to saline in nature. In some of the locations soil shows higher salinity level i.e., > 4.0 dS m^{-1} which was critical for crop cultivation. Among the three villages, Tushkhali showed comparatively higher EC with highest value of 5.23 dS m^{-1}. There was a decreasing trend in EC recorded with higher level of organic carbon content irrespective to the sampling sites. The correlation study showed that EC is negatively correlated with the organic carbon content. On an average, the organic carbon content of the studied area was medium to high in nature. The organic carbon content of the surface soils collected from Tushkhali, Duchnikhali and korakati ranged from 4.5 to 9.8, 2.13 to 7.98 g kg^{-1} and 2.8 to 9.7 g kg^{-1} respectively. The Soils were poor in available nitrogen and medium to low in available P and Zn. Higher availability status of K, Mn, Cu, Fe and S were, however found in the soils. Nutrient Index value for the available N, P, S Zn Fe and Mn ranged from 1.04 to 1.20, 1.92 to 1.99 and 2.72 to 2.88, 1.64 to 2.04. 2.78 to 2.82, 2.60 to 2.84, respectively. Organic C showed a significant negative correlation with EC (r = -0.594**) and bulk density (r = -0.071*) and positive correlation (r = 0.198**) with Zn content of soils. The available nitrogen content of the soil showed a significant and positive correlation with organic carbon (r = 0.776**) and negative correlation with EC (r=-0.383**). The available P was significantly and negatively correlated with Zn (r = -0.443**) content of soil and positively correlated with the organic carbon (r = 0.056*) and Fe (r = 0.538**). The soil pH was negatively correlated with available Zn (r = -0.097*), Fe (r = -0.170**) and Cu (r=-0.277**) which indicated enhanced availability of these cations under low pH conditions. The available N, P and Zn content significantly increased with increase in organic carbon content of the experimental soil. On the other hand organic carbon was negatively correlated with the soil salinity level. Therefore organic carbon status might play a vital role in reduction of soil salinity and simultaneously improves the soil physical condition and nutrient status which are low in content. Nitrogen based fertilization supplemented with organic inputs may be recommended for the studied area for optimum growth and yield of crops.

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Reassessment and Delineation of Micronutrients in Mehsana District of North Gujarat

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It is likely that the adoption of newer technologies, introduction of high-yielding fertilizer responsive crop verities, changing cropping patterns, heavy usage of high analysis NPK fertilizers, less use of organic manures etc. might have brought in depletion of micronutrients status in the soil. Analysis of more than 30,000 soil samples from different parts of Gujarat revealed wide spread deficiency of Zn and Fe which was to the extent of 25 and 9%, respectively. Therefore, it is necessary to monitor periodically the depletion or build up of micronutrients status over the years. Thus, the reassessments of micronutrients have been completed for the north region and thematic maps for various micronutrients have been prepared using GIS.

Under delineation programme, total 1897 (1967 to 1992), 99 (2000) and 150 (2010) surface soil samples collected from Mehsana district and analyzed for DTPA-extractable micronutrients. The per cent deficiency of Fe and Zn were found increased from 14 to 69 and 28 to 35, respectively. The increase in deficiency could be attributed to mainly higher depletion of the nutrients on account of intensive cropping, use of micronutrients free fertilizers and less use of organic manure. Per cent deficiency of soil for Mn and Cu were not much altered. In case of Mn, 21 per cent soil samples found in marginal category, indicated aggravation of Mn from the soil. Continues removal of Mn is matter of concerned. Therefore, there is a need to create the awareness among the farmers for use of micronutrients containing fertilizers in the Narmada command areas including Mehsana district.

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Spatial Distribution of Micronutrients in Soils of Kamrup District - a GIS Approach

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A systematic set of geo-referenced samples were collected from the Kamrup district covering seventeen (17) blocks to assess the micronutrient status of soils. A total of 816 geo-reference surface (0-15 cm) soil samples were analysed for physico-chemical properties and available micronutrients. The soils of the district were mostly acidic in nature having low to high in organic carbon. Available nitrogen status was low to high (9.75.12-598.65 kg ha^{-1}) but that for phosphorus and potassium were low to medium. In respect of micronutrients, DTPA-extractable Fe, Mn, Zn, Cu and hot water soluble Boron (HWSB) ranged from 21.40-360.60, 4.90-120.60, 0.42-18.88, 0.18-11.02 and 0.26-1.87 mg kg^{-1}, respectively. Among the blocks, the highest mean content of Zn, Cu and HWSB were observed in Chandrapur, Sualkuchi and Rampur blocks, respectively. While, Goroimari block recorded the highest mean amount of Fe and Mn. Based on critical levels of micro-nutrients, all soils from all blocks were adequately supplied with ETPA-extractable Fe, Mn and Cu. However, on an average Zn was predominantly deficient in all blocks (33.0%) followed by boron (7.66%).

The nutrient index values ranged from 1.32-2.97 for Zn, 3.00 for Fe, Cu and Mn, and 1.52-2.63 for HWSB. The overall fertility rating for micronutrients revealed low to medium Zn, very high Fe, Cu and Mn and medium B content in the district. Correlation studies indicated that DTPA-extractable micronutrients showed positive correlation with organic carbon and available N, but negative correlation with pH and available K_2O.

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Status and Distribution of Micronutrients under Different Land Uses in Soils of Kangra District of Himachal Pradesh

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Global Positioning System (GPS) based 15 soil profiles, 5 each from forest, grassland and cultivated land use were exposed to a depth of 1.5 m and/or upto lithic or paralithic contact. Horizon wise samples were collected from each profile and the samples were analysed for available micronutrient cations (Fe, Mn, Cu and Zn). DTPA-extractable iron varied from 55.3 to 90.3, 16.9 to 46.2 and 38.2 to 79.1, mg kg^{-1} in the surface layers, whereas, in sub-surface soils the values varied from 20.8 to 50.4, 7.7 to 15.2 and 10.4 to 47.2 mg kg^{-1} for forest, grassland and cultivated land use, respectively. The DTPA-extractable Fe content decreased with increasing soil depth. DTPA-extractable Mn values of the surface layers of forest, grassland and cultivated soil profiles ranged from 12.0 to 21.1, 4.2 to 18.2 and 25.5 to 39.9 mg kg^{-1}, and in the sub-surface layers the corresponding values varied from 5.7 to 10.6, 2.6 to 9.8 and 9.0 to 28.8 mg kg^{-1}, respectively. The DTPA-extractable Mn values were found to decrease with increasing soil depth under two land uses (forest and grassland), whereas, in cultivated lands it showed irregular trend. DTPA-extractable Cu content of soils under study ranged from 1.4 to 3.3, 0.9 to 3.0 and 1.4 to 4.0 mg kg^{-1} in surface and 1.0 to 1.5, 0.7 to 1.5 and 0.5 to 3.7 mg kg^{-1} in the sub-surface soils of forest, grassland and cultivated land use. Copper content decreased with increase in depth except two pedons of forest and grassland. In the surface layers of forest, grassland and cultivated land use, DTPA-extractable zinc varied from 1.1 to 2.3, 1.0 to 2.3 and 1.5 to 2.7 mg kg^{-1}, and in sub-surface layers, it varied from 0.8 to 1.5, 0.4 to 1.3 and 0.7 to 2.9 mg kg^{-1}, respectively. DTPA-extractable Zn decreased with increase in soil depth except one pedon of cultivated land. The status of DTPA-extractable Fe, Mn, and Cu was found sufficient under all the land uses (forest, grassland and cultivated). DTPA-extractable Fe was found dominant cation in the soils under three land uses. In general, all the micronutrient cations decreased with increasing soil depth. Zn was found deficient in 14 per cent of grassland and 8 per cent in cultivated land use. Therefore, Zn containing fertilizers should form a part of the nutrient management practices in deficient soils for sustaining/improving the soil health.

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Fertifortification of Wheat and Rice Grains to Ameliorate Zinc and Iron Deficiency in Human Beings

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Agricultural research, during the last four decades, has largely been focused on increasing food production to meet the food needs of the escalating population. The green revolution ushered by the adoption of intensive agriculture using modern agricultural techniques together with the introduction of fertilizer responsive high yielding crop varieties, however, brought in its wake the micronutrient malnutrition in humans, particularly with respect to zinc (Zn) and iron (Fe). At present, the people are not starving in great number from energy deprivation but are becoming more malnourished day by day. Micronutrient malnutrition particularly that of Zn and Fe, is presently of alarming proportions in many developing nations. The use of the modern cereal cropping systems in many developing nations has given rise to decreased per capita production of foods having higher micronutrient density. This has resulted in lower availability of micronutrient-rich food in many regions of the world. Recently more than two billion people in the world are suffering from sub-clinical deficiencies of Zn and Fe because of the low contents of these micronutrients in their diet that includes cereals like wheat and rice grains. Tackling the problem of micronutrient malnutrition to human health is the serious challenge for the scientists in the new millennium.

Rice and wheat are the staple food for more than 50 per cent of the world's population and is the main source of nutrients for most poor in many Asian countries. Zinc (Zn) deficiency is a serious nutritional problem, affecting an estimated of one-third population in the developing countries of the world thereby making these deficiencies as 6th health risk factors. This is because the polished rice contains only 1–3 mg kg^{-1} of Zn which is very low. It provides 23 per cent more calories of energy than that provided by wheat and maize crops, consumed by the world's population. On the other hand, in many Asian countries, rice provides 50–80 percent of the energy intake of the poor but it does not provide enough essential micronutrients to eliminate hidden hunger, iron deficiency anemia and zinc deficiency. Both iron deficiency causing anemia and zinc deficiency causing many human health disorders affect nearly 60 and 50 per cent of the population, respectively. Because of the high per capita consumption of rice in these countries, improving its nutritive value by increasing Fe and Zn levels in the paddy grain can have significant positive health outcomes for millions of people.

The enrichment of rice and wheat grains through fertifortification (foliar application) of Zn and Fe during reproductive growth stages is high priority area of research and it will contribute to minimizing Zn and Fe deficiencies related health problems in common population. The review of literature showed that enrichment of cereal crops with Zn could substitute the deficiency of Zn to a greater extent. In Turkey, grain concentration of wheat grown on Zn sufficient soils range, generally, between 20-30 mg kg^{-1}, whereas, on Zn deficient soils this range is between 5-12 mg kg^{-1} whereas, Zn concentration varied from 20-35 mg kg^{-1} in different cereals grains. For this a field experiment was conducted at Department of Soil Science, Punjab Agricultural University, Ludhiana, for three consecutive years on rice–wheat system for biofortification of rice and wheat with Zn and Fe. In wheat, it was observed that irrespective of durum or aestivum varieties, the results of the study indicated that 17.3-38.8 % enrichment with Zn and 13.1-30.3 % of Fe was possible through foliar application of inorganic sources of Zn ($ZnSO_4.7H_2O$) and Fe ($FeSO_4.6H_2O$) respectively. The data further showed that foliar application each of Zn (0.5%) and Fe (1.0%) at different stages of wheat growth significantly increased the grain yield and concentration of Zn and Fe in grains. Foliar application of Zn and Fe separately at different stages of wheat growth significantly increased the grain yield of wheat and the maximum grain yield of 63.1 q ha^{-1} (PBW 550) and 62.5 q ha^{-1} (PBW 343) were reported with Zn . which were 8.2 and 4.3 per cent higher than control, respectively. Similarly fertiforification of paddy with Zn (0.5 %) and Fe (1.0%) resulted in 7.0 and 8.6 per cent increase in paddy yield respectively, over control. Foliar application of 1.0 % Fe significantly increased the yield of paddy cultivars varying from 6.9-10.3 per cent. Irrespective of cultivars, the results of the present study indicated that 30.8-44.8 per cent increase in Zn concentration and 22.3-38.2 per cent of Fe concentration is achievable through foliar application of inorganic sources of Zn ($ZnSO_4.7H_2O$) and Fe ($FeSO_4.6H_2O$), respectively. Brown rice can accumulate higher Zn (47 mg kg^{-1}) than its husk (29 mg kg^{-1}) whereas, paddy husk can translocate higher Fe (378 mg kg^{-1}) than brown rice (24 mg kg^{-1}). Our results reported that the paddy husk could retain 16 times more Fe than its brown rice (without husk) whereas, brown rice had 1.6 times more Zn than its husk part. Four foliar applications of 0.5% of Zn and 1.0 % of Fe separately at different stages of wheat growth significantly increased the grain yield of wheat. On the other hand, four foliar application of Fe increased the grain yield up to 61.4 q ha^{-1} (PBW 343) and 60.6 q ha^{-1} (PBW 550) which were 2.5 and 2.2 per cent higher than control, respectively. Similarly five paddy cultivars showed differential response to yield and concentration of Zn and Fe with their foliar sprays. Irrespective of paddy cultivars, three foliar applications of Zn and Fe proved beneficial in improving the Zn and Fe concentration in paddy, brown rice and husk, which may be due to higher and quick absorption of these nutrients through foliage.

Commission 1.4: Soil Classification

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Characterization, Classification and Nutritional Status of Sugarcane Growing Soils of Chittoor District of Andhra Pradesh

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Based on variation in soils and physiography, six typical pedons namely Neruvoi (P1), Palamangalam (P2), Gollapalle (P3), Vonaruvaripalli (P4), Digavapokalavaripalli (P5) and Gattivaripalli (P6) in Chittoor district, Andhra Pradesh were characterized for their physical and chemical properties and for nutritional status of sugarcane-growing soils. These pedons were shallow (P3 and P4), deep (P2, P5 and P6) and very deep (P1) and have Munsell colour notation of 10 YR/7.5 YR hue, with value 2 to 6 and chroma 1 to 6. The dominant soil structure is fine to medium, weak to moderate and sub-angular blocky. Sand, silt and clay ranged from 32.70 to 94.04, 3.97 to 39.60 and 1.99 to 35.86, respectively in different horizons and bulk density varied from 1.29 (P4) to 1.94 Mg m^{-3} (P1). These soils are neutral to strongly alkaline in reaction (7.35 to 8.21). The CEC of the soils varied from 1.30 to 28.80 cmol(p^+)kg^{-1} in different horizons. Calcium and magnesium were found to be the dominant cations on the exchange complex. Organic carbon was low to medium. The soils were low in available N, low to high in available P and K and sufficient in available sulphur. The DTPA-extractable zinc in sugarcane-growing soils was sufficient in surface horizons and deficient in sub-surface horizons in all the pedons except in P4 (Vonaruvaripalli) and P6 (Gattivaripalli) wherein it was found to be deficient in P4 and sufficient in P6. The sugarcane-growing soils were deficient in DTPA-extractable iron and sufficient in DTPA-extractable copper and manganese. Pedon 1 showed argillic (Bt) sub-surface horizon and was classified as Ultic Haplustalfs. Pedons 2, 5 and 6 showed cambic (Bw) sub-surface diagnostic horizon and were classified as Typic Dystrustepts and Typic Haplustepts. Pedons 3 and 4 did not exhibit any diagnostic horizon and were classified as Typic Ustorthents.

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Soil-site Suitability Evaluation for Mustard and Wheat Crop in Morena District of Madhya Pradesh

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In the present research work, soil-site suitability evaluation was made for the Morena district of Madhya Pradesh for mustard and wheat crops. Seven typical pedons and twenty five mini pits were evaluated for their suitability to mustard and Wheat crops. The minipits were got dug up to 60 cm and were studied to make the profile-site representative. Soil-Site, characteristic of each profile was studied. Relative analysis was employed to investigate the contribution of selected soil and site characteristics on the production of mustard and Wheat crops. Suitability of land units for mustard and Wheat crops were worked out by matching the climatic and soil-site characteristics of each soil unit with crop requirements. Soil profiles differ from each other in respect of organic carbon, pH, texture, cation exchange capacity, available water capacity and soil depth. Actual yield of crops obtained in each soil-unit correlates well with the suitability classes determined on the basis of degree and kind of limitation.

The study suggests that the soils are marginally suitable for growing wheat and mustard crop except soils of Pedon P3 which is moderately suitable for mustard and soils of Pedon P5 which is moderately suitable for wheat crop. The soils of Pedon P1 which is shallower in depth, is non-suitable for both the crops, due to major limitation of organic carbon. Soils of Pedon P4 are actually unsuitable but potentially suitable for wheat cultivation. The variability in suitability class is due to limitation of organic carbon, texture pH and depth.

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Persistence of Oxadiargyl in Vertisol and an Alfisol of Andhra Pradesh

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Persistence is an important characteristic of an herbicide affecting efficacy, and carryover to subsequent crops. The period during which the herbicide remains intact and biologically active has great practical importance in determining how well it performs its intended task in soil. Conventional methods of quantifying persistence under field conditions is cumbersome and does not lead to any conclusions and possible forecasts. Hence, the modeling of persistence of herbicide under laboratory incubated soils to predict the persistence under field conditions holds promise. Persistence of Oxadiargyl in Alfisol and Vertisol was studied in the laboratory under controlled conditions of three moisture levels (saturation, field capacity and 50% field capacity) and two temperatures (10 ± 2^{o}C and 27 ± 2^{o}C) for the period of 137 days. These studies have indicated that there are two distinct pathways for disappearance, a faster one and a much slower one. Degradation of oxadiargyl was rapid at high temperature and moisture levels. The disappearance curve / semi longarithmic plot followed first order kinetics with two distinct pathways, an initial faster rate followed by a slower and more gradual rate of disappearance. In both the soils, at different moisture and temperature levels, these constants for the oxadiargyl varied in the order, $k>k_1>k_1$. In present investigation the rate of reentry (k_1) of oxadiargyl into labile pool was considered negligible. The rate of entry into bound pool (k_1) was higher for Vertisol than for Alfisol and was more at higher temperature. The rate of degradation of oxadiargyl from labile pool (k) was high at higher soil moisture levels in both the soils and followed the order saturation>field capacity > 50 percent field capacity. The rate of degradation was higher in Vertisol compared to Alfisol and increased with increase in temperature. The rate of degradation of oxadiargyl increased with increase in temperature from 10 ^{o}C to 27^{o}C. The effect of moisture content can be described by an equation $H = AM^{-B}$. It decreased with soil moisture in the order: saturation > field capacity > 50% field capacity. At high temperature and moisture level, the half values were lower compared to low temperature and moisture level.

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Land Capability Classification of the Soils of IARI Farm, New Delhi

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Soil is a basic natural resource and essential for plant growth. It has to be used scientifically and carefully and be conserved for sustainable development. Proper monitoring and updating the problems and potentials of soils of any research farm are thus highly essential for conducting any kind of research activities. Keeping this view in mind, the Farm of Indian Agricultural Research Institute (IARI), New Delhi was taken up for detailed soil survey and its characterization and classification.

The detailed soil survey of the farm covering 292 ha area was conducted using the base map on 1:4000 scale and studying the minipits and master pedons. Soil samples were collected horizon wise and characterized following standard procedures and classified as per USDA Soil Classification system.

Three landforms have been delineated in the area *viz.* upper piedmont plain, lower piedmont plain and old alluvial plain. Ten soil series have been identified and mapped into 16 soil mapping units as phases of soil series. Soils of upper piedmont plains occur on very gently slopes and are very deep, well drained, dark yellowish brown, sandy loam, slightly alkaline and classified as coarse loamy, mixed, hyperthermic, Typic Haplustepts. As per land capability classification they are classified into subclasses IIIs1, IIIes1, IIIs2 and IIIes2. Soils of lower piedmont plains occur on nearly level to very gentle slopes and are very deep well drained, brown in color, sandy loam to loam, slightly alkaline and classified as coarse loamy to fine loamy, both calcareous and non calcareous, Typic Haplustepts and land capability subclasses IIc1, IIes1 and IIs2. Soils of old alluvial plain occur on nearly level plains and are very deep, well drained, brown to dark yellowish brown, sandy loam to clay loam, slight to moderately alkaline and classified as coarse to fine loamy, mixed, calcareous, Typic Haplustepts and land capability subclasses IIc1, IIs1 and IIs2.

Commission 2.1: Soil Physics

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Water Retention Characteristics of Red Lateritic Soils, Red Soils and Black Soils of Tamil Nadu in relation to Soil Texture

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The present study was carried out to estimate the available water capacity of 246 soil samples collected from red lateritic soils of Dryland Agricultural Research Station, Chettinad, native red soils and application of transported black soils over the red native soils of Maize Research Station, Vagarai and black soils of Cotton Research Station, Veppanthattai of Tamil Nadu. The soils were analyzed for field capacity at 1/3 bar (33 kPa) pressure and permanent wilting point at 15 bar (1500 kPa) pressure besides, organic carbon and particle size distribution (soil texture) in surface and subsurface soils. In Red lateritic soils the moisture retention at field capacity ranged from 13.2 to 20.5 and 13.8 to 22.5%, permanent wilting point ranged from 5.4 to 10.9 and 4.9-11.6% and available water capacity varied from 4.3 to 13.3 and 4.9 to 13.9%. The moisture retention of application of transported black soils over native red soils varied from 29.2-30.4 and 19.8-22.7%, at an permanent wilting point varied from 14.8-16.9 and 7.6-9.2% and the available water capacity varied from 13.6-15.5 and 11.9-14.1%. The moisture retention of native red soils at field capacity varied from 16.2-19.4 and 16.2-18.5%, at permanent wilting point varied from 5.4-7.6 and 4.9-7.8% and the available water capacity varied from 10.2-11.6 and 11.3-11.9%. The moisture retention of black soils at field capacity ranged from 30.8 to 39.7 and 32.4 to 40.8%, at permanent wilting point 15.3% to 22.9 and 16.9-24.6%. The available water capacity varied from 13.5% to 18.5 and 13.8-18.4% in both the surface and sub surface soils, respectively. The subsurface soils of transported black soils over native red soils have high moisture retention capacity than native subsurface soils. The available water capacity and maximum water holding capacity in all soils were in the order of Black soils>transported black soils > the native red soils> Red soils > red lateritic soils. The soil parameters *viz.,* organic carbon, sand silt and clay significantly influenced the field capacity of soils. The transported black soils over native red soils is beneficial for retaining more soil moisture for sustaining crop growth particularly in rainfed situations under changing climate.

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Assessment of Soil Properties at Various Depths under Three Agro-Climatic Zones of Western Uttar Pradesh

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Reliable information on the location, extent and quality of soil and land resources is the first requirement in planning for the sustainable management of land resources. Western Uttar Pradesh comprising three agro-climatic zones is known for input intensive agriculture. Cropping intensely of the region is around 175% and well irrigated either by canals or owned tube wells. Main cropping sequences of the region are rice and sugarcane based which are much exhaustive. Due to imbalanced fertilization and cultivation of exhaustive crops, the nutrient status of soil is being affected adversely thus extensive soil analysis is most important to realize the higher crop productivity. To study the soil properties, depth wise soil samples were collected from 14 locations comprising 3 of Tarai Zone, 6 from Western Plain Zone and 5 from Mid-Western Plain Zone of western Uttar Pradesh. These samples were processed and sieved through a 2 mm sieve. Soil samples were analyzed for soil texture, bulk density, pH, EC, CEC, organic carbon, total N, available macro and micronutrients by standard procedures.

Soils of the study area are found to be neutral to alkaline in reaction. In general soil pH increased with increasing soil depth. The soils of *Tarai* zone are almost neutral while western plain and mid western plain zone soils are towards alkaline. The soils of all the locations are non saline in nature. The bulk density of the soils varied from 1.06 to 1.33 Mg m^{-3}. Tarai soils showed slightly lower bulk density. The organic carbon content varied from 0.154-0.715%. Organic carbon was correlated positively with macronutrient. The available N ranged from 85.30-274 kg ha^{-1} and most of the soils are deficit in available N. Available N decreased with increasing soil depth. The soils are medium to high in available P while low to medium in available K. Availability of P and K in soil decline with increasing soil depth. DTPA extractable cationic micronutrients were in sufficient range. CEC of soil varied from 10.32 to 22.05 cmol(p^+) kg^{-1}. Exchangeable cations were related significantly and positively with CEC and clay. Organic carbon was significantly and positively correlated with available N, P and potassium. N and K seems to be limiting factor for crop productivity in these areas. The micronutrient status of the soils is high in all the agro-climatic zones.

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Seepage Prone Well Water Suitability for Irrigation in Mula Left Bank Canal

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The water from canal or reservoirs is lost by seepage, evaporation and conveyance. The losses through seepage are upto 15 to 20% in conveyance and the conveyance losses in the irrigation canals are as high as 50-60%, which aggravated problems in fertile lands. Mismanagement of water at all levels, particularly in agriculture, has led to the problem of rising watertable, soil salinization and pollution of surface and ground water resources. Water due to deep percolation losses in the Mula command area meets to the groundwater table, resulting in the rise of ground water table. Due to isolated pumping of well water by the farmers in the command area, there is a possibility of excessive mining, build up of salinity in the surface soil if the ground water is salt affected, excessive energy consumption *etc.* However, only few studies have been carried out in determining the quality of well water. In view of this it was felt necessary to assess the well water quality of Mula left bank canal command area. One hundred well water samples were collected for water quality appraisal on 10 different sites on MLB canal at 100, 200, 300, 400 and 500 m distance away from canal on both sides. Ten canal water samples were collected at each site for quality appraisal. The water samples were alkaline in nature with dominance of sodium and sulphates. Majority of the well waters were in higher salinity class, indicating its moderate suitability for irrigation. The average values of pH, EC and SARiw were 8.33, 1.88 dS m^{-1} and 7.08, respectively, with RSC ranging from nil to 1 me L^{-1}. The total cations were in the order of $Na^+ > Mg^{2+} > Ca^{2+} > K^+$. According to criteria for the suitability of irrigation water, classes were of following order: $C_3S_1 > C_4S_1 > C_2S_1$. The average boron and nitrate concentration were under permissible limit *i.e.* 0.75 and 1.78 meL^{-1}, respectively. Decrease in pH, EC, total cations and anions, boron and nitrate concentration and SAR, SSP of well water was observed at the distance of 100, 200, 300, 400 and 500 m away from the canal. Well water samples at different sites on canal indicated that EC, cations and anions were higher at head reach compared to tail reach, indicating that the seepage losses from canal are more at head reach than the tail reach resulting in the deterioration of well waters.

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Effect of Irrigation and Nutrient Management on Growth, Yield and Economics of Potato–Onion Cropping Sequences in Alluvial Soils

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The water is key input in potato and onion production and its management problem varies from region to region. The optimum soil moisture is needed to be maintained in the root zone, to meet the crop requirements for higher yields. It can be achieved best through the use of improved irrigation method. Potato and onion are the under ground crop and nutrients removal are quite high. IPNM is an important factor responsible for increase yields and quality of tuber/bulb. In this view, the present experiment was planed to study the effect of irrigation and fertilizer levels on growth and yield of potato–onion cropping during *rabi* and *zaid* season of 2009 – 10 at Morena. The experimental soil had sandy loam to clay loam in texture having 0.45% organic carbon, pH-7.5, $KMnO_4$ extractable N-185 kg ha^{-1}, Olsen's P_2O_5-19.5 kg ha^{-1} and 1N ammonium acetate extractable K_2O-382 kg ha^{-1}. The experiment was laid out in split plot design with four replications. Fifteen treatment combinations, comprising 3 irrigation schedules (10, 13 and 16 days interval) in main plots and five fertility levels [FYM 20 tonnes ha^{-1}, 100% RDF (200: 80: 20 kg ha^{-1} for potato and 100: 50: l00 kg ha^{-1} for onion), 75 RDF + 5 t ha^{-1} FYM, 50% RDF + 10 t ha^{-1} FYM and Control] in sub plot. Potato and onion crop were sown on 10.10.09 and 10.01.10 and harvest on 10.01.10 and 20.04.10, respectively.

The growth and yield parameters of potato significantly improved with the application of irrigation at 13 days interval over 10 and 16 days. Irrigation applied at 16 days interval produced lowest value. Significant effect of fertilizer was noticed on growth and yield of potato. However, maximum values were noted under 75% RDF + 5t FYM and lowest under control. The nutrient use and production efficiency was higher in 13 days irrigation interval, further increased in irrigation the reduction was noted. However, WUE increased with irrigation interval and recorded maximum under 16 days irrigation interval. The 50% RDF + 10 t ha^{-1} FYM recorded maximum NU. The production efficiency and WUE were highest under 75% RDF + 5 t FYM ha^{-1}. Yield of potato tuber was improved significantly due to irrigation and fertilizer application. The irrigation water applied at 13 days interval showed best performance in increasing the tuber yield (264.3 q ha^{-1}) over 10 and 16 days intervals. Significantly higher tuber yield of potato (270.8 q ha^{-1}) was registered with the application of 75% RDF + 5t FYM over other fertilizer treatments. The maximum economic viability was noted in combination of irrigation at 13 days interval with 75% RDF + 5 t FYM application. Onion bulb yield increased significantly due to irrigation and nutrient. Application of irrigation at 10 days interval maximum bulb yield (147.9 q ha^{-1}) registered over 13 and 16 days irrigation. Maximum yield (142.7 q ha^{-1}) was noted under the application of 75% RDF + 5t FYM ha^{-1}. Maximum gross returns, net returns, additional returns and B:C ratio was noted in combination of 10 days irrigation interval and 75% RDF + 5t FYM ha^{-1}. The better response were observed in nutrients uptake, production efficiency and bulb diameter with irrigation applied at 10 days interval over 13 and 16 days irrigation interval. Whereas, maximum water use efficiency water recorded with application of irrigation water at 16 days interval over 10 and 13 days irrigation interval. The maximum nutrients uptake, WUE (153.4 kg ha cm^{-1}), production efficiency (155.1 kg ha day^{-1}) and bulb diameter (4.17 cm) were gained under application of 75% RDF + 5t FYM ha^{-1} and lowest in control.

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Modelling Soil Water Retention Characteristics of Shrink-swell Soils of Jalgaon District from Soil Analytical Data

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The soil water retention and release characteristics help in Modelling hydrological process, irrigation - rainwater management planning, soil-plant-water relationship, crop modelling *etc.* However, data on soil water retention release characteristics are not easily available because conventional methods of measurement are very difficult, time consuming and expensive. Therefore, it is imperative to adopt indirect estimation technique. Use of Pedo Transfer Function (PTF) is one of the widely used techniques. Most of the PTFs reported are derived from complex mathematical algorithm. There is a need for simplified easily understandable regression approach. With this objective, the present investigation has been undertaken for the major shrink swell soils of Jalgaon district. Ten benchmark soil profiles from seven distinct physiographic units namely hill ridges, table land, upper piedmont, lower piedmont, piedmont plain, river terrace and dissected flood plains were selected for the study. The soil water retention characteristics were determined using Troxller® pressure plate apparatus. The other soil properties were determined according to standard laboratory techniques. Multiple stepwise regression techniques were used to work out the coefficients in the various models using soil water content at different suctions namely 33 kPa, -300 kPa, -500 kPa, -1000 kPa, -1500 kPa and soil properties. The following PTF relationships were established. water content at -33 kPa = 220.840+0.610*sand-0.219*silt-6.905*OC-133.852*BD (R^2 = 0.799), at -300 kPa = 260.069+0.858*sand-6.290*OC-178.086*BD (R^2 = 0.814), at -500 kPa =273.868+0.935*sand-0.120*silt-7.071*OC-189.191*BD (R^2 = 0.848), at -1000 kPa = 276.048+0.963*sand-0.134*silt-7.997*OC-192.498*BD (R^2 =0.833), at -1500 kPa = 289.566+0.998*sand-0.141*silt-7.829*OC-204.269*BD (R^2 = 0.852). The high R^2 value of all the developed PTF indicate their applicability in evaluating soil water content using minimum soil properties like dry bulk density (BD), sand, clay, and OC for shrink-swell soils of Jalgaon district.

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Water Retention, Hydraulic Conductivity and Soil-Water Diffusivity of Three Biodraining Sodic Soils as Influenced by Concentration and Composition of Water

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Salt-affected soils deteriorate as a result of changes in soil reaction (pH) and in the proportions of certain cations and anions present in the soil solution and on the exchange sites. A laboratory study was carried-out to evaluate the effect of water salinity and SAR on water retention and transmission behavior of three waterlogged sodic soils, subjected to biodrainage. The three sodic soils had ESP of 16.3, 70.5 and 27.4. Very high degree of dispersion (67.2 to 80.9%) was observed in these soils. The pH ranged from 9.06 to 10.92 in soil-water suspension and from 8.25 to 10.0 in saturation paste extract. The highest ESP plot (70.5) had a pH value of 10.92 in soil-water suspension. Sodicity had marked influence on water retention and various water constants. No change was observed in drainable water, but the available water was considerably influenced by soil sodicity. Concentration and composition of the water flowing through the soil showed a marked influence on saturated hydraulic conductivity of sodic soils. Passing 1 M solution each of NaCl, $CaCl_2$ and $MgCl_2$ gave hydraulic conductivity in the order $CaCl_2$ > $MgCl_2$ > NaCl. Thus the Ca^{2+} salts had positive impact in improving the hydraulic conductivity of sodic soils. Passing mixed salt solutions through these soils also resulted in varying hydraulic conductivity. A water with SAR 5 m $mol^{1/2}$ $L^{-1/2}$ and TEC 50 me L^{-1} resulted in higher saturated hydraulic conductivity compared with SAR 50 m $mol^{1/2}$ $L^{-1/2}$ and TEC 5 me L^{-1}. Unsaturated hydraulic conductivity and soil-water diffusivity also revealed the same trend. Results clearly showed that waterlogged sodic soils are difficult to manage as the high amount of exchangeable sodium deteriorates soil structure and make soil prone to dispersion. For reclaiming these high ESP soils, Ca^{2+} salts are necessary. Results also hint towards a possibility of use of saline waters on these highly sodic impermeable soils.

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Influence of Organic Input on Properties of a Loamy Sand Soil and Crop Yield in Thar Desert of Western Rajasthan

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In hot arid Thar Desert of western Rajasthan, rain is main source of water for agriculture. However, it is low in amount (<400 mm yr^{-1}) and highly erratic in occurrence. This compels majority of the farmers to practice age old low input subsistence farming. They mostly use locally available natural resources only for nutrient supply and for insect pest control, *etc.* Thus, to a large extent, agriculture in the region is organic by default and gives low returns. However, availing opportunities provided by current worldwide demand for organically grown food could transform the existing low returns agriculture to high returns agriculture to the economic advantages of the farmers. To realize this government is encouraging/ supporting organic farming. We report here the properties of a loamy sand soil belonging to Pal series put under organic cultivation for three years at CAZRI experimental farm. The objective was to know changes in soil properties. The crop rotations during three years period were: *(i)* Cluster bean- cumin-sesame-isabgol-cluster bean-cumin and *(ii)* Sesame-cumin-cluster bean-isabgol-sesame-cumin, while the rates of applications for organic input were: *(i)* 0- ii) 2.5-, *(iii)* 5-, & *(iv)* 7.5 t ha^{-1} yr^{-1} compost plus 0.4 t ha^{-1} yr^{-1} neem cake in all treatments. The design was RBD with 3 replications. Rainfalls were 437.8 mm in 2008, 212.0 mm in 2009 and 562.2 mm in 2010. The reported investigation was done at the end of third crop cycle. Electrical conductivity, pH, organic carbon, available P, available K, dehydrogenase and water dispersible silt plus clay were investigated in 0-15 cm and 15-30 cm depths, while field capacity moisture, cone index, bulk density and hydraulic conductivity were investigated in the 0-10 cm depth. Infiltration rate was also measured. Standard procedures were adopted for all parameters. Since there was no consistent discerning effects of crop rotations on soil properties, data over both rotations have been pooled together and analyzed. Also, we have used geometric mean because of large variations between replicated values in general. Clusterbean and sesame yields in third cycle are reported to illustrate yield enhancement in organic cultivation.

The result in general revealed: *(i)* compost improved the investigated soil parameters but the changes were significant only for field capacity moisture, cone index, hydraulic conductivity, dehydrogenase, P, and K, *(ii)* improvement was more at higher rates of compost application and 5 t ha^{-1} yr^{-1} was the optimum rate, as beyond this the changes were not significant. At this rate increase in field capacity moisture and hydraulic conductivity over no application of compost was by 4% and 29%, respectively, while the decrease in cone index was by 25%, and *(iii)* marked increase in yields of sesame (2.8 times) and clusterbean (1.3 times) were also recorded. It is concluded that in hot arid western Rajasthan, organic farming improved both the soil condition and the crop yield and under reported condition, 5 t ha^{-1} yr^{-1} compost was the optimum rate of application.

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Long Term Effect of Integrated Nutrient Management in Pearl millet-Wheat Sequence on Soil Fertility Status at Different Soil Depths

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A field experiment was conducted from 1985 to 2012 at Main Integrated Faming systems Research Centre, S. D. Agricultural University, Sardarkrushinagar to study the effect of integrated nutrient management through organic and inorganic sources of nutrient in pearl millet-wheat crop sequence. The soil of experimental field was loamy sand. The climate of the area is arid. The experiment was laid out in a randomized block design having eight treatments with four replications. The treatments consisted recommended dose of inorganic fertilizers, either alone or in combination with organic manures at different proportions to *kharif* pearl millet and only inorganic fertilizers at two levels 100 and 75% of recommended dose (RD) to the succeeding wheat crop including control. The soil samples were collected at 15 cm division up to 105 depths from two replication of different treatment sites in June 2012 and analysed for organic carbon, P and K content of soils and measured bulk density, pH and electrical conductivity. The results indicated that increasing trend of bulk density and pH was observed with increased depth while increasing or decreasing trend was not observed for electrical conductivity with depth but maximum average value of EC was observed at 15-30 cm depth. Phosphorus, K and organic carbon content decreased with increasing depth. Regarding effect of different treatments, minimum average value of pH and EC was observed in 100% application of RD through fertilizer in both crops, whereas minimum average value of bulk density was observed in 50% NPK through fertilizer +50% N through FYM in *kharif* and 100% RD through fertilizer in *rabi*. Maximum average value of EC and bulk density were found in control plot. Whereas, maximum average value of pH was found in 50% NPK through fertilizer + 50% N through green organic manure in *kharif* and 100% RD through fertilizer in *rabi*. Minimum average value of P and organic carbon content were observed in control plot, whereas, minimum average K content observed in 100% application of RD through fertilizer in both crops. Maximum built up of P content was observed in 100% application of RD through fertilizer in both crops, Maximum average potassium content was observed in 50% NPK through fertilizer + 50% N through FYM in *kharif* and 100% RD through fertilizer in *rabi*. Maximum average organic carbon content was observed in 50% NPK through fertilizer + 50% N through green organic manure in *kharif* and 100% RD through fertilizer in *rabi*. Based on results of long term effect of integrated nutrient management through organic and inorganic sources of nutrient in pearl millet-wheat crop sequence, it is concluded that to sustain fertility status and physical properties of soils, organic manures should be included up to 50% for their N requirement.

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Effect of Preceding Summer (*Kharif*) Crops on Physico-Chemical Properties of Soils and N Requirement of Wheat

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Rice-wheat is the most predominant cropping sequence in the Indo Gangetic Plains. But over the years, the system has caused a negative balance of nutrients, decline in underground water table and increased incidence of insects and pests. Soybean (*Glycine max* (L.) Merr.) – wheat [(*Triticum aestivum* (L.) emend Fibri & Paol.] seems a promising diversified cropping system and may help in restoration of soil health. Soybean being a legume adds considerable quantities of N to the soil which may be used by the subsequent crop. Keeping this in mind a field experiment was conducted at Gurdaspur for three years to find out the effect of preceding summer (*kharif*) crops on physicochemical properties of soil and N requirement of wheat. In all the three years, highest grain yield of wheat was obtained after soybean followed by maize and rice. Average grain yield of wheat was 4.1, 3.8 and 3.6 t ha^{-1} after soybean, maize and rice, respectively. Thus soybean proved to be the best preceeding crop for wheat followed by maize and rice. A significant increase in grain yield of wheat was observed with N application up to 90 kg ha^{-1} after soybean and up to 120 kg ha^{-1} after maize and rice indicating a saving of 25% N for wheat sown after soybean. The results have revealed that application of 90 kg of N ha^{-1} is required for wheat after soybean instead of 120 kg N ha^{-1}. After three crop cycles, the organic carbon content of the soil increased from the initial status of 0.39% to 0.48% and to 0.47% in soybean-wheat and maize-wheat sequence respectively. The available N content of the soil was also less in rice-wheat cropping sequence compared with its initial status but in the other two sequences it was higher than its initial content. On the other hand, the available P content of the soil was significantly higher after three crop cycles under all the cropping sequences than its initial content. However, the maximum increase was observed in soybean-wheat sequence and the minimum increase was observed in rice-wheat sequence. The available K content of the soil, however, decreased in all cropping sequences than its initials level, however, the extent of decrease was maximum in rice-wheat and minimum in soybean-wheat cropping sequence. There was not much variation in the bulk density of the soil recorded for 0-15 and 15-30 cm soil layer under different cropping systems. However, in the 0-15 cm soil layer, maximum bulk density was found in the rice based cropping system and minimum in the soybean based cropping system. On the other hand the cumulative infiltration rate was lowest in rice based system and was highest in soybean based cropping system and that of maize based cropping system lied in between these two cropping systems this could be because of poor soil structure in rice based cropping system caused by puddling.

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Correlation of Soil Physical Health Index and Structural Indices with Crop Productivity

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In order to assess the production the potential of soils of Rai block of Haryana region, a survey was conducted in 25 villages and soil samples were collected and analyzed for important soil properties. Prediction maps of bulk density (BD), available water capacity (AWC), organic carbon (OC), non-capillary porosity (NCP) and saturated hydraulic conductivity (K_S) were prepared using inverse distance weighting technique in geographic information system (GIS). Physical rating index (PI) map of the study area was prepared to identify the soil physical constraints and overall production potential for different parts. Instead of interpolating entire region, 1-2 km periphery around the surveyed points were interpolated to present more realistic results with lower root mean square error value. Besides, the important structural indices such as dispersion ratio (DR), erosion ratio (ER), clay ratio (CR), clay moisture equivalent ratio (CMER) and stability index (SI) were computed and data of wheat yield was collected at all surveyed sites.

Results revealed that 60% of the soil in the surface and sub-surface had soil organic carbon (SOC)<0.45%, indicated that the soils were deficient in organic matter. In 50% of the area, higher BD indicated that sub-surface soil was compacted. Nearly 60% of the area had sub-surface K_S below the optimum range (1-3 cm hr^{-1}), which also confirmed the presence of hard pans. Available water capacity (AWC) of the surface soil was within the optimum range (>15%) but in the sub-surface, only 32% had AWC in the optimum range. Computation of PI of this region indicated that 50-60% of area had medium production potential (range 0.5-0.6) and rest had low to very high production potential (PI<0.05). Determination of structural indices (DR and ER) showed that more than 50% of area was erosion prone. Correlation between different erosion indices and crop yield were significant and indicated that DR, ER and CR were negatively correlated, whereas SI and CMER were positively correlated to wheat yield. The above results thus confirmed that poor wheat yields were due to poor structural condition of these soils.

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Water, Nitrogen and Radiation use Efficiency of Wheat as Influenced by Irrigation and Nitrogen Management Practices

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There is a need to optimize the irrigation schedule for different crops under different nutrient management practices *viz.*, organic, inorganic and integrated nutrient management practices to achieve higher resource use efficiency in the face of energy crisis and limited water supply situation. A field experiment was conducted on a Typic Haplustept at the Indian Agricultural Research Institute, New Delhi during 2010-13 in a split plot design with four levels of irrigation (0.4 IW CP^{-1}, 0.6 IW CPE^{-1}, 0.8 IW CPE^{-1} and 1.0 IW CPE^{-1}, IW= 6 cm) and three N management strategies (120 kg N ha^{-1} as urea, 60 kg N ha^{-1} as urea + 60 kg N ha^{-1} as farmyard manure (FYM) and 120 kg N ha^{-1} as FYM) to optimize irrigation schedule and N management for wheat (cv PBW 502) for improving water, N and radiation use efficiency (RUE). The pooled analysis of data over three cropping seasons showed that there was significant increase in the grain yield of wheat by 21% with the increase in the irrigation level from 0.4 IW CPE^{-1} to 1.0 IW/CPE irrigation level. However, there was no significant difference in the grain yield of wheat due to irrigation at 0.8 and 1.0 IW CPE^{-1}. The total biomass production due to different irrigation treatments followed the similar trend as the grain yield of wheat. Grain (4605 kg ha^{-1}) and biomass yield (14578 kg ha^{-1}) of wheat with sole urea application was statistically similar to integrated use of urea and FYM (4377 kg ha^{-1} and 12958 kg ha^{-1}, respectively) but higher than that of sole FYM application (3046 kg ha^{-1} and 8987 kg ha^{-1}, respectively). There was significant decrease in the water use efficiency of wheat with the increase in irrigation levels; however, the water use efficiency with urea (11.68 kg ha mm^{-1}) and urea + FYM treatment (11.74 kg ha mm^{-1}) was similar but significantly higher than that with sole use of FYM (8.05 kg ha mm^{-1}). The partial factor productivity of nitrogen decreased with decrease in irrigation level. The partial factor productivity of N with sole urea application (38.4 kg grain kg N) was similar to integrated use of urea and FYM (36.5 kg grain kg^{-1} N) but higher than that with sole FYM application (25.4 kg grain kg^{-1} N). The total intercepted photosynthetically active radiation (TIPAR) increased by 18% with the increase in the irrigation level from 0.4 IW CPE^{-1} (516 MJ m^2) to 1.0 IW/CPE (584 MJ m^2). Among the nutrient sources, the TIPAR due to sole urea application (609 MJ m^2) was 7.6% higher than integrated use of urea and FYM (566 MJ m^2) and 31% higher than sole use of FYM (466 MJ m^2). The TIPAR could account for 67-81% variation in the total above ground biomass production. There was no significant difference among irrigation levels with respect to RUE of wheat. Among the nutrient sources, the RUE due to integrated use of urea and FYM (2.446 g MJ^{-1}) was similar to sole use of urea (2.452 g MJ^{-1}) but higher than sole use of FYM (2.05 g MJ^{-1}). Thus, wheat can be grown with 0.8 IW CPE^{-1} irrigation level with integrated use of urea and FYM in sandy loam soils of Trans Gangetic Plain Region to achieve higher water, nitrogen and saving of water and fertilizer nitrogen but without any significant reduction in grain yield compared to the full dose of irrigation (1.0 IW CPE^{-1}) and fertilizer N (120 kg N ha^{-1} as urea) application.

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Modeling Root Water Uptake in Chick pea using Soil Moisture Data

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Root water extraction is a key process in the hydrological cycle in that it largely controls the partitioning of infiltrating rainfall into evaporation, transpiration, and leaching. An adequate supply of water is one of the most important resources required for plant growth and function. Due to the undoubted importance of water conditions for plant growth, effort has been expended on trying to quantify the amount of water a plant requires. In normal circumstances, the amount of water within a plant is set by a balance between the water uptake through the roots and the rate of transpiration through the leaves. If the water saturation, *i.e.* the volume of water per unit volume of soil, is below a level termed the 'permanent wilting point', then uptake ceases, and the plant will wilt. There are two different approaches to quantify root water uptake: the microscopic and the macroscopic. The microscopic approach considers that the radial flow of soil water toward-and into a representative individual root and can be represented by an infinitely long cylinder of uniform radius and water absorbing properties. Whereas, macroscopic approach deals with the removal of water from the root zone as a whole, without considering explicitly the effects of individual roots. The developed a root water uptake model, based on macroscopic approach, with three basic assumptions. The first assumption is that as soil becomes dryer, the amount of water that can be extracted decreases proportionally, due to the increase sorption potential of the soil. Secondly, the amount of water extracted by the roots is affected by the ambient climatic conditions. Drier and hotter conditions result in more water loss from the surface of leaves, hence, initiating more water extraction from the soil. The third and the final assumption is that the uptake of water from a particular section of a root is directly proportional to the amount (mass and surface area) of roots present and developed following equation to determine root water uptake from any given soil layer as:

$$RWU = \left(\theta^{t} - \theta^{t+1}\right) - (q_{out} - q_{in})$$

In this study, we have used this approach to quantify root water uptake in chick pea under different tillage and moisture regimes. Result showed that cumulative root water uptake over the growth period is more in conventional tillage than no-tillage. This is attributed to higher root length density in case of conventional tillage. Under stress condition, roots can easily take water from deeper wetter soil layers with no reduction in total rate.

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Interseasonal and Interannual Variation of Surface Energy Fluxes Over a Arid Grassland of Thar Desert

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In the present study surface energy fluxes and evapotranpiration are evaluated over the arid grassland of Thar Desert. The dekadal variations in the surface energy balance (SEB) components in association with regional rainfall, soil moisture and vegetation growth parameters are analysed for the year 2011 and 2012 to understand the relationship between residual energy and rainfall and to delineate the dry and wet spells. The study indicates the latent heat flux (LE) is relatively higher (LE: 88–115 Wm^{-2}) during monsoon and lower (*LE:* 15– 42 Wm^{-2}) during the dry period. Relatively higher latent heat is released in 2012 relative to 2011 during monsoon. Correspondingly, higher sensible heat fluxes (SH; ~375 Wm^{-2} in 2011; ~300 Wm^{-2} in 2012) are found in the pre-monsoon summer season and post monsoon associated with less vegetation growth relative to monsoon. Dekadal variability of the net upward (SH+LE) and downward fluxes indicate variation between 2011 and 2012. Both upward and downward fluxes as well as residual energy are higher in 2012 relative to 2011. The upward/ downward fluxes are found to reach maximum values in the September and October months. The total heat fluxes (SH+LH) are in close association with total net available energy (Rn-G). It has been found that the wet spells are associated with +ve residual energy and dry spells with –ve residual energy in both the years. Large heat fluxes (>400 Wm^{-2}) in association with large surface-air temperature difference (Dt ≥ 0.65 °C) are found in the summer season and is related to the large surface heating and instability of the atmosphere. The higher ET, SM, LH during the monsoon season is attributed to low net radiation, local precipitation and vegetation growth in the study region.

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Impact of Long-term Zero-tilled Wheat on Soil Physical Properties and Wheat Productivity under Rice-Wheat Cropping System

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The conservation tillage has a potential to enhance productivity, input use efficiency and improvement in resources and environment. The impact of 15 years of zero tillage in wheat in rice-wheat cropping system in the Indo-Gangetic Plains of Haryana on some soil physical properties and wheat productivity in three texturally different soils (sandy loam, loam and clay loam) was evaluated. The zero tillage had higher influence on soil physical properties in clay loam soils than in loam and sandy loam soils over the conventional tillage. A significant increase in soil organic carbon content was observed to a deeper depth with increase in the fineness of the texture of soils. The zero tillage system found to increase the compaction of surface soil, the compaction was, however, significant to a depth of 0.05 m in sandy loam and 0.10 m in both loam and clay loam soils. Continuous conventional tillage over several years resulted in development of plough sole in soils beneath the usually tilled depth, while zero tillage practice found to reduce such sub-surface compaction. Soil dispersion found to reduce significantly at almost all soil depths in soils under zero tillage indicating better aggregation. In general, the saturated hydraulic conductivity values for different depths were higher under zero tillage than conventional tillage in different textured soils with variable magnitude in differences between the two treatments. The effect of zero tillage for enhancing moisture retention at field capacity was more pronounced in clay loam soils and to a deeper depth compared with loam and clay loam soils. The water intake rate of soils increased upon zero tillage practice, however, significant increase was observed in loam and clay loam soils. No tillage practice encouraged roots to penetrate deeper in the soil profile accumulating higher root mass in all the soils. The increased bulk density of surface soil in zero tillage practice was not found to restrict the wheat growth and hence, the yield of the crops in different textured soils.

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Modelling Soil Water Movement and Root Water Uptake under Conservation Practices in a Cotton-Wheat Rotation

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The root water uptake (RWU) patterns of cotton grown under different conservation agricultural practices in a cotton-wheat cropping system were analyzed using the numerical model Hydrus-2D. Following treatments were investigated: conventional tillage (CT), zero tillage (ZT), permanent narrow beds (PNB), permanent broad beds (PBB), ZT with residue (ZT+RES), PNB with residue (PNB+RES) and PBB with residue (PBB+RES). Wheat residues (in total), leaves and twigs of cotton were retained in the residue treated plots. Results in the third cropping cycle indicate that surface bulk densities in both PNB and PBB plots were similar to CT plots. CT plots had greater root proliferation due to higher irrigation water (flood irrigation) than PNB and PBB plots (furrow irrigation) during initial stages of crop growth. In ZT plots, root growth was less due to surface compaction. Predicted soil water content (SWC) of initially saturated soil during a drying cycle showed high correlation (r2 =0.80) with actual field measured data. Cumulative RWU (cm) in different plots were in the order: CT (10.9) >PBB+RES (10.36) >PNB+RES(10)> ZT+RES (9.5) @ PNB (9.4) =PBB (9.4) >ZT(8.5). In PNB, PBB and ZT plots, residue retention improved root growth and hence, RWU. Thus, PBB+RES practice might be adopted for cotton cultivation in this region as it maximized RWU and improved soil physical health.

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Influence of Canal Irrigation on Soil Physicochemical Properties in the South Western Parts of Thar Desert of India

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The Thar Desert of India, spread over 19.6 million hectare in Rajasthan state of India, is characterized with dunes and inter-dune plains, sandy to sandy-loam soils, high temperature, very low and sporadic rainfall, very low soil fertility, severe wind erosion, and limited irrigation facility. During the late sixties a canal network under Indira Gandhi Nahar Pariyojna (IGNP) is brought in the northern part of the desert, which was later extended to the south western parts of Thar Desert. The plan was to irrigate nearly 1.54 m ha to a culturable command area in two phases covering 0.54 m ha in stage 1 and 1.0 m ha in stage II. With the available irrigation water from IGNP canal, cultivating crops in desert areas have found its reality in the command areas. Although the crop production in the canal command areas has been increased by manifold with introduction of irrigation facility in arid areas, the effect of such intensive irrigation in arid sandy soil was neglected. However, information on change in soil properties after introduction of IGNP canal in desert is not yet known. It is hypothesized that continuous irrigation may hamper the soil physical and chemical environment for plant growth in future especially in SW parts of desert. Field survey and laboratory analysis revealed that irrigation reduced soil bulk density (by 3.5 to 7.0%), infiltration rate (by 45-70%) but increased silt (by 4.5 to 6.8%), clay (by 3.2 to 4.4%) particles and water holding capacity by (40 to 51.5%). Continuous irrigation increased the concentration of soil organic carbon (SOC) by 60-75%, available P (1.65 to 2.5 times), but K content was decreased by (15.5 to 25.0%). The DTPA extractable micronutrients in general were increased in canal irrigated soils than non irrigated soils. The Fe, Zn and Cu were increased by 20.0, 25.0 and 40%, respectively. Among the soil biological properties, dehydrogenize activity and microbial biomass carbon was 18-25% higher in canal irrigated soils than non irrigated fields. All these together probably suggest that increased pedological and bio-chemical processes of soils results in improvement in physico-chemical characters of the soils in the Thar desert of India.

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Seed Yield and Water and Radiation Use Efficiency of Indian Mustard as Influenced by Variable Weather in a Semi-Arid Environment

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The data of sowing of Indian mustard (*Brasica juncea*) varies from year to year depending upon the harvesting of previous wet season crop in the northern and north-western parts of India, which exposed the mustard crop to variable weather conditions. So an experiment was conducted in Indian Agricultural Research Institute research farm during 2010-12 to study the interactive effect of variable weather and cultivars on yield, water and radiation use efficiency of mustard. In this experiment, split plot design was adopted with data of sowing (early, normal and late) as main plot treatment and mustard cultivars (Pusa Gold, Pusa Jai Kisan and Pusa Bold) as subplot factors. The soil moisture storage (gravimetric method) during peak growth and later growth period showed inverse relationship with the mustard biomass, i.e., treatment with higher biomass yield had lower soil moisture storage. Averaged over the years and cultivars, ET (field water balance method) decreased with delay in sowing. Late sowing had 13 and 6% lower ET than early and normal sowing respectively. The relation between ET and mustard seed yield for both years of study was linear and significant ($P=0.05$). Averaged over the years and cultivars, late sowing had 12% and 1% lower total intercepted photosynthetically active radiation (TIPAR) than the early and normal sowing, respectively. A significant and positive correlation was observed between TIPAR and aboveground biomass yield of mustard for both years of study. Pooled over the years, mustard seed yield, radiation and water use efficiencies were significantly ($P < 0.05$) lower in late sowing compared with early sowing (by 46, 32 and 40%, respectively) and normal sowing (by 44, 26 and 41%, respectively). Early and normal sowing were similar for mustard seed yield and water use efficiency. Among the cultivars, Pusa Jai Kisan and Pusa Bold were similar with respect to seed yield, radiation and water use efficiencies whereas, Pusa Gold registered lower seed yield, radiation and water use efficiencies compared with the cultivars Pusa Jai Kisan (by 55, 23 and 52%, respectively) and Pusa Bold (by 56, 20 and 54%, respectively). There was significant interaction between date of sowing and cultivars with respect to seed yield, radiation and water use efficiencies of mustard. Thus, normal or early sowing of the Pusa Jai Kisan or Pusa Bold cultivar may be done for achieving higher seed yield, radiation and water use efficiencies in the semi arid environment of north-western part of India.

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Soil Aggregates as Indicator of Soil Health in Waterlogged Condition

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Soil aggregates play an importance role in maintaining soil structure and sustaining soil fertility. Aggregates stability is a crucial soil property affecting soil sustainability and crop productivity. It describes the rank of behaviour of soil under effect of water, wind and management. Water stable aggregates (WSA) in size 0.25-0.1 mm generally have more organic matter and higher nutrient levels than microaggregates as well as less susceptible to erosion and create larger pores for better water infiltration and aeration. Information is limited on distribution of macro- and micro-aggregates in soil profile under different soil pH in waterlogged soils. The macro- and micro-aggregates, WSA, mean weight diameter (MWD) and geometric mean diameter (GMD) and aggregate ratio (AR) and aggregate stability (AS) in five waterlogged sodic soils with five pH (8.6, 8.8, 9.3, 9.5 and 9.7) and in four soil depths (0-15, 15-30, 30-45 and 45-60 cm) have been studied. The results showed that the increasing soil pH from 8.6 to 9.7 increased macro-aggregates from 27.90% to 56.14%, However, the micro-aggregates increased from 49.54% to 85.30% with increasing soil pH. Beyond pH 9.3, the microaggregates decreased from 85.30% to 33.84%. Although, WSA in size 0.25-0.10 mm and >2 mm were affected by the soil pH in 0-15 cm soil layer, it increased with soil pH up to 9.3, and thereafter decreased. In 15-30 cm soil depth, WSA in size 0.1-0.05 mm were also influenced by the change in soil pH and it drastically increased from 0.88 to 16.00% with increasing soil pH from 9.3 to 9.7. However, WSA in size 0.50-0.25 mm decreased with increasing soil pH up to 9.3 in 45-60 cm soil depth. The MWD and GW also influenced by the change in soil pH especially in the 0-15 cm soil depth.

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Effect of *In-situ* Recycling of Sugarcane Crop Residues and Industrial Waste on SOC Dynamics and Crop Productivity

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Sugarcane is a longer period major cash crop in Maharashtra and influencing social, economical and political set-up of the state and as well country. This crop produces high biomass and requires large quantity of fertilizers and manures. The fertility and productivity of soils from sugarcane growing area is declining due to indiscriminate use of water and fertilizers and also monocropping of sugarcane.

In-situ recycling of crop residues with appropriate technique is one of the option for enhancing crop productivity and soil health. With view of enhancing soil health and productivity of sugarcane based cropping system, the field experiment was undertaken at Central Campus, MP KV, Rahuri during year 2009 -2010 by formulating various *in situ* recycling techniques of sugarcane crop residues and industrial waste for their holistic use and study of their residual fertility for understanding the possibility to saving of recommended dose of fertilizers. Considering contribution of soil organic carbon (SOC) and their various pools for soil health and crop productivity, after harvest of each crop, the experimental soil was analysed for various SOC pools, nutrients availability, crop yields and nutrient uptake by adopting standard methods. The results of present study reveal that among the various recycling techniques, the technique of integrated *in-situ* decomposition of sugarcane crop residues + pressmud compost along with 100% recommended dose of fertilizers to crops brought significantly better stable humus, and retained greater amount of total organic carbon (TOC), active carbon pools (SMBC, WSC, POSC and AHC), physically protected POMC and which significantly improved micro aggregates in the cultivated soil by 8.8% greater as compared to the practice burning of sugarcane trash. Further, it was observed that *in-situ* decomposition of sugarcane crop residues + press mud compost coupled with 100% recommended dose of fertilizers (INM) significantly increased grain yield of soybean (3.75 q ha^{-1}) and maize (4.90 t ha^{-1}). Nutrient uptake N, P and K were significantly improved in INM treated plots. Similarly, soybean protein (37.99%) and maize starch content (58.63%) with high B:C ratio (2.36) obtained in technique of INM indicated the highest economic viability and saving of 50% recommended fertilizers dose of succeeding crops. In conclusion, the technique of integrated *in situ* decomposition of sugarcane crop residues + pressmud compost along with 100% recommended dose of fertilizers to crops proved the best for improving quality of soil organic matter and resulting in enhancing soil health and profitable crop productivity.

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Variability in Ionic Composition of Groundwater of Udaipur District of Rajasthan

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A survey was conducted in Udaipur district of Rajasthan to assess the variability in ionic composition of groundwater. Total sixty one groundwater samples were collected covering all the eleven blocks of the district and analyzed for electrical conductivity (EC), sulphate (SO_4^{2-}), chloride (Cl^-), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-, Ca^{2+} and Mg^{2+} which are the important water quality parameters to determine it's suitability for irrigation. In this study it was found that pre-monsoon groundwater samples have higher EC and toxic ion concentration as compared to the post-monsoon groundwater samples. The overall quality of groundwater of Udaipur district was found satisfactory but the Cl^- concentration of groundwater crossed the safe limits for its use for irrigation purposes in some blocks. Further, the SO_4^{2-} concentration indicated that in two (Mavli and Bhinder) blocks groundwater crossed the safe limits for its use for irrigating the crops. The farmers of these areas are growing highly sulphur responsive crops like maize, rapeseed and mustard and avoiding the Cl^{-1} sensitive crops like tomato, potato & tobacco and only a very small area is under pulse crops. Hence, the farmers are avoiding the adverse effects of poor quality groundwater adopting cropping system which is economical and sustainable.

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Carbon Mineralization from Native Soil Organic Carbon and Applied Farm Yard Manure as Affected by Biochar Incorporation

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An incubation experiment was conducted to study the effect of pigeon pea biochar (PPB) and prosopis hardwood biochar (WB) on short term carbon mineralization of native soil organic carbon (SOC) and applied farm yard manure (FYM). Biochar from pigeon pea stem and prosopis hardwood was prepared at Central Institute of Agricultural Engineering (CIAE), Bhopal, Madhya Pradesh by slow Pyrolysis at 300 ^{o}C. The experimental soil used for incubation study was *Typic Haplustert* with pH 7.86 and organic carbon 0.52%. The experiment was comprised of ten treatments: (T_1) Control (soil alone), (T_2) FYM, (T_3) FYM + WB (5%), (T_4) FYM + WB(10%), (T_5) WB (5%), (T_6) WB (10%), (T_7) FYM + PPB (5%), (T_8) FYM + PPB (10%), (T_9) PPB (5%) and (T_{10}) PPB (10%). The FYM was added to soil at the rate of 10 t ha^{-1} on dry weight basis. The biochar was added at rate of 5 and 10% of total weight of FYM. The CO_2 evolution was measured at three days interval up to 36th day using alkali (NaOH) trap method followed by back titration with acid.

The results showed that WB, PPB and FYM have 68.53, 52.34 and 29.83% total organic carbon (TOC), while dichromate oxidizable carbon (OC) contents were 20.80, 13.01 and 16.05%, respectively. The results further suggest that in prosopis hardwood biochar, pigeon pea biochar and FYM, 30.35, 24.85 and 53.80% of the TOC was oxidizable by wet dichromate oxidation process, respectively. FYM addition enhanced the soil respiration by 2 fold (107.31 mg C/500 g soil) over control (54.48 mg C/500 g soil). Among the biochars, PPB addition increased the cumulative loss of carbon as $CO_{2,}$ whereas, WB decreased the cumulative loss over control. The net loss of C from FYM (T_2) decreased considerably from 52.83 mg C/ 500 g soil to 29.34 and 21.2 mg C/500 g soil due to mixing of WB @ 5% (T_3) and 10% (T_{4-}) of the weight of applied FYM, respectively. In contrast, when FYM was mixed with PPB @ 5% (T_7), the loss of C from FYM remained same but increased significantly due to mixing of PPB @ 10% with FYM (T_8). Further, prosopis hardwood biochar induced strong negative priming effects (-44.49% and -59.88%), while pigeon pea biochar caused only a weak positive priming effects (+2.78% and +15.46%) at 5% and 10% levels of addition on short term mineralization of added labile carbon substrate. Thus, the prosopis hardwood biochar has some refractory property to inhibit the mineralization of both native soil organic carbon as well as applied organic matter, and thereby can be used as an amendment to stabilize the native and applied organic materials in soil.

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Effect of Seed Manganese Content on Root Growth and Manganese Influx Rate in Wheat

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A pot experiment was conducted to study the effect of seed manganese (Mn) content on root growth and Mn influx rate in wheat at the Department of Soil Science, Punjab Agricultural University, Ludhiana. Seed of two wheat cultivars PBW 621 (*aestivum*) and PDW233 (*durum*) with low and high inherent seed Mn content was collected from an ongoing experiment. The seed was soaked in 0, 0.2 and 0.4M $MnSO_{4.}5H_2O$ solution for five hours before sowing in a Mn deficient sandy loam soil. The shoot and roots were collected at tillering and booting stage to study the growth parameters and Mn influx rate.

The mean root dry matter at tillering stage increased from 107.6 mg plant^{-1} in control to 136.0 and 163.1 mg plant^{-1}, respectively with seed soaking treatments of 0.2M and 0.4M $MnSO_{4.}5H_2O$. Similar increase in root dry weight was also observed at booting stage. A significant effect of high inherent seed Mn content irrespective of cultivar and seed soaking treatments on the root dry matter production was also observed. Wheat cultivar PBW 621 produced a significantly higher root dry matter than PDW 233. The root length at tillering stage increased by 29 and 62% over control with seed treatment of 0.2 and 0.4 M $MnSO_{4.}5H_2O$, solution, respectively. The beneficial effect of high inherent seed Mn content on root length was also recorded and it increased from 404 cm plant^{-1} raised with low inherent seed Mn content to 493 cm plant^{-1} in high inherent seed Mn content. The root length of cultivar PDW 233 was significantly lower than PBW 621. A similar trend was also observed at booting stage. The distance between root axes and competition between roots for nutrient uptake is determined by mean half distance. Lesser the distance among the neighboring roots, more will be the competition between the roots to absorb nutrients. The mean half distance between the neighboring roots decreased significantly by seed soaking treatments. In control the mean half distance was 2.88 cm and it decreased to 2.34 and 2.0 cm with 0.2 and 0.4 M soaking treatments, respectively. The corresponding decrease at booting stage was from 2.08 cm in control to 1.61 and 1.34 cm, respectively. The mean root radius remained unaffected with seed Mn content in both the cultivars. The amount of Mn taken up by per unit root length per unit time is known as Mn influx rate. If the value of the influx is low, a large root length per unit of shoot will be required in order to take up enough nutrients to support growth. The Mn influx increased significantly over control with increase in seed Mn content. It increased from 0.17×10^{-7} nmol cm^{-1} s^{-1} in control to 0.24×10^{-7} and 0.29×10^{-7} nmol cm^{-1} s^{-1} with 0.2 and 0.4M $MnSO_4.5H_2O$ treatments, respectively. Similarly the Mn influx also increased from 0.21 $\times 10^{-7}$ nmol cm^{-1} s^{-1} in plants raised with low inherent seed Mn content to 0.26×10^{-7} nmol cm^{-1} s^{-1} in plants raised with high inherent seed Mn content. The cultivars differed significantly with respect to Mn influx and relatively low influx rate was observed in PDW 233 (*durum* wheat) than PBW 621 (*aestivum* wheat). It was 0.15 $\times 10^{-7}$ and 0.32×10^{-7} nmol cm^{-1} s^{-1} for PDW 233 and PBW 621, respectively. It may be concluded that high Mn content either achieved naturally or artificially improved the root growth parameters and Mn influx rate in both the cultivars. The poor root growth and low Mn influx rate in PDW 233 reflects its poor Mn stress tolerance power than PBW 621.

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Effect of Organic Matter on Adsorption of Pendimethalin and Oxyfluorfen on Selected Soils of Andhra Pradesh

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Soil samples varying in their physico-chemical properties were collected from seven agro climatic zones of Andhra Pradesh. At each selected location, the soil samples were collected from 15-20 different spots at a depth of 0-22 cm, quartered and about 5 to 10 kg of each soil sample was brought to the laboratory, air dried under shade and processed by passing through a 2 mm size sieve. These 2 mm sieved soils were properly labeled and stored in cloth bags for further studies. Among these soils four soils *i.e.,* two Vertisols were selected to study on adsorption of pendimethalin/oxyfluorfen after destruction of organic matter in soils. For destruction of soil organic matter the suspension was digested for thirty minutes on water bath with intermittent stirring with 30% H_2O_2. After effervescence ceased, one more dose of 10 ml H_2O_2 was added. This process was repeated till effervescence completely ceased. The soil was then shade dried and preserved for adsorption studies.

Five grams of soil was weighed and adsorption was carried out with two initial concentration *i.e.,* 25 and 50 mg mL^{-1}. Blanks were also maintained for each soil. These were incubated for 24 hrs. at 27 $\pm 1^oC$ and centrifuging the suspension at 5000 rpm for 15 mints. The adsorbed amount was calculated and fitted into the Freundlich Equation. The extent of adsorption of pendimethalin and organic matter destroyed soils varied from 11.28 mg g^{-1} (A_4) to 19.60 mg g^{-1} (V_2) as compared to the adsorption on 2 mm sieved soils and in these soils the amount of adsorption varied from 15.55 mg g^{-1} (A_4) to 27.25 (V_2). The percent reduction in adsorption of pendimethalin due to destruction of organic matter was maximum in V_2 (31.74). Similar procedure was followed to study the effect of organic matter on adsorption of oxyfluorfen and a reduction in amount of adsorption was observed for oxyfluorfen in organic matter destroyed soils. The extent of adsorption was varied from 21.06 (V_4) mg g^{-1} to 29.48 mg g^{-1} (V_2) in organic matter destruction was observed for V_2 (21.80%), as it contained highest organic carbon content. Brings out clearly the role of organic carbon in the adsorption of herbicides. The correlation at maximum adsorption on organic carbon was linear r = 0.899**) for pendimethalin and r = 0.890** for oxyfluorfen).

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Effect of Chelating Compounds on Heavy Metals Uptakes by Spinach (*Spinacea Oleracea* L.)

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Phytoremediation is a promising new technology that uses plants to degrade, assimilate, metabolize, or detoxify metals, hydrocarbons, pesticides, and chlorinated solvents. An investigation was undertaken to study the effect of chelating compounds, EDTA (0.1%), DTPA (0.1%), Citric Acid (0.1%), Oxalic Acid (0.1%) on heavy metal uptake by spinach under green house condition.

This study suggests that chelating compounds provided feasible conditions for plants to take micro and heavy metals from soil. Application of EDTA showed highest heavy metals uptake by spinach. EDTA increased uptakes of Ni and Cd 4 fold, and Cr and Pb 3 times as compared to control. EDTA was found the best chelating compound as compared to DTPA, Citric Acid, Oxalic Acid. Hence, addition of a synthetic chelating agent such as ethylene diamine tetraacetic acid (EDTA) is an efficient method to enhance heavy metal uptake by plants for facilitating phytoremediation.

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Sulphur Mineralization under Different Land Uses and Slopes in the Sub Mountain Region of Jammu

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The soils of sub—montane region of Jammu are characterized by undulating topography, subjected to severe erosion and thus the inherent nutrient status of these soils, including that of sulphur (S), is low. A study was carried out to study the mineralization of sulphur under different land uses and slopes in the region. Soil samples were collected from four different land uses namely agriculture, forest, horticulture and wasteland with moderate and gentle slope from each of the ten locations. For mineralization studies incubation was carried out in open and column system made of plastic.

Cumulative mineralized sulphur showed a curvilinear relationship with time. For all uses and both depths, the shape of the curves indicated a slower rate of organic sulphur mineralization in the latter stage of incubation. In all the locations with different land uses, maximum mineralization was found in 9th week and after that the rate of release of mineralized sulphur remained almost constant. In general the cumulative mineralized sulphur in first depth was highest in horticulture and lowest was in forest. Potentially mineralizable S was highest in horticulture land use with a value of 6.88 mg kg^{-1} and lowest in forest soils with a value of 4.45 mg kg^{-1}. It was higher under moderate slope except in horticulture land use. The value of S was more in upper depth as compared to lower depth in all the four land uses. The rate constant was higher in the lower as compared to upper depth in both slope gradients and all four land uses. The K value was almost similar in all land uses with a slight difference. Its value was higher under moderate slope except in wasteland soils. The value of $t_{1/2}$ was higher in first depth as compared to the second one except in the agriculture land use with a gentle slope where its value was higher in second depth. The value of $t_{1/2}$ was higher in moderate slope except in wasteland where it was higher in gentle slope. The value of time required to mineralize half amount of organic S was highest in horticulture land use with a value of 9.39 week and lowest being in agrilculture soils with a value of 7.50 week. The highest overall mean of rate of mineralization was higher in moderate slope except in wasteland soils where it was higher in gentle slope. The highest rate was observed in horticulture land use with a value of 0.56 mg kg^{-1} $week^{-1}$ and lowest being in forest with a value of 0.43 mg kg^{-1} $week^{-1}$.

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Inorganic Potassium Fractions in Soil and Response of Cauliflower (*Brassica oleracea* var. Botrytis) in Light Textured Soils of Rangareddy District

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Light textured soils of Rangareddy district were collected from thirty locations and analysed for inorganic potassium fractions. A greenhouse experiment was conducted to know the response of collected soils. The texture of the soils varied from loamy sand to sandy loam except the soils of Shamshabad, Emamguda and Tukkuguda which were sandy soils and the soils of Mominpet which was sandy clay loam. The level of extraction of K by different extractants followed the order : Boiling HNO_3 (1 M) > $NaBPh_4$ (0.2 M)> Citric acid (0.01 M) > NH_4OAc (NN) > Oxalic acid (0.01 M) > Acetic acid (0.01 M). The amount of K extracted by different extractants was more in sandy clay loam soil of Mominpet and very low in sandy soils of Emamguda. Among all, the boiling HNO_3 (1M) extracted higher amounts of K ranging from 654 to 1794 mg kg^{-1} with a mean of 1407 mg kg^{-1} while, NH_4OAc extracted an amount of 54.24 to 242.3 mg kg^{-1} with an average of 130.3 mg kg^{-1} and it showed highly significant correlation with 0.2 M $NaBPh_4$ extractable K ($r = 0.926^{**}$), plant K uptake ($r = 0.931^{**}$) and also with curd yield ($r = 0.975^{**}$) of cauliflower, hence can be considered as the best extractant for available K for cauliflower in the light textured soils of Rangareddy district. However, $NaBPh_4$ (0.2 M) showed significant positive correlation with citric acid (0.01 M) extractable K ($r = 0.706^{*}$), plant K uptake ($r = 0.911^{**}$) and curd yield ($r = 0.927^{**}$). The mean curd yield was 352.4 g $plant^{-1}$ in the control which showed a significant increase to 454.8 g $plant^{-1}$ with the application of 150 kg K_2O ha^{-1}. The mean response to the application of K was 25.28 kg cauliflower curd per kg of potassium applied. The response to the applied K in terms of curd yield was 12.2% with Mominpet soils, where as it was 52.5% with Emamguda soil.

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Depth-wise Distribution of Macro and Micronutrients under Different Land Use Systems in Acid Soils of Karnataka

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To study the status and distribution of macro and micronutrients in relation to the chemical properties in acid soils of southern Karnataka, ten soil profiles were studied under different land use systems. The soils were found to be slightly acidic in soil reaction and low in electrical conductivity (EC) indicating low amount of soluble salts in the soils, while organic carbon (OC) content gradually decreased with depth among the land use systems. Low cation exchange capacity values were observed under different land use systems studied which may be attributed to low clay content and dominance of Kaolinite type of clay. Calcium carbonate ($CaCO_3$) content increased from 0.32 to 0.69% in all the profiles. Free iron oxides (Fe_2O_3) that in all the profiles are relatively low and it decreases with depth. The available nitrogen, phosphorus, potassium and sulphur were decreased with depth. Exchangeable calcium and magnesium increased from 5.80 to 6.80 and 2.10 to 2.90 cmol (P^+) kg^{-1} among the land use systems. Among the land use systems micronutrient were decreased with depth it might be due to its close association with organic matter. Available nitrogen significantly positively correlation with organic carbon (r=0.364*), clay (r=0.235**), $CaCO_3$ (r=0.474*). The available phosphorus content was positively correlated with clay, pH, EC, OC, $CaCO_3$ and Fe_2O_3. Exchangeable calcium and magnesium was significantly correlated with CEC (r=0.492*, 0.547*). Available sulphur showed significant relationship with organic carbon. The DTPA extractablel Fe significantly and positively correlated with clay (r=0.374**), OC (r=0.468*), $CaCO_3$ (r=0.358*) and Fe_2O_3 (r=0.336*). Mn shows significant relationship with clay (r=0.442**), pH (r=0.265*), OC (r=0.498*), CEC (r=0.365*), $CaCO_3$ (r=0.354*) and Fe_2O_3 (R=0.566*) whereas the iron oxides are negatively and significantly correlated with Zinc and copper. DTPA extractable zinc significantly positive correlation with clay, OC, CEC. Cu significant positively correlated with organic carbon (r=0.496*). Thus it can be concluded that pH, EC, OC, $CaCO_3$, CEC and Fe_2O_3 alone in combination controls the distribution of nutrients in different land use systems.

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Copper Fractions and Their Relations with Physico-chemical Properties of Soils in the Rubber Growing Areas of North-East India

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Soil samples were collected from fifty matured rubber plantations spreading over the north-east India and subjected to sequential extraction of micronutrients to identify the proportion of the labile pool and factors affecting its availability to plants. Water soluble plus exchangeable copper (WSEX-Cu), Complexed copper (COMP-Cu) and Organic copper (ORG-Cu) fractions ranged from 0.07 to 0.31, 1.11 to 2.56 and 1.52 to 5.18 mg kg^{-1} soil, respectively. On an average they constituted 0.19, 1.49 and 3.73% of total Cu in soil, respectively. These fractions showed significant and positive correlations with clay and organic matter content of the soil. Acid soluble copper (ASOL-Cu) and citrate bicarbonate dithionite soluble copper (CBD-Cu) fractions ranged from 0.07 to 0.21 and 1.86 to 3.08 mg kg^{-1} soil, respectively with mean values was 0.13 and 2.53 mg kg^{-1} soil, respectively. These two fractions of copper did not show any significant correlation with any of the soil properties under consideration. Residual copper fraction (RES-Cu) fraction ranged from 67.32 to 124.36 mg kg^{-1} soil and the mean value was 102.60 mg kg^{-1} soil. On an average it constituted 91.66% of total Cu in soil. Total copper (TOT-Cu) ranged from 76.85 to 134.25 mg kg^{-1} soil and the mean value was 111.73 mg kg^{-1} soil. Residual and total copper did not show any significant correlation with any of the physico-chemical properties of soil studied. Significant relationships among various fractions of copper indicate the dynamic equilibrium among them. Step-down regression analyses revealed that soil organic matter and clay content are the most dominant factors contributing to the availability of copper in the labile pool.

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Crop Residue Management in Swell-Shrink Soils under Soybean-based Cropping System

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The present investigation was carried out to study the effect of crop residue management on soil properties and crop productivity under soybean - wheat and soybean-chickpea cropping systems in swell-shrink soils at the Research Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The treatments comprised of unfertilized control, chemical fertilizers alone and their combinations with organics *viz.* FYM, phospho-compost and cotton stalk, *in-situ* soybean straw and neem cake in randomised block design with three replications.

The use of organics *viz.* FYM, phospho-compost and cotton stalk and *in situ* soybean straw in conjunction with chemical fertilizers recorded improvement in physical, chemical and biological properties resulting into enhancement in soil quality. The negative balance of potassium and relatively more magnitude of potassium mining observed under only chemical fertilizers as compared with integrated nutrient management suggest the importance of organics in conjunction with chemical fertilizers. The integrated use of chemical fertilizers with FYM, phospho-compost, cotton stalk, soybean straw recorded higher dehydrogenase, urease, alkaline phosphatase and CO_2 evolution during both the years over only 100% of recommended dose (RD) through chemical fertilizers. Application of phospho-compost and soybean straw along with chemical fertilizers showed highest soil quality index under both the sequences. The only chemical fertilizers without addition of organics reduced the soil quality index. The crop yields were improved significantly due to integrated nutrient management over only chemical fertilizers. However, FYM and phospho-compost in conjunction with crop residues (100% organic) although improved the soil quality did not improve the yields under legume-cereal and legume-legume cropping system.

The predominant soil quality indicators influenced by the management practices were identified as available potassium, urease and CO_2 evolution under soybean-wheat and organic carbon, available potassium and urease under soybean-chickpea sequence which are most sensitive to management and useful for monitoring the soil quality. It can be concluded that, the most promising option of integrated nutrient management for balanced fertilization is the efficient use of crop residues and organic manure in a conjunctive mode as a supplementary source of nutrient to reduce the quantity of chemical fertilizers which is beneficial for improving crop productivity and soil sustainability.

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Distribution of Boron in Different Fractions in Calcareous Soils of Punjab

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Fractionation of boron (B) provides an insight into qualitative and quantitative significance of B fractions. Boron is being quantified in six fractions and they are readily soluble, specifically adsorbed, oxide bound, organically bound, residual and total B. Distribution of B fractions is still not well defined in case when it is applied in B deficient calcareous soils and after the harvesting of sown crop. In present greenhouse experiment with green gram crop, three B deficient soils with calcium carbonate content 0.8 (S I), 2.1 (S II) and 4.6 (S III) percent were collected from different sites of Ludhiana and Bhatinda districts, Punjab, India. The treatments comprised of five levels of soil applied B *i.e.* 0, 0.5, 0.75, 1.0 and 1.5 mg B kg^{-1} soil and the experiment was laid out in CRD factorial design with three replications. Mean readily soluble, specifically adsorbed and oxide bound B fractions got increased significantly with increase in B applications. Distribution of readily soluble B was more in low calcareous soil in comparison to high calcareous soil. Readily soluble B exists mainly in soil solution and is easily available for plant uptake. Calcium carbonate acts as sink for B sorption in calcareous soils and, therefore, boron was readily available in soils with low calcium carbonate content. Mean value of specifically adsorbed, oxide bound, residual and total B were significantly more in high calcareous soils as compared to low calcareous soils. At maturity, specifically adsorbed B converted into other fractions to maintain equilibrium in soil solution. Organically bound B was greater than oxide bound B fraction. Among all fractions, residual fraction accounted of major portion of the total B. Available B was negatively and significantly correlated with $CaCO_3$ content of soil while specifically bound B was negatively and significantly correlated with readily soluble B. Organically bound B was positively correlated with organic carbon content of soil.

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Bioavailability of Pb to Indian Mustard as Influenced by Combined Application of Lime and FYM

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In recent years, contamination of large areas of land by heavy metals has become a major concern. Thus, there is a need to develop appropriate decontamination technology using range of inorganic and organic amendments for minimizing its pollution in agricultural soils and crops grown on these soils. Keeping these points in mind an experiment was conducted at screen house keeping six levels of Pb (0, 50, 100, 200, 400 and 800 mg Pb kg^{-1} soil) and nine combinations of lime and FYM as amendments. Indian mustard (variety, RLM 619) was grown in the treated pots.

The results revealed that increasing rates of Pb application significantly and progressively increased DTPA-Pb at equilibrium. The mean Pb content in shoots of Indian mustard also increased from 2.7 mg Pb kg^{-1} in control to 166.0 mg Pb kg^{-1} in 800 mg kg^{-1} added Pb treatment in soil. However, application of amendments individually or in combination resulted in decline in Pb concentration of Indian mustard at all rates of applied Pb. Among the different combinations of amendments, combined application of 5% lime and FYM was significantly better in curtailing the bioavailability of Pb to Indian mustard as compared to other treatments. Total mean dry matter yield (DMY) of shoots of Indian mustard decreased with increasing rates of Pb application. The highest mean DMY of shoots was observed with either lone application of 5% FYM and with combined application of amendments at their highest 5% rate. The macro and micro nutrient composition of shoots of Indian mustard was also effected by application of amendments. At all levels of applied Pb, application of FYM increased the micro nutrient concentration as compared to application of lime. Root DMY of Indian mustard followed the same trend as that of shoots. It decreased significantly with increase in addition of Pb but there was an improvement in root DMY with the addition of amendments. Lead contents in roots were invariably higher as compared to their values in shoots at all levels of added Pb. The magnitude of reduction in root biomass was comparable to the shoot biomass. Maximum mean DMY of roots of Indian mustard was obtained in the treatments involving FYM in spite of the fact it was less effective in decreasing the concentration of Pb in roots of Indian mustard compared to lime. Nutrient composition of roots of Indian mustard also decreased with addition of Pb in soil. A compared to DTPA-Pb in equilibrated soil, the DTPA-Pb decreased substantially in soil after the harvest of crop. Though there was a marked reduction in DTPA-Pb but there were considerably high residual levels of Pb in almost all the treatments which might have long term consequences. These metals become available with time through natural weathering process or through breakdown of high molecular weight organic complexes.

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Effect of Long-term Use of Chemical Fertilizers and Amendments on Nitrogen Fractions in an Acid Alfisol

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The present study was undertaken in the ongoing long-term fertilizer experiment at experimental farm of College of Agriculture CSK Himachal Pradesh Agricultural University, Palampur (HP) with eleven treatments in randomized block design. The investigation was conducted to study the effect of continuous use of chemical fertilizers and amendments on nitrogen fractions in a maize-wheat system and their relationship with available nitrogen (N), crop yield and N uptake. The soil of the experimental site was silty loam and classified taxonomically as "Typic Hapludalf". Soil samples taken from a depth of 0-15 cm and 15-30 cm after the harvesting of wheat (2008-2009) were analyzed for different forms of nitrogen and total N by standard methods. Long-term application of chemical fertilizers either alone or in combination with FYM or lime influenced different organic and inorganic nitrogen fractions significantly except non hydrolysable- N at both the depths. Among different nitrogen fractions, hydrolysable NH_4-N was found to be the most dominant fraction of organic nitrogen. The study revealed that continuous cropping without fertilization resulted in depletion to the extent of 26, 22, 19, 12 and 6% in hydrolysable NH_4-N, amino acid-N, amino sugar-N and unidentified–N and non hydrolysable-N, respectively. Highest yield of wheat (2008-09) and maize (2009) was recorded under 100% NPK+FYM treatment. Correlation studies revealed that different fractions of nitrogen were found to have positive and significant relationship with yield and nitrogen uptake by wheat and maize and NH_4-N showed the highest correlation with these parameters. Hydrolysable NH_4–N exhibited highest correlation with available N in surface as well as subsurface soil layer.

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Litter Decomposition and Nutrient Release Dynamics of Arid Zone Tree Species under Field Conditions

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The dynamics of litter decomposition is strongly influenced by the initial quality of litter, environmental condition and available decomposer community. The information on these aspects is lacking in tree species of arid zone of Rajasthan. Hence, the present experiment was undertaken to study the leaf litter decomposition and nutrient dynamics of four tree species (*Acacia tortilis, Acacia senegal, Dalbergia sissoo, Colophospermum mopane*) under surface placed and buried litters using litter bag technique. The initial litter quality showed that *C. mopane* were lowest in nitrogen (0.99 %) and highest in C/N ratio (50.5%). Lowest C/N ratio was observed in *A. tortilis* (20.3%). Highest lignin (34.1%) was observed in *C. mopane* leaf litters and lowest was observed in *A. senegal* (12.65%).

The mass loss of leaf litters varied significantly with time and species. At all sampling dates, the leaf litters of *C. mopane* decomposed slowly as compared to other species. Between surface and sub surface placed litter, decomposition was slower in surface placed litters. At the end of rainy season, the wt loss ranged between 30-41% in surface and 40-65% in sub surface conditions. Among different tree species, the mass loss of leaf litter followed the order *A. tortilis*> *A. senegal* > *D. sissoo*> *C.* m*opane.* Decomposition rates were lowest for *C. mopane.* The half life for *C. mopane* was 288 and 223 days in surface and buried conditions, respectively which was significantly higher than other species. Maximum half life of *C. mopane* suggests that mopane litters resists for long term Carbon storage in system. Nitrogen release from the decomposing leaf litter of the individual species was derived using the equation: Nitrogen release (%) = $[(C_0 \times M_0 - Ct \times Mt)/(C_0 \times M_0)] \times 100$, where C_0 is the initial concentration of N in leaf litter and Ct is the concentration of the N in the decomposing leaf litter at sampling time t. Mt is the dry weight of decomposed leaf litter at time t, and M_0 is the initial dry weight of the litter. The release of N was species specific and mode of their application. Between the surface (Fallow) and buried (cultivated) application, higher concentration of nitrogen was observed in surface applied litters at each month of time which resembles that the release of nitrogen in soil was slower when the litter was applied on surface as compared to buried condition. Release of nutrients were related with lignin and C:N ratio. The nitrogen released by various tree species followed the order *A. tortilis*> *A. senegal*> *D.sissoo*> *C. mopane*. Nitrogen release after 9 months in buried condition was 41.6, 40.4, 30.6 and 19.6 kg ha^{-1} in *A. tortilis, A. senegal, D. sissoo, C. mopane*, respectively. Similar to nitrogen, the concentration of P also varied between the application method, MPTs and time. The concentration of P in residual mass increased initially and then decreased. Among the different species, the faster decomposing species release the P at rapid rate then slow decomposing one. Unlike N and P, the K concentration in litter decreased continuously in residual biomass as decomposition proceeds. The decrease was rapid at early stage of decomposition. Among different MPTs, the decrease in concentration of K was slower in mopane followed by Shisham. Between the two application methods, higher concentration of P and K was observed in residual biomass in surface applied as compared to buried litters.

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Sulphur Transformation in Rice-Wheat and Rice-Maize Based Cropping Systems with Varying Tillage and Crop Residue Management Practices

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Sulphur transformation was studied in a long-term on-going field experiment started during *kharif* 2009 on a Typic Haplustept at IARI farm, New Delhi. The experiment was laid out in split plot design in which two cropping systems (rice-wheat and rice-maize) constituted the main plot treatments and eight combinations of tillage and crop residue management practices *viz.* direct seeded rice (DSR) followed by zero tilled wheat (ZTW)/zero tilled maize (ZTM) (T_1), T_1 + rice residue (T_2), DSR + brown manuring (BM) – ZTW/ZTM (T_3), T_3 + rice residue (RR) (T_4), DSR + moong residue (MR) – ZTW/ZTM + relay moong (RM) (T_5), T_5 + rice residue (T_6), puddled transplanted rice – conventional tilled wheat (CTW)/ conventional tilled maize (CTM) (T_7) and puddled transplanted rice – ZTW)/ZTM) (T_8) constituted sub-plot treatments. The plot-wise composite surface (0-15 cm) soil samples were collected before sowing of *kharif* 2012 rice crop and soil sulphur fractions (SO_4^{2-}, water soluble, heat soluble, inorganic, organic and total sulphur) were determined by using standard procedures. Cropping systems significantly affected sulphate, inorganic, organic and total sulphur content of soil and these fractions were significantly higher under rice-wheat as compared to rice-maize cropping system. Mean available sulphur content in rice-wheat system slightly increased where as it slightly decreased in rice-maize cropping system over its initial content (19.4 mg kg^{-1}) after three cropping cycles. However, cropping systems affect on water soluble and heat soluble sulphur contents were non-significant. All the soil sulphur fractions were significantly affected by tillage and crop residue management practices also. The different sulphur fractions behaved differently under different tillage and crop residue management practices. In rice-wheat cropping systems the highest content of sulphate sulphur was found in direct seeded rice and zero tilled wheat (DSR-ZTW) which was at par with DSR+BM– ZTW + RR (T_4) and the lowest in DSR+BM-ZTW (T_3). Under DSR-ZTW (T_1) available sulphur content increased from its initial content whereas it decreased in DSR+BM- ZTW (T_3). Similarly, in rice-maize cropping system the highest content of sulphate sulphur was observed under DSR-ZTW (T_1) and significantly the lowest content under DSR+MR-ZTM+RR+RM (T_6). Significantly higher mean content of SO_4^{2-} (23.80 mg kg^{-1}), inorganic (28.27 mg kg^{-1}), organic (225.3 mg kg^{-1}) and total sulphur (253.5 mg kg^{-1}) contents were found in treatments having direct seeded rice and zero tilled wheat (DSR-ZTW) as compared to transplanted rice and conventional wheat (TR-CW).

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Contribution of Soil-Zn, Fertilizer-Zn and Sprayed-Zn in Fortification of Brown Rice and Husk of Two Contrasting Paddy Varieties

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Zinc-65 isotopic studies were conducted to find out the contribution of soil native-zinc (Zn), applied fertilizer zinc and externally sprayed zinc to fortify the brown rice and husk of two contrasting varieties differing in their fortifiable capacities. In case of *Erramallelu* variety, when soil application of zinc fertilizer alone was done, the contribution of soil and fertilizer pools to the mean zinc content of brown rice of paddy was to an extent of 83 and 17%, respectively. However, when spraying of zinc was done in addition to soil application, the zinc content in brown rice of same variety was contributed to an extent of 55, 11 and 34%, respectively. In case of MTU-1010, a high zinc fertilizer pool when it was applied to soil. The contribution of soil, fertilizer and spray pools of zinc into brown rice of this variety was 36, 27 and 37% when spraying of zinc was done along with soil application. The contribution of zinc into its content in hust of *Erramallelu* was 81% from soil and 19% from fertilizer when zinc was applied to soil. When additional sprays of zinc were given, the contribution of zinc content into husk of this variety was 54% from soil, 11% from soil applied zinc and 35% from sprayed zinc which is almost similar to that brown rice of the same variety. The extent of zinc contribution from soil applied zinc to its content of husk of MTU-1010 was 68% and it changed to 41% when zinc spray was given additionally. The contribution of fertilizer and sprayed zinc into the husk of MTU-1010 was found to be 19 and 39% when external zinc spray was done. Studies revealed that the extent of contributions of different pools of zinc to its content in brown rice and husk of Erramallelu variety remained almost the same. In case of MTU-1010 variety, the contributions from soil applied zinc and sprayed zinc to its content of brown rice and husk were higher and hence more responsive for fortification compared to that of *Erramallelu* variety.

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Water Retention and Release Characteristics of a Polymer and its Effect on Available Water Content, Tomato Productivity and Water Use Efficiency in a Semi-arid Sandy Loam Soil

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The problem of inefficient use of rain and irrigation water by crops is most important on light textured soils of semi-arid and arid regions. Application of super absorbent polymers into the soil could be an effective way to increase water use efficiency in crops. Of late, several polymers have been introduced into the Indian market for agricultural use without systematic research under Indian conditions. Therefore, laboratory and field investigations have been conducted to study water retention and release characteristics of a cross linked polymer of polyacrylamide and potassium acrylate (PAM) and to evaluate its effect on yield and water productivity in tomato grown on sandy loam soil under field conditions. Irrespective of source of water, polymer showed rapid initial hydration followed by a progressive decrease in the rate of absorption of water towards the point of equilibrium. The amount of water absorbed by polymer decreased from 367 g g^{-1} to 110 g g^{-1} with increasing electrical conductivity (EC) of the source of water from 0.03 to 2.23 d S m^{-1}. When water absorbed polymers were subjected to 0.33 bar (FC) and 15 bar pressure (PWP), about 92-98% and 97-6-99.6% of absorbed water was released from polymer, respectively. Application of polymer at graded rates (0.25% - 1% of soil, w/w) to sandy loam and sandy clay loam soils increased the available water content by 101-192% as compared to untreated soils. Application of polymer at 25 kg ha^{-1} with alternate week irrigation not only produced the higher tomato yield but also increased the water productivity to 290.6 kg ha^{-1} mm^{-1} and thereby saved 180 ha^{-1} mm^{-1} irrigation water during a crop growth season.

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Nitrogen Release Pattern under Laboratory Incubation Conditions

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The effect of three different organic manures, *viz.,* FYM (with 0.50% N, 0.26% P and 0.33% K), vermicompost (with 1.10% N, 0.64% P and 0.34% K) and poultry manure (with 1.51% N, 0.78% P and 0.37% K) and fertilizers on the release pattern of nitrogen (N) was evaluated under laboratory incubation at the Zonal Agricultural Research Station, Shimoga, Karnataka during 2012. The experiment consisted of nine treatments, *viz.,* T_1 – 100% recommended N (no organic manure), T_2 – 100% recommended N and FYM, T_3 – 100% recommended N + 2 times of recommended FYM, T_4 - 100% recommended N + N equivalent of recommended FYM through Vermicompost, T_5 – 100% recommended N + 2 times of N equivalent of recommended FYM through Vermicompost, T_6 – 100% recommended N + N equivalent of recommended FYM through poultry manure, T_7 – 100% recommended N + 2 times of N equivalent of recommended FYM through poultry manure, T_8 – 100% recommended N through neem oil coated urea (2 ml neem oil/100 g urea), T_9 – 100% recommended N through neem oil coated urea (4 ml. neem oil/ 100g urea). One kg of soil sample (Typic Haplustalf) was taken in plastic containers (5 kg capacity) and incubated for 90 days with different types of manures with fertilizers. Field capacity was maintained in all plastic containers.

With days of incubation, NH_4^+- N increased up to 60 days and decreased thereafter due to volatilization loss. Poultry manure decomposed easily and released more of NH_4^+-N compared to FYM and vermicompost. At 30 days of incubation, higher value of NH_4^+-N was recorded with application of 100 per cent recommended N + 2 times of N equivalent of recommended FYM through poultry manure (1750 mg kg^{-1}) compared to other treatments. At 60 and 90 days of incubation, higher value of NH_4^+- N was recorded in the treatment, 100% recommended N through neem coated urea (4 ml. neem oil/100g. urea) (2253 and 1480 mg kg^{-1}, respectively) due to inhibition in nitrification process and reduced volatilization loss. Significantly higher value of NO_3-N was recorded in 100% recommended N (no organic manure) (550 mg kg^{-1}) treatment at 30 days of incubation. At 60 and 90 days of incubation, 100 per cent recommended + 2 times of recommended FYM recorded significantly higher value of NO_3-N (733 and 426 mg kg^{-1}, respectively) over other treatments. Total nitrogen also behaved similarly and significantly higher value being recorded in neem oil coated urea. Organic manures took some time for decomposition and nitrification process compared to fertilizers alone. To conclude, the net release of nitrogen from the manures was in following order; poultry manure > vermicompost > FYM. Neem coated urea also released nitrogen slowly thereby increasing the availability of ammoniacal form of nitrogen.

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Development of Phosphorus Saturation Indices for Selected Soils of India

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Phosphorus(P) chemistry in soil is complex with its unique property to become less available to crops with slow diffusion and high fixation. But under intensively cultivated area of India continuous addition of fertilizer and manure in excess of crop requirement will result in increased phosphorus content in the surface soil, contributing to accelerate P losses from soil system as reported in some studies. Phosphorus, lost from agricultural soils via surface and sub-surface pathways depends upon the soil type, rate of P application, source of P, amount and intensity of rainfall, soil P status *etc.* It it therefore necessary to develop a more appropriate technique to know the actual potential of soil contributing to the non point source of P pollution. Degree of Phosphorus Saturation (DPS) has been widely used and accepted method of determing P saturation capacity of the soil in many countries. A study was undertaken to determine DPS for major soil orders *viz.,* Vertisol (Jabalpur), Inceptisol (Delhi), Alfisol (Bangalore) and Ultisol (Trivandrum) using different extractants.

The P sorption maxima (P smax) as determined by Langmuir equation followed the order Jabalpur (716.85 mg kg^{-1})> Bangalore (563.78 mg kg^{-1})> Delhi (522.93 mg kg^{-1}). Soils were incubated with 0, 25, 50, 100, 150, 200 and 400 per cent Psmax. The incubated soils were analysed for labile P content with different extractants namely Olsen, Bray, Mehlich 3 and Ammonium Oxalate. In Jabalpur soils DPS was calculated with DPS_{01}, $DPS_{A.O.}$ and DPS_{M3} ranged 0.86-74.59, 0.3-36.3 and 0.40-88.45% respectively for P1 to P7 treatments. Similarly in Delhi soils DPS_{O1}, $DPS_{A.O.}$ and DPS_{M3} ranged from 1.2-89.68, 0.4-29 and 1.36-104.49% for P1 to P8 treatments. In Bangalore soil $DPS_{By\ 1}$, DPS_{M3} and $DPS_{A.O.}$ ranged from 0.7-75.8, 0.90-94.66 and 0.61-31.9% for P1-P7 treatments. In Trivandrum soil $DPS_{By\ 1}$, DPS_{M3} and $DPS_{A.O.}$ ranged from 0.58-91.56, 0.91-73.9 and 0.26-27.22% for P1 to P7 treatments. The results indicated that DPS based on Olsen can be used for neutral to alkaline soils of Delhi and Jabalpur and DPS based on Bray 1 for acid soils of Bangalore and Trivandrum, Mehlich3 and ammonium oxalate can be used for determining DPS in all the four soils.

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Relative Effect of Different Long-term Manurial Treatments on Flood Water Concentration of Ammonium and Potassium and Assessment of Holding Period of Irrigation Water after Fertilization in a *Rabi* Rice

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Nitrogen (N) and potassium (K) are two important elements limiting low land rice production. Both the nutrients either applied through the fertilizers or released from soil are subject to losses by number of ways. Field to field or field to stem flow of flood water during irrigation in cannel commands is a common phenomenon in wet land rice soils. Runoff loss of flood water from a field following fertilizer application leads to loss of substantial quantity of these two nutrients depending of concentration of N and K prevailing is flood water. It is estimated that by holding the irrigation water in the field up to certain critical period when the concentration in the best manorial treatment and control plots levels up will save more than 10-15 kg N and 4-8 kg K ha^{-1} in a season. Soil properties of different long term manuring treatments differ and they may interact differently with the applied fertilizers that may result in different flood water concentration of nitrogen and potassium. As hydrolysis of urea occurs within 48 hours and nitrate concentration of flood water is negligible, measurement of flood water concentration of ammonium along with potassium following split application can be used as a tool to study the effect of long term manuring and minimum holding period of irrigation water in the field. For the purpose a long term fertility Trial conducted on a moderately well drained acid lateritic soil with rice-rice system was used and study was undertaken in a *rabi* rice (cv. Lalat).

Depending on the treatments varied concentration of ammonium and potassium were measured in flood water. Flood water concentration both ammonium and potassium measured after basal application was higher than mid season application. In general, the treatments were in the order 100% NPK+ FYM>100% NPK + lime>150% NPK>100% NP>100% N>100% NPK>50% NPK > Control with respect to NH_4^+ concentration that recorded a much higher concentration of NH_4^+-N in flood water (2.67 mM L^{-1} or 37.38 mg L^{-1}) one day after basal application than that after first (0.6 mM L^{-1} or 8.4 mg L^{-1}) and second top dressing (0.26 mM L^{-1} or 3.64 mg L^{-1}). In contrast K+ concentration varied from 0.17 to 0.63 mM L^{-1} in case of basal and 0.09 to 0.25 mM L^{-1} in case of top dressing at panicle initiation stage and the treatments were in the order 100% NPK + lime > 100% NPK+FYM 150% NPK > 100% NPK > 50% NPK > 100% N > 100% NP > Control. The concentration of both NH_4^+ and K^+ decreased with time and leveled up with the concentration in control plot after some days. In case of high yielding treatments such as 100% NPK+ FYM, 150% NPK, 100% NPK and 100% NPK + Lime it took 5 days after application in case of basal, 3 days after first top dressing and 5 days after second top dressing in both NH_4^+ and K^+ concentration. After that the difference was not significant. From the results it is suggested for a minimum holding period of 5 days after application of both N and K fertilizers at planting (basal) and at panicle initiation stage. For first top dressed N applied at maximum tillering stage, there should however be a minimum holding period of 3 days.

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Effect of Coated Urea Fertilizers and Moisture Levels on Release of Nitrogen from an Alfisol

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Nitrogen is one of the nutrients that is subjected to losses at each state of its mineralization. The nitrogen use efficiency (NUE) in terms of added fertilizers is low. Urea is one of the commonly used fertilizers by the farmers which under goes quick hydrolysis releasing NH_4^+–N and further oxidized to NO_3-N. These two forms are subjected to volatilization and leaching losses and decrease the NUE of crops. The process of ammonification and nitrification were also governed by moisture content of the soils. To minimize the losses of nitrogen and to improve the use efficiency by crops, coated urea fertilizers (controlled release fertilizers) can be preferred over prilled urea. Several types of coated urea fertilizers are available whose efficiency need to be studied in terms of release of nitrogen.

A study was conducted to know the release pattern of nitrogen from coated urea fertilizers *viz.,* Neem cake coated urea (NCCU), *Vitex negundo* leaf coated urea, humic acid coated urea (HCU) and prilled urea (PU) at two moisture levels (field capacity and saturation point) from an Alfisol. The soil samples with different treatments were incubated for 0, 3, 5, 7, 10, 15, 30, 45, 60, 75 and 90 days and analyzed NH_4-N and NH_3-N. The results reveled that irrespective of incubation period and coated urea fertilizers, the release of NH_4-N was highest under saturated conditions (322 mg kg^{-1}) than at field capacity (310 mg kg^{-1}). These values were recorded at 10 days after incubation (DAI) in coated urea fertilizer treatments. Where as the release of NH_4-N was highest at 7 DAI (402.6 mg kg^{-1}) with prilled urea and later than was a decrease in NH_4-N. The nitrate nitrogen content was highest at field capacity, with regard to different coated fertilizers, than was slow release of NH_4-N upto 15-30 DAI and NO_3-N showed an increase from 30-90 DAI. Based on the release pattern of nitrogen, the order of preference of coated fertilizers was N CCU < VCU < HCU < PU as there was slow and prolonged release of NH_4-N and NO_3-N compared to prilled urea. Hence, use of neem cake coated urea, *vitex negundo* coated urea (botanical products) having slow release and nitrification inhibition properties can be used than prilled urea to minimize the losses and to improve the NUE of crops.

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A Comparison between Effects of Chemically and Biologically Synthesized Zinc Nanoparticles on Pearl Millet (*Pennisatum glaucum*)

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The development of eco-friendly technologies in material synthesis is of considerable importance to expand their biological applications. An experiment was performed during *kharif* 2012 to compare the effects of chemically and biologically synthesized zinc nanoparticles on Pearl millet (*Pennisatum glaucum*) var. HHB 67. Zinc nanoparticles were synthesized chemically from sedimentation technique and biologically synthesized from fungi *Aspergillus terreus* (Accession No JN 194186) under optimum conditions. Both types of nanoparticles were characterized for confirmation of size, shape and surface structure, crystalline and elemental properties. Average diameter for both was found to be below 25 nm. These nanoparticles were applied as foliar spray at a concentration of 10 ppm on two week old plants in a randomized block design with three replicates for each treatment. Biologically synthesized zinc nanoparticles showed positive effect over chemically synthesized zinc nanoparticles on crop production with significant improvement in enzyme activities (acid phosphatase, alkaline phosphatase and phytase) by 20.68%, microbial activity by 23.58% and dry biomass by 0.5% at critical growth period (six weeks). These result indicated that biosynthesized nanoparticles are more effective and due to its stability it may be better suited for agriculture.

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Effects of Soil Amendments and Hydrogel Application on Soil Hydro-physical Properties under Soybean-Wheat Cropping System

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Soil amendments and conditioners such as FYM, tank soil and hydrogels have the potential to improve the soil structure and water retention capacity of soil which in turn modifies other soil properties such as soil mechanical impedance, water stability of aggregates, soil hydraulic properties and soil temperature. Use of hydrogels for raising agriculture crops could be an economically viable option only if they are applied in smaller quantities at shallow depths in rows just below the seeds. In order to test the efficiency of hydrogel applied in such small quantities in improving the hydro-physical environment of alluvial sandy loam soil, a field study was conducted at the Indian Agricultural Research Institute, New Delhi. The main treatments include FYM and tank soil applied @ 5 t ha^{-1} and no amendment and sub-treatments included three rates of hydrogel *i.e.,* 5, 2.5 and 0 kg ha^{-1} hydrogel was applied at 5-7 cm depth just below the seed in rows using a manual seed drill. Soil structural condition was monitored by evaluating structural indices, mechanical strength by measuring soil penetration resistance, hydraulic behaviour through saturated hydraulic conductivity and soil thermal environment by measuring the soil temperature.

Results revealed that FYM along with gel application @ 5 kg ha^{-1}, significantly increase mean weight diameter, water stable structural units and structural coefficient while reduced penetration resistance and saturated hydraulic conductivity. In general, hydrogel application reduced soil temperature because of more moisture retention by gel. Hence, it can be concluded that hydrogel along with FYM improved soil structure, lowered soil mechanical impedance, retained more soil moisture, reduced saturated hydraulic conductivity and kept the soil environment cooler as compared to control in the surface layer and thus created a favourable soil physical environment for better crop growth.

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Long-term Fertilization Effect on Crop Yield, Phosphorus Fractions and P Nutrition of Wheat under Jute-Rice-Wheat Cropping System

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A long-term field experiment which has been in progress since 1971 at CRIJAF Farm, Barrackpore, was used to evaluate effects of continuous jute-rice-wheat cropping on crop yield, soil fertility and phosphorus fractions in a sandy loam soil of neutral reaction. Soil and plant samples were collected from the on-going experiment after wheat harvest and the treatments adopted for the study were 50, 100 and 150% of recommended dose of nitrogen (N), phosphorus(P) and potassium (K) NPK, 100% NP, 100% N, 100% NPK^{+} FYM, and no-fertilizer/control. The recommended dose of N, P and K in kg ha^{-1} were 120, 26 and 50 for rice and wheat, and 60, 13 and 50 for jute, respectively. In 100% NPK+FYM treatment, farmyard manure @10 t ha^{-1} was applied along with NPK before jute sowing every year. Different inorganic fractions of P in the soil were sequentially extracted as per standard procedure. Crop yield and P uptake significantly increased with P application. While availability of P in the soil significantly decreased in P-omitted treatments, there was remarkable build-up of P in the soil under the fertilizer-P and FYM treatments. Of the total inorganic P, calcium phosphates (Ca-P) was the dominant form followed by aluminium phosphates (Al-P), iron phosphates (Fe-P) and saloid-P. While the build-up of Ca-P, Al-P and saloid-P fractions in the soil was maximum under the NPK+FYM treatment followed by 150% NPK, build-up of the Fe-P was maximum with 150% NPK treatment. All the inorganic fractions of P in the soil were found to be significantly correlated. Further, Olsen-P was significantly correlated with all the inorganic P fractions and maximum correlation coefficient was observed with saloid-P (0.966**). Grain yield was correlated significantly with Olsen-P (r=0.760**), Al-P (0.682**), Fe-P (0.825**), saloid-P (0.777**), and Ca-P (0.637**). Similarly P uptake by the crop was correlated significantly with Olsen-P (r=0.827*), Al-P (0.764*), Fe-P (0.848**), saloid-P (0.832**) and Ca-P (0.681**). Data on relative contributions of various soil P fractions to grain yield and P uptake of wheat showed that all the P fractions in surface soil together contributed 74% towards grain yield of wheat and 80% towards P uptake, with saloid-P fraction contributing significantly. Information generated from this study will be useful for determining P fertilizer requirement of wheat in different soil types.

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Effect of Different Management Practices on Stubble Decomposition and Yield of Rice

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A field experiment was conducted at the Regional Research Technology and Transfer Station (RRTTS), Chiplima, Sambalpur, Odisha during *rabi* 2012 to evaluate the efficacy of different stubble management practices through different ploughing methods, irrigation depth and urea application. The soil of the experimental site was sandy loam with acidic pH (5.45), low organic carbon (0.42%) and available nitrogen (N), phosphorus (P) and potassium (K) status of 223, 9.0 and 152 kg ha^{-1}, respectively. The experiment was laid out in split plot design with 3 replications. The four different ploughing methods treated as main plot was conventional method *i.e.* tractor operated double cage wheel twice (T_1) tractor operated nine tyne cultivator followed by cultivator with cage wheel (T_2) tractor operated mould board plough followed by cultivator with cage wheel (T_3) tractor operated mould board plough followed by rotavator with cage wheel (T_4) and two levels of urea application such as no urea (U_0) and 10 kg urea ha^{-1} (U_1) along with two levels of irrigation depth such as 5 cm (I_1) and 10 cm (I_2) in sub plots. Treatments were imposed for incorporation of stubble and its decomposition followed by transplanting. The results indicated that, irrespective of urea application and depth of water, the highest mean grain yield of 4.25 t ha^{-1} was observed when field preparation was done with tractor operated M.B. plough whereas the lowest rice grain yield of 3.68 t ha^{-1} was observed when field preparation was done by conventional method *i.e.* tractor operated double cage wheel twice. Irrespective of tillage treatment, application of Urea 10 kg ha^{-1} for stubble decomposition was effective for easy decomposition which on the other hand produced significantly highest grain yield of 4.06 t ha^{-1} whereas 3.95 t ha^{-1} of grain was obtained due to no urea application for decomposition of stubble. Similarly, 10 cm of standing water was kept in the field for stubble decomposition facilitated the easy decomposition of stubble which indirectly produced highest grain yield of 4.06 t ha^{-1} where as 5 cm standing water for decomposition produced lowest grain yield of 3.95 t ha^{-1}. So, it was observed that field preparation by tractor operated MB plough followed by cultivator with cage wheel (T_3) along with application of 10 kg urea ha^{-1} (U_2) having standing water of 10 cm (I_2) created suitable environment for easy and quick decomposition of stubble which indirectly produced the highest grain yield of rice with recommended dose of fertilizers.

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Different Soil Carbon Forms and Water Stable Aggregates under Vertical Stratification of 4-Year Block Plantation of *Populus* and *Eucalyptus*

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Soils are one of the major sink of carbon. Hence, change in land use is expected to sequester bountiful atmospheric carbon in soils. But information on how land use change influence different fraction and water stable aggregation is not known. The objective of this study was to better understand the patterns of soil carbon fraction dynamics and water stable aggregates (WSA) under 4-year block plantation of *Populus* and *Eucalyptus*. The field experiment was conducted at Hara Farm, Yamunanagar (30º 7' N and 77º 18' E) and Raina Farm, Shahabad (30º 10' N and 76º 53' E), Haryana. Soil samples were collected up to 1 m depth from both *Populus* and *Eucalyptus* block plantation. Mean weight diameter (MWD) and geometric mean diameter (GMD) over the soil depth of the WSA were 0.34 and 0.19 mm in *Populus* whereas 0.62 and 0.55 mm in *Eucalyptus*. MWD was higher in all the soil depths except 0-15 cm *Eucalyptus* as compared to *Populus*. Mean aggregate ratio was higher in *Eucalyptus* (2.72) as compared to *Populus* (0.90). Aggregate stability, which is an indicator of good soil health, was higher in *Populus* (0.36) as compared to *Eucalyptus* (0.27). Aggregate stability in 75-90 cm soil depth was highest for both *Populus* and *Eucalyptus* block plantation indicating higher sequestration potential. Mean particulate organic carbon was maximum under 0-15 cm soil depth in 0.25-2.0 mm sieve size in both the block plantations. Particulate organic carbon was decreased with soil depth in 0.25-2.0 mm sieve size but no such trend was found in other sieve size. Macro and micro aggregates were 62.9 and 22.1% higher in *Eucalyptus* than *Populus*. Over the soil depths mean water stable aggregate percent was highest in 0.25-0.125 mm sieve size for both the block plantations. Mean total inorganic carbon was 0.60 and 1.60 g kg^{-1} under *Populus* and *Eucalyptus* block plantation, which was 62.5% higher in *Eucalyptus* than *Populus*. Total soil carbon (TC), total soil organic carbon and oxidizable organic carbon in both the plantation was declined with soil depth. In *Populus* and *Eucalyptus* block plantation TC in upper soil depth (0-15 cm) was 19.92 and 15.60 g kg^{-1}, respectively, which was 75% and 78.5% higher than the lowest soil depth (90-105 cm) studied. Thus, the present study indicates block plantation of *Populus* and *Eucalyptus* has higher potential to sequester carbon besides improving soil health.

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Soil Oxidizable Carbon and Nutrient Dynamics under Different Age of *Populus*-based Agroforestry System

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The objective of the study was to quantify soil organic carbon (SOC) and nutrient dynamics under different age of four *Populus* based agroforestry systems (*Populus* + turmeric, *Populus* + mango, *Populus* + pear and *Populus* + wheat) at Hara Farm, Yamunanagar (30º 7' N and 77º 18' E). Soil samples were collected up to 1 m soil depth and analyzed for SOC, macro and micronutrients. Among the agroforestry systems investigated, *Populus* + wheat had optimum organic carbon (0.68%) followed by *Populus* + pear (0.63%) and minimum in *Populus* + turmeric (0.53%) in the top 15 cm soil layer. Irrespective of the agroforestry systems, organic carbon decreased with soil depth but in case of available nitrogen (N), phosphorus (P) and potassium (K) no such trend were found. In all the four agroforestry systems studied pH and electrical conductivity (EC) were normal. Available P was high in the case of *Populus* + mango in all the soil depths, while it varied from medium to high in the case of *Populus* + turmeric, *Populus* + pear and *Populus* + wheat. Available K was very high in four upper soil depths under *Populus* + turmeric. Our study on micronutrient of four agroforestry systems indicated that mangnese was high in all the soil depths in all the systems, whereas zinc was high in upper two (0-15 and 15-30 cm) soil depths in all the systems except *Populus* + mango, where it was in high upto 60 cm soil depths. DTPA extractable copper was high in all the soil depths of *Populus* + turmeric and *Populus* + wheat, where in case of *Populus* + mango and *Populus* + pear it showed high range in upper five soil depths (upto 75 cm). Agroforestry systems maintain nutrient balance by recycling through litter fall and fine root biomass. Our study also reports that optimum nutrient buildup was recorded with increasing age and the phenology of litterfall of the agroforestry system. Thus by efficient use of nutrients agroforestry systems enhanced soil health and biological productivity.

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Evaluation of Iron Kinetics and its Uptake Efficiency of Chickpea (*Cicer arietinum* L.) Cultivars using Mechanistic Model

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The large variation in iron acquisition efficiency of different crops provides opportunities for screening crop species that perform well on low content of iron (Fe) in soil. Fe uptake efficiency and its depletion in the rhizosphere of Fe-efficient and Fe-inefficient chickpea cultivars was studied in a pot culture experiment with Fe-deficient Typic Ustochrept sandy loam soil with three different levels of Fe (0, 20 and 40 mg kg^{-1}), Anand Agricultural University, Anand, Gujarat. A recent version of NST 3.0 nutrient uptake model, which is very useful for evaluating plant parameters regarding Fe uptake, was used to predict Fe uptake and influx to carry out sensitivity analysis of the rhizosphere of chickpea. The shoot weight and shoot length of Fe-inefficient cultivars of chickpea (ICCC-4 and GJG-305) responded well to the application of Fe as compared to Fe-efficient chickpea cultivars (GG-1 and GAG-735). The Fe-efficient varieties registered maximum root length over Fe-inefficient varieties; and it has increased with Fe application and age of plant. However, 20 mg Fe kg^{-1} soil application was found to enhance the parameters like shoot length; shoot growth rate, root growth rate and influx. The varietal trend on root radius, water influx and iron influx was observed as ICCC-4>GJG-305>GAG-735>GG-1. On the other hand Fe-inefficient cultivars had 2 times of higher mean Fe-influx at 40 mg Fe kg^{-1} soil application than Fe-efficient cultivars. Among the soil parameters influencing Fe availability to the plant, soil solution Fe concentration and buffer power were found maximum with the Fe application of 40 mg kg^{-1}. In sensitivity analysis, root radius (r_o) and initial soil solution concentration of Fe (C_{Li}) were found most sensitive parameters influencing Fe uptake, which was followed by maximum net influx (I_{max}). In control treatment, increasing r_0, C_{Li} by a factor of 2.0 times individually caused increase in Fe uptake by 1.60, 1.45 times, 1.36, 1.53 times, 1.16, 1.15 times and 1.05, 1.25 times, respectively in GG-1, GAG-735, ICCC-4 and GJG-305 varieties of chickpea compared than the parameters of I_{max} and K_m. The ICCC-4 instead of GG-1 and GAG-735 could be rational choice to grow with application of Fe @ 20 mg kg^{-1} soil on Fe deficient soil to get the desire Fe content. Combining crop productivity and grain quality aspects such as total content and bioavailability of nutrients in developing new micronutrient sensitive genotypes is necessary.

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Soil Carbon Dynamics under Tillage and Crop Residue Conservation Strategies for Partially Reclaimed Sodic Soils of Indo-Gangetic Plain

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Large extent of salt affected area in the Indo-Gangetic plain provides both challenge and opportunity to bolster food security and sequester carbon after reclamation. Sustainable management of partially reclaimed soils via resource conservation is key to prosperity of farmer as well as it boosts expensive initiatives to further reclaim sodic land area currently lying barren.

We evaluated the changes in different soil carbon pools and crop yield of a long-term experiment on resource conservation strategies for rice-wheat systems on a partially reclaimed sodic soil. Amongst all resource conservation techniques which were tested, rice-wheat crop residue addition (30% of total production) was most effective in increasing soil organic carbon. In rice, without crop residue addition (WCR), soils under zero-tillage with transplanting, summer ploughing with transplanting and direct seeding with brown manuring showed significant increase in soil organic carbon (SOC) over control (puddling in rice, conventional tillage in wheat). In these treatments relatively higher levels of carbon were attained in all aggregate fractions compared to control. Soil aggregate sizes in meso (0.25-2.0 mm) and macro (2-8 mm) ranges increased whereas micro (<0.25 mm) fractions decreased in soils under zero-till practices both with and without crop residue addition. Direct seeding with brown manuring and zero tillage with transplanting also showed an increase of 135% and 95%, respectively, over control, in microbial biomass carbon without crop residue incorporation. In zero tillage with transplanting treatment, both with crop residue and without crop residue showed significant increase in soil carbon sequestration potential. Though the changes in accrued soil carbon did not bring about significant differences in terms of grain yield, overall synthesis in terms of balance between yield and carbon sequestration indicated that summer ploughing with transplanting and zero tillage with transplanting sequestered significantly higher rates of carbon, yet yielded at par with conventional practices. These could be the appropriate alternatives to immediately replace conventional tillage and management practices for rice-wheat cropping systems in the reclaimed sodic soils of Indo-Gangetic region.

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Carbon Footprint of Sugarcane, Wheat and Rice Production in Western Plain Zone, India

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Atmospheric CO_2 level has increased to 379 ppm in 2005 from a pre-industrial concentration of around 280 ppm predicted to affect the human civilizations catastrophically on further increase in its concentration. The quantification of green house gases (GHG_S) emission from agriculture is fundamental to identifying mitigation solutions that are consistent with the goals of achieving greater resilience in production system, food security and rural welfare. A carbon (C) footprint is a measure of C emission in terms of the amount of GHGs produced in units of CO_2 equivalent for quantifying and benchmarking the C emissions arising from crop production activities and identifying the hotspots to reduce the C footprint of a given crop production system. Knowing the scale and source of GHGs emission from production of a crop will help to find the ways to reduce them and pave the way in enabling to C labeling for farming products. Hence, an exercise was made to calculate the C footprint of sugarcane, wheat and paddy production by the farmers of Meerut district using the required activity data of a case study 2006.

Mechanical farm operations, application of FYM and fertilizers, irrigation and use of pesticides by the selected farmers were taken into account for calculation of C inputs. For C output, reported grain yield of these crops was taken up. Straw yields for both wheat and paddy were computed by using the values of grain: straw ratios from literature. The below-ground root biomass was also calculated from the published values of shoot: root ratios. Standard C emission values were utilized for farm operations, pesticides and irrigation. Fertilizer nitrogen (N) application in soil results in direct and indirect emission of N_2O. These emissions were estimated using IPCC default factors. The CO_2 equivalent (CO_2 eq) was added for mechanical farm operations, application of FYM, production and application of fertilizers, irrigation, use of pesticides and direct and indirect emissions from synthetic fertilizer application in each crop to assess the total C footprint of production of these crops. C efficiency was calculated as ratio of C output to C input, whereas C sustainability index (CSI) was calculated by deriving difference between C output and C input and divided by C input.

Results showed that among the crops, sugarcane being C_4 is the highest accumulator of C and hence more C sustainable followed by wheat and paddy. Across different categories of the farmers, mean C footprint per unit production (kg) is lowest for sugarcane (65 g CO_2 eq) followed by paddy (507 g CO_2 eq) and wheat (514 g CO_2 eq). Likewise, CSI of sugarcane, wheat and paddy varied in the range of 27.6 – 32.1, 6.15 – 6.36 and 5.00 – 5.67, respectively. Among different components of C footprint across crops and categories of farmers, fertilizer production and application is the major component in C emission hot spot activities requiring decreasing the N doses and increasing its use efficiency by disseminating the available technologies. Further, fertilizer production and application contributed 81.7, 80.9 and 60.2 per cent of total CO_2 eq emission in production of sugarcane, wheat and paddy production, respectively with corresponding contribution from N fertilizer of 79.8, 78.9 and 55.1%. There were no perceptible differences in CO_2 eq emission among different categories of farmers.

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Changes in Root and Shoot Morphology of Coriander and Soil Available Nutrients with N and P Application in Typic Haplustepts

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Plant root and shoot morphology depends on genetic and environmental factors. For the varietal evaluation, stability of characters needs to be assessed and also changes with environmental factors. Among the environmental factors, some of are very prominent with nutrient supply could considered as bio-indicator for the nutrient management. Biological indicators of a species which can be used by observers to determine how various conditions in an environment have changed over time. Just like leaf colour-chart, some other phenotypic character can be used for nutrient management in crops. Such technologies will be cost effective or costless and can be used by a layman. Therefore, two experiments were conducted with each of 7 levels of nitrogen (N) and phosphorus (P) in loamy sand soil to monitor the changes in root and shoot morphology as well as changes in soil available nutrients and their relationship with coriander yield. Results revealed that plant height, no of leaves per plant, petiole length, root area, average root diameter, total root length, no of root tips, chlorophyll content, no of primary and secondary branches, no of umbel per plant, no of umbellates per umbel, no of seeds per umbel, seed and straw yield and nutrient uptake increased with higher doses of N. All these parameters were also increased with P. However, root area decreased with increase in P supply, whereas, total root length and no of root tips decreased at 50 kg P and beyond their higher levels. Moreover, petiole length and root length is more governed by nitrogen than phosphorus, while root and shoot diameter is more governed P than N. Harvest index was highest with 60 kg N and with 40 kg P. It shows that a higher dose of N and P contributes more towards the plant biomass than the economic yield. Availability of all the nutrients and soil organic carbon (SOC) were lower than its initial level, except N and P. However, the trend was in increasing order of nutrients availability and SOC (%) with increase in N and P supply. However, taproot length and leaf angle decreased with increase in N and P doses. Leaf angle was negatively correlated (r = -1.0) with yield and nutrient supplied or soil available N. Therefore, 'leaf angle' in Ajmer-coriander-1 is a prominent character and indicator for deficiency and sufficiency of N supply and also P, among the entire parameters of root and shoot morphology. While keeping other factor constant, if there is a leaf angle of Ajmer coriander-1 is 70º means N requirement is 70 kg ha^{-1} and if leaves lie down on soil surface or zero angle means there is no need to apply N and so on. This character is more prominent at the age of 55-65 days and may be considered as a bio-indicator for N supply in coriander under light textured soils of semi-arid region. By using this technique, there is no need to analyze soil or plant for assessment of N requirement of this crop.

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Effect of Inorganic Fertilizers and Manure on Yield of Maize (*Zea mays* L.) and Potassium Fractions in Haplustepts

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A field study entitled "Effect of inorganic fertilizers and manure on yield of maize (*Zea mays* L.) and potassium fractions in haplustepts" was conducted during *kharif* 2012 in the long term fertilizer experiments initiated in *kharif*, 1997 at the Instructional Farm of the Rajasthan College of Agriculture, Udaipur. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in reaction, medium in available nitrogen and phosphorus, while high in potassium and zinc.

The objectives were to assess effect of continuous application of plant nutrients through organic and inorganic sources and its combination on crop yield, content and uptake of both macro and micro nutrients and macro nutrient balance. The experiment consisted of 12 treatments comprising chemical fertilizers, organic manure, *Azotobacter* and their combinations, *viz*., control, 100% N, 100% NP, 100% NPK, 100% NPK + Zn, 100% NPK + S, 100% NPK + Zn + S, 150% NPK, 100% NPK + *Azotobacter*, FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM), 100% NPK + FYM 10 t ha^{-1} and FYM 20 t ha^{-1}. These treatments were evaluated under randomized block design (RBD) with four replications. Maize (PEHM-2) was taken as test crop. The highest maize grain and stover yield (4.03 and 6.03 t ha^{-1}) were obtained by applying 100% NPK + FYM 10 t ha^{-1}. Integrated use of chemical fertilizers and manure increased available N, P, K, S and Zn content of the soil. These contents decreased significantly in the plot, where neither fertilizer nor manure was added. Similarly, maximum N, P and K uptake was recorded by use of 100% NPK + FYM 10 t ha^{-1} with statistical equivalence with 150% NPK. However, integrated use of chemical fertilizers along with FYM (100% NPK + FYM 10 t ha^{-1}) led to maximum uptake of S and Zn. Availability of N and K was recorded maximum when soil enriched with 100% NPK + FYM 10 t ha^{-1}, P maximum with application of 150% NPK, S maximum with application of 100% NPK + S, availability of Zn in 100% NPK + Zn treatment at all three depths (0-15, 15-30 and 30-45 cm). Soil pH and EC were found to unaltered under any integrated nutrient treatment. However, application of FYM 20 t ha^{-1} increased organic carbon in soil. Soil enrichment with 150% NPK resulted in highest positive balance of N and P in soil and negative K balance was observed under all treatments except application of FYM 20 t ha^{-1}. The maximum negative K balance was computed when soil enriched with 100% NP. Application of FYM alone or in combination and 150% NPK application related in higher value of all fraction of K whereas availability of different fraction of potassium reduces under without K application. Available K concentration in soil at all depths can be explained by exchangeable K fraction which has highly significantly co-related ($r = 1.00^{**}$) with available fraction of K. All six potassium fractions jointly explained 86.92 and 56.33% of variation in potassium content of maize grain and stover.

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Influence of Different Rootstocks on Petiole Nutrient Content in Commercial Grape Varieties

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Sustainable vineyard fertilization can lead to cost saving while protecting environment. Appropriate fertilization depends on rootstocks which differ in their uptake of macro and micronutrients. Therefore in the present study the petiole nutrient content of three commercial grapes varieties *i.e.* Thompson Seedless, Flame Seedless and Kishmish Chorni which were grafted on three different root stocks *i.e.* 1103 P, SO_4 and Dogridge were analyzed at bud differentiation and full bloom stages along with varieties raised on their own roots. There was significant influence of different rootstocks on petiole nutrient content in commercial grape varieties. There was significant effect of interaction between rootstocks and varieties also on the petiole nutrient content. Dogridge rootstock had significant influenced the accumulation of higher nitrogen (N) when compared to other rootstocks at bud differentiation stage. Whereas, at full bloom stage significantly high N content was on own rooted vines and 1103 P rootstock and were on par with each other. Significantly high N content was recorded in Thompson Seedless at both the stages. Significantly high P content was recorded in 1103 P rootstock followed by own rooted vines at both the stages. Thomson Seedless recorded significantly high P content followed by Kishmish Chorni. Significantly high K content was in Dogridge and own rooted vines, at bud differentiation where as at full bloom it was in 1103 P and own rooted vines. They were statistically on par with each other. Among the varieties Kishmish Chorni recorded significantly high K. Significantly high petiole Ca was in SO_4 and own rooted vines at bud differentiation where as at full bloom stage it was in 1103P and SO_4 recorded and were statistically on par with each other. Significantly high Ca content was recorded with Flame Seedless. Significantly high Na was on own rooted vines and Dogridge when compared to other rootstocks. Kishmish Chorni recorded significantly less Na. At both stages rootstock significantly influenced accumulation of micronutrients. Significantly high copper, mangnese and iron content was in general recorded on 1103 P. Whereas, in case of Zinc it was significantly high content in own rooted vines when compared to other root stocks. Thompson Seedless recorded significantly higher micronutrients.

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Dissipation and Persistence of Quizalofop p Ethyl in Soil, Plant and Grain in Soybean and its Effect on Soil Properties

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Quizalofop P ethyl is a widely used herbicide in all dryland and ID crops to control grassy weeds. A field experiment was conducted during *kharif* 2010 and 2011 at the College Farm, ANGRAU, Hyderabad, on an Alfisol, to study the dissipation and persistence of varying doses quizalofop p ethyl (25, 375.5, 50, 75 and 100 g a.i ha^{-1}) in soil and soybean. Influence of the herbicide on soil physical, physico-chemical and fertility properties was also assessed. Residues of the quizalafop p ethyl in soil and soybean were estimated on GC-ECD. Recovery of the herbicide in soil was 92.6-98.5%. In the grain and plant, the recovery was 87.5 - 94.6% and 90.8 to 94.4%, respectively. Limit of Quantification (LOQ) was 0.01 mg kg^{-1}.

No significant changes in physical (texture, bulk density, particle density, pore space, maximum water holding capacity), physico-chemical (pH, EC, CEC, Organic carbon) and available nutrient status of the soil (Available N, P and K) were noticed at any of the applied doses of the herbicide. Quizalofop p ethyl dissipation in soil followed a first-order decay process ($C=C_o exp^{-kd \cdot t}$ where C_o is the initial concentration in soil, C is the concentration in the soil after t days, and K_d is the dissipation rate coefficient). Half-life and DT_{90} of the herbicide in soil increased with increasing dose. At sub-optimal doses, 25.0 and 37.5 g ha^{-1}, residues of quizalofop persisted in the soil upto 15 and 30 days after application (DAA), respectively with a half life (DT_{50}) of 14.44 and 18.24 days. At recommended dose (50 g ha^{-1}) half-life of quizalofop P ethyl was 20.38 days and residues reached Below Detectable Limit (BDL) at 45 DAA. At doses above recommended level (75.0 and 100 g ha^{-1}), herbicide residues in the soil persisted for longer period (45 and 60 DAA respectively) with DT_{50} of 21.66 and 23.10 DAA, respectively. DT_{90} (time taken, in days, for 90% dissipation of initial detected amount) in soil increased with higher doses of herbicide from 47.97 days (25 g ha^{-1}) to 76.75 DAA (100 g ha^{-1}) with higher rate of application. No detectable residues of quizalofop p ethyl were detected in the soybean straw or grain at the time of harvest.

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Oxidisable Organic Carbon Fractions and Profile Carbon Stocks in Rice Soils under Long-term Integrated Nutrient Management

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A permanent plot experiment was established on Inceptisols of College of Agriculture, Rajendranagar during 1988-89 to study the long-term effects of chemical fertilizers alone and in combination with organic sources on the sustainability and soil fertility under rice-rice cropping system. Twelve treatments comprising of chemical fertilizers alone and in conjunction with FYM, paddy straw and gliricidia at 50% and 25% substitution levels of nitrogen during *kharif* and with 75 and 100% RDF were studied in *rabi*. In the treatments, where 50% N was substituted with organic sources in *kharif* 100% RDF was applied through chemical fertilizers where as in 25% substitution treatments only 75% RDF through fertilizers was applied in *rabi*. At the end of 24th crop cycle (2011-12), efforts were made to estimate the changes in fractions of oxidisable soil organic carbon (SOC) and profile carbon stocks as influenced by long term integrated nutrient management (INM) by collecting depth wise soil samples at 15 cm interval from 0-60 cm. There was a significant variation in total SOC content with treatments up to top 30 cm depth and there after the total SOC values were found at par. Variation in the labile and non labile fractions of SOC was significant in the top layer (0-15 cm) while in lower depth (15-60 cm) such variation due to nutrient supply system was not significant at the end of 24 years. Among the different fractions of soil organic carbon, the contribution of very labile fraction varied from 29-36%; labile fraction from 24-30%; less labile fraction from 14-19% and passive fraction from 21-25% to total SOC in 0-60 cm deph. The amount of total oxidisable carbon sequestered in the soil up to a depth of 60 cm was greater with 50% NPK + 50% N through FYM over other nutrient supply systems; while in surface layer of 0-15 cm nitrogen substitution through paddy straw recorded higher sequestration of labile carbon. The sequestration of passive SOC, a stable fraction, was also higher with 50% RDF + 50% N substitution through FYM. The percent increase in total oxidisable carbon sequestration in 0-60 cm depth was in the range of 18-26% with nitrogen substitution through gliricidia, 31% with 100% RDF, 35-38% with nitrogen substitution through paddy straw and 44-48% with nitrogen substitution through FYM over control.

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Fine Tuning of SOILN Model in Rainfed Rice Soil of Varanasi

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For fine tuning or calibration of SOILN model, soil sample was collected at 15 days interval upto harvesting from direct seeded rice field of long term fertilizer experiment under AICRP of dry land agriculture in research farm of the Institute of Agricultural Sciences, Banaras Hindu University, with 82.52^0 E longitudes and $25^010'$ N latitude. The soil (mixed hyperthermic udic-ustochrept) was a sandy loam with pH 7.8, organic carbon 0.3%, EC 0.2 dSm^{-1}, available soil N 190 kg ha^{-1}, available Olsen's P 18 kg ha^{-1}, available soil K 215 kg ha^{-1}. In the present paper we have mainly focused on the available quantity of nitrogen in two different form *i.e.*, NO_3^- and NH_4^+ varies at different crop growth stages under the influence of different management inputs *viz.*, no fertilizer and manure (T1), 100% RDF, *i.e.,* total N, P and K rates of 80, 40 and 30 kg ha^{-1} (T2), 50% RDF (T3), 50% RDF + 50% N through foliar spray (T4), 50% N through FYM (T5), 100% N through FYM (T6), 50% NPK + 50% N through FYM (T7), Farmer's Practice -20 kg N ha^{-1} (T8) and compared with the yield of the crop. Nitrogen dynamics of 0-30 cm soil was predicted in direct seeded rice by Soil N model. This model predicted organic carbon and nitrate nitrogen very well than ammonical nitrogen. Model revealed that total mineralization was highest (77.87 mg kg^{-1}) in case of 100% FYM treatment and leave more residues (473.7 kg ha^{-1}) after 96 Days After Sowing, but total nitrification was highest (59.6 mg kg^{-1}) under integrated nutrient management treatment (T7) over other treatments but total denitrification of all treatments were at par. Decomposition rate constant of residue, mineralization rate constant, nitrification rate constant, denitrification potential were optimized as 0.03, 0.0005, 0.0011, 0.46 respectively. This model predict soil ammonical and nitrate nitrogen status every day, so it helps for better nitrogen management on minimum initial input dataset and synchronize application of nitrogen fertilizer with crop demand which reduce environmental risk and ultimately cost of cultivation.

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Effect of Different Factors on Nitrogen Mineralization in Soil Amended with Legume Residues

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The use of legume residues to maintain the nitrogen status of the soil provides a mean of reduction our dependence solely on commercial nitrogenous fertilizers in the production of food and fiber. As commercial fertilizers become more costly in terms of energy consumption, legume residues become a vital source in providing available soil N for crop productivity. Keeping in view the above, a green house and laboratory experiment was conducted to study effect of different factors *viz.* temperature, moisture and soil type on nitrogen mineralization. Four levels of N *viz*. 40, 80, 120, 160 mg N Kg^{-1} soils were applied through urea and legume residues. In laboratory, nitrogen mineralization from legume residues was studied at 28 days incubation period. With reference to soil type, the nitrogen mineralization from legume residues during 28 days incubation period was in the order: clay loam>sandy loam> loamy sand. Nitrogen mineralization at 28 days was maximum at 35°C followed by 28°C and 45°C. The amount of nitrogen mineralized increased with increase in moisture content from 50% field capacity to field capacity and decreased at flooding in all residue treatments.

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Change in Soil Labile Carbon Pool under Different Cropping Systems in Acid Alfisol of Kangra District of Himachal Pradesh

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Global Positioning System (GPS) based soil samples were collected randomly from different cropping systems (cereal, vegetable and oilseed) practised in Kangra district of Himachal Pradesh to study the effect of cultivation on soil organic and labile carbon. Fifty surface soil samples (0-15 cm) were collected for each cropping system. Surface soil samples from the uncultivated land adjacent to the cultivated land were also collected as reference to study the change in soil labile carbon pool and to evaluate the sustainability of cropping systems using the Carbon Management Index (CMI). Soils under cereal and oilseed showed a depletion of total carbon in soil, whereas, an improvement was observed under vegetable based cropping system. Depletion of soil labile carbon was under all the cropping systems, of which, vegetable based cropping system recorded minimum depletion. Comparatively less labile carbon in cultivated soils than the adjacent uncultivated soils may be attributed to higher oxidation rate of organic matter in cultivated soils. Among the three cropping systems, vegetable based cropping system had higher labile and total carbon in comparison to cereal and oilseed based cropping systems which might be attributed to frequent addition of organic matter in vegetable based cropping system. From the mean value of CMI, the sustainability of various systems can be arranged as vegetable followed by oilseed and cereal based cropping systems. Correlation studies have shown that labile carbon was positively correlated with CEC, available N, P, K and total carbon but negatively with bulk density.

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Distribution of Soil Acidity, Salinity and Nutrients Status in Soils of Gosaba Island, West Bengal

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The Gosaba island is located in 22.16° N latitude and 88.8° E longitude formed by the deltaic alluvium in Sundarbans ecosystem of West Bengal, covering an area of 285.85 km^2 on an average elevation of 4 m above mean sea level. The climate is sub tropical humid with annual rainfall of 1700-1800 mm. Soils are very deep (>150 cm) and silty loam to silty clay texture. Soil colour varied from dark gray to gray in surface matrix; (subsurface) mottles yellowish brown to olive yellow. Four soil series namely Chandipur, Bipradaspur, Pathankhali and Manmathanagar were selected for this investigation. Soil pH and salinity were most critical in the island. Soil pH varied from 4.3 to 4.9 and electrical conductivity (EC) varied from and 4.5 to 20.2 dS m^{-1} in 0 to 25 cm depth. The acidity in the soil profile increased down to the depth in 25-150 cm while salt content decreased with depth. Exchangeable acidity varied from 0.1 - 3.95 me 100 gm^{-1} of soil. Cation exchange capacity was moderate; ranging from (12 - 18 cmol (+) kg^{-1}). Organic carbon content ranged from 0.9 - 1.51% in 0 - 25 cm and 0.24 - 3.44% in 25 - 150 cm soil depth. Available N, P and K varied from medium to high (N-209-502; P-1.1-44.6 and K-284 - 462 kg ha^{-1}) on the surface; low to medium (N,45- 383, P, trace - 51.7 and K, 296 - 572 kg ha^{-1}) in the sub surface layers. Sulphur content was high ranging from 83 to 610 mg kg^{-1} soil. Available micronutrients were adequate both in the surface and subsurface. Strong soil acidity in lower part of the profile while salt content was maximum in the surface. Acidity at the sub-surface was significantly correlated with exchangeable Al (r=-0.814) and available sulphur (r=-0.613). The study concludes that acidity and salinity were the major constraints for crop production in the island.

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Soil Carbon Stability in Different Aggregate Size Class in Some Long-term Fertilizer Experiments of India

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Carbon (C) stabilization in soil is a critical process influencing global C cycle. The investigation was carried out by using the samples collected from long-term fertilizer experiments of Jabalpur, Palampur, Ranchi and Delhi. Three treatments *viz.* control, 100% NPK and 100% NPK + FYM was selected to ascertain the fate of residue carbon stability in different soil aggregate size classes. The data on soil aggregate size distribution indicated that about 9-15, 59-66, 13-17 and 8-11% of soils are distributed in the size fraction of 2-4 mm, 250-2000 μm, 53-250 μm and <53 μm, respectively in Vertisol of Jabalpur . In case of Palampur, here also majority of aggregates were found in the size range of 250-2000 μm. In Ranchi, soil aggregates in the size range of 2-4 mm were almost negligible. Here, soils are almost equally distributed in remaining three size classes. In case of Delhi, majority of aggregates were found in the size range of 53- 250 μm and <53 μm. In general application of FYM increased the size of soil large and small macro aggregate size class in all the sites. Soil organic carbon was also found maximum in soil large (2-4 mm) and small (250-2000 μm) macro aggregate size class in all the sites. In general, the carbon content in aggregates decreased with the decrease in the size of the aggregates. However, in case of Delhi, it was found minimum in the aggregate size class of 53- 250 μm. The carbon stability in different aggregate size class indicated that high carbon input (high C:N ratio) in the treatment of 100% NPK may decrease soil carbon stability due to priming effect in soils of low clay content. We observed negative relationship between C input (high C:N ratio) and soil carbon stability in micro aggregates and silt+clay associated carbon in soils of low clay content. The process is completely reversed when we apply FYM (low C:N ratio) along with chemical fertilizer to soil. The carbon stability significantly enhanced by application of FYM to soil. Hence, integrated approach of NPK+FYM offers opportunity for soil carbon sequestration in all soils.

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Soil Carbon Stocks in Relation to Physiography in Soils of Bhilwara, Rajasthan

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Soil organic matter is an important component that regulates most of the soil properties. It is a prominent indicator for assessing soil quality and climate change phenomenon. Climate change is attributed to increase in atmospheric concentration of several green house gases (GHGs) by fossil fuel combustion, land use change and deforestation, and human induced soil degradation. Soil resources of Bhilwara district of Rajasthan were surveyed as per standard methodology for characterization and classification using the IRS 1B imageries and survey of India toposheet on 1:50,000 scale. Management of both soil organic carbon (SOC) and soil inorganic carbon (SIC) pools in semi-arid ecosystems can play a major role in reducing the rate of enrichment of atmospheric CO_2. The term soil C sequestration implies transfer of atmospheric CO_2 into soil C pool through humification of crop residue and formation of secondary carbonates or bicarbonates. The SOC pool includes highly active humus and relatively inert charcoal C. The SIC pool includes elemental C and carbonate minerals (*e.g.,* gypsum, calcite, dolomite, aragonite, and siderite). On the basis of physiographic characteristics, the study area were grouped in three units *viz.* Eastern plain (76.2%), Aravalli (11.36%) and Vindhyan landscape (9.01%). Forty soil series has been identified. Out of that 22 occurred in Eastern plain, 10 in Vindhyan and 8 in Aravalli landscape. The area received 700 mm annual rainfall with potential evapo-transpiration (PET) of 1380 mm. All soil series were assessed for organic (SOC) and inorganic (SIC) carbon stocks occurring in different physiographic units.

Physiographic units of Bhilwara were evaluated for variation in SOC and SIC stock. Carbon stocks were calculated considering the values of organic carbon and calcium carbonate content along with bulk density and thickness of horizon at various depths *viz.* 0-15, 15-30, 30-50 and 50-100 cm as per standard procedure. Aravali landscape, Eastern plain and Vindhyan landscape had SOC pool 11.3, 12.1 and 14.8 mg ha^{-1} at 0-15 cm depth whereas 6.4, 9.3 and 11.6 mg ha^{-1} at 15-30 cm depth, respectively. The SIC pool in these physiographic units were 4.9, 6.1 and 3.1 mg ha^{-1} at 0-15 cm depth whereas 3.5, 10.8 and 3.1 mg ha^{-1} at 15-30 cm depth, respectively. The soils of Vindhyan landscape were highest in SOC pool whereas the soils of Eastern plain was highest in SIC pool. In this semi-arid region, SOC pool was mainly regulated with clay content and SIC pool was regulated with soil pH. Taxonomically the soils of this area belong to 3 orders, 4 suborders, 4 great groups and 8 subgroups. Inceptisols cover the maximum area (68.85%) followed by Entisols (10.32%) and Vertisols (3.69%). Among these orders Vertisols sequestered highest SOC (77.1 mg ha^{-1}) and SIC (148.5 mg ha^{-1}) up to profile depth followed by Inceptisols and Entisols.

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Predicting Nitrogen and Phosphorus Mineralization from Sewage Sludge Applied to Soil

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A laboratory study was conducted to study the nitrogen (N) and phosphorus (P) mineralization pattern from sewage sludge applied to soil over a period of 90 days. The sewage sludge was applied @ 5 g kg^{-1} soil with and without of urea nitrogen. Following treatments were applied with three replications: (1) Control (2) Urea @ 100 mg urea N kg^{-1} soil, (3) Sewage sludge @ 5 kg kg^{-1} soil, (4) Sewage sludge @ 5 g kg^{-1} soil + urea @ 100 mg urea N kg^{-1} soil. Soil samples were withdrawn at 0, 10, 20, 40, 60 and 90 days, and mineral –N and Olsen P were determined. At 10 days after incubation, N mineralization in soil amended with sewage sludge with and without urea N was 5-7% lower than control, indicating microbial immobilization. At 20 days, while the amount of mineral-N in sewage sludge treatment was higher to that in control, it was lower (2.2%) in sewage sludge + urea compared to that of urea alone treatment. The net release of mineral-N at 60 and 90 days after incubation amounted to 31% and 47% of total N applied through sewage sludge. Unlike N mineralization, the P release from sewage sludge was rapid. After an initial increase, the available P content did not change much thereafter. At 60 and 90 days after incubation, available P in the control soil showed declining trend, suggesting refixation of release P. Available P content was not influenced by the application of fertilizer N in both unamended and sewage sludge amended soil.

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Distribution and Plant Availability of Soil Copper Fractions to *Avena sativa* L. Nutrition in Harayan Soils

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The distribution of copper (Cu) to oat nutrition among various chemical forms may vary significantly in response to changing soil properties. Therefore, a pot and laboratory study were conducted to investigate the distribution and plant availability of Cu fractions in eighteen (18) different soils of Haryana that varied in physical and chemical properties and an evaluation of plant availability of native and added Cu fractions in oat (*Avena sativa* L.). For this purpose a seven-step sequential fractionation showed that most of the total Cu (51.12%) was associated in the residual fraction (RES). The percentage of soil Cu in the exchangeable fraction (EX), carbonated bounded (CARB), organically associated (OM), Mn oxide bound (MnOX), amorphous Fe oxide (AFeOX) and crystalline Fe oxide (CFeOX) fractions averaged 2.71, 0.74, 2.74, 0.21, 13.35, and 29.11%, respectively. Amount of Cu in MnOX, AFeOX, CFeOX, RES fractions and total Cu were interdependent and varied directly with DTPA-extractable Cu and clay content. On the basis of stepwise regression analysis, the residual fraction contribute very little whereas exchangeable and carbonate bound fraction contribute maximum to the availability of Cu to Oat plant. The concentration of Cu and its uptake into oats were positively correlated with DTPA-extractable Cu, MnOX-Cu, AFeOX-Cu and total Cu, which in turn were correlated with clay content. Plant Cu concentration and uptake can be predicted by an equation which includes DTPA-extractable Cu and clay content. These results showed that DTPA-extractable Cu is a good predictor of Cu availability in Haryana soils.

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Availability and Different forms of Iron in Salt-affected Soils of Muktsar District of Punjab

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Ten representative salt-affected soils profiles from different parts of the Muktsar district of Punjab were studied for their morphological, physico-chemical characteristics and different forms of iron (Fe). The concentration of different forms of iron in the soil samples collected from different profile depths were estimated with the help of atomic absorption spectrophotometer. Texturally, the soils varied from silty clay loam, silt, silt loam through loam to sandy loam whereas soil pH ranged from 8.3 to 10.2, 8.6 to 10.0 and 8.2 to 9.4 and falls under the saline, sodic and saline-sodic soils category, respectively. DTPA-extractable Fe in these soil profiles ranged between 1.08 to 31.2 mg kg^{-1} and followed the order as sodic < saline-sodic < saline soils. The SpAd-Fe content was reported the highest in the saline and the lowest in the saline-sodic soils. Iron adsorbed on oxide surfaces followed the order as Mn-oxide bound (MnOX-Fe) < amorphocus iron oxide bound (A.FeOX-Fe) < crystalline iron oxide (CFeOX-Fe) whereas organically bound iron (OM-Fe) followed the order as saline-sodic > saline > sodic soils. The residural iron (RES-Fe) was highest in the saline soils and lowest in the saline sodic soils. The DTPA- Fe was significantly and positively correlated with EC and OC respectively. Also the DTPA-Fe showed significant positive correlation with forms of Fe such as MnOX-Fe and AFeOX-Fe. However, significantly negative correlation was observed between water soluble and exchangeble iron (WSEX-Fe) and CFeOX-Fe, SpAd-Fe and CFeOX-Fe, SpAd-Fe and OM-Fe form. Results of the present study showed that the mean total content of Fe in different soils was 2.10% which is lower than the mean global value of 3.50%.

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Depthwise Distribution of DTPA Extractable Zn, Fe, Cu and Mn in Relation to Some Soil Properties of CCS, HAU Regional Research Farms

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A systematic study on surface and depthwise distribution of DTPA extractable Zn, Fe Cu and Mn of soils of regional research farm Kaul (Kaithal) and horticultural research farm, Buria (Yamunanagar) was carried out. The regional research farm Kaul (Kaithal) is under rice-wheat cultivation and situated at about 29^o 51'N latitude and 76^o 40' E longitude on Pehowa-Nilokheri road, where as horticultural research farm, Buria is situated between 30^o 9' N latitude and 77Ú 18' E longitude in district Yamunanagar. Geologically, the study area constitutes part of Indo-Gangetic alluvial plain and belongs to the Pleistocene age. The Kaul farm has a basinal type of topography with a gentle to very gentle slope while the Buria farm has a plain topography with gentle slope, careful observation further reveal the existence of micro-relief variation. The climate of the study area is sub-tropical, continental, dry sub-humid and monsoonal type. The entire area of each farm was traversed on foot and with the help of post-hole auger, the soils were examined at an interval of 100-150 meters depending upon the variation in the soils. Profile samples were evaluated for their colour, texture, $CaCO_3$, mottlings, concretions and surface features like salt, erosion, land use etc. The objective of the present study was to know the variation of micronutrient status in relation to soil properties of the research farms having different cropping System. Soil samples at different horizons of the profiles were analyzed for their physico-chemical and micronutrient analysis.

The samples collected from Kaul revealed that DTPA extractable Zn, Fe, Mn and Cu varied from 0.20-4.34, 3.38-24.06, 2.70-9.70 and 0.32-2.66 mg kg^{-1} respectively. Among all the micronutrients Zn was found most deficient (12.82%) followed by Fe (5.13%). None of the samples fell under deficient category of Cu & Mn. Even on the basis of nutrient index value, the soils of Kaul farm fell under high fertility status and can support a good crop production. In case of Buria farm soils, the DTPA extractable Zn, Fe, Mn and Cu contents were found to be vary from 0.40-1.64, 2.26- 20.44, 2.32-10.14 and 0.22-0.98 mg kg^{-1} with a mean of 0.76, 9.23, 5.32 and 0.53 mg kg^{-1}, respectively. As per already established critical value of Zn Fe, Mn and Cu, the Zn was found highly (46.66%) deficient in samples followed by Fe (5.13%) and Mn (6.66%) in these soils. However no deficiency of Cu was noticed in Buria soils. Even on the basis of nutrient index, except Zn which falls under low category, none of the micronutrients were found deficient in these soils.

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Available Boron Content in Some Soils of Different Moisture Regimes of Haryana

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Horizon wise soil samples representing different soil series located in different moisture regimes in Haryana were collected and analyzed for physical and chemical characteristics and available boron. The texture of the soils varied from loamy sand to clay loam and organic carbon from 0.10 to 2.40%. The available boron (hot water soluble) ranged from 0.20 to 0.75 in the surface and 0.12 to 0.55 mg kg^{-1}. The available boron decreased in the order Ustic>Aridic>Udic soil moisture regimes. The available boron was found to be accumulated more in upper layers and it decreased with depth in most of the lower horizons. Available boron was positively correlated with soil pH (r=0.41) and electrical conductivity (EC) (r=0.49) and negatively correlated with clay (r = 0.34) and cation exchange capacity (CEC) (r=-0.24).

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Mineralization Pattern of Basic EDTA Extractable Organic Phosphorus under Organic Tea Garden Soils

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With a view to understand organic phosphorus (P) mineralization under organic farming systems, soils were sampled from certified organic tea gardens under two agro-ecological zones *viz.*, Brahmaputra and Barak Valley of Assam. Soils from conventional tea gardens of those regions were also collected and treated as check for the purpose. A set of extractants comprising graded strength of NaOH [0.125 to 1.0 (M)], with 0.05 (M) EDTA were used to extract different organic phosphorus fractions. With the use of first-order kinetics model, organic P mineralization rate, half-life of residual organic P and their mean residence time (MRT) of different organic P fraction extracted by different extractants were measured under both organic and conventional tea gardens. Net organic P mineralized from different fractions under different tea gardens were also worked out. The first order model well described the mineralization of different fractions of organic phosphorus extracted by basic EDTA extractant. Organically managed tea gardens stimulated faster mineralization with shorter half-life and mean residence time. Overall results showed that in few cases 0.125 (M) NaOH + 0.05 (M) EDTA extractable organic P was identified as most contributing P pool but in other cases 0.5 (M) NaOH + 0.05 (M) EDTA extractable organic P was identified as the most potential. But in most of the cases, 1 (M) NaOH + 0.05 (M) EDTA extractable organic P was qualified as potential contributor as measured by predicted mineralized P. Thus this extractant might putatively be selected as suitable extractant for potential P estimation under organic production systems. The outcome of the present exercise will help to develop novel soil tests method for routine phosphorus estimation to cater the need of organic farmers.

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Depthwise Distribution of Extractable Boron in Soils under Long-Term Experiments at Different Agro-Ecological Zones in India

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Boron (B) is the most widely deficient micronutrient in the world. Long-term experiments are also useful for determining the availability of micronutrients as they can manifest the effects of different treatments applied for years together. The present investigation was conducted with four long-term experiments at different agro-ecological zones in India to evaluate the distribution of hot $CaCl_2$ extractable B content in soils along depth in relation to soil properties as modified by different management practices. Soils were collected at 0-0.15, 0.15-0.30, 0.30-0.45 m depth from three selected treatments *viz.* control, 100% recommended dose of fertilizer (RDF), 50% RDF + 50% N through FYM and a fallow where no cropping was done with any of the above treatments. Among the treatments, control recorded the lowest amount of extractable B in Raipur and Junagarh and soils with FYM recorded the lowest amount in RSpura and Mohanpur; while fallow recorded the highest amount in all the sites. A negative correlation was observed between available B content and pH of the soils; while a positive correlation was observed with organic carbon.

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A Simple Method for the Determination of Ammoniacal Nitrogen (NH_4^+-N) in Soils, for the Assay of Soil Urease, Asparaginase and Glutaminase

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Two methods for the determination of ammoniacal nitrogen (NH_4^+-N) in soil *i.e.,* modified Nessler method and steam distillation method were compared in soils with varying properties at different periods of incubation. Among these two methods modified Nessler method involving the colorimetric determination of ammoniacal nitrogen (NH_4^+-N) at 436 nm, resulted in higher amounts of ammoniacal nitrogen (NH_4^+-N) while steam distillation recorded comparately lesser amount of ammoniacal nitrogen (NH_4^+-N) at different periods of incubation. There was significant and positive correlation between these two methods at 2 hours (r = 0.94**) and at 96 hours (r = 0.91**) suggesting that modified Nessler method can be used for the determination of ammoniacal nitrogen (NH_4^+-N) in soils and this method is found to be simple accurate and can be used for determination of ammoniacal nitrogen (NH_4^+-N) in a large no of soil samples. This method can also be used for the studies on the assay of soil urease, L-asparaginase and glutaminase activity.

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Effect of Long Term Fertilizers and Manure Application on Yield of Maize and Different Phosphorus Fractions in Haplustepts

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Maize (*Zea mays* L.) is an important cereal crop of India. In Rajasthan state, maize is grown in 1.05 m ha^{-1} area, which is second largest area in India but productivity is only 1120 kg ha^{-1}. The nutrient balance sheet of Rajasthan agriculture reveals that constant mining of nutrient elements through crops and subsequent insufficient addition of these nutrients to the soil in form of manures and fertilizers has tilted it in a negative balance. Field experiment was carried out during *kharif* 2012 in the Long-term fertilizer experiments initiated in *kharif*, 1997 at the instructional Farm of the Rajasthan College of Agriculture, Udaipur. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in reaction, medium in available nitrogen and phosphorus, while high in potassium and zinc. The experiment consisted of 12 treatments comprising chemical fertilizers, organic manure, *Azotobacter* and their combinations, *viz.*, 100% NPK, 100% NPK + Zn, 100% NPK + S, 100% NPK + Zn + S, 100% NPK + *Azotobacter*, FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM), 100% NPK + FYM 10 t ha^{-1}, FYM 20 t ha^{-1}, 150% NPK, 100% NP, 100% N and control in randomized block design with four replications.

The results of the present investigation revealed that the highest maize grain and stover yield (4033 and 6038 kg ha^{-1}) were obtained by applying 100% NPK + FYM 10 t ha^{-1}, though the results were at par with 150% NPK. Similarly, maximum N, P, K uptake was recorded by use of 100% NPK + FYM 10 t ha^{-1} with statistical equivalence with 150% NPK. However, integrated use of chemical fertilizers along with FYM (100% NPK + FYM 10 t ha^{-1}) led to maximum uptake of Zn, Cu, Fe and Mn. Availability of N was recorded maximum when soil enriched with 100% NPK + FYM 10 t ha^{-1}, P and K maximum with application of 150% NPK, availability of Zn in 100% NPK + Zn + S treatment, Cu in FYM 10 t ha^{-1} + 100% NPK (-NPK of FYM) and availability of Fe and Mn maximum in application of FYM 20 t ha^{-1} at all three depths (0-15, 15-30 and 30-45 cm).

The study revealed that soil enrichment with 150% NPK resulted in highest positive balance of nitrogen and phosphorus in soil and negative potassium balance was observed under all treatments except application of FYM 20 t ha^{-1}. The maximum negative potassium balance was computed when soil enriched with 100% NP. Application of FYM alone or in combination and 100% NP related in higher value of all fraction of phosphorus whereas availability of different fraction of phosphorus reduces under without phosphorus application. Concentration of all fraction of phosphorus was showed decreasing trend with depth. Available phosphorus concentration in soil at all depths can be explained by calcium bound phosphorus fraction which has highly significantly co-related with available phosphorus. All eight phosphorus fractions jointly explained 99.45 and 96.46% of variation in phosphorus content of maize grain and stover.

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Role of Zeolite in Improving Sewage Quality

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A column experiment was conducted using zeolite to estimate its heavy metal removal efficiency from sewage of Miralam sewage treatment plant situated in peri urban area of Hyderabad, Andhra Pradesh. The leachates collected from the column treatment where zeolite was applied @ 1.5% on soil weight basis recorded maximum cobalt removal (0.431 mg L^{-1}) as compared with control (without zeolite, 0.492 mg L^{-1}). The cobalt removal efficiency was 12.36%. Similarly, lead and cadmium removal efficiency analyzed using Atomic absorption spectrophotometer was 32.76% and 20.67%, respectively with 1.5% of zeolite application. The data collected on chemical properties of sewage leachate also revealed a significant reduction in biological oxygen demand and chemical oxygen demand.

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Distribution of Nickel into Different Fractions in Soils and their Contribution Towards Plant Uptake

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Very limited numbers of studies have been conducted on fractionation of nickel (Ni) in soil and they are mostly confined to soils having much higher content of organic matter and are highly polluted soils. Therefore, the present investigation was undertaken on fractionation of Ni in tropical soil to study the distribution of different fractions of Ni in soil to evaluate the contribution of different fractions of Ni in soil towards plant uptake. For this purpose, fifteen bulk surface (0-15 cm) soil samples with wide variation in physicochemical properties were collected from cultivated fields of various locations in and around Delhi. A pot experiment was conducted with these soil to assess to contribution of different fractions of Ni in soil towards plant uptake using soybean as a test crop. Nickel was mostly concentrated in the residual fractions as compared to the other fractions (3.19-63.6%). The range of immediately bioavailable pools *i.e.* water soluble plus exchangeable Ni was very low *i.e.* 0.70 to 4.04% of total Ni present in soil. Organically bound Ni varied from 1.60 to 6.85% of total Ni in these soils, which is relatively lower as compared to what reported in literature for temperate soils. Most of the experimental soils were low to medium in organic carbon content. Free Fe_2O_3 and organic carbon content mainly contributed towards various fractions of Ni in soil. Water soluble plus exchangeable, Mn-oxide bound and organically bound and residual are the dominant fractions which control the phytoavailability of Ni in soil.

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Ground Covers Differ in their Effect on Soil pH in Rubber (*Hevea brasiliensis*) Plantations

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Acidification of agricultural and forest soils has long been considered as a major challenge for sustaining/ increasing productivity. Conventionally lime is applied for ameliorating soil acidity, but in many agricultural systems, the economic returns from liming does not compensate for the cost of liming. Hence it is highly essential to identify the causes of soil acidification in a given agricultural system and develop alternative strategies for managing soil acidity.

Incorporation of leguminous ground covers in agro-ecosystems is a common practice due to their multiple functions and advantages. Legume cover crops *Pueraria phaseoloides* and *Mucuna bracteata* are established between planting rows in rubber plantations along with rubber. Most of the rubber plantations in the traditional rubber growing regions are in the third cycle of repeated cultivation and there are concerns about many of the plantations becoming more acidic. The present study was taken up with an objective to compare the effect of different ground covers *viz.*, *Pueraria phaseoloides*, *Mucuna bracteata* and natural flora on soil pH in rubber plantations.

The study was carried out at two locations, Central Kerala and North Central Kerala. Rubber plantations were divided in to eight blocks each before establishing various ground covers and composite soil samples (0-30 cm) were collected from each block before establishing ground covers and after four years, to study the change in soil pH over time. Soil samples were collected from adjacent young rubber plantations in North Central Kerala with these ground covers for comparison of soil properties. Soil pH (1: 2.5 soil water ratio), exchangeable Al content and cation and anion content of litter of ground covers were determined using standard analytical procedures. The concentration of alkalinity (excess cations) in litter was calculated as the difference between the sum of cations and anions using the following equation:

$$\text{Excess cations} = (K^{+} + Ca^{2+} + Mg^{2+} + Na^{+}) - (H_2PO_4 + SO_4^{2-} + Cl^{-})$$

Study on the change in soil pH under different ground covers over time showed that *Pueraria phaseoloides* did not change soil pH, whereas *Mucuna bracteata* lowered and natural flora increased soil pH significantly in four years. In paired plot studies, soil pH was significantly lower under *Mucuna bracteata*. However, exchangeable Al content was not correspondingly higher under *Mucuna bracteata*. Comparison of litter alkalinities showed that *Mucuna bracteata* litter had the lowest alkalinity followed by *Pueraria phaseoloides* and natural flora had the highest litter alkalinity. Soil calcium status was significantly higher under natural flora. Study clearly showed that leguminous ground covers differ in their effect on soil pH and appropriate ground cover management is an ameliorative strategy in rubber plantations to check soil acidification.

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Retaining *Mucuna bracteata* in Mature Rubber (*Hevea brasiliensis*) Plantations Reduces Soil pH, but Increases Soil Organic Carbon Status

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Acidification of agricultural soils is a global concern, and despite increasing awareness about its causes and impact on crop productivity, the cultivated area under acid soils is steadily increasing. Soil acidification is a continuous long term process when water percolates through the soil profile, but it is accelerated by some of the management practices. One of the major factors leading to soil acidification is the imbalance in the uptake of cations over anions by nitrogen fixing leguminous crops. In areas of Australia where clover has been grown continuously for more than 30 years, the soil pH has decreased by about one unit.

Rubber (*Hevea brasiliensis*) is cultivated in more than 10 Mha globally and the area under rubber cultivation is fast expanding in several South East Asian and African countries. In many traditional rubber growing areas, rubber has been repeatedly cultivated for more than a century and there are reports that many plantations are becoming more acidic. Rubber plantations are mainly established on sloping and undulating lands in these regions and leguminous ground covers are established along with rubber due to their well-documented advantages. *Pueraria phaseoloides* and *Mucuna bracteata* are the popular cover crops in India. *Pueraria* is shade sensitive and after the luxuriant growth in the initial years, die off when shade intensifies in the plantation whereas, *Mucuna* is comparatively shade tolerant and once established will continue to survive throughout the plantation cycle in most cases. The present investigation was taken up to study the long term effect of *Mucuna bracteata* on soil pH in rubber plantations. The effect of retaining *Mucuna* on soil exchangeable Al status and other soil properties were also studied.

The study was conducted at four locations, one location in North Central Kerala, two locations in Central and one location in South Kerala. In each location, soil samples were collected from adjacent 17-20 year old plantations with and without *Mucuna bracteata* as ground cover. Each plantation was divided in to eight blocks and composite soil samples (0-30 cm) were collected from each block for chemical analyses during August 2012 before post monsoon fertilizer application. Soil samples were dried in the shade, sieved through 2mm sieve and analyzed for soil pH (1:2.5 soil water ratio), organic carbon content, exchangeable Al and nutrient status following standard analytical procedures. The data were subjected to analysis of variance. Soil pH was significantly lower in mature rubber plantations with *Mucuna* as ground cover compared with adjacent plantations without *Mucuna,* but the magnitude of the difference varied between locations. Exchangeable Al content was significantly higher when *Mucuna* was retained in the plantation. Soil organic carbon status was significantly higher under *Mucuna bracteata*, however the contents of other nutrients were not significantly influenced. The results showed that retaining *Mucuna bracteata* in rubber plantations for long periods will reduce soil pH, but improve soil organic carbon status.

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Effect of Arsenic on Soil Enzyme Activities

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Arsenic (As) is considered the most potential carcinogen and human are exposed to it from soil, water, air and food. Hence its origin and mobilization in the environment, biochemistry and bioavailability should be well understood to monitor and manage it. Soil enzyme activities are very sensitive to both natural and anthropogenic disturbances and show a quick response to the induced changes. Soil enzymes such as dehydrogenase activity (DHA) is one of the main indicators of microbial activities participating in and assuring the correct sequence of all biochemical routes in soil biogeochemical cycles. It is also an important parameter to study soil microbial activity under stress conditions. In the present work, effects of various induced As concentrations spanning different incubation time periods on the soil enzymes activity was undertaken. Soil samples were collected from uncultivated area of IARI farm, New Delhi. Concentrations of As in soil was analysed using ICP-MS (Perkin Elmer, NexION 300X, USA). Soil samples were induced with various concentrations (upto 100 ppm) of As and incubated at 28 ^{o}C for a period of 4 weeks. It has been observed that soil enzymes activities had declined with increasing intensity of soil contamination with As. Interestingly, it has been observed that irrespective of As concentration there was a slight increase in DHA activity at initial period during incubation time. Arsenic at concentration beyond 20 ppm showed significant decrease in DHA and other enzymes. It is indicative that microbes need more energy to survive in unfavorable conditions but at higher concentrations, they are unable to survive in unfavorable conditions. There was no clear relationship between the DHA and incubation time. It can be concluded from this study that soil microbial activity could be drastically reduced when As concentration beyond 20 ppm in soil.

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Efficacy of Phosphate Solubilizing Microorganisms under Varying FYM Levels and Their Effect on Yield of Soybean in Inceptisol

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A pot experiment was conducted to study the efficacy of phosphate solubilizing microorganisms, with varying FYM levels, on yield and uptake of soybean and their effect on residual fertility on Inceptisol, during *kharif* 2012, at the Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri. The results of the investigation revealed that the highest soil available nitrogen at 45 DAS and harvest stage was observed with *Aspergillus awamori* seed inoculation with 10 t ha^{-1} FYM, due to profuse root growth and higher root nodulation. The efficacy of phosphate solubilizing microorganisms for solubilizing the inorganic soil phosphate was observed to be in the order of *Aspergillus awamori* > *Bacillus polymyxa* >*Penicillium digitatum* > *Pseudomonas striata*. *Aspergillus awamori*, the fungal strain was observed to be most efficient phosphate solubilizing microbial strain among all the strains, with higher levels of FYM. *Bacillus polymyxa* was observed to be the most efficient phosphate solubilizing bacterial strain. The soil fungal and bacterial population increased with seed inoculation of phosphate solubilizing microorganism and increasing levels of FYM. The bacterial population was almost 2 folds higher than the fungal population. The soil pH decreased in all treatments of phosphate solubilizing microorganisms. A slight decrease in $CaCO_3$ content was also observed in the phosphate solubilizing microorganism seed inoculation treatment. The highest grain and straw yields of soybean were obtained in the *Aspergillus awamori* and *Bradyrhizobium japonicum* seed inoculation treatment with 10 t FYM ha^{-1}, followed by *Bacillus polymyxa* seed inoculation. It can, therefore be inferred that the efficacy of phosphate solubilizing microorganism for obtaining higher yields of soybean, improving the soil N and P fertility and improving other soil properties was in the order of *Aspergillus awamori* > *Bacillus polymyxa* >*Penicillium digitatum* > *Pseudomonas striata* with higher levels of FYM.

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Effect of Organophosphate Insecticides on Phosphorus Mobilization in Soil

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Application of agrochemicals in the course of crop production is an indispensible practice and pesticide is one of the group of agrochemicals is being used to combat with the crop loss due to pests. Whatever be the method of insecticide application, either it is foliar or it is soil, the pesticide ingredients ultimately in the form of 'insecticidal fall-out' find their way to the soil surface of 15 cm depth which harbours the maximum microbiological activities and may affect soil microbial dynamics and thereby transformation and availability of plant nutrients.

A laboratory experiment was designed to observe the effect of four organophosphate insecticides, viz. monocrotophos, profenofos, quinalphos and triazophos at their field applications rates (750 g, 1000 g, 500 g and 600 g a.i. ha^{-1}, respectively) on phosphorus mobilization in an alluvial soil of West Bengal. Collected soil samples were incubated for a period of 60 days after the application of the insecticides and at 15 days interval, five parameters (count of phosphate solubilizing microorganisms, phosphate solubilizing capacity, activity of acid and alkaline phosphatase and available P content in soil) related to the soil available P were studied. Among the insecticides, monocrotophos significantly increased the phosphate solubilizing capacity of soil but profenofos increased significantly the count of phosphate solubilizing microorganisms. Profenofos, quinalphos and triazophos have decreased significantly the activity of alkaline phosphatase and the activity of acid phosphatase decreased significantly with the application of all of the selected insecticides excepting quinalphos, but the content of available P in soil was not significantly influenced.

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Soil Enzyme Activity and Nutrient Availability under Long-term Fertilizer Experiment of a Rice-Rice Cropping System in an Udic Ustochrept

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Continuous and intensive conventional agricultural production system resulted in a steady decline of farm productivity and increased deterioration of the soil environment. Status of soil microbial community and enzyme activities is a potential tool in soil quality assessment. Thus, for long-term fertilizer trials, besides monitoring the long-term effect of organic and inorganic fertilizer on yield and yield components, it is important to monitor soil biological properties as a means of assessing soil health and productivity of agricultural ecosystem. In order to investigate the effect of organic and inorganic fertilization on enzymic activities in paddy soil samples of pre *kharif* 2011 were collected from long term fertilizer experiment started during 2005-06 in the Central Farm of OUAT under AICRP in an acidic sandy soil, taking Swarna (MTU-7029) as a test crop. The experiment was systematically initiated with quadruplicated 12 treatments in a Randomized Block Design. Almost all treatments received different combinations of nutrients. Out of the 12 treatments, eight treatments were selected for the present study *i.e.* 50% NPK, 100% NPK, 150% NPK, 100% NPK + FYM, 100% N, 100% NP, 100% NPK + Lime and un fertilized control. The results revealed that over periods of 2005-06 to 2010-11, soil organic carbon increased in 100% NPK+ FYM by 33%. 100% NPK+ FYM had highest dehydrogenase activity (246 mg TPF kg^{-1} soil/24 h). The urease activity varied with SOC. With low SOC, the assay showed low enzyme activity and vice-versa. Urease activity significantly correlated with SOC (r = 0.71*). Treatments with no P (100% N), sub –optimal P (50% NPK) and low applied P indicated more phosphatase activity. Soils with over dose of P (150% NPK) exhibited low phosphatase activity. In 100% NPK + FYM , the optimal dose of P along with FYM accounted for the highest (452 mg p- nitrophenol kg soil hr^{-1}) phosphatase activity. The integration of optimal dose of NPK (80:40:60) and organic manure like FYM (5 t ha^{-1}) also showed the highest uptake of nutrients and consequent highest yield. Long term application of organic and mineral fertilizer enhanced the microbial activity and functions in soils, which may be favourable to sustain soil productivity and soil health.

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Changes in Soil Biological Quality Indicators in a Rice-Wheat Agro-ecosystem under Tillage-water-nutrient Management

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Few soil biological parameters, that are dynamic and responsive to management practices, are considered to be important indicators of soil quality. The present investigation was carried out to study the influence of tillage, water and nutrient-management practices on dehydrogenase activity (DHA), microbial biomass carbon (MBC), potentially mineralizable nitrogen (PMN), soil respiration and microbial metabolic quotient (qCO_2). The soil samples were collected after completion of eight cropping cycles of rice and wheat. Two tillage management treatments, *i.e.* puddling (transplanted) and non-puddling (wet seeded) in rice, whereas the same puddling history were allocated to main plots in wheat. Three water management treatments, *viz.* continuous submergence (W_1), irrigation after one day of drainage (W_2), and irrigation after three days of drainage (W_3) in rice and five times irrigation *i.e.* W_1 (crown root initiation, tillering, jointing, flowering and dough stages), three times irrigation *i.e.* W_2 (crown root initiation, jointing and flowering stages) and two times irrigation *i.e.* W_3 (crown root initiation and flowering stages) in wheat were allocated to sub plots. Nine nutrient treatments were allocated to sub-sub plots in rice and wheat as control (T_1), 100% NPK (120, 26.2 and 50 kg N-P-K per ha) (T_2), 150% NPK (T_3), 100% N (25% N substituted by FYM) +PK (T_4), 100% N (25% N substituted by green manure, *Sesbania*) + PK (T_5), 100% N (25% N substituted by biofertilizer) + PK (T_6), 100% N (25% N substituted by sewage sludge) + PK (T_7), 100% N (25% N substituted by crop residues incorporated (of previous crop) + PK (T_8), 100% N through organic sources (50% FYM + 25% biofertilizer + 25% crop residues/green manure) (T_9). For wheat, again splitting was done in each nutrient management plot to impose two tillage treatments *i.e.* conventional tillage (CT) and no-tillage (NT). After eight cropping cycles, the soil samples were collected to a depth of 0-15 cm from the above treatments both at harvest of wheat and rice. Non-puddling significantly enhanced DHA (5.2%), MBC (2.5%), and PMN (5.0%), whereas puddling was beneficial to soil respiration (47.6%) and qCO_2 (41.3%) during rice. The organic treatments T_4, T_7, T_9 could be promoted for enhancing DHA by (35.6%), MBC (32.9%), PMN (57.1%) and in some instances soil respiration, but dropped the qCO_2. This implied an accumulation of stable organic C after both the crops. At though the drainage of irrigation water in rice increased DHA (W_2: 13.7%, W_3: 35.3%) and MBC (W_3: 32.4%), it adversely affected soil respiration (W_3: -11.4%). Contrarily in wheat, W_1 and W_2 significantly improved these indicators. NT in wheat could be useful in maintaining the biological indicators of soil quality. qCO_2 significantly correlated ($p < 0.01$) with both soil respiration ($r = 0.711, 0.426$) and negatively with MBC ($r = -0.618, -0.858$) for both crops. From this study, qCO_2 and DHA emerged as two most promising indicators by principal component analysis to contribute soil biological quality of the present agro-ecosystem.

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Noval Nutrient Management for Boosting Crop Productivity, N-fixation, Nutrient Recoveries in Black gram Crop

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A field experiment was conducted in a sandy loam acidic (pH 5.25 *Inceptisols*) soil with low organic carbon content (3.9 g kg^{-1} soil), medium available N and P, but low K and S status. On yield maximization of black gram crop (OBG-17), adopting all possible measures including seed inoculation with *Rhizobium*, application of soil test based recommended dose of fertilizers, integrated with addition of organics and soil ameliorative measures (lime as paper mill sludge @ 0.2 LR).

The study indicated that seed inoculation with Rhizobium, supplementation deficient nutrients through soil test based fertilizers application, added with organics and acid soil ameliorant, not only influenced the nodular behavior like nodule number, nodule weight, N-content in nodule of the crop, but also the seed yield, pod length, number of seeds per pod, their thousand seed weight with higher protein content in grain compared to un-inoculated control. The nodule number varied between 40 and 105, nodule weight between 344.3 and 838.7 mg $plant^{-1}$, nodular N between 4.87 and 14.17 mg $plant^{-1}$, seed yield between 327 and 940 kg ha^{-1}, the green residue biomass between 1317 and 2070 kg ha^{-1}. All improved practices resulted in extra N gain from 23.5 and 73.2 kg ha^{-1}, apparent P, K and S recoveries values increase from 22 and 54.5% , 21.4 and 34.2%, 9.2 and 36.7% respectively. The *in situ* residue incorporation recycled N, P, K, Ca, Mg and S and the corresponding values increased from 41 and 69 kg ha^{-1}, 5.1 to 10.1, 9.6 to 17.3 kg ha^{-1}, 14.2 to 26.3 kg ha^{-1}, 8.6 to 12 kg ha^{-1} and 1.7 to 4.2 kg ha^{-1}, respectively. The complete integrated treatments could improve post-harvest soil properties in better way, except maintaining the K and S status for the next crop (knol khol) suggesting their external supplementation. There is ample scope for increasing the productivity of black gram crop from state average yields of 433 kg ha^{-1} to a level of 940 kg ha^{-1}, with seed treatment with sodium molybdate and cobaltos chloride @ 10 and 1 g per 25 kg seed, inoculated with *Rhizobium*, soil applied with soil test based nutrients integrated with organics and ameliorated with paper mill sludge applied @ 0.2 LR doses. Legume crop residue *in situ* incorporation not only can improve the site of cultivation but also supplement the costly inorganic agro-inputs.

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Evaluation of Potassium Mobilization from Waste Mica by Potassium Solubilizing Strain as an Alternative Source of Potassium

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An attempt was made in this study to evaluate waste mica inoculated with potassium solubilizing strain as an alternative source of K. Potassium solubilizing microorganisms (*Bacillus mucilaginosus*) was isolated from biological potassium fertilizer (BPF) imported from China. Waste mica, a potassium bearing mineral, was obtained from the surroundings of mica mines located at Koderma district of Jharkhand, was used as source of potassium due to significant amount of potassium (8-10% K_2O) present in it. Incubation experiment was carried out in different temperature for different duration in culture medium (*Bacillus mucilaginosus*) to find out K mobilization from waste mica. To know the acid produced by the microorganisms and their activity, pH and total sugar content were measured as per the standard procedures. To judge the K solubilizing capacity of BPF (*Bacillus mucilaginosus*) culture from waste mica, available K content was measured for different periods of time under solid, liquid and broth culture medium. K release rate and structural change of waste mica workout through release kinetics model and X-ray diffraction analysis respectively. The result showed that irrespective of temperature and period of incubation, significant higher mobilization of K was recorded in all treatments whereas, incubation was carried out in presence of BPF culture compared to control. The pH decreased in presence of BPF culture as compared to control, but lowest pH (5.47) was observed at 28 °C at 21 days after incubation. The total sugar content decreased considerably in presence of BPF culture compared to control. In presence of BPF culture the K mobilization increased up to 14 DAI and thereafter decreased when temperature was maintained at 15 °C and 29 °C. Among the different from of culture, BPF liquid culture released significantly higher amount of K than solid and broth culture. Release kinetics K and X-ray diffraction analysis showed significant release of K from waste mica treated with microbial culture. Thus, BPF culture was efficient in releasing K from waste mica and combination of could be used successfully as a cheaper source of K-fertilizer in place of costly K-fertilizers.

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Effect of Herbicides on Nodulation, N_2-Fixation Yield and Total NPK Uptake by Soybean

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A field experiment was conducted during rainy season on soybean Cv:JS-335 in Inceptisol to study the effect of different herbicides on soybean and its impact on the fertility status. Results indicated that maximum yield was noted under mixture of chlorimuron ethyl @ 9 g+fenoxaprop @ 90 g ha^{-1} as post emergence, which produced 142.88% higher yield than control but was similar to yield obtained under 3 handweeding (20, 30 and 50 DAS). These treatments also improved nodulation, N_2-fixation, growth, yield attributing parameters and total NPK uptake by the soybean crop. Application of herbicides at recommended dose had no impact on rhizobial and PSB counts. However, cultural operations improved the counts. Status of available N after soybean increased up to 20 kg ha^{-1} and depleted up to (-) 13.5 kg ha^{-1}. Similarly, status of available P and K was also reduced to 13.26 and 23.34 kg ha^{-1}, respectively, over the initial status of soil. A significant positive relationship was observed between symbiotic, physiological and yield attributing characteristics with dry biomass. NPK uptake was also positively associated with each other.

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Response of Groundnut to Different Levels of N and K with and without Biofertilizers in Relation to Yield, Quality and Nutrient Uptake

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The field trial was conducted at Pangari block of Irrigation Scheme at Central Experimentation Station, Wakawali during *kharif* 2008. The experiment was conducted on newly terraced lateritic soil. The soil was sandy loam and has 43.13% porosity, 54.29% maximum water holding capacity, slightly acidic in reaction (pH 5.5) and has 0.051 dS m^{-1} EC. The status of organic carbon (8.3 g kg^{-1}) was high, whereas available N (307.3 kg ha^{-1}) and available P (14.36 kg ha^{-1}) was medium. The available K was (270.0 kg ha^{-1}) high. The exchangeable Ca and Mg content was 5.3 and 4.8 cmol(p^+)kg^{-1}, respectively. The available sulphur was 21.0 mg kg^{-1}. The experiment was laid out in randomized block design with eight treatments replicated thrice. It includes application of N, P and K through mineral fertilizers *viz.* urea, single super phosphate and muriate of potash respectively. Seed inoculation with biofertilizers *Rhizobium* and phosphate solubilizing bacteria (PSB) was done.

The first two treatments T_1 and T_2 were without any application of mineral fertilizers. 50 kg P_2O_5 ha^{-1} was applied to treatments T_3 to T_8. A dose of 20 kg N ha^{-1} and 15 kg K_2O ha^{-1} was applied to treatment T_3 and T_4. 25 kg N ha^{-1} and 30 kg K_2O ha^{-1} was applied to T_5 and T_6. Treatment T_7 and T_8 received a dose of 30 kg N ha^{-1} and 45 kg K_2O ha^{-1}. Seed inoculation with biofertilizers was done in T_2, T_4, T_6 and T_8. A common dose of FYM @ 5 t ha^{-1} was given to all treatments. All mineral fertilizers and FYM were applied through line application. The result indicated that the application of N:P_2O_5:K_2O @ 25:50:30 kg ha^{-1} with biofertilizers has superior result in pod yield, kernel yield, methionine content, crude fiber as well as total uptake of Ca, Mg and S. Also, significantly highest haulm yield, oil yield, protein content and total uptake of N, P and K were found in the treatment (T_8) *i.e.* 30:50:45 @ N:P_2O_5:K_2O kg ha^{-1} with biofertilizers over the control.

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Dehydrogenase Activity in Teak and Sandalwood Supporting Soils in Seoni District, Madhya Pradesh

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Two pedons from teak and two from sandalwood supporting soils occurring on different landforms were studied for their morphology, some relevant soil properties and dehydrogenase activity (surface horizons) in Seoni district, Madhya Pradesh. The thickness of solum, texture and colour of the pedons varied significantly with landform (plateau/side and escarp slopes) and parent material (basalt/laterite). Teak supporting Parasia pedon (plateau) is characterised by shallow, dark reddish brown, clay cambic B horizon (Clayey Typic Mollisol) developed from basalt whereas Mohgaon (undulating plateau) soil had very deep solum, dark reddish brown, clay enriched Bt horizon with more than 50% gravels (Clayey-skeletal Typic Rhodustalf) developed from laterite of basaltic origin. The sandalwood (natural) supporting Salaia pedon (foot slope) is characterised by shallow, dark reddish brown to reddish brown cambic B horizon (Clayey Typic Haplustept), whereas other pedon (scarp slope) is shallow, very dark greyish brown, clayey cambic B horizon (Typic Haplustept). The pH of the pedons varied from 5.9-6.7 and 6.8-7.0 and organic carbon from 1.26-2.37% and 0.37-1.56% in teak and sandalwood supporting soils, respectively. In general, the pH of the studied pedons increased and organic carbon decreased with depth. The DHA in surface horizon varied from 1.16-3.61 μg TPF and 1.62-5.52 μg TPF in teak and sandalwood supporting soils, respectively. Soil organic carbon seems to be in reliance with dehydrogenase activity.

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Efficiency of Plant Growth Promoting Rhizobacteria (PGPR) in Enhancing the Growth of Tomato (*Lycopersicon esculentum*)

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PGPR are free living soil borne bacteria which when applied to seeds or crops as microbial inoculants enhance the growth parameters of the associated crops through its multifarious activities. It promotes the exchange of plant nutrients and reduce application of chemical fertilizers as well as reduce disease incidence. To assess the fact, a pot experiment was conducted during February 2013 in the Biofertilizer Production Unit, Assam Agricultural university, Jorhat, to investigate the effects of PGPR inoculation on growth and development of tomato plants. Seven efficient cultures, designated as PGP 3, PGP 10, PGP 17, PGP 25, PGP 33, PGP 49 and PGP 51 evaluated through lab screening tests were selected for pot culture evaluation, based upon their performance in various qualitative and quantitative tests. The tomato crop was inoculated with efficient PGP cultures and grown for 45 days. The growth parameters were recorded after harvest. The result on plant growth promotion was observed in all inoculated treatments over uninoculated control which was evident for culture PGP 17 that showed increased in total biomass (211%), shoot weight (by 207%), root weight (by 246%), shoot length (by 83%), root length (by 35.6%), root shoot ratio (by 12%), number of branches (by 300%), number of leaves (by 100%), number of flowers (5.7%), and number of fruits (4.3%) over control. Among the test organisms, PGP 17 significantly enhanced plant growth promoting parameters and thereby showed efficient PGPR as microbial inoculants compared to treatment receiving recommended dose of fertilizer. The results further showed that other PGP organisms also performed better in respect of yield attributing parameters when compared with uninoculated control, but in most cases their performance was either similar or lower than standard treatment comprising recommended doses of fertilizers. Therefore, PGP 17 has been considered as efficient PGPR having biofertilizer activities that can be harnessed for future microbial inoculants.

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Contribution of Some Indigenous Phosphate Solubilizing Bacteria to Phosphorus Bioavailability and their Influence on the Growth and Yield of *Ahu* Rice

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The phosphate solubilizing bacteria can solubilize insoluble forms of P into simple soluble forms that can be taken up by plants. The main focus of this study was to isolate and characterize some indigenous phosphate solubilizing bacteria from the soils of different areas of Jorhat district of Assam followed by their evaluation on the growth and yield of *Ahu* rice. A total of 57 phosphate solubilizing bacteria were isolated from different rhizospheric soils of turmeric, maize and sugarcane and were characterized on the basis of morphological and biochemical tests. These PSB isolates were screened for further evaluation on the basis of P-solubilization both qualitatively and quantitatively. Out of test phosphate solubilizing bacteria isolated, isolates PSB-5, PSB-7 and PSB-13 (all *Bacillus* sp.) solubilized insoluble tri-calcium phosphate to the tune of 2.5, 3.25 and 4.5%, respectively, and were selected for further evaluation. The evaluation of the selected PSB isolates was done on the growth and yield of *Ahu* rice with and without rock phosphate under net house conditions. The results of the study showed significant increase in growth and yield parameters *viz.* plant height (50-55%), root and shoot growth (48-50%), number of panicles (75-78%), and 1000 grain weight (150-165%) in inoculated plants over uninoculated control plants. The addition of rock phosphate further enhanced the yield. The application of these potential inoculants in an appropriate combination with mineral fertilizers could be considered in organic and sustainable rice cultivation system.

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Survival and Establishment of Potential Phosphate Solubilizing Bacteria Under Biotic and Abiotic Stresses

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The ability to convert insoluble forms of P to an accessible form is an important trait in phosphate solubilizing microbes for increasing plant yields. Most often the efficient cultures isolated fail to show appreciable yield enhancement, when applied as biofertilizers. This may be ascribed to abiotic and biotic stresses that affect microbial inoculants to survive in particular environment. Therefore, a study was undertaken on survival and establishment of potential phosphate solubilizing bacteria (PSB) as affected by some biotic and abiotic stresses so as to evaluate efficient cultures adapted under stress condition. In the present investigation, an *in vitro* incubation study was conducted for 30 days with five potential PSB cultures (PSB-3, PSB-5, PSB-6, PSB-7 and PSB-13) on their survival under varying biotic (antibiotics) as well as abiotic stresses (pH, temperature and moisture regime). The results revealed that all test PSB cultures differed in the survival to different antibiotics, pH, temperature and moisture content. Among the test cultures, PSB-5 and PSB-7 showed a very high tolerance level of three antibiotics (Penicillin, Ampicillin and Streptomycin) upto a concentration of 1500 ppm. The cultures also showed increased survival at pH range of 3.5 - 6.5, temperature range of 15- 40°C and moisture range of 20-40%, irrespective of days of incubation. Therefore, PSB-5 and PSB-7 were regarded as the most efficient cultures that established and survived under adverse ecological conditions, which could be accepted biofertilizer agents for sustainable agriculture.

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Effect of Phosphorus and Phosphatic Biofertilizers on Yield and Nutrient Uptake by Wheat (*Triticum aestivum* L.)

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A field study entitled "Effect of Phosphorus and Phosphatic Biofertilizers on Yield and Nutrient Uptake by Wheat (*Triticum aestivum* L.)" was conducted at the Instructional Farm of the Rajasthan College of Agriculture, Udaipur during *Rabi* season of 2011-2012. The objectives of this field experiment were to assess the efficiency of phosphatic biofertilizers in soil, effect of phosphorus and phosphatic biofertilizers on crop yield, nutrient content and uptake, soil available. The experiment consisted of 16 treatment combinations comprising four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5 ha^{-1}) in integration with four treatments of phosphatic biofertilizers (Uninoculated, *Aspergillus awamori*, VAM and *Aspergillus awamori*+ VAM). The experiment was laid out in Factorial randomized block design with three replications. Wheat (Raj. 4037) was taken as test crops. The results of the experiment indicated that application of 60 kg P_2O_5 ha^{-1} significantly increased the grain and straw yield. Plant height, yield attributes N, P, K, Mn and Cu uptake in plant and soil available P, Mn and Cu after harvesting of crop was significantly higher at 60 kg P_2O_5 ha^{-1}. N, P, K, Mn and Cu content in plant were also significantly higher at 60 kg P_2O_5 ha^{-1} but the available N, Fe and Cu in soil were significantly decreased. Use of *Aspergillus awamori* and VAM as inoculants significantly increased the grain and straw yield. The yield attributes, N, P, K, Mn and Cu uptake in plant and soil available P, Mn and Cu after harvesting of crop were significantly higher under *Aspergillus awamori* + VAM treatments. Application of 60 kg P_2O_5 ha^{-1} followed by dual inoculation of *Aspergillus awamori*+VAM gave maximum grain and straw yield, N, P, K, Mn and Cu content in grain and straw, increased the population of *Aspergillus awamori* in rhiozospheric soil.

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Effect of the Different Enzymes on Mobilization of Phosphorus in Alfisols and Inceptisols Soils of Rajasthan

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Field study was carried out to assess the effect of the different enzymes on mobilization of phosphorus. Wheat, maize, sorghum and mustard in rhizosphere and non-rhizosphere of plants under Alfisols and Inceptisols. A significant ($p=0.05$) difference in dehydrogenase, acid phosphatase, biomass carbon, biomass P and phytase by different plant species were observed between the soils under study.

Phosphorus is an important nutrient in crop production. It promotes root growth and helps in energy transformation as well as photosynthesis in plant. The function of phosphorus as a constituent of macromolecular structures especially in nucleic acids, found in DNA and RNA is well known. However, being immobile largely, its remains unavailable to the plants. The P cycle in soil is a dynamic system involving soils, plants and microorganisms. It passes through utilization by plants biological return through plant and animal residues, mineralization-immobilization, and solubilization through the activities of microorganisms.

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Effects of Organic Substrates on Population Dynamics of Earthworm and Quality of Vermicompost

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The present investigation was planned to work out the effects of various sources of organic matter such as animal dung, farm residues and kitchen wastes, saw dust, *Parthenium*, lantana, bagasse, pine needle *etc.* on the quality of vermicompost and population dynamics of earthworms. The quantity of biomass was calculated according to their composition so as to obtain variable C: N ratio of about 30, 40, 50, 60 and 70 of the homogenous mixture. The experiment was conducted using cement rings (collar) of 0.19 m^3 volumetric capacity (diameter : 110 cm × height : 20 cm) with exposed top surface area of 0.95 m^2 of substrate and an estimated quantity of water was sprinkled on the homogeneous mixture (20 kg) of substrate to achieve a range of moisture content between 60-75% throughout the experimentation. The rings were established on plastic sheet to avoid leaching losses of humus and nutrients *etc.* and leachate was collected in a plastic container of 5 litre capacities and sprinkled over the substrate for maintaining moisture content. After 15 days, 300 g of earthworms of species *Eisenia foetida* (approx. 500 nos.) were released. The vermicompost ready at different intervals were analyzed for their nutrient contents and found significantly higher under lower carbon nitrogen ratio of the substrate. The organic carbon content in the vermicompost was decreased at greater extent at lower carbon: nitrogen ratio (30:1) compared to higher one, where as, decrease in C: N ratio was more under high C: N ratio (70:1) compared to lower one. Other properties of vermicompost like pH, Electrical conductivity and Bulk density were also significantly higher in lower C: N ratio. Use of pine needle as substrate was found inferior compared to all other substrates, whereas, boiled pine needle proved to be better option for vermicomposting. The population dynamics of earthworm *viz.* reproduction, growth and multiplication was greatly affected by quality of substrate and its carbon nitrogen ratio. The earthworm population was higher under lower carbon: nitrogen ratio as compared to higher one. The quality of vermicompost and population dynamics of earthworms was found best under substrate *Parthenium* in combination with cow dung, bagasse and kitchen waste compared to all other combination. Substrates of higher carbon: nitrogen ratio produced poor quality of vermicompost and also takes more time for decomposition, however, carbon: nitrogen ratio of 30 to 40 was found optimum for the process of vermicomposting. Microbial activity during the process of vermicomposting was significantly increased in all the treatments subsequently up to the end of experimentation. Vermicompost samples of 30th and 60th day of composting showed increasing trend in microbial activity at 12, 24 and 36 hrs of incubation, whereas, microbial activity in the samples of 90th and 120th day showed decreasing trend at 24 and 36 hrs of incubation.

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Impact of Sodicity on Microbial Activity and C Dynamics in Different Soils

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Soil organic matter (SOM) is important for maintaining structural stability in sodic soils because it prevents dispersion and disaggregation. Dissolved organic matter (DOM) is the most mobile and dynamic organic matter fraction which is frequently used as an indicator for SOM because changes caused by environmental and management stresses are detected earlier in this fraction than in SOM as a whole. Dissolved organic carbon (DOC) which represents the main component of DOM, along with other nutrients can be lost from soil via runoff and leaching into surface water bodies and groundwater which can have detrimental effects on water quality. Moreover, leaching can reduce the amount of DOC available for mineralization within the soil and reduce soil nutrient cycling and fertility. Therefore, an incubation study was conducted to assess the impact of sodicity on microbial activity and C dynamics in soils with varying texture. (4, 13, 24 and 40% clay, termed S-4, S-13, S-24 and S-40). The non-sodic soils were leached with 1M NaCl solution resulting in two SAR levels [sodium absorption ratio; $SAR_{1:5}< 3$ (non-sodic) and >20 (sodic)]. After adjusting the water content to levels optimal for microbial activity in different soils, finely ground pea straw residue was added (20 g kg^{-1}) as substrate to stimulate microbial activity. Irrespective of texture, cumulative respiration, DOC/DON and SUVA were higher in sodic soils as compared to non-sodic soils after 8 weeks of incubation. Sodicity results in dispersion of clay and organic matter because high proportion of the monovalent sodium ions on the surfaces of the soil particles prevents binding of clay particles and organic matter. The lighter textured (S-4 and S-13) soils had overall greater cumulative respiration, compared to the heavier textured soils (S-24 and S-40). Thus, more soluble C was respired in the light textured soils. Despite the higher cumulative respiration rates at $SAR_{1:5}$ 20 compared to $SAR_{1:5}< 3$, DOC and DON concentration were higher at $SAR_{1:5}$ 20 in all soils suggesting that the release of organic compounds and lack of binding of added C was greater than what the soil microbes were able to decompose. Although sodicity increased DOC concentrations, it also increased SUVA indicating that the proportion of aromatic C in the DOC was increased by sodicity. Since soluble C is the most important energy source for microorganisms, losses of C and N from the sodic soils is likely an un-recognised factor in further degradation of these agricultural soils.

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Dynamics of Soil Microbial Biomass Carbon and Enzyme Activity under different Crops from Salt Affected Coastal Soils

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Soil quality in terms of soil physical, biochemical properties, carbon stocks and microbial population under different cropping systems were studied in coastal salt affected soils. Different cropping systems significantly change the soil physical and chemical properties, and hence plant growth and crop yields will be affected. Soil samples were collected from different farming systems such as cereal, oilseed, horticulture, vegetables, pulses, cashcrop, fodder, spices and wasteland from salt affected coastal soils of Gujarat. Soil physical, chemical, biochemical characteristics, exchangeable cations, available nutrient status and microbial biomass varied considerably with different cropping system. The microbial communities more closely related to different properties of soil. The microbial biomass consists mostly of bacteria and fungi, which decompose crop residues and organic matter in soil. This process releases nutrients into the soil that are available for plant uptake. Soil properties such as pH, EC, texture and organic carbon content influences the size of the microbial biomass.

Soil microbial biomass carbon (MBC) was observed to be higher in soil under spice crops about 600 mg kg^{-1} in compare to cashcrop like cotton where it was observed lower. Microbial biomass nitrogen (MBN) was maximum (87.5 mg kg^{-1}) in soils under cereals and minimum (19.5 mg kg^{-1}) in wasteland system. Carbon stocks such as organic and inorganic C stock were observed to be maximum in soils from vegetable and cashcrop system, respectively having content of 21.68 Mg ha^{-1} and 9.91 Mg ha^{-1} and minimum in oilseed (6.21 mg ha^{-1}) and wasteland (2.82 Mg ha^{-1}), respectively. Enzyme activities such as alkaline phosphatase activity was observed maximum of 54.25 μg PNP g h^{-1} in sub-surface layer in cereal in compared to wasteland having minimum of 15.25 μg PNP g h^{-1} in sub-surface layer whereas acid phosphatase activity was higher (24.75 μg PNP g h^{-1}) in surface layer of soil in Horticulture system and lower (5.25 μg PNP g h^{-1}) in sub-surface layer of soil in pulse system; dehydrogenase activity was maximum of 85.35 μg TPF g h^{-1} in surface layer in cashcrop and minimum of 1.465 μg TPF g^{-1} h^{-1} in sub-surface layer in waste land.

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Effect of *Rhizobium* Inoculation and Nitrogen Application on Growth, Nodulation and Yield of Pea Crop (*Pisum sativum* L.)

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Nitrogen is the most limiting nutrient in acidic soils of Ranchi and can be corrected by application of inorganic fertilizers and *Rhizobium* inoculation. A study was conducted to compare the effects of *Rhizobium* (4 different isolates) inoculation and nitrogen fertilizer application (0, 10, 20 kg ha^{-1}) on nodulation and yield of Pea (variety Azad P1). Field experiment was conducted at Research Farm of department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Ranchi. Variety Azad P1 was inoculated with three different acid tolerant isolates (BRP1, BRP2 and BRP4) along with reference one (BRP3) and assessed for their effect on nodulation, crop growth and yield in combination with 0, 10 and 20 kg ha^{-1} nitrogen in the acid soil (pH 5.3) of Ranchi. All the isolates showed an increase over native rhizobia in terms of nodule number, dry nodular biomass and N content in nodules but the isolate BRP2 performed relatively better followed by BRP4 which are having significant increase over others. Maximum grain yield (15.09 q ha^{-1}), straw yield (37.33 q ha^{-1}), nodule number (33.0 plant^{-1}), nitrogen content of nodule plant^{-1} (2.88%) were observed due to inoculation with BRP2 supplemented with 20 kg ha^{-1} nitrogen. This study can be helpful for future recommendation of *Rhizobium* inoculation.

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Changes in Enzymatic Activities during Retting of Jute (*Chorchorus olitorius* L.)

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Retting of jute is a biochemical process carried out by the enzymatic action secreted by the retting microbes present in retting water. Pectin and hemicellulose primarily xylan are the main binding agents bind the fibre. So, the pectin and xylan degrading enzymes secreted by the microbes play an important role in degradation of pectin and xylan during retting of jute. The information regarding the changes in enzymatic activities especially of polygalacturonase, pectin lyase and xylanase during retting of jute was very meagre. Hence, a retting trial was conducted using microbial formulation to monitor the enzymatic activities during retting period. Retting liquor was collected exactly after every 24 hours interval throughout the retting duration for analysis of poygalacturonase, pectin lyase and xylanase enzymatic activity following standard procedure. Monitoring of pectin degrading activity during retting period reveals a nearly constant level of polygalacturonase production with higher activity at the mid stage and a slight decrease at the end stage of retting period. Pectin lyase activity dynamics showed a sharp decrease on the 2nd day after initiation of retting trial and from day 3 onwards high level of activity was observed followed by a steady decrease of activity at the end point of retting period. A steady increase in xylanase activity was observed throughout the retting period. This clearly indicated the fact that after the degradation of pectin starts, the xylan present below the layer of pectin is exposed to the retting microbes for degradation, hence a sharp increase in xylanase activity was observed with increase in duration of retting.

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Activities of Enzymes as Influenced by the Application of Phosphamidon in Typic Ustochrepts

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Silty loam soil from agricultural field of Indo-Gangetic alluvial of Varanasi was investigated for the effect of phosphamidon application at recommended dose (RD) and double the recommended dose (2RD) on soil enzyme activities under controlled laboratory conditions. Phosphamidon (2-chloro-2-diethylcarbonyl-1-methylvinyl dimethyl phosphate) is a broad-spectrum, non-cumulative systemic organophosphorus pesticide and cholinesterase inhibitor widely used in agriculture. The laboratory incubation study was carried out at 50% maximum water holding capacity of soils at 28 ± 2^{0}C for a period of 42 days. The stock solution (100 mg L) of the pesticide were prepared in double distilled water and applied to each soil sample by preparing 10 mg L of pesticide. Incubated soil samples were used to study the changes in the enzyme activities of typic ustochrepts alluvial soil, with and without applied phosphamidon. Soil enzyme activities (cellulase, β-glucosidase, invertase, protease and dehydrogenase) were analysed over a period of 7, 14, 21 and 42 days. The results showed that the value of soil enzymatic activities without application of pesticide is higher compared to the recommended and double the recommended dose of phosphamidon in all days of treatment. The findings showed the accumulation of reducing sugar was not pronounced more at 14 days and the activity of the invertase and cellulase was drastically decreased. β-glucosidase activity is considered to be a useful index for measuring side effects of pesticides as they are the sensitive biomarkers of soil quality and found higher up to two weeks and significantly decreased at later phase. The protease activity decreased up to 21 days and then increase which may be due to the utilization of initial energy and nutrients from the decomposed organic matter. Dehydrogenase can be regarded as indicative of the overall microbial activities of soil. The activity of dehyrogenase decrease significantly with the increasing days of incubation. It can be concluded that phosphamidon had a transient harmful effect on the soil enzymatic activity after 14 days of incubation. Moreover, severity of the detrimental effects could be avoided by the application of the pesticide as spray, rather than as granular formulation in soils.

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Efficacy of Selected Fungi for Removal of Heavy Metals from Municipal Solid Waste Compost

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Most of the metropolitan cities of India have generated on an average of 64.8 million tonnes of city refuse during the year 2010, which has a potential of 9.1 million tonnes of compost. It is expected to increase to 107 million tonnes during 2030. Heavy metal content in municipal solid waste is one of the most dangerous to soil pollutants because this heavy metal may easily move from soil to edible plants through root absorption, and fairly large amounts can accumulate in their tissues without showing stress. In biotransformation and biosorption, microorganisms are used to transform or adsorb metals. Therefore, for effective and efficient removal of major contaminants in municipal solid waste compost, an efficient fungal consortium is needed to develop and apply for the removal of heavy metals. For that, the mesophilic fungi namely *Trichoderma viride; Aspergillus heteromorphus; Rhizomucor pusillus; Aspergillus flavus; Aspergillus terrus; Aspergillus awamori* were identified from municipal solid waste compost by standard method at institute's laboratory. It was observed that LD_{50} of *T. viride* were 10, 50, 150 ppm for Cd, Cu and Cr, respectively. However, no adverse effect of Zn and Pb was observed even at 400 ppm of both the heavy metals. The LD_{50} of *A. heteromophus* for Cd, Cu and Cr was 25 ppm and for Pb and Zn was 200 ppm. In case of *Aspergillus flavus,* the LD_{50} for Cd, Cr and Cu were 5, 25 and 50 ppm, respectively. However, the mycelia growth was less effect at higher concentration of Pb and Zn (400 ppm). The LD_{50} of *Aspergillus awamori* was observed at 10, 25, 25 and 75ppm of Cd, Cr, Cu and Ni, respectively. The adsorption parameters of Freundlich model for Cr, N and K value varied from 0.6 to 1.00 and 54.2 to 206.7, respectively and for Zn, n and K values varied from 0.62 to 0.69 and 73.4 to 88.1, respectively. Higher values of K indicate higher biosorptive uptake capacity of metal ions. In the present study K values were higher for *Aspergillus heteromophus* followed by *Trichoderma viride* for Zn and for Cr. It was also observed that higher the "n" value, higher the metal adsorption binding affinities towards fungi cell. The Cr and Zn adsorption equation studied conformed to the Freundlich isotherm for fungi that adsorption of Zn is relatively higher than Cr.

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Soil Enzymes and Microbial Population Dynamics under Organically Grown Rainfed Pearl Millet in Vertisol

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The management of nutrients to maintain productivity and quality in organic farming systems is a challenge that must be met through a combination of organic amendments and management of soil organic matter. The living soil is central part of soil fertility because the activity of soil organisms rendered available the element in plant residues and organic debris entering in soil. The maintenance of soil organic matter is the problem in tropical countries like India, hence, the application of organic residues is essential for the maintenance of biological fertility level. Pearl millet (*Pennisetum glaucum*) is the most widely grown millet. It also occupies an important place in daily diet of Indian people particularly in Gujrat, Maharashtra and Uttarpradesh, where, it is grown comparatively on large scale under rainfed condition. India is the largest producer of Pearl millet having an area under Pearl millets in India is about 12.4 mha. During the year 2010-11, the area under Maharashtra was 10080 ha and production was 10533 tonne.

Enzymes and microbial activity to be a sensitive indicator of soil health. This prospectus for improved management of enzymes activities and microbial population there by improved nutrient turnover, will lead to more cost effective efficient agriculture which is more organically oriented. Considering the paramount importance of soil biological fertility and to know the enzyme activities, microbial population influenced by manure application, the present investigation was carried out during *kharif*, 2011.

The experiment was laid out with eight treatments replicated thrice in Randomized Block Design. Treatments were, T_1-Control, T_2-2.5 t FYM ha^{-1}, T_3-5.0 t FYM ha^{-1}, T_4-7.5 t FYM ha^{-1}, T_5-1.0 t Vermicompost ha^{-1}, T_6-2.0 t Vermicompost ha^{-1}, T_7-3.0 t Vermicompost ha^{-1}, and T_8-2.5 t FYM ha^{-1} + 1.0 t Vermicompost ha^{-1}. Soil biological properties were estimated at sowing and 45 DAS of crop. The experimental findings indicated that the dehydrogenase (97.26 µg TPF g^{-1} soil 24 h^{-1}) and alkaline phosphatase activities (137.43 µg PNP g^{-1} soil 24 hr^{-1}) were observed maximum with 2.5 t FYM ha^{-1} + 1.0 t Vermicompost ha^{-1}. The highest urease activity (0.382 mg NH_4 -N released g^{-1} soil 24 hr^{-1}) was noticed under application of 7.5 t FYM ha^{-1}. Although, it was noticed that the soil biological activities were stimulated with the higher availability of carbon substrate. Also, these activities found less at sowing stage and further, increased at 45 DAS of crop with increase in microbial population. The total count of fungi, bacteria and actinomycetes, and the population of beneficial microorganisms *viz., Azotobacter*, *Azospirillum*, PSB, and PSF were increased with the increased levels of organic manures. Similarly, the enzyme activities (Urease, dehydrogenase and alkaline phosphatase) were also found to be increased with higher levels of organic manures. The maximum population of fungi (22.00×10^4 cfu g^{-1} soil), bacteria (41.00×10^7 cfu g^{-1} soil), actinomycetes (32.00×10^6 cfu g^{-1} soil), *Azotobacter* (28.00×10^4 cfu g^{-1} soil), *Azospirillum* (26.00×10^4 cfu g^{-1} soil), PSB (24.00 x 10^4 cfu g^{-1} soil), and PSF (21.33×10^4 cfu g^{-1} soil) were recorded in the treatment receiving 7.5 t FYM ha^{-1} at 45 DAS followed by the treatment receiving 2.5 t FYM ha^{-1} + 1.0 t Vermicompost ha^{-1}.

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Effect of *Rhizobium* Isolates along with Fe and Zn on their Content and Yield of Pigeonpea in Loamy Sand (Typic Ustochrepts) of Anand

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A field experiment was carried out to study the effect of *Rhizobium* with Fe and Zn on growth and yield of Fe-efficient and Fe-inefficient pigeonpea cultivar on loamy sand soil having marginal status for Zn and Fe availability. The treatment consisted sole application of Fe, Zn, *Rhizobium* -16 and *Rhizobium* -19 as well as their combinations to see the effect of *Rhizobium* isolates on mobilization of native nutrient in presence and absence of applied nutrients.

The results revealed that Fe application either alone or in combination with R-16 and R-19 was caused higher improvement in yield of Fe-inefficient variety (AAU-07-08) than Fe-efficient variety (BDN-2). The average per cent improvement in yield was to the tune of 21.7 and 13.9 per cent and the average improvement in Fe content in seed of pigeonpea was to the tune of 17.2 and 5.7 per cent in Fe-inefficient and Fe-efficient cultivar, respectively over control. The effect of Zn applications either alone or in combination with R-16 and R-19 was found equally effective to improve the pigeonpea yield of both Fe-inefficient variety (AAU-07-08) and Fe-efficient variety (BDN-2), and the improvement was to the tune of 16 and 18.7% in Fe-efficient and Fe-inefficient cultivar, respectively over control. In case of average improvement in Zn content in seed of pigeonpea, it was to the tune of 12.8 and 14% in Fe-efficient and Fe-inefficient cultivar respectively. The total *Rhizobium* count at harvest of pigeon pea variety AAU 2007-08 (Fe-inefficient) showed significantly higher counts and this variety was found more responsive to *Rhizobium* application compared to other treatments and controls.

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Effect of Different Levels of Phosphorus on Yield, and Nutrient Uptake of Sugarcane in Presence and Absence of Cane Trash and Mycorrhizae

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A field experiment on "Effect of different levels of phosphorus on yield, quality and nutrient uptake of sugarcane in presence and absence of cane trash and mycorrhizae" was conducted during 2010-2011 and 2011-2012 plant crops at Regional Agricultural Research Station, Anakapalle. The soil of the experimental site was sandy clay loam in texture, neutral in reaction, medium in available nitrogen, phosphorus and high in available potassium. The experiment was laid out in split plot design with four main treatments *viz.,* control (M1), mycorrhizae alone @ 12.5 kg ha^{-1} (M2), combination of cane trash @ 3 t ha^{-1} plus mycorrhizae @ 12.5 kg ha^{-1} (M3) and cane trash alone @ 3 t ha^{-1} (M4) and four phosphorus levels (0, 50, 100 and 150 kg P_2O_5 ha^{-1}) as sub plots and replicated thrice . Significantly higher cane yield (118 t ha^{-1} and 119 t ha^{-1} in two plant crops respectively) was obtained when inorganic P @ 50 kg P_2O_5 ha^{-1} was applied in combination of both cane trash and mycorrhizae. The sugar yield was significantly higher with cane trash and mycorrhizae application at all the inorganic P levels, with corresponding values of 12.3 and 12.2 t ha^{-1} as against 9.5 and 14.7 t ha^{-1} in the absence of both cane trash and mycorrhizae. Significantly higher mean sheath moisture percentage was recorded in the treatment receiving 50 kg P_2O_5 ha^{-1} *i.e.* 84, 82.7, 79.9 at formative, grand growth and at maturity stages respectively. During both the years of study, significantly higher mean sheath moisture was observed with the application of both cane trash and mycorrhizae (84.7, 82.9, 80.1). Significantly higher phosphorus uptake (49.7 and 50.5 kg ha^{-1}) was noticed with 150 kg P_2O_5 ha^{-1}(P3) in 1st plant crop in 2nd plant crop respectively and was high when compared to the uptake at 100 kg (P2) and 50 kg P_2O_5 ha^{-1} (P1). Uptake of nitrogen, phosphorus and potassium (245, 55.1, 326 kg ha^{-1} in 1st plant crop and 257, 55.5, 267 kg ha^{-1} in 2nd plant) was significantly higher at grand growth stage with cane trash plus mycorrhizae application (M3). Significantly highest NPK uptake was observed with cane trash plus mycorrhizae (241, 41.8 and 241 kg ha^{-1}).

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Co-inoculation Effect of PGPR with Rhizobia in Urdbean and Chickpea on Nodulation, Yields, Nutrient Uptake and Soil Biological Properties

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Field experiments were conducted at Pantnagar during 2011-12 to evaluate the co-inoculation effect of *Rhizobium* sp. with different plant growth promoting rhizobactera (PGPR) strains CRB-1 (*Pseudomonas fluorescens*), CRB-2 (*Pseudomonas* sp.), CRB-4 (*Bacillus subtilis*), PUK-46B6 (*Pseudomonas diminuta*), PUK-171 (*Klebsiella* sp.), KB-133 (*Pseudomonas* sp.) and RB-1 and RB-2 (*P. fluorescens*) in urdbean and *Mesorhizobium* sp. with PGPR strains LK-791 (*Pseudomonas* sp.), LK-786 (*Kurthia* sp.) and LK-884 (*Pseudomonas diminuta*), BSY-101 (*Bacillus* sp.), PSM-15 (*Pseudomonas* sp.) and PGPR-3 (*Pseudomonas* sp.) in chickpea on symbiosis, productivity and soil health. Experimental soil was sandy loam of neutral in reaction and medium in organic C, low in available N and medium in available P and K. Inoculation of *Rhizobium* sp. in urdbean and *Mesorhizobium* sp. in chickpea alone showed marginal increase in nodulation, plant dry matter, grain and straw yields, N uptake, organic C and available N and P in soil. However, co-inoculation of *Rhizobium* sp. with different PGPRs in urdbean recorded significant increases of 12.1 to 50.3% in nodule number, 21.6% in nodule dry weight and numerical increases of 8.2 to 28.9% in grain yield over uninoculated control and 5.6 to 41.7, 4.5 to 26.1 and 2.3 to 21.8% over *Rhizobium* sp. alone, respectively. Combined use of *Rhizobium* sp. with PGPRs also gave significantly more N uptake by grain and straw and available N and P in soil over *Rhizobium* sp. alone. Different PGPR with *Mesorhizobium* sp. in chickpea produced significantly more nodule number (8.3 to 32.5%), nodule dry weight (7.3 to 30.1%), grain yield (3.4 to 20.7%) and straw yield (5.9 to 11.7%) over *Mesorhizobium* sp. alone. Their combined inoculation also resulted in significant increases in soil organic C of 3.9 to 10.6% and soil available P content of 15.1 to 37.6% over uninoculated control and 2.0 to 8.5% and 13.2 to 35.4% over *Mesorhizobium* sp. alone, respectively. Application of *Rhizobium* sp. with PUK-171 in urdbean and *Mesorhizobium* sp. + LK-786 were found superior to other treatments by registering highest nodulation, yields, N uptake and soil organic C and available N and P.

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Biosynthesized Mg Nanonutrients and its Effect on Wheat (*Triticum aestivum* L) Crop

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Unique fungi *Aspergillus brasilensis* TFR23 was isolated and developed from arid soils which have shown capacity to produce Mg nanoparticle of < 30 nm size from $MgNO_3$ salt with 0.1 mM concentration under our laboratory condition. A greenhouse experiment was conducted to understand the positive influence of biosynthesized Mg nanoparticles on wheat at an optimum concentration (20 ppm) obtained from our preliminary experiment. The nanoparticles were sprayed on leaves at two weeks old plant. There were three treatments (control, mega particle, nano particle) each of six replications. At critical growth stages (6 weeks), it was found that 17.6% more absorption of solar radiation by the nano-Mg treated leaves than control while mega-Mg particle treated plants at same concentration shows only 2.3% improvement. Around 16.7% more chlorophyll content was also observed over control plants. The microbial activity (dehydrogenase activity) was improved by 12.3% by application of nano-Mg. Beneficial enzyme activities due to nano-Mg treatment has also improved. For example 8.2% improvement in aryl-sulphatase, 14.8% improvement in acid phosphatase and 71.3% improvement in nitrate reductase as compared to control. At crop maturity the dry matter yield has been improved by 26.7% and grain yield by 35.2% in nano treatment over control. The available P in the rhizosphere has also improved by 9.2%. The results clearly indicate that Mg in nanoform has the positive effect on wheat plant and can be use as nanonutrients for improvement in crop yield.

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Influence of Inceptisol and Alfisol's Potassium Solubilizing Bacteria (KSB) Isolates on Release of K from Waste Mica

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Major part of potassium in soil exists in form of insoluble K-minerals. Fraction of K-solubilized from such minerals through potassium solubilizing bacteria (KSB) will reduce cost on import of K- fertilizers. Nine and four isolates of K-solubilizing bacteria from Inceptisol (KI) and Alfisol (KA), respectively were evaluated for their ability to release of K from waste mica at 7, 14 and 21 days of incubation in modified Aleksandrov medium containing powdered waste mica as sole source of potassium. Morphological characteristics, zone of solubilization at week end and acidity of broth at different incubation periods were also studied. Majority of the isolates were entire smooth margin, raised, translucent, gram + ve rods and whitish to creamy in appearance. Isolates from cereals caused more zone of solubilization than pulse isolates. Isolates either from Alfisol or from Inceptisol efficiently decreased pH of the broth with increase in incubation periods. Isolates of same soil type differed in their K-release capacity. KSB isolates from Inceptisol showed higher K solubilization potential than isolates from Alfisol. Isolate KI_1 and KA_{19} caused maximum acidity but lowest release of K from mica indicated that decrease in pH of the medium is not the only mechanism of K release from native K mineral of soil. Isolate KI_{16} and KA_{59} were high slime producer and showed highest 23.88 and 13.71 μg mL^{-1} K solubilization capacity, respectively and emerged out as potential isolates of K-solubilizers as a K- biofertilizers.

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Consequences of Wastewater Recycling in Lower Reaches of Ahar River - A Case Study

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Water and soil pollution due to urban effluent is a cosmopolitan problem, creating acute insanitation as well as affecting the soil and crops when wastewaters are used for irrigation. Like other cities in the country, Udaipur city also has no wastewater treatment plant and sewerage lines. Most of the wastewater of Udaipur city is being discharged in the Ahar river through different '*nalas*'. Therefore, the present study was undertaken to find out the effect of urban effluent on quality of soil, vegetable crops and groundwater, especially with reference to heavy metal contamination. For this purpose four sites were selected for soil, groundwater and vegetable samples. Site 1: Horticulture Farm (as control) - Land is irrigated with groundwater and situated 3 km away from Ahar river. Site 2: Manva Kheda village - Land is irrigated with urban effluent and polluted groundwater. This site is located in the middle reach of Ahar river. Site 3: Kanpur-Madri village - Land is irrigated with urban effluent and polluted groundwater. This site is also located in the middle reach of Ahar river towards Udaisagar. Site 4: Matoon village - Land is irrigated with urban effluent and polluted groundwater. This site is situated in the lower reach of Ahar river near Udaisagar lake.

Three samples of soil, groundwater and selected vegetable crops were collected from Horticulture Farm as control to compare with the samples collected from sites irrigated with polluted groundwater and urban effluent. Soil, groundwater, urban effluent and vegetable samples were collected from selected sites in the middle and lower reaches of Ahar river *viz.* Manva Kheda, Kanpur-Madri and Matoon. These samples were analyzed for Fe, Mn, Cu, Zn, Cd and Ni content with the help of Atomic Absorption Spectrophotometer (AAS) model EC 4141-8. The heavy metal accumulation in groundwater irrigated vegetables was found to increase with the increasing contamination of these metal in the groundwater at different locations but the metallic accumulation in all selected vegetable crops (cauliflower, cabbage, brinjal, spinach, tomato and radish) irrigated by groundwater at all selected locations were found within the maximum permissible limits as prescribed by WHO. In case of urban effluent irrigated vegetables the spinach, tomato and radish crossed the maximum permissible limits of Fe, Zn and Cd accumulation in edible parts at site 3 (Kanpur – Madri Villave). Urban effluent irrigated spinach found to have accumulated with Fe, Zn and Cd to a great extent (more than the maximum permissible limit) at all three selected locations and most unsafe for human consumption.

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Evaluation of Grape (*Vitis vinifera*) Growing Soils of Osmanabad District, Maharashtra

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Osmanabad district is located at an elevation of 600 to750 m above mean see level exactly in between 18^o 28' to 19^o 28' N latitude, and 76^0 16' to 77^0 25' E longitude. The geographical area is 7512.40 sq.km and the annual rainfall ranges between 741 to 840 mm. Maximum and minimum temperature of this district is 43.3^0 C and 11.9^0 C, respectively. Nine representative soil profiles from different physiographic unit of grape orchards in Osmanabad district were characterized, classified and evaluated soil site suitability for grape.

The soils were very shallow to very deep, very dark grayish brown (10 YR 3/2) to light yellowish brown (10 YR 6/4) in colour, loam to clayey in texture and granular to angular blocky in structure. The bulk density of these soils varied from 1.20 to 1.93 Mg m^{-3} and plant available water capacity (PAWC) varied from 33.6 to 281.7 mm. The soils are slightly to moderately alkaline (pH 7.1 to 8.3), low to very high organic carbon content (0.1 to 2.07%) and calcareous in nature (1 to 41%). The maximum CEC was recorded in Typic Haplusterts (30.9 to 62.0 cmol(p+)kg^{-1}) . The Ca^{++} is the dominant cation in the exchange complex followed by Mg^{++}, Na^+ and K^+. Taxonomically these soils were classified as Typic Haplusterts, Typic Ustochrept Calcic Ustochrept, and Lithic Ustorthent. As per FAO (1983), the soils of Typic Haplusterts and Calcic Ustochrept were moderately suitable (S2), whereas Typic Ustochrept and Lithic Ustorthent soils were highly suitable (S1) for grape. As per FAO (1984), the soils of Lithic Ustorthent were highly suitable (S1) for grape cultivation in Osmanabad district. This suggested that Lithic Ustorthent soil were better performing in terms of productivity of grapes.

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Available Major Nutrient Status in Mulberry (*Morus sp.*) Growing Soils of Raichur District, Karnataka

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Sericulture is an important commercial crop of the Raichur district with an area of 206.1 ha and caccoon production of 89.3 tonnes. The major area's in Lingasugur taluk (65%), where both red and black soils prevail. One hundred forty eight surface soil samples of Mulberry (*Morus sp.*) growing farmers' soil samples were analysed for pH, EC and available major nutrient status. The results revealed that pH ranged between 5.6 and 9.4, indicating slightly acidic to alkaline. The EC varied between 0.08 and 1.40 dS m^{-1} in which majority were in normal condition and few soils slightly saline. The available N ranged between 62.5 and 190 kg ha^{-1}, with an average of 128.4 kg ha^{-1} which was quite low and which demands urgent attention to ensure N availability to the crop requirements. The available P_2O_5 ranged between 0.5 to 744.75 kg ha^{-1} with an average of 161.3 kg ha^{-1}. The available status in soils showed considerable build up of soil P in all the talukas except Manvi taluka, probably because application of DAP fertiliser over 10-25 years. The available K values ranged between 18.75 and 1035 kg ha^{-1} with an average of 397.6 kg ha^{-1}. Majority of soils were in low to medium in available potash status because these soils were both red and black soils and wherever red soils occur they were found low in available nutrient status and black soils high. This clearly reveals that red soils should be managed properly with potash nutrient from the external source which otherwise would limit yield. Thus, a lot of imbalanced nutrient levels prevails in these soils.

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Delineation of Nutrient Status of Soils of Banaskantha District and their Relationship with Soil Properties

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Major and micronutrients are essential plant nutrients and critical for crop production as the completion of the life cycle of plant could be limited by their restricted supply. Their deficiencies have presently become one of the major constraints in sustaining crop production in the present exploitive agriculture. Scantly information is available regarding nutrient status of soils and their relationship with soil properties of Banaskantha district. Thus, present survey work was planned to conduct systematic soil survey work to delineate nutrient status of soils of Banaskantha district of Gujarat. In order to know the available major and micronutrients and their relationship with physicochemical properties of soil in Banaskantha district, 494 representative surface (0-15 cm) soil samples of farmers' field were collected from different talukas (Palanpur, Danta, Vadgam, Amirgadh, Deesa, Dahnera, Dantiwada, Kankarej, Tharad, Bhabhar, Deodar, and Vav) of Banaskantha district. The samples were analyzed for particle size distribution, pH, EC, organic carbon and available P_2O_5, K_2O, S and micronutrients cations by adopting standard analytical procedures. The soils of Banaskantha district are sandy to loamy sand in texture, neutral to alkaline in reaction and have soluble salt content under safe limit. The soil pH and EC values varied from 7.51 to 8.02 and 0.08 to 2.57 dS m^{-1}, respectively. Most of the soils (80.7%) of Banaskantha district are low in organic carbon content indicating overall poor fertility of soil. The soils of Banaskantha district are low to medium in available P (33.7 to 59.1 kg ha^{-1}), medium to high in available K (119.6 to 93.8 kg ha^{-1}) and availability of sulphur is in the low to medium category (4.81 to 77.80 mg kg^{-1}). Among micronutrient cations, 24.5% deficiency of iron and 26.7% deficiency of Zn were found in soil of Banaskantha district which certainly warrants that Fe and Zn fertilization should be given due importance in fertilizer package to be evolved for crops of this district. Most of the areas of Banaskantha district have sufficient amount of available Cu and Mn. The availability of P, K, S and micronutrient cations in soils were positively correlated with clay and organic carbon content, and there were negatively correlated with sand content of soils.

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GPS-GIS Based Soil Fertility Maps for Fertilizer Recommendarion of Rahuri

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GPS-GIS based soil fertility maps for precise fertilizer recommendations of 'Block A and B, Central Campus, Mahatma Phule Krishi Vidyapeeth, Rahuri.' was conducted during 2011-2012. The objectives were to identify and delineate the deficiency areas of macro and micronutrients.

The pH values of the soil samples are between 7.62 to 9.10 and 7.68 to 8.85 and EC values of the soil samples are between 0.11 to 1.60 and 0.11 to 1.00 dS m^{-1} in Block A and B, respectively. The percent organic carbon and calcium carbonate content in soil of Block A are between 4.1 to 7.3 and 52.5 to 125 g kg^{-1} and 4.2 to7.4 and 55 to 125 g kg^{-1} in Block B respectively. The available N, P and K in Block A ranged from 160.3 to 271.7, 10.3 to 27.5 and 313.6 to 716.8 kg ha^{-1} and from 184.6 to 278.2, 9.9 to 27.5 and 324.8 to 616 kg ha^{-1} in Block B respectively. Both the blocks recorded very low to low available N, low to medium available P and very high available K. The exchangeable Ca and Mg in Block A are between 11.4 to 28.2 and 7.1 to 20.5 [cmol(p^+) kg^{-1}] and from 12.8 to 32.4 and 7.7 to 20.5 [cmol(p^+) kg^{-1}] in Block B, respectively. Both blocks are deficient in exchangeable Ca and sufficient in exchangeable Mg. The available S, B and Md in Block A is varied from 3.8 to 19.1, 0.35 to 0.75 and 0.07 to 0.14 mg kg^{-1} and from 5.4 to 17.9, 0.25 to 1.10 and 0.084 to 0.14 mg kg^{-1} in Block B, respectively. Block A recorded 50.8% deficiency and Block B showed 27.7% deficiency of available S. Block A and B showed 50% deficiency of available boron and both the blocks are sufficient in available molybdenum. The available Fe, Mg, Zn and Cu in Block A are between 3.30 to 17.89, 0.68 to 22.24, 0.14 to 1.17 and 0.49 to 6.83 mg kg^{-1} and 2.36 to 19.26, 4.73 to 38.53, 0.25 to 0.97 and 1.71 to 17.34 mg kg^{-1} in Block B respectively. Both the blocks are sufficient in available Fe, Mg and Cu and deficient in available Zn. The positive correlation of organic carbon with available N and exchangeable calcium is noticed. The negative correlation of pH with micronutrients and P with Cl, Cu is observed

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Minimum Dataset Selection for Assessing Soil Fertility and Environmental Status of Two Benchmark Soils of Punjab

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Availability status of various nutritionally and environmentally important elements in soil depends upon a multitude of parameters. Collection of data on multiple variables is constrained by monetary and time aspects. Large number of variables, however, precludes modelling all the measures individually. Also, due to the complex and multi-phasic nature of soil, most of these variables are more or less interrelated. Monetary and time restrictions on comprehensive soil sampling and subsequent characterization can be partly overridden by restricting to benchmark soils. The purpose of benchmark soils is to focus data collection and research efforts on soils that have the greatest potential for expansion of data and interpretations. In Punjab State, 17 benchmark soils have been established that occupy around 56% area of the state and the rest 44% of the area is occupied heterogeneously by 104 associations of soil families. Thus, multivariate characterization of various benchmark soils selected from the state's agro-ecological sub-regions implicated in productivity stagnation and/or increased incidence of environment-related medical conditions and subsequent analysis through multivariate statistical techniques can help draw representative inferences about the fertility and environmental status of soils of such areas. This study was undertaken with the objective of selecting a minimum dataset for reducing the bulkiness of data and to choose the variables which cause major variation in the data set of two benchmark soils Gehri Bhagi and Nabha. For this, firstly the variables with loading > 0.25 in Principal Components Analysis were retained. Then the variables with correlation coefficients less than 0.6 were retained. Thereafter, each principal component (PC) was allotted numerical weight. The weight of the first PC was equal to the ordinal rank of the last selected PC and so on in descending order, the weight of the last PC being equal to 1. Loading of a variable within a PC was squared. Squared loading was multiplied with the weight allotted to that PC. Products across all selected PCs were summated. These products were ranked in descending order. The variables with the higher ranks were selected. In Gehri Bhagi soil series, 14 variables out of total 59 variables were selected. The selected environmental variables included Total Pb and Mehlich-3 Cr and total P, total Zn, Mehlich-3 Mg, total Na, exchangeable K, total Cu, Ec, pH, exchangeable cations, calcium carbonate, DTPA-Fe and organic carbon constituted important soil fertility dataset. In Nabha soil series, 17 variables out of total 59 variables were selected. Mehlich-3 Pb, Cr, B, total Cd, total Fe, total Pb constituted environmentally important minimum dataset, whereas available S, EC, pH, DTPA Mn, clay, total S, Mehlich-3 Zn and available K formed important soil fertility dataset.

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Effect of Land Use on Soil Organic Carbon Distribution in Deep Soil Layers in a Reclaimed Sodic Soil

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Soil is a major reservoir of terrestrial C. There is an imperative need to increase our understanding of the dynamics of C in soils as it plays a vital role in maintaining soil sustainability. Land use changes have caused emission of ~20% GHGs globally that leads to shrinkage of C-storage in the potential areas. Soil carbon pools change rapidly in response to land use change. However, in-depth understanding of C-dynamics is needed in respect to eco-systems variability. Suitable land use systems can help sequestering C and reduce GHG's adverse effect. For this purpose seven land uses namely Guava (*Psidium guajava*), Litchi (*Litchi chinensis*), Mango (*Mangifera indica*), Jamun (*Syzygium cumini*), Eucalyptus (*Eucalyptus tereticornis*), Prosopis (*Prosopis alba*) and rice-wheat cropping system were selected to study their impact on distribution of soil organic carbon (SOC) in deep soil layers in a reclaimed sodic soil. Soil samples were collected upto a depth of 2 m i.e. 0-0.2, 0.2-0.4, 0.4-0.6, 0.6-0.8, 0.8-1.0, 1.0-1.5 and 1.5-2.0 cm. Results showed that soil pH and bulk density increased with depth in all land uses. Minimum and maximum pH were associated with Litchi (6.81) at 0-0.2 cm and Eucalyptus (9.52) at 1.5-2.0 cm depth, respectively. Eucalyptus recorded minimum and maximum (1.41 and 1.76 Mg m^{-3}) bulk density at 0-20 and 150-200 cm soil depth, respectively. Carbon content in passive pool along with its recalcitrant nature was increased with depth in all land uses. Depth-wise maximum decreasing tendency of lability index in Jamun plantation (0.44 at 1.0 to 1.5 m and 0.72 at 1.5 to 2.0 m depth of the soil) reiterated more recalcitrant nature of SOC. Highest stratification ratio (3.2) of organic carbon in Jamun plantation represented the maintenance of good soil quality followed by rice-wheat (2.6). However, overall highest SOC storage (108.9 Mg ha^{-1}) was maintained in Eucalyptus but maximum passive pool storage of SOC (56.2 Mg ha^{-1}) was associated with Guava plantation.

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Performance of Different Modules in Lands of Chambal Ravine

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Five modules *viz*. diversified cropping system, agri–horti, horti–pastoral, silvi- medicinal and silvi - pastoral modules designed for ravine land were adopted in plots of 60 x 70 m in three replications. The results regarding survival and growth (in terms of height and diameter at 15 cm) indicates that among fruit trees, Drumstick and Ber are very potential and started fruiting even only after 9 months of transplanting. The survival of Aonla (86%) and Ber (68%) are very good and growth rate of Drumstick (height 1.72 m and girth 12 cm) and Ber (height 1.25 m and girth 11 cm) were very promising. The performance regarding their survivals of all medicinal tress (Arjuna, Mahuwa, Neem, Gugal, Karanj) were very high (> 72%) and the growth parameters showed satisfactory condition for Neem and Karanj plants. Among the forest tree plants (Siras, Babool, Sheesham and Khamer), the survival is excellently good in case of Babool (96%) followed by Siras (92%) and Sheesam (80.5%).

The medicinal crops/grasses were also planted and the result shows that the performance of Palmarosa, Lemon grass, Adusa and alovera are performing better while crops like Chandrasur and Isabgol are cultivable under ravines. The grasses like Para and Napier are better choice to adopt under pastoral systems. Although Chambal ravines, being very deep in nature, are classified not suitable for cropping system, but in changing present scenario due to escalating prices of land the ravines can be converted in to terrace lands only with marginal expenditure. In future it is possible these plots would come under cultivations. The crops like pearl millet, sesame, black gram and cluster bean in *kharif* and mustard and taramira in *rabi* seasons are right choices to cultivate in such lands.

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Suitability and Sustainability for Cotton Based Cropping Systems in Some Soils of Western Haryana

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The cotton crop is predominantly grown under irrigated ecosystem in Sirsa district of Haryana (29°14' to 30^0 01'N latitude and 74°29'to75°18'E) occupying about 45% of the total geographical area (4.27 lac ha). The crop is cultivated primarily on the market driven criteria and abundance of irrigation facilities with least regard to soil and site characteristics, quality of underground water and sustainability of the system. It is, therefore, essential to generate the basic data of soils and its environment to evaluate their suitability for cotton and other crops grown for suggesting cotton based cropping systems and their sustainability. Thus, the present investigation was undertaken with the objective to generate the maps of physical resources (soil and water) and to assess the problems and potentials of natural resources for cotton based cropping system and its sustainability. Soil resource inventory of Sirsa district was prepared on 1:50,000 scale using remote sensing data, besides, collecting socio-economic data. The soils have been grouped in to 15 soil series and mapped into 20 associations and were classified under Entisols and Aridisols. Coarse loamy soils occupy the largest area followed by sandy soils and fine loamy soils. Nearly 67% of total area qualifies for class III and class IV lands and rest of the area put under class V to class VII lands due to limitations of climate, erosion, wetness, coarse texture and salinity/sodicity. Nearly 66% area is suitable to moderately suitable (33% each) for irrigation and rest of area rated as marginally suitable or unsuitable due to severe problem of soils, topography and drainage. Under ground water quality of 38% of total area of district is good and fit for irrigation, while quality of water rest of area is rated as marginally or unsuitable for irrigation. The soil resource data assessed and evaluated for its suitability for cotton and other crops. The results revealed that about 60% area can be put under cotton cultivation. The other crops can be grown are rice (14%), wheat (19%), mustard (87%) and cluster bean (70%). The examination of data further transpired that 57% of the area is suitable for cotton based cropping system. Out of which, 36% of the area is suitable for cotton- wheat, the dominant cropping system followed in the district, 14% area is suitable for cotton - barley/mustard /pulses having low moisture requirement and marginally suitable for wheat. About 6% of total area is suitable for cotton-barley/mustard/pulses under irrigation in coarse loamy soils whereas guar/bajra/pulses/oil seeds under rain fed in sandy soils of reclaimed sand dunes as both soils ocur side by side and only 1% is suitable for cotton –sugarcane cropping system. Rice-wheat cropping system is suitable in 7% of total area where cotton cannot be grown due to waterlogging. Cotton based cropping system is not feasible and profitable in about 22% area because of sandy texture, limited availability of canal water, need of high input and erosion may be put under guar/millets/oil seeds/pulses. It has been estimated that cotton-wheat cropping system is sustainable only in 56% of total area. The major issues for sustainability are soil drainage, flooding/wetness, imbalanced fertilization, little diversification, weak financial resources, profitability, excessive use of pesticides, poor quality of underground water, heavy/coarse texture, little recycling of farm waste and undulating land. The rest of the area was categorized as marginal or unsustainable for cotton production due to high severity index.

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Delineation and Categorization of Silicon for Intensively Rice Growing Soils of Periyar Vaigai Command Area, Tamil Nadu

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Silicon is considered as the most important nutrient element in conferring resistance to biotic stresses *viz.* insect pests, nematodes and diseases and abiotic stresses *viz.* drought, lodging, salinity, water logging, and nutrient imbalances in soil. Si depletion can occur in traditional rice soils from the continuous monoculture of high yielding varieties. Hence, the present investigation was ventured to assess the status of available silicon in the intensively rice growing soils of Periyar Vaigai Command (PVC) area. Total 100 surface soil samples were collected and analyzed for plant available Si. In order to assess the response of rice to applied Si for arriving the optimum Si level and also to fix critical limit of Si, a pot experiment was conducted making use of the bulk soil samples collected from twenty locations (out of 100 locations) of rice growing tract of the PVC area with five levels of Si (0, 75,150, 225 and 300 ppm) replicated twice in a completely randomized design using rice variety ADT -45 as test crop. The effect of Si on yield attributing characters and grain yield of rice were also recorded. The grain and straw samples were analyzed for Si content for calculating the uptake values.

The present investigation revealed that available silicon in the rice soils ranged from 4 to 250 ppm. The available Si was significantly and positively correlated with pH, clay, CEC and free $CaCO_3$ and negatively correlated with the other soil properties namely EC, fine sand, R_2O_3 and Fe_2O_3. The various yield attributes *viz.,* number of productive tillers per hill, panicle length, number of filled grains per panicle and percentage of chaffy grains were positively influenced by the addition of Si. The grain and straw yield of rice were significantly increased with Si application up to 225 ppm level. However, the optimum physical and economic dose of Si was found to be 368 and 310 ppm, respectively, in the rice growing soils of PVC area. A critical limit of 40 ppm plant available Si was established for the rice soils of the study area. The critical limit of Si in grain and straw were 0.45 and 2.33%, respectively. The soil, grain and straw silicon levels were categorized into low, medium and high based on per cent relative yield. Accordingly, the soil available Si up to 120 ppm (<75% relative yield) shall be considered as low, 122 to 181 ppm (75 to 95% relative yield) as medium and more than 181 ppm (>95% relative yield) as high in Si availability. As per this categorization, out of 100 soil samples tested in PVC area, 64% of the soil samples were deficient in Si supply cautioning the seriousness of Si deficiency, while the remaining 14 and 22% areas were medium and high in Si status, respectively. Hence the soils analyzing less than 122 ppm of available Si need balanced fertilization including Si to avoid its deficiency. The immediate application of Si fertilizer may not be necessary for soils more than 181 ppm of plant available silicon.

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Assessment of Soil and Water Status in Coastal Saline Belts of West Bengal

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The major constraints of agriculture in coastal saline belt consisting of Sundarbans are high salt concentration, lack of good quality irrigation water, low efficiency and poor management of plant nutrients. So there is a need to assess the status of soil and water status of the study area for suggesting proper management practices. In this context GPS based soil (0-20 cm depth) and water samples from existing pond and shallow tube-wells as a sources of surface and ground water, respectively, were collected from four blocks, namely, Kakdwip, Sandeskhali, Canning and Nimpith both under North and South 24 Parganas in Coastal Saline region of West Bengal during the peak summer month (May) of 2010. The soil samples were collected from the agricultural land in the vicinity of pond which is used as the source of water for cultivation and analysed for pH, EC, exchangeable Ca, Mg, Na, oxidizable organic carbon, available N, K and P, total P and inorganic P. The water samples were analyzed for pH, electrical conductivity (EC), soluble cations (Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}) and anions (CO_3^{-2}, HCO_3^{-} etc). Results revealed that EC and TDS, TCC, SSP SAR, MAR of the pond water were much higher than shallow water, which is indicative of the fact that the surface water contains higher salt and hence, moderately suitable to unsuitable for irrigation. The surface water i.e. pond water of the studied area is saline and saline-sodic i.e. brackish in nature. Effect of application of such water in agricultural land was assessed through correlation study between the soil and water parameters, particularly SAR, EC and Na^{+} content. Result showed that Na^{+} content of the soil positively correlated with Na^{+} content of water, irrespective of sites. Soil SAR value was also positively correlated with SAR of pond water in Kakdwip, Sandeskhali and Canning with correlation coefficient value of 0.60, 0.44, 0.33 and 0.51, respectively. Thus, continuous application of such pond water in the agricultural fields may degrade soil physical properties by sodium hazard. Result also showed that 65% of pond water collected from Nimpith block categorized as good quality water with class A, whereas 52 and 29% of water categorized under such class in Kakdwip and Sandeskhali, respectively. No good quality pond water was found in Canning block. All water samples collected from Canning block were marginally saline and saline type with coverage of 60 and 40% of total samples, respectively. Marginally saline water coverage of Kakdwip, Sandeskhali and Nimpith were 28, 41 and 20%, respectively. Saline water was found 20, 29 and 15% of total water samples collected from Kakdwip, Sandeskhali and Nimpith, respectively. The results and interpretation of hydro chemical analysis reveals that the ground water particularly shallow water of the studied area is good and suitable for irrigation. Thus, in order to maintain sustainable production of the experimental area it is necessary, to use the shallow water judiciously in conjunction with application of pond water with suitable reclamation.

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Status of Plant Available Macro, Micro and Secondary Nutrients in District Hoshiarpur of Punjab

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Six hundred forty two soil samples were georeferenced from different blocks of District Hoshiarpur and analyzed to judge the status of macro, micro and secondary nutrients. Available N status of surface soils varied from 31.4 to 141.1 kg ha^{-1} with a mean value of 77.6 kg ha^{-1}, indicating that soils were invariably deficient in N. Phosphorus status were found to be high in 60.3% soils and 32.4% soils had medium P status and only 7.30% soils were falling in low category. Potassium status of 49.8 and 44.9% of the soils were high and medium, respectively while remaining 5.30% were low. Percent samples for available S under low, medium and high categories were 36.7, 30.2 and 33.1%, respectively. Nearly half of the soils (48.3%) have medium Zn status followed by 33.8% soils, which were having low and only 17.9% soils were having high Zn status. The deficiency of Cu was prevalent in 4% soils while 47.3% soils were in high and 48.3% were in medium status. It was observed that in case of Fe, deficiency was observed in only 7.3% soils, while 62.5% and 30.2% soils exhibited high and medium Fe content, respectively. More than half the soils were medium in Mn (56.7%) followed 30.2% and 13.1% soils which were low and high in Mn content, respectively. Overall, only 12.9% soils were deficient with respect to B in this district. Besides Zn, higher percentage of soils were also found deficient in Mn and S, indicating that these elements will be the limiting factors in crop production. Zinc deficiency was still prevalent in about 1/3rd of soils, indicating that farmers of this district are not practicing regular use of zinc fertilizers.

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Impact of Crop Covers on Runoff, Soil Loss and Crop Productivity in Vertisols of Central India

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A field experiment was conducted at Indian Institute of Soil Science, Bhopal to evaluate the impacts of crop covers on soil and nutrient losses through runoff, soil organic carbon (SOC) and other structural parameters of vertisol. Seven treatments consisted of three sole crop cover *viz.,* soybean, maize and pigeon pea and three intercrop covers namely soybean+ maize (1:1), soybean + pigeon pea (2:1) and maize + pigeon pea (1:1) along with one cultivated fallow (control). Results over two years of experimentation revealed that the highest runoff (208 mm) and soil loss (2.87 t ha^{-1}) was recorded under cultivated fallow. The values were higher as compared with sole as well as intercrops in both years. Among the crop cover treatments, the runoff and soil loss was higher under sole pigeon pea (177 mm and 2.15 t ha^{-1}), respectively, followed by sole maize (167 mm and 1.99 t ha^{-1}), maize + pigeon pea (140 mm and 1.60 t ha^{-1}), soybean + maize (135 mm and 1.48 t ha^{-1}), soybean + pigeon pea (132 mm and 1.34 t ha^{-1}) intercrops and lowest was under soybean sole crop (132 mm and 1.48 t ha^{-1}). The erosion rate is much below the critical limit of < 5 t ha^{-1} which has been classified as very slight erosion category in Central India. System productivity in terms of soybean equivalent yield (SEY) was higher under maize + pigeon pea (5164 kg ha^{-1}) and soybean + maize (3193 kg ha^{-1}) compared with soybean yield. Therefore the combinations of maize + pigeon pea (1:1) and soybean + maize (2:1) as intercrops are the best options for reducing runoff and soil losses and sustaining crop productivity. Hence, adoption of different crop covers/intercrops coupled with proper soil conservation measures are better options for erosion control, reducing the soil and nutrients losses, sustaining crop productivity as well as improving soil health in vertisol of central India.

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Effect of Different Irrigation Water Levels and Methods on Water Use Efficiency of Onion

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A field experiment was conducted at the Research Farm of Department of Soil Science, Punjab Agricultural University, Ludhiana for comparing the drip, furrow and flood methods of irrigation on the onion yield and water use efficiency in a sandy loam soil of central Punjab, during *rabi* 2012 season. On drip irrigated and furrow irrigated beds three onion rows were planted on 55 cm wide beds at spacing of 15 cm from row to row. Effects of different water levels on yield components and on onion quality were also evaluated. Three levels of irrigation water were tested *i.e.* IW/PAN-E ratio of 0.3, 0.4 and 0.5 in drip irrigated onions and 1.2, 1.6 and 2.0 in both bed and flood method of irrigations. The depth of irrigation water was kept constant *i.e.* 30, 40 and 60 mm, respectively, for drip, bed and flood methods of irrigation. The results of the experiment indicated that by applying same quantity and 50% of water as of surface flood irrigation, the yield was increased by 25 and 10%, respectively. The soil moisture distribution along the vertical direction increased and laterally it was decreased. Soil moisture was observed to be around field capacity level throughout the crop growing season under drip irrigation. The onion yield increases with the increase in irrigation level for all the methods of irrigation. The highest yield of 32.5 t ha^{-1} was obtained in the drip irrigated plots where irrigation water was applied with IW/PAN-E ratio of 0.5, followed by bed *i.e.* 30.5 t ha^{-1} and least in flood method of irrigation *i.e.* 25.0 t ha^{-1}. The highest irrigation water use efficiency (IWUE) was obtained with the IW/PAN-E ratio of 0.3 under drip irrigation followed by bed and flood irrigation at equivalent IW/PAN-E ratio. Onion grade size was significantly influenced by methods of irrigation. Bigger sized onions (> 40 mm) were observed under drip irrigation followed by bed irrigated and smallest onion size was recorded under flood method of irrigation. However, the quality of onions with respect to TSS value was observed to be non significant. The results revealed that drip irrigation could be successfully used for onion production with better quality, water saving and higher production levels.

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Productivity and Nutrient Uptake by Rainfed Mustard as Influenced by Sowing Time and Moisture Conservation Practices

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Indian mustard (*Brassica juncea* L.) is particularly being deep rooted and are able to utilize the soil moisture and nutrient of deeper soil layers. Therefore, they are mostly grown under rainfed condition at residual soil moisture on marginal and sub marginal land. However, crop under such condition result in poor yield. Water scarcity affects the root growth, nutrients availability and nutrients uptake by the crop. So there is a need for efficient utilization of water through appropriate moisture conservation practices for achieving higher water and nutrients use efficiency and productivity of mustard. Keeping in view, the present experiments were conducted at the research farm of the college of Agriculture Gwalior during *rabi* (winter) seasons of 2010-11 and 2011-12 to study the effects of sowing time and moisture conservation practices on root growth, nutrient uptake and moisture extraction pattern by mustard (Cv. Pusa bold.).

The experimental soil is sandy clay loam in texture, with pH 7.88, EC 0.38 dS m^{-1}, Organic carbon 0.38% with available N (188.3 kg ha^{-1}), P_2O_5 (20.8 kg ha^{-1}) and K_2O (288.2 kg ha^{-1}). The experiment was laid out in a split plot design with 3 replications. Three sowing time *viz.* D_1: 2nd week, D_2: 3rd week and D_3: 4th week of October, considered as main plot treatments and 8 moisture conservation practices *i.e.* M_1 : Control, M_2: Weeding by khurpi at 20 DAS, M_3: M_2 + Paddy straw mulch @ 2.5 t ha^{-1}, M_4: M_2 + Paddy straw mulch @ 5.0 t ha^{-1}, M_5: M_2 + Grass mulch @ 2.5 t ha^{-1}, M_6: M_2 + Grass mulch @ 5.0 t ha^{-1}, M_7: M_2 + Pearl millet husk mulch @ 2.5 t ha^{-1} and M_8 : M_2 + Pearl millet husk mulch @ 5.0 t ha^{-1} in sub plots. Mean seed yield was observed in the range of 1780.6 to 2385.4 and 1838.8 to 2412 kg ha^{-1} under different sowing dates and moisture conservation practices. It is observed that sowing on 2nd week of October gave higher seed and straw yield than 4th week of October sowing but yields were similar to 3rd week of October sowing. Application of moisture conservation practices was superior to control in terms of seed and straw yield. Uptake of nutrients (NPKS) was higher in 2nd week of October sowing and different moisture conservation practices over control. Mulching @ 5.0 t ha^{-1} showed higher seed yield and nutrient uptakes than respective mulching materials applied @ 2.5 t ha^{-1}.

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Natural Resource Management under a Watershed Development Project in Rajgarh District

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Natural resource like soil and water play a key role in agriculture. Hence, improved soil and water conservation technologies need to be disseminated among farmers for making agriculture profitable. Water requirement and management vary from crop to crop. Conservation and management of soil and water will play an effective role in increasing food production. In Rajgarh district normal annual rainfall varies from 800 to 1200 mm. Delayed mansoon adversely affects the food production. The natural calamities like drought, flood and frost do affect the food production and food security. Under this situation water harvesting and water management serves as contingent plan to ensure timely water supply to crops. Micro irrigation in crops yields better results and leads to judicious use of water and on farm water management aiming for additional food production with natural resource conservation.

Efficient soil and water management includes aspects like evaluation of surface irrigation methods, irrigation scheduling, optimum crop sequence with irrigation, on farm water management, afforestation, pasture land development, Med Bandhan, Gully plugging, Khet Talab, Recharging, Check Dem, Stop Dem, Bori Bandhan, Talab, Percolation Tank, Biogas, Nadep, Vermicomposting are the major technology disseminated in Rajgarh district. Integrated development of rainfed area in district through dissemination of improved technologies leads to increase in productivity with soil and water conservation, increase in ground water level, waste land converts to cultivable land, more areas comes under irrigated land, pasture land development to reduce flow of rain water, INM practices with biogas slurry, Nadep and vermicomposting in animal based agriculture system in the district. Before the initiation of watershed programme, the water availability in dug wells and tube wells were for 8 months in a year. After water harvesting technologies there is round the year availability of irrigation water the ground water level increased by 3 to 6 meter. By more irrigations and soil health improvement, the productivity of major crops increased by 2 to 4 q ha^{-1}. In arable and non arable lands of Rajgarh, emphasis was given on multiple/mix/strip cropping preferably legume, organic farming integrated nutrient and pest management agro-forestry for sustainable growth of agro based economy. The KVK and other Govt. Agencies engaged in transfer of technology to farmers and the ultimate adoption of technology by farmers has lead to the achievement of land mark in food grain production through green revolution, white revolution, yellow revolution and blue revolution. The judicious use of natural resources like soil and water and its management not only help their conservation but also contributed to making agriculture profitable.

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Effect of Tillage, Mulching and Fertilizer Doses on Rice in Mollisols of Uttarakhand

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The study was undertaken during *kharif* 2010 at N. E Borlaug Crop Research Centre of G.B Pant University of Agriculture and Technology, Pantnagar to evaluate the effect of tillage, mulching and fertilizer doses on rice in Mollisols of Uttarakhand. The experiment was laid out in a split plot design with two tillage treatments *viz.* T_1 (Reduced tillage) and T_2 (Conventional tillage) and two treatments of mulch *viz.* M_0 (No mulch) and M_1 (Surface mulch), serving as main plot and two treatments of fertilizer rates *viz.* F_1 (recommended dose of fertilizer 150:40:60 NPK kg ha^{-1}) and F_2 (25% higher recommended dose of fertilizer) serving as sub-plots. The soil had loam texture, 7.01 pH, 0.13 dS m^{-1} EC, 0.6% walkley black organic carbon and 147.39 kg ha^{-1}, 20.36 kg ha^{-1} and 179.41 kg ha^{-1} available N, P and K respectively. Soil samples were collected from 0-15 cm depth before sowing and after harvesting of crop. Soil was analysed for organic carbon and available NPK using standard procedures and different yield attributing characters and yield per ha was recorded. Cost of cultivation for different treatments was also calculated.

The T_1 had 15% higher amount of organic carbon in soil over T_2. M_1 exhibited plots under 20% higher levels of organic carbon than M_0. Available nitrogen in soil was recorded 8.4% less in T_2 than T_1. M_1 and F_2 showed 17.3% and 4.00% higher levels of available nitrogen over M_0 and F_1, respectively. Available P in soil was not significantly affected by different options of tillage, mulch and fertilizer doses. Significantly higher level of available K was found under M_1 (189.79 kg ha^{-1}) compared with M_0 (168.13 kg ha^{-1}). Tillage options recorded substantial changes in the plant height after 30 and 60 days of sowing while non considerable variation in the plant height was seen in different options of mulch and fertilizer rates. More tillers were recorded in T_1 (486 m^2) than T_0 (316 m^2) after 30 days of sowing and the value obtained in T_1 was superior to the values recorded in all other treatments. Number of panicles m^2 was observed to be 320, 312 and 309 under T_1, M_0 and F_2, respectively. These values were higher than the values recorded under T_0, M_1 and F_2. More number of grains per panicle was found in conventional tillage (102) than reduced tillage (81). F_1 was recorded with less number of grains per panicle than F_2 (96). Recorded test weight was higher in T_1 (26.65 g) than T_0 (25.89 g). 2.7 g higher test weight was recorded in F_2 than F_1. Economical and biological yield showed in significant changes. Reduced tillage without mulch and with recommended dose of fertilizer had least cost of cultivation and less expenditure of Rs 7144 ha^{-1} than conventional tillage with mulch and with 25% higher recommended dose of fertilizer.

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Assessment of Quality of Irrigation Water and its Influence on Nutrient Addition to Wheat

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An experiment was conducted at Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola during 2012-13 to assess the quality of water and addition of nutrients through irrigation water to the wheat crop. The water samples were collected using GPS from wells, tube wells and rivers, at interval of four months and analyzed for various parameters. The pH of the irrigation water was in the range of 7.39 to 8.07 in 2011 and 2012, respectively. The TDS of irrigation water (*i.e.* 337.07 to 846.4 mg L^{-1}) was higher than the permissible limit of 500 mg L^{-1} in all water samples except river water. The concentration of Ca was in the range of 28.5 to 58.2 mg L^{-1} while Mg was in the range of 20.1 mg L^{-1} to 63.38 mg L^{-1} which was higher than the recommended. The sodium concentration was higher than permissible limit. The NO_3-N content in irrigation water was in the range of 0.67 to 1.54 mg L^{-1}. The P content in water was in the range of 0.42 to 1.78 mg L^{-1}, which was more than recommended value of 0.1-0.4 mg L^{-1}. The content of Fe was Fe .011 to 0.26 Mg L^{-1}, which was in normal range. The SAR of irrigation water was recorded in the range of 2.26 to 9.4 mml^{½} L^{½} which was also in safe range.

The amount of NO_3-N contributed to wheat through irrigation with underground water varied from 3.8 to 6.2 kg ha^{-1}. The supplemented average amount of phosphorus ranged from 1.68 to 7.12 kg ha^{-1}. The K contribution was in the range of 3.8 to 11.96 kg ha^{-1}. The amount of calcium added through irrigation water was in between 114 to 290 kg ha^{-1}, whereas Mg contributed 80.4 to 253.52 kg ha^{-1}, which was somewhat higher. The contribution of sodium was in the range of 187.08 to 738.32 kg ha^{-1} which may cause adverse effect on soil. The SO_4 addition was in between 276.64 to 422.6 kg ha^{-1}. The average amount of Fe supplementation through irrigation varied from 0.45 to 1.064 kg ha^{-1}. The contribution of Mn ranged from 0.08 to 6.18 kg ha^{-1}. The Cu contribution was in between 0.084 to 0.178 kg ha^{-1} and Zn contribution was in the range of 0.18 to 1.34 kg ha^{-1}. Hence, based on the generated data, the supply of safe irrigation water helps to add remarkable quantity of nutrients to the wheat crop. This ultimately helps to minimize the amount of fertilizers.

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Growth, Yield and Quality of Tomato (*Solanum lycopersicum*) as Influenced by Drip Fertigation with Humic Acid

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Studies were conducted on tomato during 2010-2012 at Dr.Yashwant Singh Parmar, University of Horticulture & Forestry, Solan, Himachal Pradesh (India). Four fertigation levels (100, 80, 60 and 40% recommended NPK) were tried with humic acid (combined fertigation) and without humic acid (control). The experiment comprising eight treatment combinations in randomized block design, replicated four times. The investigations revealed that combined fertigation resulted in higher available N and K concentrations in the 0-20 cm and higher P in the 20-30 cm soil layers over control. Crop response was positively and significantly related to different fertigation levels. Application of humic acid significantly increased plant height (5.7%), total dry matter (7.7%), leaf area index (3.2%), chlorophyll content (4.7%) and fruit yield (9.6%) over control. Titratable acidity and ascorbic acid content were also significantly influenced by humic acid application. Further, growth, yield and fruit quality of tomato was statistically similar between combined fertigation with 80% recommended dose (T_4) and fertigation with 100% recommended dose with humic acid (T_2) and without humic acid (T_1). The results, therefore, suggest the potential use and substitution of mineral fertilizers with humic substances through fertigation.

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Effect of Drip Fertigation and Mulch on Soil Nutrient Distribution in Apricot (*Prunus armeniaca*) cv. Harcot

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The sustainability of any production system requires optimum utilization of resources, be it water, fertilizers or soil. There is a need for technological interventions that will help in minimizing the use of these precious resources and maximizing crop production without any detrimental effects on the environment. The consequences of drip irrigation and fertigation especially, in conjunction with mulch, in apricot (*Prunus armeniaca* L.) orchards of Himalayan region have not yet been established. It was, therefore, found imperative to study the effect of drip irrigation, fertigation and mulch on nutrient distribution and productivity of the apricot (cv. Harcot). A field experiment was conducted in the University orchard wherein, three fertigation levels (100, 80 and 60% of recommended doze) were tried and compared with the conventional practices, with and without mulch. Available N and K content under drip fertigation and conventional fertilization were significantly higher in the upper 0- 10 cm soil layers. Among all treatments, high available P content was noted in the surface soil layer (0-10 cm) compared to the lower layer (10–20 cm). Soil moisture content under drip fertigation and conventional soil fertilization remained higher in the upper soil layers. Mulch raised the minimum soil temperature by 2.7^{o} C, whereas, it failed to alter the maximum soil temperature appreciably. Leaf nutrient contents were unaffected by the kind and method of fertilizer application. Drip fertigation resulted in significantly higher tree growth of apricot, compared with conventional soil fertilization. Thus, saving in fertilizers and irrigation water can be achieved through drip fertigation plus plastic mulch besides improvement in soil hydrothermal regimes.

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Effect of Mulches and Nutrient Levels on Growth, Nutrient Uptake and Productivity of Cauliflower (*Brassica oleracea* var. *botrytis* L.) in Mid Hills of Himachal Pradesh

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Field study on the effect of mulches and nutrient levels on weed infestation, growth, nutrient uptake and productivity of cauliflower (*Brassica oleracea* var. *botrytis* L.) was conducted during 2009-10 and 2010-11 in mid hills of Himachal Pradesh. Twelve treatment combinations comprising four mulches *viz.* black plastic mulch (BP), grass mulch (GM), pine needles mulch (PN), unmulched control (UM) and three levels of nutrients *i.e.* F_1 (125% of recommended dose of NPK), F_2 (recommended dose of NPK) and F_3 (75% of recommended dose of NPK) were replicated thrice in a factorial randomized block design. Results revealed that mulches effectively checked weed infestation and minimum weed growth was observed under BP. Plant growth expressed as foliage weight, root growth, curd weight and curd yield were significantly influenced by mulches and nutrient levels. Black plastic mulch and 125% NPK application together promoted plant and root growth, nutrient uptake, curd quality, yield of cauliflower. Treatment combination BPF_1 recorded 88.7% higher productivity (head yield 266.8 q ha^{-1}) closely followed by BPF_2 (83.6%, 259.6 q ha^{-1}) over unmulched control with 75% nutrient level (UMF_3). Black plastic mulch with higher dose of nutrient level increased the nutrient uptake in cauliflower compared with other mulches. The seasonal incomes under the treatments of BPF_1, BPF_2, PNF_1, PNF_2, GMF_1 and GMF_2 were 2.3, 2.2, 2.2, 2.1, 2.0 and 2.0 times higher, respectively, over UMF_3.

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Assessment of Conservation Agriculture on Soil Health in the Hilly Terrains of Odisha

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Soil degradation through loss of forest cover, accelerated water erosion, mining activities and shifting cultivation coupled with practice of growing monoculture of maize under intense tillage has rendered the soils unproductive in the hilly tracts of North Central Plateau zone of Odisha. Conservation agriculture CA involving minimum tillage, legume based intercropping and a follow up cover crop has been thought of as the best possible long term solution for this region that not only maintains the quality of environment but also conserves the natural resources, keeping it buffered against risks. Hence, field experiment has been initiated on a *Fluventic Haplustepts* at the Regional Research and Technology Transfer Station, OUAT, in Kendujhar district located under the hilly terrains of North Central Plateau Zone, Odisha, during 2011-2012, in a split plot design and the impacts of CA on soil health was assessed at the end of 2nd cropping cycle. The treatment combinations were conventional tillage (CT) and minimum tillage (MT) with sole maize (M) and inter crop maize+cowpea (M+C) in main-plots during wet season and horsegram, mustard and no cover crop in sub-plots during dry season. Practice of MT increased the water stable macro-aggregates (+8.7%) with concomitant decrease in water stable micro-aggregates (-13.4%) over the initial status. CT increased the BD by 0.03 Mg m^{-3} whereas, it remained unchanged under MT. The accumulation and preservation of organic matter in MT elevated the SOC (+17%), CEC (+15.3%), Ca^{++} (+20.4%), Mg^{++} (+20.3%), K^+ (+10.1%), base saturation (+3.8%) over the initial contents at the end of two cropping cycles in succession. Physical protection of SOM due to less soil disturbances in MT resulted in higher available N (305 kg ha^{-1}), P (17 kg ha^{-1}) and K (364 kg ha^{-1}). The elevated SOM in MT enhanced the population of bacteria (+10.8%), actinomycetes (+14.6%) and MBC (+13.6%) over initial. The inclusion of cover crops in CA significantly enhanced the SOC (+6.8%), available N (+7.5%), P (+8.6%), actinomycetes (+6.4%) and MBC (+5.8%) over the soils with NCC. Considerable buildup of SOM due to residue incorporation and its protection under MT contributed significantly in improving the status of macro-aggregates (R=0.92**), BD (R= -0.87**), CEC (R=0.89**), base saturation (R-0.86**), available N (R=0.96**), P (R=0.66*), K (R=0.93**), population of Bacteria (R=0.93**), actinomycetes (R=0.92**) and MBC (R=0.87**). Though the system yield of M+C under MT was marginally lower than that under CT at the end of second cropping cycle, the positive influence on soil health is expected to be reflected in yield in the long run.

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Irrigation Water Requirement and Soil Salinity in relation to Growth of Two *rabi* Crops Grown in Coastal West Bengal

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In coastal West Bengal, the principal crops grown in the *rabi* season are rice and vegetables. High soil salinity and non-availability of non-saline irrigation water are problems that affect crop growth in this area. In this study, crop water requirement of rice and vegetables grown in *rabi* season of 2012-13 were estimated using CROPWAT 8.0. Assessment of crop growth was made using green vegetation index (GVI), which was derived from IRSP6 L3 data of March, 2013. Rice crop and vegetable areas were determined using MXL classification of the image. Soil samples were collected from 0-15 cm layer of cultivated and non-cultivated fields. Soil texture, EC, pH were also determined. The EC values were correlated with crop growth. Agro-climatic data were merged with satellite data to find out surplus / deficit of irrigation water for the crops. Textural classes of the soils were clay to clay loam. Results showed that soil EC values were negatively correlated with crop growth (r=-0.29). GVI values for non-cultivated fields were having slightly higher correlation with soil EC values than observed in cultivated fields. Merged agro-climatic data with satellite image showed that approximately 4785 ha area came under rice and 1889 ha^{-1} under vegetables and there were 2860 ha-m surplus of non-saline irrigation water for rice and 358.7 ha m^{-1} deficit of water for small vegetables.

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Effect of Drip and Furrow Irrigation Methods on Growth, Yield and Nutrient Uptake by Bt Cotton (*Gossypium hirsutum* L.) under Semiarid Condition

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A field experiment was conducted at the Research Farm of CCS Haryana Agricultural University, Regional Research Station Sirsa, for three years (2007, 2008 and 2009) to find out the effect of different levels of irrigation and fertilizer on productivity and nutrient uptake of Bt cotton. The experiment was conducted under a split plot design with three replications by taking four irrigation levels (I_1=0.6 Etc, I_2=0.8Etc, I_3=1.0 Etc and I_4=furrow irrigation) in the main plots and four fertilizer levels (three through drip *i.e.* F_1=75% RDF, F_2=100% RDF, F_3=125% RDF and one through pora method *i.e.* F_4=100% RDF) in the sub plots. The soil was sandy clay loam texture having pH 8.1. The organic carbon (0.12%) and available nitrogen (85 kg ha^{-1}) were in very low category. The available phosphorus (16 kg ha^{-1}) and potassium (475 kg ha^{-1}) were in medium and high category, respectively. The seed cotton yield increased with increasing levels of irrigation and highest yield (2889 kg ha^{-1}) were observed under I_3 (Etc=1.0). That highest yield was about 14% higher than furrow irrigation method (I_4). Similarly, yield increased with increasing levels fertilizes and highest yield (2751 kg ha^{-1}) was observed at 125% RDF (F_4) and it was about 9% higher than pora method (F_4). The number of boll plant^{-1} and boll weight also increased with increasing levels of irrigation and fertilizers. The nitrogen and phosphorus uptake by Bt cotton increased from 50% boll opening stage (120 days) to harvesting stage (4.85 to 5.13 g plant^{-1} and 0.80 to 0.86 g plant^{-1}, respectively). However, potassium uptake decreased at harvesting stage (5.66 to 5.49 g plant^{-1}). The 14% higher seed cotton yield and 30% saving of irrigation water was observed at 1.0 Etc irrigation level compared with furrow irrigation method.

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Effect of Continuous Crop Residue Incorporation on Yield of Groundnut and Soil Enzyme Activity in an Acid Soil of Jharkhand

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Continuous cropping without application of adequate quantity of nutrients in balanced doses or without addition of organics leads to loss of soil productivity. For restoration of soil productivity there is an urgent need to look forward to other options of plant nutrient supply besides the use of chemical fertilizers. Continuous recycling of crop residues with chemical fertilizers restores the organic matter content. Precise information on the long term effect of recycling of crop residues along with chemical fertilizers on an acid loam soil under climatic condition of Ranchi is needed for enhancing the nutrient availability of soils. A long term experiment with crop residue incorporation under maize-wheat cropping sequence is in operation since 1991. After 18th crop cycle, cropping system was changed to urd-wheat for two years, then again to groundnut-wheat. The experiment was laid out with three replications having 8 treatments *i.e.* T_1 (control), T_2 (crop residue), T_3 (50% NPK + CR), T_4 (75% NPK + CR), T_5 (100% NPK + CR), T_6 (50% NPK), T_7 (75% NPK) and T_8 (100% NPK). Soil samples were collected during 2012-13 to study enzyme activities. Pod yield of groundnut ranged from 9.67 to 20.3 q ha^{-1} and significantly highest pod yield was observed in T_5 *i.e.* application of 100% NPK along with and crop residue (wheat) @ 10 t ha^{-1}. Post harvest (after groundnut) soil analysis for enzyme activity *viz.,* phosphatase (µg PNP g^{-1} soil hr^{-1}), dehydrogenase (µg TPF g^{-1} soil hr^{-1} and cellulase (mg glucose g^{-1} soil 24 hrs.) varied from 123.1 to 193.9, 1.42 to 5.99 and 0.72 to 1.05, respectively, and was also found to be highest in treatment T_5. Thus, supplementing organic manures as crop residue incorporation is of paramount importance but not substitution of chemical fertilizers for enhancing crop productivity in acid soils of Jharkhand.

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Effect of Conservation Agriculture on Net Primary Productivity and Soil Organic Carbon Retention in the Western IGP

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Carbon retention in arable soils has been considered as one of the potential mechanisms to mitigate the elevated levels of atmospheric greenhouse gases. We evaluated impacts of conservation agriculture (CA) on net primary productivity (NPP) or aboveground biomass yield, change in total soil organic C (SOC; analysed with a TOC analyser) and relationship between C addition and storage in a sandy loam soil of the Indo-Gangetic Plains (IGP). Cotton (*Gossypium hirsutum* L.) and wheat (*Triticum aestivum* L.), wheat and green gram (*Vigna radiate* L.) were cultivated. Results indicate after three years of cropping, plots under conventional tillage-flat planting (CT-F), zero tillage-bed planting (ZT-B) and zero tillage-flat planting (ZT-F) had similar mean NPPs of cotton. However, mean (of three years) cotton NPP of the plots under conventional tillage-bed planting (CT-B) was about 14.7% higher than ZT-F (6.86 Mg ha^{-1}) plots. In the fourth years, plots under ZT-B had about 19.4% higher maize (2011) NPP compared with CT-F treated plots (~11.8 Mg ha^{-1}) (Table 3). Again, CT-B, CT-F and ZT-B had similar mean cotton NPP. Tillage and crop establishment methods had no impact on the mean (of four years) wheat NPP. The greengram NPP of summer 2012 (the fourth years) closely followed the wheat yield under different tillage treatments. The plots under ZT-B and zero tillage with ZT-F had nearly 28 and 26% higher total SOC stock compared with CT-B (~5.5 Mg ha^{-1}) in the 0-5 cm soil layer. Plots under ZT-B and ZT-F contained higher total SOC stocks in the 0-5 and 5-15 cm soil layers than CT-B plots. Although there were significant variations in total SOC stocks in the surface layers, SOC stocks were similar under all treatments in the 0-30 cm soil layer. Residue management had no impact on SOC stocks in all layers, despite plots under cotton/maize + wheat residue (C/M+W RES) contained ~13% higher total SOC concentration than no residue treated plots (N RES; ~7.6 g kg^{-1}) in the 0-5 cm layer. Hence, tillage and residue management interaction effects were not significant. Although CT-B and ZT-F had similar maize aboveground biomass yields, CT-F treated plots yielded 16% less maize biomass than CT-B plots. However, both wheat and green gram (2012) yields were not affected by tillage. Plots under C/M+W RES had ~17, 13, 13 and 32% higher mean cotton, maize, wheat and green gram aboveground biomass yields than N RES plots, yielding ~16% higher estimated root (and rhizodeposition) C input in the 0-30 cm soil layer than N RES plots. About 9.3% of the gross C input contributed towards the increase in SOC content under the residue treated plots. However, ~7.6 and 10.2% of the gross C input contributed towards the increase in SOC content under CT and ZT, respectively. Thus, both ZT and partial or full residue retention is recommended for higher soil C retention and sustained crop productivity.

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Assessment of Soil Salinity in a Subsurface Drainage Project Site using Electromagnetic Induction Technique

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Soil salinity is a serious environmental problem adversely affecting the crop yield, soil health and socio-economic conditions of the farming community. Monitoring the development and severity of soil salinity is important to assess its adverse effects on crop production and environmental degradation. Electromagnetic (EM) measurements provide a rapid and easy method to study the spatial variability and regional distribution of soil salinity over large areas. An EM induction survey was conducted in subsurface drainage project area at Mokrakhri, Dist. Rohtak, Haryana in 2012 for characterizing soil salinity at the start of subsurface drainage project. The area gets waterlogged in rainy season and has a very shallow and saline ground water. The ground water table depth during the month of May ranged from 0-1.2 m. EM-38 horizontal and vertical survey observation on a 100 x 100 m grid spacing were made over 3 ha area. Soil samples upto 60 cm depth at 15 cm increment (*i.e.,* 0–15, 15–30, 30–45 and 45–60 cm) were collected from eight representative sites keeping in view the locations of EM observations. The soil samples were analyzed for electrical conductivity of saturated extract (EC_e), pH, cations (Ca^{2+}, $Mg^{2+}$and Na^{1+}), anions ($CO3^{2-}$, HCO^2, Cl^{-1}) and sodium adsorption ratio (SAR) using standard analytical procedure. Geo-statistical based krigging approach was applied using SURFER software to study spatial variability of apparent conductivity derived from EM 38 observations in horizontal and vertical modes. The apparent conductivity in the horizontal EC_a (H) and vertical EC_a (V) modes ranged from 14-95 dS m^{-1} and 20-72 dS m^{-1} in the study area with median values of 70 and 50 dS m^{-1}, respectively. Correlations analysis between EC_a (V), EC_a (H) and EC_e for different soil layers (*i.e.,* 0–15, 0-30, 0-45 and 0–60 cm) showed highest correlation in 0-60 cm composite depth zone. The correlation coefficients (r^2) of EC_a (V) and EC_a (H) were 0.69 and 0.74 with EC_e and 0.58 and 0.84 with SAR of 0-60 cm soil, respectively, indicating higher correlations for horizontal EM observations. The results of the study suggest good reliability of EM approach for characterizing regional scale soil salinity. Similar results from a number of other locations in waterlogged saline areas in Haryana, with or without subsurface drainage, are being synthesized to standardize EM approach for monitoring soils salinity over large areas.

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Quality of Underground Irrigation Waters in Bathinda District of Punjab, India

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The main limitation of underground water in South-Western region of Punjab is that it contains higher amounts of salts compared with canal water. This may cause salinity or sodicity in soil depending upon the compositions of salts. In order to study the quality of irrigation waters, tubewell waters from different villages of Bathinda were collected during September 2012 to July 2013. About 32% water samples had an electrical conductivity < 2 dS m^{-1}, and thus could be used without any possible risk of soil salinization except in case of high water table and clayey soils. Further 35% water sample had EC between 2 to 4 dS m^{-1} and thus were rated as marginal with regard to their suitability for irrigation.

During the study period 60, 15 and 25% of the samples tested, having RSC <2.5 (safe), 2.5 to 5.0 (marginal) and > 5.0 me L^{-1}. Taking into consideration both salt concentration and residual sodium carbonate, the water samples were classified into fit, marginal and unfit categories. About 23% water were fit for irrigation purpose while 50% water were marginal, used for irrigation only after adopting recommended farm management practices. About 27% waters were unfit for irrigation. It can be concluded from the study that the quality of irrigation waters deterioted in this area. Further there were much variation in salt concentration of irrigation water and salinity/sodicity is the main problem of the area.

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Effect of Lime, Boron and Zinc on Soil pH and Growth and Yield of Maize Crop in Red and Lateritic Soils under Dryland Situation of Kandhamal District, Odisha

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Dryland area are rainfed and low productive. These soils are generally light textured, highly acidic in nature and deficient in major nutrients. Continuous cropping leads to depletion of secondary and micronutrients from soil affecting the crop yield. Keeping this in view, a field experiment was conducted for three years (2010-2012) at Dryland Research Stations, Phulbani in North Eastern Ghat Zone of Odisha to study the effect of lime and micronutrients as boron and zinc on maize yield and soil health. The experiment was laid out in RBD with three replications and seven treatments. The treatments combination were recommended dose (RDF) NPK @ 80:40:40 kg ha^{-1} alone and in combination with lime, boron, zinc and its mixture.

Yield data of three years revealed that application of recommended dose of fertilizer along with lime 0.2 LR as soil amendment significantly increased the maize yield (29.40 q ha^{-1}) by 33.99% higher over recommended dose (21.62 q ha^{-1}). When the crop is supplemental with boron and zinc, either isolation in two different doses or in combination at lower dose increased the yield to 35.77 q ha^{-1} which is 65.5% higher over RDF. The response of maize to boron and zinc varies from 0.77 to 6.37q ha^{-1} over application of lime @ 0.2 LR with RDF. It shows no interaction effect within lime, boron and zinc. After harvest of the crop, the pH of the soil was recorded between 4.7 to 5.6 which was higher over initial value (4.38) due to soil amendment. The water productivity ranged from 2.79 to 4.09 kg ha mm^{-1} in different treatments with higher value recorded in lime with boron application. However, the combined application of NPK with lime, boron and zinc can be recommended for higher productivity of maize and maintenance of soil health in red lateritic soil of dryland situation.

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Effect of Potassium Humate and Chemical Fertilizers on Nutrient Availability Pattern in Soil at Different Growth Stages of Rice

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In view of the increasing cost of chemical fertilizers and the ill-effects arising from the imbalanced application, use of natural soil conditioners has become imperative for reducing the quantity of fertilizers without sacrificing the crop production on a sustainable basis. Potassium humate is one such material which has been reported recently as a potential to improve soil properties and nutrient dynamics. A pot experiment was, therefore, conducted during *kharif* 2009 and 2010 to study the influence of potassium humate and chemical fertilizers on nutrient availability pattern in soil at different growth stages of rice. The experiment was arranged in factorial completely randomized design with three replications. Potassium humate was applied @ 0, 5 and 10 mg kg^{-1} soil along with 75 and 100% RDF and 12.5 mg kg^{-1} zinc sulphate. The result showed that sole and combined applications of potassium humate with RDF and zinc sulphate significantly ($P<0.05$) improved the availability of major nutrients and zinc. Application of 10 mg kg^{-1} potassium humate along with 100% RDF recorded significantly higher grain yield and soil available N, P, K, S and Zn at all the growth stages (tillering, panicle initiation and harvesting) of rice than 75 and 100% of recommended doses of fertilizers alone.

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Yield, Nutrient Content, Uptake, Available Nutrient Status and Economics of Pearl Millet as Influenced by the Integrated Use of Green Leaf Manure with Nitrogen Levels in Agri-Silviculture System

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A field experiment on pearl millet was conducted in young pongamia plantation to study the effect of integrated use of pongamia green leaf manure with nitrogen levels on yield, nutrient content, uptake, available nutrient status in *kharif* 2011 at Agroforestry Research Block, Acharya N.G. Ranga Agricultural University, Rajendranagar campus, Hyderabad. The experiment was laid out in Randomized Block Design in 3 replications and consists of 11 treatments *viz.,* T1-Control, T2-Pongamia green leaf manure (PGLM) @ 10 t ha^{-1}, T3- N 80 kg ha^{-1}, T4- N 60 kg ha^{-1}, T5- N 40 kg ha^{-1}, T6- N 20 kg + PGLM 10 t ha^{-1}, T7- N 80 kg + PGLM 10 t ha^{-1}, T8- N 60 kg + PGLM 10 t ha^{-1}, T9- N 40 kg + PGLM 10 t ha^{-1}, T10- N 20 kg + PGLM 10 t ha^{-1} and T11- N 80 kg ha^{-1} under sole pearl millet crop *i.e.* without trees. The experimental soil was red sandy loam, neutral in pH (7.46), non-saline with low organic carbon and available N, medium in available P_2O_5 and K_2O.

The grain (2597 kg ha^{-1}) and stover (4500 kg ha^{-1}) yields were significantly influenced by the integrated use of N @ 80 kg ha^{-1} along with PGLM 10 ha^{-1} compared to all other treatments. The NPK content (1.54, 0.51, 0.53, and 0.40, 0.22, 0.78%) and NPK uptake by both grain (39.99, 13.33, 13.68 kg ha^{-1}) and stover (18.00, 9.90 and 121.65 kg ha^{-1}) were high with N 80 kg ha^{-1} + PGLM 10 ha^{-1}. Soil pH, EC, available P_2O_5 and K_2O were not influenced significantly by either individual levels of N and pongamia green leaf manure or combined application. However, organic carbon content significantly increased over control, when conjoint use of N levels from 40 to 80 kg ha^{-1} along with PGLM 10 ha^{-1} was applied. Highest available N was also found with same nutrient management practice. Maximum net returns (Rs. 10,975/-) and benefit cost ratio (1.76) were realized with combined application of N 80 kg + PGLM 10 t ha^{-1}. It can be inferred that conjunctive use of N 80 kg ha^{-1} along with PGLM 10 t ha^{-1} was the best nutrient management practice for obtaining higher yields, better fertility status as well as net returns of rainfed pearl millet in pongamia based agri-silviculture system.

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Effect of Nitrogen and Phosphorus Levels and Ratios on Growth, Yield and Nutrient Uptake by Groundnut in Northern Transition Zone (Zone 8) of Karnataka

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A field experiment was conducted during *kharif* 2012 to study the effect of nitrogen and phosphorus levels and their ratios on growth, yield and nutrient uptake by groundnut in northern transition zone of Karnataka at MARS, Dharwad under rainfed situation. The experiment comprised of eleven ratios of nitrogen (N) and phosphorus (P) fertilizers (0.00 to 1.00) at a constant potassium fertilizer rate (25 kg K_2O ha^{-1}) laid out in randomized complete block design with three replications.

Influence of N/P ratios on the growth and yield parameters were found to be significant. Treatment receiving N/P ratio of 0.50 (30 kg N, 60 kg P_2O_5) recorded significantly higher growth parameters *viz.,* leaf area $plant^{-1}$ (17.31 dm^2), leaf area index (4.53), leaf area duration (113.27 days) and total dry matter production (36.00 g). Further, the same treatment produced significantly higher number of filled pods $plant^{-1}$ (17.47) and 100 kernel weight (38.50 g) resulting in higher dry pod yield (3310 kg ha^{-1}). Nitrogen and phosphorus ratios tested significantly influenced the quality parameters of groundnut. N/P ratio of 0.50 (30 kg N, 60 kg P_2O_5) accounted for significantly higher oil content (45.70%), oil yield (1115 kg ha^{-1}) and higher kernel yield (2441 kg ha^{-1}). Significantly higher uptake of 147.0 kg N, 23.3 kg P_2O_5, 118.4 kg K_2O and 10.93 kg S ha^{-1} with N/P ratio of 0.50 was recorded. In general, there was a reduction in soil fertility compared to initial status. Among different N/P ratios, ratio of 0.50 resulted in higher net monetary returns of INR 1,01,426 ha^{-1} and B: C of ratio 4.16. Therefore, N/P ratio of 0.50 was found to be promising for optimized production of groundnut under rainfed condition.

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Impact of Foliar Spray of Nutrients on Yield of Cashew

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Two field experiments were conducted during 2009-2013 at Directorate of Cashew Research, Puttur to evaluate the effects of foliar spray of nutrients on yield of cashew. Eight treatments were used in each experiment. The treatments for the experiment I (Major nutrients) were: T1= 3% urea, T2 = 0.5% orthophosphoric acid (H_3PO_4), T3 = 1% K_2SO_4, T4 = 3% urea + 0.5% H_3PO_4, T5 = 3% urea + 1% K_2SO_4, T6 = 0.5% H_3PO_4 + 1% K_2SO_4, T7 = 3% urea + 0.5% H_3PO_4 + 1% K_2SO_4 and T8 = control. The treatments for the experiment II (Secondary and micronutrients) were: T1 = 0.5% $ZnSO_4$, T2 = 0.1% solubor, T3 = 0.5% $MgSO_4$, T4 = 0.5% $ZnSO_4$ + 0.1% solubor, T5 = 0.5% $ZnSO_4$ + 0.5% $MgSO_4$, T6 = 0.1% solubor + 0.5% $MgSO_4$, T7 = 0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$ and T8 = control. Foliar nutrients were administered three times. *viz.,* flushing, flowering and nut development of cashew. The experimental plants were nine years old (During first year of study) of cashew variety 'NRCC Sel-2' spaced at 5 m × 5 m. Soil properties at the start of the experiment showed acidic pH (5.66-6.11) and non-saline (EC = 0.018-0.034 dS m^{-1}) soils high in organic carbon (7.9-8.5 g kg^{-1}), low in Exch. Mg [0.45-0.58 cmol(p^+)kg^{-1}], available N (172-182 mg ha^{-1}), available P (17.5-19.1 kg ha^{-1}), low to medium in available K (133.4-146.5 kg ha^{-1}), sufficient in DTPA- Fe (32.6-37.8 mg kg^{-1}), DTPA-Mn (22.2-25.0 mg kg^{-1}), DTPA-Cu (0.58-0.61 mg kg^{-1}), and deficient in DTPA-Zn (0.25-0.26 mg kg^{-1}) and available B (0.21-0.24 mg kg^{-1}) contents. Results showed that all major nutrient, secondary and micronutrient applications individually and combinations increased cumulative nut yield (2009-13) over control. Among the major nutrient applications, significant yield increase was obtained with 3% urea + 0.5% H_3PO_4 + 1% K_2SO_4 (7.30 kg $tree^{-1}$), 0.5% H_3PO_4 + 1% K_2SO_4 (7.20 kg $tree^{-1}$) and 3% urea + 0.5% H_3PO_4 (6.93 kg $tree^{-1}$) as compared with the control (6.29 kg $tree^{-1}$). Of secondary and micronutrients, application of either 0.5% $ZnSO_4$ or 0.1% solubor individually resulted in a small but significant increase in nut yield over control. Application of 0.5% $MgSO_4$, although superior to control, was less effective than either 0.5% $ZnSO_4$ and 0.1% solubor supplied individually. The highest cumulative nut yield (2009-13) was obtained with combined application of 0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$ (8.18 kg $tree^{-1}$) followed by 0.5% $ZnSO_4$ + 0.1% solubor (8.01 kg $tree^{-1}$) and $ZnSO_4$ + 0.5% $MgSO_4$ (7.79 kg $tree^{-1}$). Application of 3% urea + 0.5% H_3PO_4 + 1% K_2SO_4 increased nut yields by 16.05% while, application of 0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$ increased nut yields by 30.54% averaged over the four years (2009-2013) as compared to control. This study suggests that nut yield response to foliar spray of secondary and micronutrients was appreciably higher as compared to the foliar spray of major nutrients. Application of $ZnSO_4$ + 0.1% solubor gave maximum B:C ratio (2.41) followed by 0.1% solubor (2.35) and 0.5% $ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$ (2.32) which differed significantly from other foliar treatments including control. It could be inferred that foliar application of secondary and micronutrients was not only augmenting the nut yield but also improved the economic status of cashew growers.

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Efficient Fertilizer Management of Finger Millet (*Eleusine coracana*) through Fertilizer Briquettes

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Experiments were conducted in the assured rainfall region located at Zonal Agricultural Research Station, Shenda Park Farm, Kolhapur on Entisol, Sub-Montane Zone of Maharashtra during the *kharif* seasons of 2010-2012 to study the response of finger millet crop to application of fertilizer briquettes containing nitrogen and phosphorus. The response of conventional method of fertilizer application through chemical fertilizers *viz.* urea and di-ammonium phosphate was studied in comparison to briquette application at different levels of fertilizer. The fertilizer briquettes containing nitrogen and phosphorus were prepared on a small scale briquetting machine by compaction of the fertilizer materials viz urea and di-ammonium phosphate without adding any binder. The finger millet crop was sown in paired rows having alternate spacing of 20-40 cm and fertilized through briquettes placed at depth of 5-7 cm alternate bands of the paired rows to accommodate different fertilizer levels. The recommended dose (RDF) of fertilizers applied to the P crop was 60: 30 (kg N, P_2O_5 ha^{-1}). The fertilizer treatments consisted of 100% RDF applied through conventional fertilizers and 100%, 75% and 50% RDF applied to the crop and through briquettes. Nitrogen was applied in two equal splits while phosphorus was applied as basal. The briquettes containing the entire dose of fertilizers was applied as basal at the time of sowing of the crop.

Application of 100% recommended dose of fertilizers through fertilizer briquettes significantly increased the grain yields of finger millet (27.6 q ha^{-1}) when compared to the RDF applied through conventional fertilizers (23.8 q ha^{-1}). Application of fertilizer briquettes @ of 75% RDF also revealed significantly higher grain yield (26.0 q ha^{-1}) as compared to the recommended dose (23.8 q ha^{-1}) applied through conventional fertilizers. The treatment RDF through conventional fertilizer (23.8 q ha^{-1}) was superior over 50% RDF through briquettes (21.6 q ha^{-1}). The straw yields of the crop also revealed the similar trend. The soil analyses after harvest of the crop revealed that the N and K contents did not differ significantly amongst the different treatments. Application of fertilizer through briquettes recorded significantly superior values of P when compared to recommended dose applied through conventional fertilizers. Application RDF through briquette recorded higher uptake of N, P and K (58.3, 21.7, 146 kg ha^{-1}) as compared through RDF applied through conventional fertilizer (52.5, 19.3, 130 kg ha^{-1}). The B:C ratio revealed that application of RDF through briquette recorded significantly highest B:C (1.64) compared to RDF applied through conventional fertilizer (1.45).

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Studies on Zinc Fertilization to Maize Crop

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An experiment was conducted on zinc deficient soil located at Zonal Agricultural Research Station, Shenda Park, Farm, Kolhapur, Sub-Montane Zone of Maharashtra during the *kharif* 2011. The object of the experiment was to study the response of maize crop to application of zinc through soil and also through foliar sprays at different stages of crop growth. The experimental soil was neutral in reaction (pH 7.0) having OC 0.31%, available N 240 kg ha^{-1}, available P 20 kg ha^{-1}, available K 174 kg ha^{-1} and DTPA extractable zinc in soil 0.30 mg kg^{-1}. Zinc sulphate was applied as basal @ 20, 25 and 30 kg ha^{-1}. Crop was sprayed with zinc sulphate @ 0.5% one spray at 20 days of sowing (DAS), two sprays at 35 and 55 DAS, three sprays at 20, 35 and 55 DAS. The recommended dose of fertilizers (150: 60: 40 kg N, P_2O_5, K_2O ha^{-1}) were applied as per soil test (AST) to the crop. Nitrogen was applied in two equal splits as basal and after one month.

The application of zinc to the maize crop through soil was more effective in increasing the yields of maize when compared to the foliar sprays. The treatment AST + $ZnSO_4$ soil application @ 25 kg ha^{-1} recorded the highest grain yield (60.3 q ha^{-1}) and was significantly superior over AST + 5 t FYM ha^{-1} (53.3 q ha^{-1}). Similar pattern was observed in straw yields and uptake of nutrients. Highest uptake of Zn was recorded by the treatment AST + $ZnSO_4$ soil application @ 30 kg ha^{-1} (945 g ha^{-1}) which was at par with AST + $ZnSO_4$ soil application @ 25 kg ha^{-1} (875 g ha^{-1}) and significantly superior over AST + 5 t FYM ha^{-1} (717 g ha^{-1}). Amongst the different treatments of foliar application, the uptake of Zn was highest (781 g ha^{-1}) when the spray was applied at three stages of crop growth. Data revealed that the highest level of $ZnSO_4$ application through soil resulted in slightly lower uptake of phosphorus (28 kg ha^{-1}). The zinc fractions in the soil were marginally influenced due to soil application of zinc sulphate. The treatment AST + $ZnSO_4$ soil application @ 30 kg ha^{-1} recorded significantly higher values of DTPA extractable Zn (0.44 mg kg^{-1}) and acid soluble Zn (0.27 mg kg^{-1}) whereas values at par were observed for water soluble Zn (0.17 mg kg^{-1}) as compared to AST + 5 t FYM ha^{-1} DTPA Zn (0.36 mg kg^{-1}) and acid soluble Zn (0.24 mg kg^{-1}) and water soluble and acid soluble Zn (0.15 mg kg^{-1}).

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Effect of Nutrient Management on Yield Attributes, Yield and Quality of *Kharif* Groundnut (*Arachis hypogaea*) in a Loamy Sand Soil

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A field experiment was conducted at Agronomy Instructional farm, S.D. Agricultural University, Sardarkrushinagar in loamy sand of North Gujarat to study the efficiency of soil application of S, Fe and Zn in combination with FYM on yield, quality, nutrient content and uptake by groundnut and changes in available nutrients status in soil after harvest. There were 15 treatments comprising of combination of three levels of FYM along with N and P : No FYM (F_0), 10 t FYM + 12.5 kg N ha^{-1} (F_1), 10 t FYM + 12.5 kg N +25.0 kg P_2O_5 ha^{-1} (F_2) and five nutrient treatments [S (M_1), Fe (M_2), Zn (M_3), Fe+Zn (M_4) and S + Fe + Zn (M_5)]. The S, Fe and Zn were applied @ 40, 10, and 5 kg ha^{-1} as gypsum, $FeSO_4$ and $ZnSO_4$, respectively. Initial available N, P_2O_5 and S were low but DTPA-extractable Fe and Zn content were medium in soil.

Application of FYM @ 10 t ha^{-1} along with recommended dose of N (12.5 kg ha^{-1}) and P_2O_5 (25 kg ha^{-1}) significantly increased pod and haulm yield, number of pods plant^{-1}, pod yield plant^{-1}, test weight, shelling percentage, chlorophyll content, protein content and oil yield as well as concentration of N, P and Zn in pod and haulm, Fe content in pod; uptake of N, P, S, Fe and Zn by pod and haulm. The combined application of S-Fe-Zn @ 40, 10 and 5 kg ha^{-1} significantly increased the pod and haulm yield, test weight, quality parameters viz., chlorophyll content, protein content, oil yield and P content in pod and haulm, uptake of N, P, S, Fe and Zn by pod and haulm. Application of FYM along with N and P significantly increased available N, P_2O_5, S, Fe and Zn contents in soil. In view of deficiency of available N, P_2O_5, S and medium in Fe and Zn content in soil and high yielding nature of groundnut *var.* GG-20, a distinct advantage of application of S, Fe and Zn @ 40, 10 and 5 kg ha^{-1}, respectively and 10 t ha^{-1} FYM along with recommended dose of N and P was evident.

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Effect of Foliar Applied Thiourea and Micronutrients on Growth, Yield Attributes, Yield and Quality of Wheat (*Triticum aestivum*) in a Loamy Sand Soil

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A field experiment was conducted during *rabi* 2011-2012 at Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. Ten treatments *viz.* T_1 (Control water spray), T_2 (Thiourea @ 0.05%), T_3 (Thiourea @ 0.1%), T_4 ($FeSO_4$ @ 0.5%), T_5 ($ZnSO_4$ @ 0.5%), T_6 (Thiourea @ 0.05% + $FeSO_4$ @ 0.5%), T_7 (Thiourea @ 0.05% + $ZnSO_4$ @ 0.5%), T_8 (Thiourea @ 0.1% + $FeSO_4$ @ 0.5%), T_9 (Thiourea @ 0.1% + $ZnSO_4$ @ 0.5%) and T_{10} (Thiourea @ 0.05% + $FeSO_4$ @ 0.5% + $ZnSO_4$ @ 0.5%) were comprised in randomized block design with three replication. The treatments were applied in wheat as foliar feeding at two stages of plant growth, first at tillering and second at flowering stage. Maximum plant height at 60 DAS and at harvest were observed under T_9 and it was significantly superior over control (T_1) and T_4. The growth parameters *viz.* total and effective tillers per metre row length were found significantly higher under T_9 over control (T_1). The treatment T_9 remarkably secured highest grain yield (55.35 q ha^{-1}) and straw yield (73.94 q ha^{-1}) of wheat which was significantly superior over control (T_1), T_4 and T_5 treatments. Similarly, the protein content of grain was recorded highest under T_9 followed by T_7, T_8 and T_{10} treatments.

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Effect of Foliar Thiourea and Micronutrients on Nutrient Content and Uptake by Wheat (*Triticum aestivum*) in a Loamy Sand Soil

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A field experiment was conducted during *rabi* 2011-2012 at Agronomy Instructional Farm, C.P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. Ten treatments *viz.* T_1 (Control, water spray), T_2 (Thiourea @ 0.05%), T_3 (Thiourea ($ZnSO_4$ @ 0.5%), T_6 (Thiourea @ 0.05% + $FeSO_4$ @ 0.5%), T_7 (Thiourea @ 0.05% + $ZnSO_4$ @ 0.5%), T_8 (Thiourea @ 0.1% + $FeSO_4$ @ 0.5%), T_9 (Thiourea @ 0.1% + $ZnSO_4$ @ 0.5%) and T_{10} (Thiourea @ 0.05% + $FeSO_4$ @ 0.5% + $ZnSO_4$ @ 0.5%) were comprised in randomized block design with three replications. The treatments were applied in wheat as foliar feeding at two stages of plant growth, first at tillering and second at flowering stage. Treatment T_9 gave significantly higher nutrient content i.e. nitrogen, phosphorus, sulphur and zinc were 1.928, 0.393, 0.264 per cent and 14.41 mg kg^{-1} in grain and 0.607, 0.276, 0.256 per cent and 26.54 mg kg^{-1} in straw, respectively over rest of the treatments except T_8, T_{10}, T_7 and T_3. Maximum uptake of nitrogen (151.75 kg ha^{-1}), phosphorus (42.25 kg ha^{-1}), potash (93.54 25 kg ha^{-1}), sulphur (33.52 kg ha^{-1}) and zinc (274.77 g ha^{-1}) were recorded under T_9 but was at par with the treatments T_8, T_{10}, T_7, T_6, T_3 and T_2 while, the maximum content and uptake of Fe (1278.33 g ha^{-1}) was observed in T_8 treatments. Maximum net return of Rs. 51,769 ha^{-1} and benefit : cost ratio (2.34) were also recorded in T_9.

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Effect of Sulphur and Zinc with Recommended Dose of Fertilizers on Growth and Yield of Wheat (*Triticum aestivam* L.)

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The productivity of wheat can be improved considerably by suitable input management practices *viz.,* water and nutrient. N, P, K, Zn and S are important and inevitable nutrients responsible for yield and quality, however, in general, it has not reached to the farmers' practices. Trials on farmers' field were conducted during 2011-12 in the adopted villages of Krishi Vgyan Kendra, Aron. The experimental soil had pH 7.8, electrical conductivity 0.40 dS m^{-1}, organic carbon 0.45%, alkaline $KMnO_4$–extractable N 180 kg ha^{-1} and 1N ammonium acetate extractable–K 395 kg ha^{-1}. Two practices were adopted : Farmers practices (80 kg N and 40 kg P_2O_5 ha^{-1} and improved practices (120, 60 and 30 kg N, P_2O_5 and K_2O ha^{-1}) + 20 kg S ha^{-1} + 5 kg Zn ha^{-1} + 5 t FYM ha^{-1}. All the doses were applied at the time of sowing. Five farmers' fields were selected. A common pest management practices were adopted for the experiment. The growth and yield parameters were influenced by the treatment. Highest tillers $plant^{-1}$ (7.8), earhead length (7.8 cm), seed yield (40.36 q ha^{-1}) and 12.23% increase in yield were recorded under improved practices against the farmers practices i.e. tillers $plant^{-1}$ (5.9), earhead length (7.0 cm) and seed yield (35.99 q ha^{-1}). Highest cost of cultivation (18500 ha^{-1}) gross return (52432 ha^{-1}), net return (33932 ha^{-1}) and B:C ratio (2.83) were recorded under improved practices. Lowest cost of cultivation (17200 ha^{-1}) gross return (46652 ha^{-1}), net return (29452 ha^{-1}) and B:C ratio (2.71) were recorded under farmers practices.

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Distribution of Available Macro and Micronutrients in Soils of Dewas District of Madhya Pradesh

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Role of micronutrients in balanced plant nutrition is well established. However, modem agriculture involving use of high analysis NPK fertilizers coupled with limited use of organic manures and limited recycling of residues are important factors contributing accelerated exhaustion of micronutrients from soil. Micronutrients (Zn, Fe, Cu and Mn) play important role to maintain the soil fertility. The availability of micronutrients to plants is influenced by other soil characteristics. For an effective correction of a micronutrient deficiency in the field, it is necessary to understand the reasons of its deficiency in the soil.

Five soil samples (0–15 cm) from each village (13 village from Sonkatch tehsil and 12 villages from Dewas tehsil) of Dewas district (total 125 samples) were collected and analyzed for physico-chemical properties, macro and micronutrients by using standard procedures. All the samples were moderately alkaline (7.6–8.2). The electrical values varies from 0.35 to 0.61 dS m^{-1}. The calcium carbonate content varied from 2.5 to 4.5% with mean conductivity of 3.6%. Organic carbon content varied from 0.39 to 0.76% with mean value of 0.55%. Available N content varied from 180 to 281 kg ha^{-1} (mean of 226 kg ha^{-1}). Among the samples 83.2% were low and remaining 16.8% medium in available N. The available phosphorus content varied from 16.7 kg ha^{-1} to 26.0 kg ha^{-1} with a mean of 20.9 kg ha^{-1} in which 28.8% were low and remaining 71.2% samples fall under medium in available phosphorus. Available potassium ranged from 368 to 469 kg ha^{-1} with mean value 414 kg ha^{-1}; 100% samples were high in potassium content. Available sulphur varied from 14.0 to 21.9 kg ha^{-1} with an average of 17.6 kg ha^{-1}; 92% samples were low and 8% samples were medium. Available nitrogen, phosphorus, potassium and sulphur content had significant and positive correlation with organic carbon and were negatively and significantly correlated with pH, EC and calcium carbonate. The DTPA-Fe varied from 3.39 to 6.61 mg kg^{-1} with mean value of 4.80 mg kg^{-1} [43.2% samples were deficient, 24% marginal and 56.8% in sufficient]. The DTPA-Zn ranged from 0.38 to 0.74 mg kg^{-1} with mean value 0.54 mg kg^{-1}. Out of 125 samples, 53.6% samples were deficient and remaining are sufficient in DTPA-Zn. Available copper content in the samples varied from 0.08 to 0.16 mg kg^{-1} with mean value of 0.12 mg kg^{-1}. 100% of soil samples were deficient in available Cu and The DTPA-Mn varied from 1.83 to 3.57 mg kg^{-1} with mean value of 2.59 mg kg^{-1}. Among these 3.2% samples were medium and 96.7% high in contents. The availability of Fe, Zn, Cu and Mn increased significantly with increase in organic carbon. DTPA - Fe, Zn, Cu and Mn were negatively and significantly correlated with pH, EC and calcium carbonate.

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Sunflower Productivity and Available Phosphorus Status under Long-term Fertilizer Management in Sunflower-Sorghum Cropping System

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A long-term fertilizer experiment was initiated during 1999-2000 to evaluate the different nutrient management practices in sunflower-sorghum cropping system in *Alfisols* on various soil fertility parameters and the productivity of sorghum and sunflower crops. Fixed plot field experiment was conducted at Directorate of Oilseeds Research farm located at Narkhoda village representing *chalka* soil series, red sandy loams of Southern Telangana region of Andhra Pradesh with low available N (282 kg ha^{-1}) medium in available P (13.3 kg ha^{-1}) and organic carbon (5.2 g kg^{-1}) and high in K (319 kg ha^{-1}). Sorghum (CHS-1) was grown during *kharif* season followed by sunflower (DRSH-1) in *rabi.* Twelve fertilizer treatments were imposed with 3 replications as per recommended doses N: P_2O_5: K_2O: 60:30:30 as N, N-P, N-P-K, 50% N-P-PK, 15% N-P-K, 150% N-P-K and absolute control, N-P-K + crop residues and FYM (5 t) was applied to sorghum, while, N-P-K + S (25 kg)/B (1 kg)/Zn (5 kg) individually and in combination was applied only to sunflower. Soil samples from 0-15 cm depth were collected at post-flowering period of both the crops to assess various soil fertility parameters. Sorghum and sunflower seed yields were recorded at harvest.

Results at 14th year (2012) on sunflower growth, yield and soil available phosphorus status are discussed here. After 14 cycles of cropping, substantial build up of available phosphorus was recorded in all the treatments receiving regular P application of different levels (0, 50, 100 and 150% of recommended P). Significantly highest build up of available P (137 kg ha^{-1}) was recorded in treatment receiving 150% NPK compared to the initial level (13.3 kg P ha^{-1}). In no-manure control and N alone treatment, the available P was at par with initial fertility status. Soil enzyme activities of glutaminase, asperginase, urease and dehydrogenase at post-flowering period were highest in all the treatments receiving P except in N alone and no manure. Growth and yield parameters significantly improved due to application of P as against N alone. This could be due to proliferated root growth and high P uptake by crop when it is supplied with P. The productivity of sunflower over a period of 14 years showed significant variation due to different nutrient management practices. Decline in sunflower productivity was recorded due to continuous application of N alone (651 kg ha^{-1}) which was lower by 47% compared to N + P (1239 kg ha^{-1}) and by 53% compared to NPK application. High sustainable yield index (SYI) for sunflower for the period 1999 to 2012 was attained with P applications, the highest (73%) was noticed due to NPK + S application followed by NPK+FYM treatment (72%) and least was recorded in N alone (41%).

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Response of Mustard (*Brassica juncea*) to Varying Levels of Sulphur and Fortified Vermicompost under Loamy Sand Soil

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Effect of sulphur and fortified vermicompost on growth and yield of mustard [*Brassica juncea* (L) Czern and Coss] was carried out at College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner (Rajasthan) consecutively during *rabi* season: 2010-11 under loamy sand soil. Sixteen treatment combinations comprising four levels of each sulphur and fortified vermicompost were evaluated. Progressive increase in levels of sulphur from control to 40 kg ha^{-1} resulted significant improvement in growth and yield attributes *viz*, plant height, branches $plant^{-1}$, number of siliquae $plant^{-1}$, seeds $siliqua^{-1}$ and test weight. Seed yield (15.98 q ha^{-1}) was 8.9 and 24.02 per cent higher than 20 kg ha^{-1} and control, respectively. Remaining at par with 60 kg ha^{-1}, it also fetched 10.47 and 30.4 per cent higher net returns than above levels of sulphur. Growth and yield attributes, seed yield as well as net returns in mustard also increased considerably with every increase in levels of fortified vermicompost. The highest value of most of these attributes was recorded under 6.0 t ha^{-1}, only. Providing the seed yield of 18.65 q ha^{-1}, this level enhanced it to the extent of 10.86, 13.34 and 79.68 per cent over 4.0 t ha^{-1}, 2.0 t ha^{-1} and control, respectively. Application of fortified vermicompost at 6.0 t ha^{-1} fetched the maximum net returns of Rs 29551 ha^{-1} that were 8.17, 33.73 and 86.05 per cent higher than 4.0 t ha^{-1}, 2.0 t ha^{-1} and control.

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Use of Leaf Colour Chart and Chlorophyll Meter for Site Specific Nitrogen Management in Rice (*Oryza sativa* L.)

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The leaf photosynthetic rate and leaf N concentration are closely related. Chlorophyll meter (SPAD meter) and leaf colour chart are the tools that have been employed for N management in rice, recently. The technology here involves indirect assessment of N requirement of crop based on leaf greenness values and application of N and to match with that of crop need. A field experiment in rice crop (Variety BPT 5204) was carried out during *kharif* season 2012 in randomized block design to study the effect of different dynamic N management options as well as soil test based and blanket (recommended) N application to arrive at a best N management practice. The treatments included recommended fertilizer dose (T_1), soil test based fertilizer application (T_2), SPAD chlorophyll meter based approach *i.e.,* apply N30 if SPAD value < 37 (T_3), < 39 (T_4) and < 41 (T_5) and LCC based approach *i.e.,* apply N30 if LCC reading < 4.0(T_6) < 4.5 (T_7) and < 5.0 (T_8) and were replicated thrice. Nitrogen content in leaves increased up to flowering and was significantly influenced by different N management options. Highest N content of 3.7% in leaves was observed in T_8 at flowering. The highest grain yield of rice (5879 kg ha^{-1}) was recorded in T_7 (N_{30} if LCC value < 4.5) which received 180 kg N ha^{-1} in 6 splits, but found on par with T_5 (N_{30} if SPAD value < 41) which received 180 kg N ha^{-1} in 6 splits, T_2 (soil test based approach) that received 159 kg N ha^{-1} and T_8 (apply N_{30} if LCC value <5.0). SPAD values at 65 DAT and LCC 55 and 65 DAT correlated significantly and positively with N content in leaves and grain yield indicating that leaf colour chart and SPAD chlorophyll meter could be effectively used for monitoring leaf N content in rice and there by N application for achieving higher yields synchronizing the N demand. N application if LCC value is < 4.5 or SPAD value < 41 seems to be good N management options as grain yield, net returns and benefit : cost ratio were the highest.

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Potassium Balance and Use Efficiency under Long-term Fertilizer Experiment of a Rice-Rice Cropping System in an Acidic *Inceptisols*

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As the world population is still increasing and will be about 8.3 billion by 2025 and expansion of arable land is hardly realistic in densely populated Asia, crop intensification is often the main vehicle for increasing the food output. Rice is the staple food of billions of people in Asia, and rice cropping was indeed intensified in many Asian countries during the last 30 years of the 20th century. This intensification crop production, in combination with unbalanced fertilization, has resulted in depletion of potassium in soils over large areas in India. A study was thus conducted to increase the understanding of the effect of potassium together with nitrogen and phosphorous fertilizer supply on grain yield and K- use efficiency and K- balance of the rice-rice cropping system in a long-term fertilizer experiment (LTFE). Soil samples were drawn from a LTFE in progress since *kharif*, 2007 on a sandy loam soil (Udic Ustochrept) at Central Farm, OUAT, Bhubaneswar under the All India Coordinated Research Project. The treatments included various combination of N, P, K and FYM replicated four times in a randomized block design. The site comes under the Agro-Eco region 12.2. The land type is medium with pH-5.08, SOC-4.3 kg ha^{-1}, CEC-3.73 cmol (p+) kg^{-1}, available N, P, K- 187 kg, 19.4 kg and 43.4 kg ha^{-1}, respectively. Data on yields were recorded at harvest and soil samples were analysed for different parameters by standard method. Results from this study showed that 5 years after continuous intensive cropping under various fertilizer and manurial treatments, the application of FYM @ 5 t ha^{-1} along with 100% NPK produced highest yield in both the seasons. Total uptake of K was higher in *rabi* than in *kharif* season but the highest total uptake of K was observed with 100% NPK + FYM for both the seasons. The uptake rate of K varied between 13.35 to 17.86 kg t^{-1}. The highest annual negative K balance of 61.82 kg ha^{-1} was observed in the treatment that received 100% NP followed by 59.79 kg ha^{-1} in 100% N treatment. The 50% NPK treatment showed the highest K recovery of 73.42% white. FYM has got tremendous effect in building up and maintaining the reserve K status over the years. Application of FYM in conjugation with 100% NPK also caused a significant increase in both available and reserve K levels in the surface soils. Thus, long-term rational application of K fertilizer may increase sustainable K fertility of the continuous rice-rice cropping system.

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Response of Foliar Application of Calcium Silicate and Herbal Extract (Ultra Sil) on Nutrient Uptake and Yield of Maize

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Silicon is considered as a beneficial element for higher plants. It is accumulated in plants at a level equivalent to that of macronutrient elements such as calcium, magnesium and phosphorous. Many of the researchers reported increase in nitrogen, phosphorous and potassium uptake and it is helpful In increase in growth parameters and yield of the crops. Hence the present study was undertaken with an objective to study the effect of calcium silicate and herbal extract (Ultra Sil) on growth, nutrient uptake and yield of maize. A field experiment was conducted at Post Graduate Institute, Research Farm, during *rabi* season, 2011-12 with view to study the response of foliar application of calcium silicate and herbal extract (Ultra Sil) on growth and yield of maize. The field experiment was laid out in a randomized block design with twelve treatments and three replications. The treatments comprised of 0.01% calcium silicate and 1 and 2 ml Ultra Sil alone and in combination were applied at one time at 20 and 45 DAS. Nitrogen @ 120 kg ha^{-1} in two splits, phosphorous and potash @ 60 and 40 kg ha^{-1}, respectively were applied at sowing. Significantly higher N, K and Si uptake (228.5, 178.9, 285.7 kg ha^{-1} respectively), grain (85.69 q ha^{-1}) and straw (99.08 q ha^{-1}) yields were recorded under T_6 which received foliar application of 0.01% Ca-silicate spray + Ultra Sil @ 2 ml L^{-1} along with chemical fertilizer dose at 20 and 45 DAS. Maximum phosphorous uptake (107.9 kg ha^{-1}) was recorded under the treatment T_4 which was at par with T_6 and T_9.

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Integrated Management of Zinc in Rice Grown in *Inceptisols* of Odisha

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Zinc deficiency was observed in intensive rice growing areas of Odisha. The DTPA-extractable Zn content in soils of Orissa ranged from 0.24 to 2.18 mg kg^{-1} with mean value of 1.10 mg kg^{-1}. The magnitude of Zn deficiency in the state ranged from 0-76% with mean value of 19%. A field experiment was conducted during 2007-08 to 2010-11 at Central Farm, OUAT to study the integrated management of zinc with eight different treatments and three replications in a randomised block design (RBD). Treatments comprised of T_1-Control, T_2-Zn @2.5 kg ha^{-1}, T_3-Zn @ 5.0 kg ha^{-1}, T_4-Plant residue incorporation, T_5-Zn @2.5 kg ha^2 + plant residue incorporation, T_6-FYM @ 5 t ha^{-1}, T7- Zn @2.5 kg ha^{-1} + FYM @ 5 t ha^{-1}, T8-0.25% Spray as $ZnSO_4$. All the treatments received recommended dose of fertilizer *i.e.* 80-40-40 kg ha^{-1} of N-P_2O_5-K_2O respectively through DAP, urea and MOP. Zinc was applied as soil application and foliar spray in the form of $ZnSO_4$. The soil of the experimental site at Bhubaneswar was *Inceptisol*, sandy loam in texture, acidic (pH 6.1) in reaction and non-saline with EC 0.3 dS m^{-1}, organic carbon content of 0.4%, available P is 11.25 kg ha^{-1}, available K is 120.0 kg ha^{-1} and DTPA extractable Zn of 0.43 mg kg^{-1}. The results revealed that the application of graded level of Zn and its combination with organics significantly increased the grain and straw yields of rice. Highest average yield of (4 years) 4.2 t ha^{-1} and highest harvest index of 46 per cent were obtained when Zn was applied @ 2.5 kg ha^{-1} alongwith FYM. Therefore, application of Zn @ 2.5 kg ha^{-1} along with FYM may be suggested for boosting yield of rice in Zn deficient Inceptisols. The Zn content and uptake was affected by different treatments. The highest Zn uptake of 653 g ha^{-1} was recorded with application of Zn @ 2.5 kg ha^{-1} alongwith FYM @ 5 t ha^{-1}.

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Effect of Different Types of Urea-Briquettes on Yield of Groundnut and Soil Properties

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The experiment was conducted to study the effect of Konkan Annapurna Briquette, Urea Suphala and Urea - DAP briquettes on yield of groundnut. The experiment was conducted during the year 2009-12 at Regional Agricultural Research Station, Karjat, Dist. Raigad (M.S.). The soil was medium black having neutral pH, low electrical conductivity and medium in available nitrogen, phosphorus and potassium. The experiment was laid in randomized block design replicated thrice. Ten treatments were applied *viz.,* T1- Absolute control, T2- Recommended dose of N, P, K; T3- Urea-Suphala briquettes; T4- Konkan Annapurna briquettes; T5- Urea- Suphala briquettes + RHA; T6- Urea-Suphala + Phorate briquettes; T7- Konkan Annapurna Phorate briquettes; T8- Urea- Godavari + SSP briquettes; T9- Urea-DAP briquettes and T10- Urea-DAP briquettes + RHA. The pooled data revealed that the highest pod yield was recorded in the treatment T_6 (41.45 q ha^{-1}) which was significantly higher over treatments T_1, T_7 and T_9. The highest haulm yield was recorded in T_6 (46.78 q ha^{-1}) which was significantly higher over the treatments T_1, T_2, T_5, T_8 and T_{10} but at par with treatments T_3, T_4, T_7, and T_9. The lowest haulm was recorded in T_1 i.e. absolute control (42.05 q ha^{-1}).

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Micronutrient Status in Soils and Plants of Tomato (*Lycopersicon esculentum* L.) in Transition Zone of Karnataka

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Soil and plant samples of tomato (*Lycopersicon esculentum* L.) were collected from fifty-one villages representing dominant tomato growing districts in transition zone of Karnataka for assessing their micronutrient status. Micronutrient status in soils was categorized based on sufficiency and deficiency levels as per critical limits suggested by Lindsay and Norvell (1978). Delineation maps were prepared by superimposing boundary maps with corresponding deficient area. Results revealed that the pH and organic carbon of the soils ranged from 5.14 to 6.13 and 0.31 to 1.11%, respectively. The soils had relatively low DTPA-Zn and Cu than Mn and Fe. The soils were deficient in Zn (ranged from 0.12 to 1.00 mg kg^{-1} with mean value of 0.52 mg kg^{-1}) as its value is below the critical level of 0.6 mg kg^{-1}. Soils were medium to low in boron status that ranges from 0.06 to 0.2 mg ka^{-1} with mean value of 0.10 mg kg^{-1}. Micronutrient content in tomato plants varied widely and locational differences were markedly reflected in their status. Results suggest the need for close monitoring of zinc and boron status in soils to enhance and/or improve the productivity of tomato in Karnataka.

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Nitrogen Efficiency of 27 Promising Potato Germplasm in Comparison to Some Released Cultivars

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Fertilizer inputs are increasing the cost of production of farmers, and there is a major concern for environmental pollution due to excess fertilizer inputs. Higher demands for food and fiber by increasing world populations further enhance the importance of nutrient efficient cultivars that are also higher producers. The objective of this study was to evaluate agronomic efficiency of N in 27 promising potato germplasm in comparison to other cultivars including best control, cvs. Kufri Gaurav and Kufri Pukhraj which had been shown most nitrogen-efficient among the released varieties in various experiments conducted by different workers during last eight years in India.

Field experiments were conducted during the autumn of 2011-12 on an alkaline loam deep alluvial soil (Ustochrept) at the Central Potato Research Station, Jalandhar, Punjab. The 27 germplasm, were tested in a replicated trial using randomised block design with 4 replicates, 4 N rates of (0, 80, 160, 240 kg N ha^{-1}) and 5 control potato cultivars, Kufri Badshah, Kufri Jyoti, Kufri Pukhraj, Kufri Gaurav and Kufri Pushkar. Available N, P and K in experimental site were 112, 6.6 and 114 ppm, respectively. Total tuber yields were recorded at harvest. Agronomic use efficiency (AUE) of N (kg tubers produced kg^{-1} N supply) were calculated as, $AUE = \frac{Y}{X1+X2}$, where Y is tuber yield in a particular treatment (kg ha^{-1}), X1 is soil available N ($KMnO_4$) (kg ha^{-1}) and X2 is quantity of fertilizer N applied (kg ha^{-1}).

Application of different rates of N affected tuber yields of germplasm differently. Quadratic equations describing the relation between tuber yield and the rate of N indicated that that germplasms MS/82-398, J-93-58, J-92-159, MS/82-638, JW-160, E-4486, 83/P-142, JX-115, JN-1197 and JP-132 required 40, 41, 41, 47, 50, 57, 64, 74, 83 and 92 kg N ha^{-1}, respectively to produce tuber yield of 20 t ha^{-1} in comparison to 49 kg N ha^{-1} required by earlier identified the most N-efficient cultivar, Kufri Gaurav to produce this much yield on the same field. Whereas J-93-58, MS/82-638, Kufri Gaurav, MS/82-398, J-92-159 and JW-160 required 125, 140, 153, 158, 182 and 210 kg N ha^{-1} to produce yield of 32.5 t ha^{-1}, respectively. Potato germplasm showed considerable variation in agronomic use efficiency (AUE) of N at different rates of N application. Germplasm MS/82-398, J-93-58, J-92-159, MS/82-638, JW-160, E-4486, 83/P-142, JX-115, JN-1197 and JP-132 showed agronomic efficiency of 51, 44, 54, 42, 48, 42, 33, 34, 40 and 37 kg tubers kg^{-1} N supply without N application in comparison to 42 kg tubers kg^{-1} N supply shown by earlier identified most N efficient cultivar, Kufri Gaurav. Again, MS/82-398, J-93-58, J-92-159, MS/82-638, JW-160, E-4486, 83/P-142, JX-115, JN-1197 and JP-132 had agronomic efficiency of 80, 88, 76, 82, 72, 70, 73, 72, 62 and 62 kg tubers kg^{-1} N supply at N application of 160 kg N ha^{-1} in comparison to 80 kg tubers kg^{-1} N supply shown by cv. Kufri Gaurav. Whereas J-93-58, MS/82-638, MS/82-398, J-92-159, Kufri Gaurav and JW-160 showed mean agronomic efficiency of 71, 70, 69, 69, 67 and 66 kg tubers kg^{-1} N supply. Results showed that the germplasm, J-93-58, MS/82-638, MS/82-398 and J-92-159 appear to be more N- efficient than previously identified most N-efficient cultivar, Kufri Gaurav based on their agronomic efficiency at different rates of N application.

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Effect of Boron Application on Cracking of Arecanut

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A field experiment was conducted on effect of boron application on cracking of arecanut at arecanut Research Station, Shrivardhan, Dist. Raigad (M.S.). The experiment was carried out in coastal saline soils of Maharashtra comprising of twelve treatments. This experiment was started in the year 2010-11 and concluded in year 2012-13. Boron was applied through soil as well as foliar application to arecanut. In soil application 1.0 (T_2), 2.0 (T_3), 3.0 (T_4) and 4.00 (T_5) kg B ha^{-1} and in foliar application 0.025 (T_6), 0.050 (T_7), 0.075 (T_8) and 0.1 (T_9) % boron was applied and compared to control (T_1). The recommended dose of NPK was applied to all treatments.

From the pooled analysis, it was evident that the lowest splitted nuts (5.94) were recorded in T_5 *i.e.* 4 kg B ha^{-1} treatment which was found superior over control. However, in the pooled analysis, it was observed that the effect of B application on arecanut yield was found statistically non significant. However, T_5 treatment recorded maximum yield (8.85 kg palm^{-1}). The non significant results were obtained in pooled data regarding the number of nuts per palm with different boron application. The lowest cracking (1.95%) was recorded in T_5 treatment which was T_9 treatment. The highest N content (0.88%) in nut was recorded in T_4 at par with T_3 and T_5 treatments. In the pooled data, in husk, the highest P content (0.38%) was recorded by T_8 treatment which was at par with the rest except T_1, T_3, and T_4 treatments. The highest K content (6.61%) was recorded in T_5 treatment which was at par with T_6 treatment. But, in husk, potassium content showed non significant results. The highest boron content (28.67 ppm) in nut was recorded by treatment T_5 which was superior over rest of the treatments except T_9, which was at par with T_5. In husk, T_9 treatment recorded highest B content (20.99 ppm) which was at par with T_4, T_5 and T_8 treatments. The soil reaction, electrical conductivity, available N, P showed non-significant results to the different B application to the arecanut. But the available K and B in the soil after harvest showed the significant results. The highest B: C ratio (1.91) was recorded by T_5 treatment *i.e.* 4 kg ha^{-1} B through soil application followed by T_2 and T_3 treatments. Data suggests that the treatment T_5 recorded the highest B : C ratio with higher yield and lowest percentage of cracking in the arecanut of North Coastal Zone of the Konkan region. From the above data, it is concluded that the application of B @ 4 kg ha^{-1} through the soil application along with the recommended dose of fertilizer plays significant role in the reducing the splitting of arecanut.

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Comparative Efficacy of Different Fertilizer Briquettes and Organic Manures on Chilli (*Capsicum annuum* L. CV. Pusa Jwala) in Lateritic Soils of Konkan

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The present investigation entitled "Comparative efficacy of different fertilizer briquettes and organic manures on chilli (*Capsicum annuum* L. cv. Pusa Jwala) in lateritic soils of Konkan" was conducted at Central Experiment Center, Wakawali during *rabi season* 2010-2011. The field experiment was laid out in randomized block design comprising of twelve treatments replicated thrice. Treatments comprised of T_1 (control), T_2 (RDF), T_3 (Urea-DAP briquettes first two at transplanting and second one at 30 days after transplanting (DAT), T_4 (Urea-DAP briquettes first at transplanting, second at 30 DAT and third at 60 DAT), T_5 (Urea-Godavari briquettes first two at transplanting and second one at 30 DAT), T_6 (Urea-Godavari briquettes first at transplanting, second at 30 DAT and third at 60 DAT), T_7 (Urea-Suphala briquettes first two at transplanting and second one at 30 DAT), T_8 (Urea-Suphala briquettes first at transplanting, second at 30 DAT and third at 60 DAT), T_9 (RDF based on soil test), T_{10} (FYM N based), T_{11} (Vermicompost N based) and T_{12} (Poultry manure N based).

It is observed that the application of Urea-Godavari briquettes (3 briquettes plant^{-1}) at transplanting, 30 DAT and 60 DAT) was found significantly superior over rest of the treatments in respect of yield and recorded higher plant height and number of pods plant^{-1}. Quality of the pods in terms of ascorbic acid and capsaicin content increased with application of organic manures alone. Application of Urea-Godavari briquettes at transplanting 30 and 60 DAT recorded higher total N and P uptake while application of Urea-Suphala briquettes at transplanting, 30 and 60 DAT recorded higher total K uptake. However, the total uptake of micronutrients was found non-significant except Cu. The available nutrient status (N, P and K) in soil after harvest improved due to application of all three types of briquettes as compared to RDF and RDF based on soil test; RDF based on soil test significantly increased the available nutrient status over manure application. However, DTPA extractable Fe, Mn, Zn and Cu was found non-significant except Fe at 90 DAT. In general, it is observed that the applications of fertilizers briquettes were found beneficial for getting higher yield of green chilli. It is concluded that the application of Urea-Godavari (14:35:14) briquettes, first briquette at transplanting 30 and 60 DAT was found promising to enhancing the green chilli pod yield of Pusa Jwala variety in lateritic soils of Konkan.

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Agronomic Bio-Fortification of Zn in Rice and Wheat

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Among the micronutrients, Zn deficiency in cereals particularly in rice throughout the world, does not only suppress the productivity of the crop but also causes micronutrient malnutrition in human and animals. Zn deficiency in human causes serious health hazards like disturbance in physical growth, functioning of the immune system, reproductive health, neurobehavioral development *etc.* Zinc malnutrition is considered as a serious problem also in India as held. Improving Zn concentration in economic parts (grain and straw) of cereals is one of the ways to curb the problem. Knowledge regarding zinc accumulation potential of cereal cultivars is thus useful. With this view, the research programme has been taken to study the Zinc bio-fortification in rice and wheat. We evaluated six cultivars of rice and wheat, which were raised in *kharif* and *rabi* seasons respectively, with standard management practices and also with six levels of zinc *i.e.* T_1: no Zn, T_2: Zn as basal soil application @ 5 kg ha^{-1} as $ZnSO_4.7H_2O$, T_3: two foliar applications of Zn @ 0.5% $ZnSO_4.7H_2O$ solution, one at maximum tillering and another at flowering, T_4: Zn as soil application (basal) @ 5 kg ha^{-1} as $ZnSO_4.7H_2O$ + one foliar @ 0.5% $ZnSO_4.7H_2O$ solution at flowering, T_5: Zn as soil application (basal) @ 5 kg ha^{-1} as $ZnSO_4.7H_2O$ + one foliar application @ 0.5% $ZnSO_4.7H_2O$ solution at maximum tillering stage and T_6: Zn as soil application (basal) @ 5 kg ha^{-1} as $ZnSO_4.7H_2O$ + two foliar @ 0.5% $ZnSO_4.7H_2O$ solution, one at maximum tillering and another at flowering with two levels of FYM *i.e.* no FYM and FYM @ 5 t ha^{-1} were applied to the tested cultivars of each crop. Application of Zn fertilizer through different methods increased grain yield from 4.1 to 7.1 and 2.4 to 4.7% in wheat and rice, respectively. Maximum Zn enrichments *i.e.* 37.2 and 87.4% over control in the grains and 85.6 and 73.8% over control in the straws of wheat and rice, respectively were recorded when Zn was applied through soil (basal) + 2 foliar. The extent of antagonism between Zn and Fe on application of Zn fertilizer through different methods followed the decreasing order - wheat (r= - 0.63**) > rice (r= - 0.55**) in grains and wheat (r= -0.68**) > rice (r= - 0.13) in straws. Highest and lowest Zn accumulation potential in the grains were recorded with the cultivars UP 262 and Sonalika respectively in wheat and KRH-2 and Lalat respectively in rice; while in the straws highest and lowest potentials were recorded with the cultivars PBW 343 and DBW 39 respectively in wheat and Gobindo Bhog and GB1, respectively in rice.

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Influence of Phosphorus and Potassium on Yield and Quality of Redgram in Rainfed Alfisols

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India is cultivating 3.9 Mha of pigeon pea (about 77% of the total global area) with annual production of only 2.89 Mt due to low productivity at 741 kg ha^{-1}. To make the nation self sufficient in pulses, productivity levels need to be increased substantially from 741 kg ha^{-1} to 1800 kg ha^{-1} by 2020. Besides increasing the yields, protein content of grains also has to be addressed for improving human health. Therefore, present investigation was conducted to assess the relative effectiveness of soil application of phosphorus and potassium in enhancing the protein and yield of redgram. Field experiments were conducted at Research farm, Agricultural Research Station, Utukur, Kadapa on Alfisols in the Southern Agro-climatic zone of Andhra Pradesh during 2011-12 and 2012-13 to study the effect of phosphorus and potassium fertilization on yield, quality and nutrient uptake by redgram under rainfed conditions. The treatments comprising two varieties (LRG 41 and TRG 38), three levels of phosphorus (50, 75 and 100 kg P_2O_5 ha^{-1}) and five levels of potassium (00, 20, 40, 60 and 80 kg K_2O ha^{-1}) were tested in factorial randomized block design with three replications. The crop (LRG 41 and TRG 38) was sown on 12th July, 2011 and 18th July, 2012 with a spacing of 120×20cm. A uniform dose of 20 kg N ha^{-1} was applied to all treatments.

Results revealed that, application of phosphorus in combination with potassium increased test weight, grain yield, protein content of the grain and nutrient uptake. Test weight, seed yield and protein content of seeds increased significantly up to 75 kg P_2O_5 ha^{-1}. Application of K_2O to the crop had significant positive influence on seed yield up to the dose of 60 kg ha^{-1}. The response of potassium on grain yield over control was 208,330 and 475 kg ha^{-1} with corresponding yield increase of 1.3, 1.4 and 1.6 times respectively during 2011-12. The same trend was also observed during 2012-13.Combined application of P_2O_5 @ 75 kg ha^{-1} and K_2O @ 60 kg ha^{-1} recorded highest grain yield of 1307 kg ha^{-1} during 2011-12 and 661 kg ha^{-1} during 2012-13. Treatments receiving K_2O @ 60 kg ha^{-1} and 75 kg P_2O_5 ha^{-1} found more effective and potent in increasing the test weight (121 gms) over all other combinations. Plots receiving K_2O @ 60 kg ha^{-1} maintained consistency in both the years in improving quality parameters like protein content and volume of dhal, to the tune of 1.1 times higher over control. Potassium content and uptake in grain increased significantly with increasing levels of K_2O, while increasing levels of P_2O_5 did not improve phosphorus content in grain. Application of P_2O_5 @ 75 kg ha^{-1} and K_2O @ 60 kg ha^{-1} with a yield response of 299 kg ha^{-1} was found to be optimum for redgram under rainfed conditions on Alfisols of Southern Agro-climatic zone of Andhra Pradesh.

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Intergrated Application of Fertilizer and Manures on Crop Productivity and Fertility Status in Sunflower in Centenary Old Permanent Manurial Experiment at Coimbatore

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The Permanent manorial experimental at Tamil Nadu Agricultural University, Coimbatore is the oldest in India and second in the series of Permanent Manorial Experiments next to Rothamsted Permanent Manurial Experiment in U.K. This experiment was started in the year 1909, under irrigated condition from 2008 onwards and being maintained by LTFE unit till now. The experiment consisted of 18 treatments which having plot size of 100 m^2 and imposed it as non replicated trial. The main objective of the experiment is to investigate the effect of continuous application of fertilizer nutrients either singly or in combination of two or three nutrients with and without organic manure on yield, uptake and available nutrient status of soil.

Application of recommended dose of 100% NPK along with farm yarm manure @ 12.5 t ha^{-1} recorded the highest grain yield of 1461 kg ha^{-1} and straw yield of 5217 kg ha^{-1} followed by STCR-IPNS. The INM practice recorded its superiority by recording 9.9 and 128.3% increase in grain yield and 16.4 and 251.1% increase in straw yield over 100% NPK and control. Application of organic manures alone and sole application of inorganic fertilizers did not produce higher yields as like that of balanced fertilization and INM practice. Similarly, total NPK uptake by sunflower hybrid was also found to be high in INM practice. Regarding the pH and EC, there was not observed changes in all the treatments. Continuous application of fertilizer nutrients along with organic manures had a profound effect on available nutrients and organic carbon status in post harvest sunflower hybrid grown soil. The results also revealed that the organic C content (0.63%), available nitrogen (224 kg ha^{-1}) and potassium (696 kg ha^{-1}) status found to be high in INM treatment. In case of available phosphorus, application of poultry manure on N equivalent basis recorded the highest available P (31.54 kg ha^{-1}) followed by application of FYM on every year (29.14 kg ha^{-1}) and INM practice (21.56 kg ha^{-1}). When compared to balanced NPK fertilization, skipping of any one or two of the fertilizer from the schedule reduced the available nutrient remarkably.

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Effect of Continuous Manuring and Fertilization on Changes in Enzymes Activity under Permanent Manurial Experimental at Coimbatore

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The Permanent Manurial Experiment (PME) was started in the year 1909 and is being maintained at Tamil Nadu Agricultural University, Coimbatore. The Experimental soil is red sandy loam is texture which belongs to Palathurai soil series (Typic Haplustalf). The soil of PME was initially non saline and alkaline in pH. The present study was conducted with sunflower hybrid being the 156th crop in maize-sunflower cropping sequence of PME trial. PME trial has eighteen treatments, neither replicated and non randomized. Soil samples were collected in four treatments such as control, NPK blanket, INM practice and application of FYM on every year basis at three stages (just prior to basal application of fertilizers, 30 and 45 days after sowing, DAS) and analyzed for enzyme properties.

The acid phosphatase, alkaline phosphatase and dehydrogenase activities were recorded higher in 100% NPK + FYM and lower recorded in control. In case of urease activity, the highest value was recorded in NPK fertilization (T_9), closely followed by INM practice. With the advancement of growth stage of crop, all the enzyme activities increased from 11.21 to 16.37 mg g^{-1} soil h^{-1} for acid phosphatase, 49.99 to 52.45 37 mg g^{-1} soil h^{-1} for alkaline phosphatase, 47.35 to 79.96 mg g^{-1} soil h^{-1} for urease and 5.98 to 8.06 37 mg g^{-1} soil day^{-1} for dehydrogenase. Except urease, all the three enzyme activities recorded higher values in the treatment receiving integrated application of 100% NPK + FYM (T_{10}) and lower value was recorded in control. Balanced NPK fertilization registered the highest urease activity followed by the INM practice. Higher activity of all the enzymes was noticed in just prior to basal fertilizer application followed by 35 and 45 DAS of the crop.

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Continuous Fertilization and Manuring on Yield and Fertility Status in Finger Millet Grown Soil of Long-term Fertilizer Experiment of Coimbatore

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The All India Co-ordinated Research Project on Long Term Fertilizer Experiment (LTFE) was started in 1972 and being maintained till now at Tamil Nadu Agricultural University (TNAU), Coimbatore. The main objective was to study the effect of continuous application of plant nutrients at various combinations of both organic and inorganic forms on the yield and fertility status in finger millet under finger millet-maize cropping system.

The experiment consisted of ten treatments with plot size of 200 m^2 which were replicated four times in randomized block design. The experimental soil (Periyanaickenpalayam soil series) is sandy clay loam in texture and taxonomically grouped under *Vertic Ustropepts*. Results revealed that application of 100% NPK along with FYM @ 12.5 t ha^{-1} recorded the highest grain (3125 kg ha^{-1}) and straw (5123 kg ha^{-1}) yields of finger millet. The grain yield increase in INM practice was 15.7% and 23.5% increase was seen in straw yield over 100% NPK. The drastic reduction in grain and straw yield of finger millet was noticed in continuous addition of N alone and in control. Grain yield of finger millet recorded in 100% NP was also comparable with 100% NPK. Higher total uptake of NPK by finger millet was also noticed like that of yield of finger millet. With respect to soil pH and EC, no significant changes was observed in the treatments. Organic carbon ranged from 0.43 to 0.63%. Higher organic carbon was recorded in 100% NPK + FYM which was 18.9 and 46.5% increase over 100% NPK and control. This was followed by 150% NPK whereas the lowest value recorded in control. Application of recommended dose of 100% NPK along with FYM recorded the highest available N (211 kg ha^{-1}), P_2O_5 (26.65 kg ha^{-1}) and K_2O (774 kg ha^{-1}). The INM practice recorded 21 kg ha^{-1} increase in available N, 4.57 kg ha^{-1} increase in available P, 41 kg ha^{-1} in available K than 100% NPK. Available micronutrients like Cu, Fe and Zn was found to be deficient in all the treatments except Zn in Zn-applied treatment whereas Mn seemd to be sufficient in all the treatments. Biomass C and N also higher in the INM practice followed by 150 and 100% NPK.

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Response of Different Level and Method of Application of Boron (B) and Zinc (Zn) on Crop Yield under Rice–Wheat Cropping System in Acid Alfisol of Jharkhand

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This rice-wheat cropping system is the most nutrient exhaustive. Replenishment of major nutrients and ignorance towards micronutrients have resulted in an imbalanced situation which is limiting the yield maximization efforts. In general, zinc (Zn) deficiency is very common in rice growing areas whereas zinc (Zn) and boron (B) deficiencies are prevalent in wheat.

A field experiment was conducted during 2012-13 at research farm of Dept. of Soil Science & Agril. Chemistry, BAU, Ranchi to know the response of different levels and method of application of Boron (B) and zinc (Zn) under rice - wheat system. During *kharif* test crop rice (*var*. Sahbhagi) was grown and after crop harvest, wheat (*var*. K- 9107) was grown in the same plot with same treatment combinations. All together 16 different treatments combination of four levels of Zn (0, 5, 10 and 5 kg Zn ha^{-1} + 2 foliar sprays of $ZnSO_4$. $7H_2O$ (0.5%) at tillering and before flowering) and four levels of B (0, 1, 1.5 and 1 kg B ha^{-1} + 2 foliar sprays of Borax (0.2%) at tillering and before flowering) with 3 replications were laid down in field. The results revealed that application of 1 kg B ha^{-1} + 2 foliar sprays of Borax (0.2%) was found at par with soil application of 1.5 kg B ha^{-1} and was found superior to control and 1 kg B ha^{-1}. Similarly, application of 5 kg Zn ha^{-1} + 2 foliar sprays of $ZnSO_4$. $7H_2O$ (0.5%) was found at par with soil application of 10 kg Zn ha^{-1} and was found significantly higher than control and 5 kg Zn ha^{-1}. Foliar application of Zn, and B solution at tillering and before flowering stage in rice-wheat cropping system was found to significantly increase the system yield.

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Improving N Use Efficiency through Modified Scheduling under Pearlmillet-Wheat Cropping System

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Recent diagnostic surveys indicated that in the high productivity areas of irrigated ecosystems, like Trans- and Upper Gangetic Plain zones, farmers have resorted to excessive use of fertilizers, especially N, to maintain the yields at levels attained previously with less fertilizer input. Such indiscriminate use of N fertilizers not only aggravates the extent of soil fertility depletion, but also proves harmful in terms of low nutrient use efficiency, poor quality of produce, enhanced susceptibility of crops to biotic and abiotic stresses, and a potential threat to groundwater due to excessive leaching of nitrates beyond root zone. Hence a field experiment was conducted for three consecutive years on a Typic Haplustept of IARI, New Delhi to study the effect of different N levels under conventional and modified N scheduling with or without organic manures on N use efficiency and crop productivity in a pearlmillet-wheat cropping system.

The experiment, laid out in spilt-plot design with 03 replications, was comprised of 4 main plots *i.e.* FYM, sulphitation pressmud (SPM), *Sesbania* green manure and summer fallow (No-organic), 2 sub-plots *i.e.* conventional N splits (basal+2 top dressing) or modified N splits (no basal+ 3 top dressings), and 4 sub-sub-plots *i.e.* N rates (0, 40, 80 and 120 kg N ha^{-1} in pearlmillet, and 0, 60, 120 and 180 kg N ha^{-1}, in wheat). Instead of conventional 3-splits *i.e.* basal dressing + 2 top dressing, skipping of basal N for one additional top dressing resulted in substantial increase in pearlmillet yield by about 0.3 t ha^{-1} and wheat yield by more than 0.5 t ha^{-1} across the organic manure treatments. The agronomic N use efficiency and N recovery was also improved with the skipping of basal N application and increasing an additional N top-dressing in pearlmillet-wheat system. It was also possible to curtail 20-25 kg N ha^{-1} in each crop by modified N scheduling. Results further revealed that modified N splits increased not only the N use efficiency, but also minimized the NO_3-N leaching.

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Herbicide-*Comlizer* Mixture for Weed and Nutrient Management in Winter Rice

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High effectiveness of chemical control as against soaring wage *vis-à-vis* shortage of agricultural worker had facilitated increase in the consumption of herbicides day by day. The herbicides and the nutrients are often subjected to loss by runoff water owing to erratic rainfall during winter rice. The present study was carried out to evaluate efficacy of herbicide and effect of nutrients in winter rice through possible increase in their retention in soil by applying as herbicide-compost-fertilizer mixture. Biofertilizer-incubated (*Azospirillum* and PSB 2 g kg^{-1} each for 15 days with 25±1% moisture) vermicompost 2 t ha^{-1} and four levels *viz*., 30, 60, 75 and 90% of recommended dose fertilizer mixture (*Comlizer*) was evaluated along with recommended practice in terms of weed and nutrient management in rice crop. The *comlizer* was applied at 3, 30 and 60 days after transplanting (DAT) of rice seedlings and pretilachlor 750 g ha^{-1} was applied by mixing with the *comlizer* at 3 DAT followed by one hand weeding at 30 DAT. The 30% RDF level was additionally evaluated with 3 t ha^{-1} vermicompost following the same method. Mixing of fertilizers or herbicide with the compost significantly reduced the population of bacteria in the *comlizer* and the difference was significant between 10 and 20% or 20 and 30% RDF. Use of herbicide, irrespective of application with sand or *comlizer*, significantly reduced weed density and dry weight at 30 and 60 DAT compared to untreated control, which accounted for highest nutrient removal by weeds at different crop growth stages. Application of 75% RDF with 2 t ha^{-1} vermicompost as *comlizer* recorded longest panicle length, highest filled grains $panicle^{-1}$, grain and straw yield, which differed significantly to others barring few instances. The highest uptake of N, P and K was observed due to application of 75% RDF with 2 t ha^{-1} vermicompost as *comlizer* and the difference, except for few cases, was statistically significant to other treatments. The soil pH, organic carbon and available nutrient content in soil after harvest of crop was not affected by the treatments. The population of *Azospirillum* and phosphate solubilizing bacteria in soil at 30 DAT was significantly higher in *comlizer* applied plots, the difference among the treatments was statistically insignificant.

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Influence of Long-term Balanced Nutrition on Yield and Yield Sustainability of Rice-Rice Cropping System in an Inceptisol

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Influence of long-term balanced nutrition in rice-rice cropping system was studied in the Long-Term Fertilizer Experiment being conducted since 2000-01 at Jagtial, Karimnagar district, Andhra Pradesh. Low grain yields were obtained (2000-01 to 2010-11 data) in control plots (average of 3124 by ha^{-1} in *kharif* and 2591 kg ha^{-1} in *rabi*). Application of only nitrogen (@ 120 kg ha^{-1}) recorded 40.7% higher grain yield (4395 kg ha^{-1}) in *kharif* and 34.3% higher grain yield (3481 kg ha^{-1}) in *rabi.* However, when balanced nutrition was given by applying NPK (120–60-40 kg ha^{-1}) yield increase was much higher. Application of NPK resulted in a grain yield of 5385 kg ha^{-1} in *kharif* and 4903 kg ha^{-1} in *rabi*. The yield increase over control was 2261 kg ha^{-1} (72.4%) in *kharif* and 2312 kg ha^{-1} (89.2%) in *rabi.* Balanced nutrition (application of NPK) increased the yield over imbalanced nutrition (application of only N) by 990 kg ha^{-1} (22.5%) in *kharif* and 1422 kg ha^{-1} (40.9%) in *rabi.* The sustainability yield index (SYI) in control was 0.31. The yield sustainability increased with successive addition of each nutrient. Sustainability yield index of 0.45, 0.50 and 0.53 was recorded with application of N alone, NP and NPK, respectively. Further, the balanced nutrient application at lower dose (50% NPK, 60-30-20 kg ha^{-1}) resulted in higher grain yield than imbalanced nutrient application with higher dose of N alone (100% N alone). Application of 50% NPK resulted in a grain yield of 4554 kg ha^{-1} (3.6% higher than only N) in *kharif* and 3898 kg ha^{-1} (12.0% higher than only N) in *rabi*. Application of organic manure (FYM @10 t ha^{-1} in *kharif*) along with fertilizer NPK did not increase the yields over application of only fertilizer NPK. But it recorded higher SYI (0.53) than only fertilizer NPK (0.53) application indicating the importance of integrated nutrient management for higher yields. Depletion of available phosphorus was observed where phosphorus was not applied (control and only N treatments) while build up of available P was observed in all the other treatments where phosphorus was applied. The importance of balanced nutrition for higher yields and sustainability of the yields is evident from the study.

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Declined Productivity in Alfisols under Long-term Fertilizer Experiments: Magnitude and Remedies

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Alfisols covers sizeable areas in the states of Kerala in South, Assam, Arunachal, Meghalaya in North East, Uttaranchal and Himachal Pradesh in North and Chhatisgadh, Jharkhand and Orrisa in East. Nearly 25-30 m ha cultivable land having pH < 5.5 is associated with several inherent problems like inadequacy of P, K, Ca, Mg and B and toxicity of Cu, Al and Fe. Application of nitrogenous fertilizer further declined the soil pH which reduces the availability of P and K. Therefore, availability of these elements / nutrients needs to be ensured in acid soil. Soil acidity and poor fertility have very strong positive relationship. Long-term fertilizer experiments played a vital role to enhance and sustain the productivity of these soils. In Alfisols, the nitrogenous fertilizer had detrimental effect on productivity and soil health if supply or availability of other nutrients in right proportion were not ensued. Application of P enhanced the crops productivity by 2.2 - 21.0 q ha^{-1} and K 3.6 to 33.0 q ha^{-1}. At Palampur, S was another nutrient which has increased the crop productivity to the extent of 11 to 14 q ha^{-1}. Application of soil amendments like lime and FYM coupled with recommended doses of N, P, K and S increased the crop yield to the extent of 2.7 to 8.9 q ha^{-1} and 3.6 to 14.2 q ha^{-1}, respectively. Thus, balanced nutrients application coupled with soil amendments enhanced productivity approximately by 2 t ha^{-1} per annum which could give predictably additional grain production of 50 Mt. Superimposition of nutrients in N treatment that was degraded for 32 years proved that those can be rejuvenated within a period of 2-3 years with balanced application of nutrients and soil amendments.

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Long-term Effects of FYM and Fertility Levels on Depletion of Micronutrients under Intensive Cropping System in Loamy sand Soil at Anand

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The use of high analysis fertilizers has created deficiency of micronutrients in soil which started showing signs of fatigue, as judged by decline in yield of crop as well as lower response to applied chemical fertilizers. A long-term experiment (since 1980) is in progress to study the role of low (50% NP of recommended dose, RD), medium (100% NP of RD) and high (150% NP of RD) fertility on micronutrients depletion under *bajra*-mustard-cowpea (fodder) cropping sequence on loamy sand (*Typic Ustochrepts*) at Anand. The experiment was modified in 1994 to study the depletion pattern of micronutrients in presence of FYM application. The application of FYM @ 10 t ha^{-1} were made every year before the *kharif* crop.

The initial soil micronutrient status in 1980 was 11.5, 15.7, 0.61 and 2.4 mg kg^{-1} for Fe, Mn and Cu, respectively. The Zn declined and reached below critical limit of 0.5 mg kg^{-1} after 13 crops grown in quick succession. The Zn status was improved through supplement after 14 crops and again it had declined below the critical limit of 0.5 mg kg^{-1} after 28 crops in 10 year. Similarly after 28 crops, Fe availability had almost attained the critical level of 5.0 mg kg^{-1} demanding replenishment of Fe to sustain production. Thus, there is a need to supply adequate quantity of Zn and Fe after 13 to 14 and 28 successive crops, respectively. In case of Mn, the continuous decline was noticed and it had reached below the critical limit of 5.0 mg kg^{-1} after 90 crops grown in quick succession.

The improvements in yield of the crops over control were to the tune of 60, 102 and 130 per cent due to low, medium and high fertility levels, respectively. The minimum quantity of micronutrients removal was recorded under FL0 as against the maximum removal under the highest fertility level of FL3. The soil status after 90 crops of cowpea showed significantly improvement in Fe, Mn, Zn and Cu contents due to FYM application.

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Effect of FYM and Nitrogen on Growth and Nutrients Uptake by Kalmegh (*Andrographis paniculata*) in Typic Torripsamments of Hisar

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Kalmegh, also known as 'king of bitter' belonging to the family 'Acanthaceae', has wide range of medicinal applications for controlling many diseases, due to its powerful immune strengthening benefits. Quality of any crop depends upon the concentration of different nutrients in it. Therefore, a pot experiment was conducted to study the effect of N in combination with FYM on plant growth and nutrients uptake by kalmegh cv. local) at screen-house, Department of Soil Science, CCS Haryana Agricultural University, Hisar. The soil (Typic Torripsamment) used was loamy sand in texture having pH 8.0, EC (1:2) 0.34 dS m^{-1}, OC 0.26%, available N, P and K 112.6, 12.0 and 192.0 kg ha^{-1}, respectively. The OC, N, P and K content in FYM were 38.4, 0.87, 0.29 and 0.73%, respectively. The treatment combination comprised of four levels of nitrogen (0, 12.5, 25 and 37.5 mg N kg^{-1} soil) applied through urea along with three levels of FYM (0, 12.5 and 25 t ha^{-1}). Completely Randomized Design was followed with three replications. The crop was harvested after 120 days of sowing and observations were recorded separately in each pot. Application of N significantly increased the dry weight of kalmegh from 4.0 to 5.1 g pot^{-1} over control. Application of FYM also increased the dry weight significantly from 4.0 to 4.6 g pot^{-1} over control. Application of N @ 12.5, 25 and 37.5 mg N kg^{-1} soil significantly increased the N uptake by kalmegh from 130.0 to 155.2, 171.0 and 178.0 mg kg^{-1}, respectively over control. Application of 12.5 and 25 t FYM ha^{-1} increased the N uptake by kalmegh from 149.6 to 159.3 and 166.6 mg kg^{-1} over control. Application of N @ 12.5, 25 and 37.5 mg N kg^{-1} soil also increased average P uptake by kalmegh from 10.2 to 12.2, 13.9 and 14.6 mg kg^{-1} respectively over control and this increase was to the tune of 19.6, 36.3 and 43.1 per cent. Application of FYM @ 12.5 and 25 t ha^{-1} enhanced the P-uptake from 12.0 to 12.8 and 13.2 mg kg^{-1} respectively. Average K-uptake by kalmegh increased from 103.7 to 125.2, 142.5 and 151.4 mg kg^{-1} with the application of 12.5, 25 and 37.5 mg N kg^{-1} soil, respectively over control. This increase was to the extent of 20.7, 37.4 and 46.0% over control. Application of FYM @ 12.5 and 25 t ha^{-1} enhanced the K-uptake from 119.8 to 133.2 and 139.1 mg kg^{-1} respectively over control. Application of N improved the available N status in soil after the harvest of crop. However, P and K were decreased. Application of FYM improved the status of all these nutrients in soil after the harvest of crop.

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Physiological Approaches for Improving Phosphorus Use Efficiency of Crops–Recent Dvelopments

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Phosphorus is a precious nutrient element for agriculture as it cannot be substituted by other element in crop production. It is an essential macronutrient required for plant growth and development. It is one of the key constituents of bio-molecules and also regulates many biological processes. In many agricultural production systems covering 70% of terrestrial biomass of the world, P is the limiting nutrient in soils affecting crop productivity. Natural P reserves are limited in nature. Most of the P fertilizers used in agriculture are derived from mined rock phosphates and its availability is speculated to peak at the end of next decade. According to the Global Phosphorus Research Initiative (2009), the demand for P globally will increase in future leading increased burden on economy of any country in order to make phosphatic fertilizers available to farmers.

Plants have developed several adaptive strategies involving changes at physiological, biochemical and molecular levels which is ultimately expressed as phenotypic traits under low P stress. Changes in root system architecture such as increase in root-to-shoot ratio, number of lateral roots, root hair length and density are some of the traits that enhance plants' P mining ability. In plants belonging to Proteaceae family, special structures like 'proteoid' or 'cluster' roots are formed which are efficient in exudation of carboxylates. Increased production and secretion of organic acids and enzymes such as purple acid phosphatases and ribonucleases in the rhizosphere helps in mobilization of P. Association between plant roots and arbuscular mycorrhizal fungi is another means of improved P acquisition studied in several crops.

Developing P efficient plants by modifying the plants' own strategies to cope with P-stress would be a sustainable approach without compromising on the environment as well as non-renewable P resources. Enhancement of P efficiency includes 'acquisition/uptake' efficiency and 'utilization' efficiency. In this regard characterization of existing germplasm for genetic variation towards adaptation to low P among food crops is urgently required. Such variations are critical for development of crop plants with better growth and development under P limiting conditions through marker assisted breeding or genetic manipulation. The genes encoding for Acid Phosphatases, transcription factors, Pi transporters, protein kinases and those involved in the production of organic acids may be targeted for improving P use efficiency of plants. Deployment of root phenes in crop breeding programs will also enable to develop superior genotypes with enhanced P acquisition efficiency of crops. Furthermore crops can be inoculated with specific PGPR or mycorrhizal inoculants to improve the potential yield under such limiting P conditions. The integration of genetically improved P efficient cultivars with better agronomic management is important for improving phosphorus use efficiency. In conclusion, development of P-efficient crops with less dependency on chemical P fertilizers is indispensable for the future sustainable crop solutions in the light of ever diminishing P reserves.

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Long-term Effects of Manures and Fertilisers on the Productivity of Rainfed Cotton and Soil Fertility in Vertisols

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Cotton is the major commercial crop widely grown in black soils in the raifed belt of krishna zone. The region has assured annual rainfall of around 1000 mm and soils are highly fertile black cotton soils (Vertisols). Monocropping of cotton has been followed from many years and heavy fertiliser usage is also wide spread. Hence to understand the effects of cotton monocropping and application of only inorganic fertilisers on soil fertility and soil productivity, a long-term soil fertility experiment was initiated at Regional Agricultural Research Station, Lam, Guntur in *kharif*, 1991-92 with eleven treatments which include various doses of RDF (0, 50, 100, 150, 200%) and different orgnic and inorganic amendments like FYM, Gypsum, $ZnSO_4$ and $MgSO_4$. The soils of the experimental location were black cotton soils slightly alkaline, non saline, low in orgnic carbon and available N and P_2O_5 and high in available K_2O.

Year wise kapas yield and changes in various soil properties like pH, EC, % organic C and available N, P and K status over the 21 years of experimentation was recorded. The mean kapas yield over the years ranged from 1163 to 1821 kg ha^{-1} with a mean value of 1610 kg ha^{-1}. The highest mean yield of 1821 kg ha^{-1} was recorded in the treatment of 100% RDF+FYM 10 t ha^{-1} treatment followed by 1765 kg ha^{-1} in 150% RDF and 1736 kg ha^{-1} in and 200% RDF treatments while the lowest mean yield of 1163 kg ha^{-1} was recorded in the control treatment. The mean soil pH ranged from 8.14 to 8.27 with a mean of 8.21. Even though the soil pH did not vary widely, the treatments receiving higher dose of RDF, *viz.* 150% RDF, 200% RDF and tretments receiving FYM (100% RDF+FYM 10 t ha^{-1}) and gypsum (100% RDF+gypsum 500 kg ha^{-1}) recorded lower pH values of 8.19, 8.15, 8.14 and 8.16 respectively compared to control which recorded the highest value of 8.27. The mean EC values ranged from 0.24 to 0.31 dS m^{-1} with a mean of 0.27 dS m^{-1} and the treatments 200% RDF and gypsum (100% RDF + gypsum 500 kg ha^{-1}) recorded the higher EC values of 0.31 dSm^{-1} and control plot recorded the lowest (0.24 dS m^{-1}). However all the treatments have showed decline in pH and EC values over the initial values of 8.4 and 0.60 dSm^{-1} respectively. There was slight build up in the organic C content in soil which ranged from 0.37 to 0.56% when compared to initial value of 0.37%. The tretments receiving FYM (100% RDF+FYM 10 t ha^{-1}) recorded the highest C content of 0.56%. The soils are low in available N and showed further decline over the years from the initial value of 196 kg ha^{-1}. The mean available N content ranged from 165 to 197 kg ha^{-1} and the 100% RDF+FYM 10 t ha^{-1} recorded the highest available N content (197 kg ha^{-1}). The availble P_2O_5 and K_2O contents showed build up over the years. However the build up in availble P_2O_5 was not so high when compared to initial value of 23 kg ha^{-1} and the mean values ranged from 22.77 to 37.74 kg ha^{-1}. The mean available K_2O content ranged from 557 to 748 kg ha^{-1} and significant build up was noticed in all the treatments when compared to the initial value of 392 kg ha^{-1}.

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Efficacy of Organic Sources in relation to Dry Matter Yield of Rice, Nitrogen Uptake and Release Kinetics in a Typic Haplustept

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A pot culture and incubation experiments were conducted to study the relative efficacy of five organic sources *viz.* farm yard manure (FYM), biogas slurry (BGS), sewage sludge (SS), rice straw (RS) green leaves of dhaincha (GLD) having variable C:N ratio (15.7-59.4) on dry matter yield of rice (Pusa Sugandh-4), N uptake release kinetics in a Typic Haplustept at IARI, New Delhi. The experimental soil was sandy loam in texture, alkaline in reaction, low in organic C and available N. All organic sources were mixed in the soil @ 2% along with 50% recommended doses of N, P and K for pot culture experiment. Treatments of 100% NPK and control were also taken for comparison. For incubation study organic sources were added @ 2% in soil and soil samples were kept for incubation up to 90 days in plastic bottles.

Results of the incubation study revealed that the magnitude of mineral N (48-78 mg kg^{-1}) in soil amended with organic sources increased up to 45 days of incubation. Thereafter, it started decline due to progressive immobilization. The highest magnitude of mineral N was recorded in GLD amended soil and followed by sewage sludge. The kinetics of N mineralization showed that the GLD amended soil gave the highest potentially mineralizable nitrogen (N_o) 42.6 mg kg^{-1} among all the organic sources used. The 1st order N mineralization rate constant (K) ranged between 0.084 and 0.110 day^{-1}. Whereas the nitrogen availability index (N_oK) of organic sources amended soil was in the following order GLD>SS>BGS>FYM>RS. Findings of pot culture revealed that application of GLD and SS along with 50% NPK gave the maximum dry matter yield of rice (41 and 38 g pot^{-1}) which was at par with 100% NPK alone. Results also showed that dry matter yield and N uptake in rice increased from 42 to 81% and 46 to 85% over control with the application of organics along with 50% NPK. The study highlights the importance of nitrogen supply to plant growth from different organic sources which along with fertilizer have higher efficacy.

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Interaction Effects of Nitrogen and Potassium on Yield, Nutrient Uptake and Nitrogen Use Efficiency (NUE) by okra (*Abelmoschus esculentus* L.)

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Okra is one of the important vegetable crops that grows on light textured soils (*Alfisols*). In general the crop responds well to nitrogen and potassium application. The present investigation was carried out to identify the optimum N and K combination for Okra crop in *Alfisols*. A field experiment was carried out during *kharif*, 2011 on a sandy loam soil (*Alfisol*) at Student's Farm, College of Agriculture, Rajendranagar, Hyderabad with a view to study the effect of levels of nitrogen (N_0-0, N_1-60, N_2-120 and N_3-180 kg N ha^{-1}) and potassium (K_0-0, K_1-30, K_2-60 and K_3-90 kg K_2O ha^{-1}) on okra pod yield, uptake of nutrients and nitrogen use efficiency (NUE) by okra. Randomized Block Design with factorial concept was followed. There was a significant increase in the pod yield of okra with increase in levels of N and K. Among the different interactions (NxK), the highest pod yield (126.17 q ha^{-1}) was recorded with N_3K_3 (180 kg N ha^{-1} + 90 kg K_2O ha^{-1}) followed by N_3K_2, N_2K_3 and N_2K_2 combinations. The N and K uptake was significantly increased with increase in the levels of N and K at all the growth stages *viz.,* 30, 60 and 90 DAS. The synergistic effect of N × K on increase in NUE was used as one of the measure to identify the optimum combination of N and K. The N_2K_2 (120 kg N ha^{-1} + 60 kg K_2O ha^{-1}) combination recorded higher NUE (38) than N_3K_3 combination (22.6), which gave maximum yield. Though the pod yield and nutrient uptake was recorded at N_3K_3 level was high, keeping in view the NUE, application of 120 kg N ha^{-1} combined with 60 kg K_2O ha^{-1} *i.e.,* N_2K_2 can be suggested as optimum combination which also reduces the cost on fertilizers applied to okra grown on Alfisols.

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Available Cationic Micronutrients in Soils of Kachchh District (Gujarat) in Relation to Soil Properties

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Micronutrients are important for maintaining soil health and also for increasing productivity of the crops. Increased removal of micronutrients as a consequence of adoption of high yielding varieties and intensive cropping together with shift towards high analysis NPK fertilizers has caused declined in the level of micronutrients in the soil to below normal at which productivity of crops cannot be sustained. Available micronutrient cations status of soils of Kachchh district has not been comprehensively studied. Hence, there is an urgent need to assess the availability of micronutrient cations in soils of Kachch district and their relationship with some important soil properties.

A total of 488 surface soil samples (0-15 cm) were collected from all the talukas of Kachchh district (Bhachau, Rapar, Abdasa, Lakhpat, Nakhatrana, Anjar, Bhuj, Mundra, Mandvi and Gandhidham) and analyzed for particle size distribution and various soil characteristics (pH, EC, OC, Available P_2O_5, K_2O, S, Fe, Zn, Mn and Cu) using standard analytical procedures. The results indicated that the DTPA-extractable Fe, Zn, Mn and Cu content of soils varied from 1.26 to 16.44, 0.20 to 2.88, 2.78 to 18.79 and 0.16 to 2.20 mg kg^{-1} with the mean value of 5.47, 0.84, 7.62 and 0.78 mg kg^{-1}, respectively. Considering 5.0 and 0.5 mg kg^{-1} as critical limit for DTPA-extractable Fe and Zn, respectively, 48.36 and 26.48 per cent soil samples falls under low category in Fe and Zn, respectively. A relatively less extent of Mn deficiency (15.37%) was observed. However, Cu deficiency is almost negligible (0.41%) in the soils. A significant and positive correlation of Fe (r=0.291**), Zn (r=0.340**), Mn (r=0.273**) and Cu (r=0.317**) with organic carbon content of the soils was obtained which indicates the importance of organic matter in promoting the availability of these nutrients. Thus, it becomes apparent that Fe and Zn deficiencies is wide spread in soils suggesting a need for using Fe and Zn fertilizers for sustained crop production.

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Soil Fertility Status in Patan District of North Gujarat

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Agriculture with sustained efforts to increase crop yield has not only depleted our soils of their nutrient reserves, but also resulted in the emergence of a number of new nutrient deficiency in the soils. Amount of fertilizers required for the same crop varies from soil to soil. Maintenance of soil fertility is immense concern to harness higher yields. Therefore, an attempt was made to study the fertility status of cultivated soils of Patan district of Gujarat. Three hundred sixteen surface (0-15 cm) soil samples were collected from the seven talukas (Siddhpur, Patan, Chanasma, Harij, Sami, Radhanpur and Santalpur) of Patan district during 2012. The samples were analyzed for particle size distribution and various soil characteristics (pH, EC, OC, available P_2O_5, K_2O, S, Fe, Mn, Zn and Cu) by adopting standard analytical procedures.

Soils are sandy to loamy sand in texture and neutral to alkaline in reaction. More than 69% soil samples have soluble salt content under safe limit and only 23.4 and 7.3% soil samples falls under moderate and harmful categories, respectively with respect to salinity. Most of the soils (78.8%) of Patan district are low in organic C content indicating overall poor fertility of the soils. The nutrient index values for available phosphorus, potash and sulphur ranged from 1.78 to 2.43, 2.27 to 2.93 and 2.19 to 2.3, respectively. These indicating marginal to high fertility status of phosphorus, high to very high fertility status of potash and adequate amount of sulphur in these soil. The nutrient index for Fe and Zn ranged from 1.79 to 2.22 and 1.80 to 2.17 indicating marginal to adequate fertility status of soils in respect to Fe and Zn. The higher nutrient index was noticed in all the talukas for Mn (2.37 to 2.74) and Cu (2.67 to 2.89) with fertility status ranging from high to every high.

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Site Specific Nutrient Management on Turmeric (*Curcuma longa* L.) under Reclaimed Sodic Soil

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Turmeric (*Curcuma longa* L.) belongs to family Zingiberaceae. It is widely used as spices and natural coloring agents in food cosmetics and dye. Curcuminoids is its active constituents and have some medicinal properties. The Site Specific Nutrient Management (SSNM) is the concept of nutrient management, done on the basis of soil testing from the particular field where the crops are to be grown. For optimization of the rhizome yield, a field experiment was carried out at Banthra Research Station of National Botanical Research Institute, Lucknow during 2011-12 and 2012-13. The properties of the soil were pH - 8.65, EC- 0.31 dS m^{-1}, organic C - 4.6 g kg^{-1}, available N - 146 kg ha^{-1}, available P - 32.0 kg ha^{-1}, available K - 194 kg ha^{-1}, available S - 16.4 kg ha^{-1} and DTPA extractable Zn - 0.54 ppm. The treatment combination were T_1 - Control, T_2 - 100% NPK (125: 60: 90), T_3 - 100% NPK + S_{30}, T_4 - 100% NPK + Zn_{30}, T_5 - 100% NPK + S_{30} Zn_{30}, T_6 - 100% NPK + S_{30} Zn_{30} + 20 t FYM, T_7 - 125% T_5, T_8 - 150% T_5 with four replications and design was RBD. The variety of the test crop was APH-1. Results indicated that plant height, number of leaves $plant^{-1}$, mother rhizomes, primary rhizomes and rhizome yield increased with the application of nutrients corresponding to treatments on the basis of soil test. Application of 100% NPK with S and Zn @ 30 kg ha^{-1} either in combination significantly increased the fresh rhizomes yield showing the value of 229.84, 232.65 and 240.15 q ha^{-1} in T_3, T_4 and T_5, respectively in comparison to 100% NPK alone (T_2) showing the value of 214.61 q ha^{-1}. Application of 100% NPK + S_{30} Zn_{30} + 20 t FYM (T_6) produced at par fresh rhizome yield in comparison to T_7 and T_5 showing the value of 260.71 q ha^{-1} and 262.54 q ha^{-1}, respectively. Maximum fresh rhizome yield was recorded (270.39 q ha^{-1}) with T_8= and T_5 however it was at par (262.54 q ha^{-1}) in comparison to T_7. Maximum chlorophyll a (0.72 mg g^{-1}) and chlorophyll b (0.34 mg g^{-1}) was recorded in the treatment T_6 followed by T_7. However, maximum chlorophyll a & b both were recorded in the order of middle leaves > new leaves> old leaves.

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Nutrient Use Efficiency of Maize (*Zea mays* L.) Genotypes under Different Sets of Fertilization

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A field experiment entitled, "Nutrient Use Efficiency of Maize (*Zea mays* L.) Genotypes under Different Sets of Fertilization." was conducted at agronomy farm, Rajasthan College of Agriculture, Udaipur during *kharif*, 2012. The experiment comprising of fifteen treatment combinations of three fertility levels 100% RDF (120 kg N + 40 kg + P_2O_5 + 25 kg $ZnSO_4$ ha^{-1}), SSNM Based (140 kg N + 34 kg P_2O_5 + 71 kg K_2O ha^{-1}) and farmer's practice (60 kg N + 20 kg P_2O_5 + 12.5 kg $ZnSO_4$ ha^{-1}) and five maize genotypes (DHM-117, PMH-3, PMH-1, HM-5 and HQPM-1) was laid out in factorial randomized block design with three replications.

The highest plant height, cob length, weight of cob^{-1}, No. of grain rows cob^{-1}, No. of grain rows^{-1}, 1000 grains weight, grain, stover and biological yield and N, K, Cu, Fe and Mn content (except P and Zn content which were maximum at 100% recommendation dose of fertilizer) and their uptake were recorded in site specific nutrient management which was higher over 100% RDF and farmer's practices. The available N, P and K status of soil at harvest increase significantly as compared to farmer's practice. Application of SSNM gave the maximum economic grain (4869.29 kg ha^{-1}), stover (7953.90 kg ha^{-1}) and biological yield (12823.19 kg ha^{-1}) and gross (70362 ha^{-1}) and net return (50892 ha^{-1}) as compared to other fertility levels. Genotype "PMH-1" of maize came out as most promising genotype when judged in terms of cobs plant^{-1}, cob length, weight of cob^{-1}, No. of grain rows cob^{-1}, No. of grain rows^{-1}, 1000 grains weight, grain, stover and biological yield and N, P and K content and their uptake. This genotype also produced significantly highest grain (5537.34 kg ha^{-1}), stover (8641.71 kg ha^{-1}) and biological (14179.05 kg ha^{-1}) yields and gave maximum gross (79411 ha^{-1}) and net (61807 ha^{-1}) return and B:C (19.44) as compared to other genotypes.

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Effect of Sulphur and Phosphorus on Yield and Quaility of Soybean

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A field experiment entitled "Effect of Phosphorus and Sulphur on Yield and Nutrient Uptake by Soybean [*Glycine max* (L.) Merrill]" was conducted at the Instructional farm of Rajasthan College of Agriculture, Udaipur during *kharif* season of 2012 with the objectives to work out the most appropriate doses of phosphorus and sulphur for soybean cultivation in Udaipur soil. The soil of experimental site was medium in available phosphorus (20.73 kg ha^{-1}), nitrogen (281.30 kg ha^{-1}) and low in available sulphur (8.9 mg kg^{-1}). The experiment consisting of 16 treatment combinations comprising four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) in integration with four levels of sulphur (0, 15, 30 and 45 kg S ha^{-1}). The experiment was laid out in factorial randomized block design with three replications. Results indicated that application of 60 kg P_2O_5 ha^{-1} improved the yield and yield attributes of the crop in terms of pods per plant, seeds per pods, grain yield, stover yield, protein content and oil content in grains of soybean. Application of 30 kg S ha^{-1} significant increased the plant height, pods per plant, grain and stover yield, protein and oil content in grain, however, it was observed at par 45 kg S ha^{-1}. The application of 60 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} gave maximum grain yield, N, P, K, S and Mn uptake by grain of soybean.

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On-Farm Trial on Integrated Nutrient Management in Hybrid Tomato

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Tomato is one of the most remunerative crops in the mid hill zone of Himachal Pradesh. The excessive use of chemical fertilizers especially nitrogenous fertilizers are leading to poor soil health conditions. Thus an approach to use chemical fertilizers in conjunction with biofertilizers is thought to be the best alternative, but the technology needs to be refined and disseminated to the farmers. With this objective, a field trial on farmers' field was laid out in the year 2011-12 and 2012-13 to study the impact of use of biofertilizers in conjunction with chemical fertilizers, in Chamba district of Himachal Pradesh. The treatments consisted of 100% NPK (recommended doze), 75% NPK + Biofertilizers, 50% NPK + Biofertilizers and Farmers' Practice (Use of N fertilizers only). The trial was conducted at three locations. Amongst the Biofertilizers, Azotobacter and PSB were applied @ 2.5 kg each ha^{-1}. The tomato plants of hybrid variety Naveen 2000+ was selected for trials. The recommended doze of chemical fertilizers consisted of 150 kg N, 120 kg P and 55 kg K ha^{-1}. The experiment was repeated and the observations for two years were recorded with respect to plant growth and fruit yield. The data shows that during the year 2011-12 the maximum plant height and fruit yield were recorded in the treatment where the dual inoculation with Azotobacter and PSB was done along with 75% NPK, followed by 100% NPK treatment. The minimum yield of 224.7 q ha^{-1} was noted in the farmers' practice thereby showing an increase of about 48% over control. In the year 2012-13, the trend remained the same with the maximum fruit yield of 321.8 q ha^{-1} in the treatment where 75% recommended NPK was applied alongwith the biofertilizers. The B:C ratio of 5.44:1 was obtained for the above treatment as against a B:C ratio of 3.34 in case of farmers' practice.

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Effect of Different Organic Manures on Yield and Nutrient Uptake by Maize (*Zea mays* L.)

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A field experiment was conducted at the Instructional Farm, Rajasthan Collele of Agriculture, Udaipur to assess the effect of three organic manures on yield and nutrient uptake by maize. The experiment was laid out in randomaized block design with three replications and ten treatments comprised of three type of organic manures *i.e.* FYM, vermicompost and Bokashi manure (BK) and three levels of application *i.e.* 5, 10 and 15 t ha^{-1} and control (no organic manures). The organic manures were tested on maize crop. Bokashi manure was prepared with the mixture of 4 parts fresh leaves of N-fixing trees, 3 parts virgin/forest soil, ½ part maize/wheat/rice bran, ½ part small particles of charcoal, ½ part poultry droppings (chicken dung), molasses or rotten fruits.

Application of organic manures at higher levels significantly increased yield (grain, biological and stover) and growth parameters *viz.,* plant height, chlorophyll content, leaf area index, and dry weight. The maximum plant height at 60 DAS and at harvest, chlorophyll content, leaf are index at 30 DAS, 45 DAS and 60 DAS, dry weight, number of grains cob^{-1}, cob weight, cob length, test weight and shelling percent (216.67 cm, 23.67 cm, 79.66 μg L^{-1}, 1.63, 1.79, 3.79, 178.67 g $plant^{-1}$, 565, 171.33 g, 18.50 cm, 250 g, and 83 per cent respectively) was recorded under application of vermicompost and Bokashi at the rate of 15 t ha^{-1} which was significantly superior over plots without organic manures. The maize yield significantly increased with the increased rates of organic manures from 5 to 15 t ha^{-1} in all the three types of organic manures used the highest grain, stover and biological yield (3200, 5980 and 9180 kg ha^{-1}, respectively) was attained under application of vermicompost at 15 t ha^{-1}. Nitrogen, phosphorus, potassium, zinc, iron, copper and manganese content and uptake in grain and stover significantly increased with increased rate of organic manure application. Nitrogen content and uptake significantly increased with the application of vermicompost at 15 t ha^{-1} while phosphorous content and uptake was significantly influenced by the application of Bokashi manure at the same rate. Zinc, iron and copper content in grain and stover were greatly influenced by vermicompost application while Bokashi increased the content of manganese. Maize productivity was not improved significantly by farmyard manure in comparison to vermicompost and Bokashi manures.

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Soil Test Based Fertilizer Doses for Attaining Different Yield Targets of Maize under Semi-Arid Alfisols in South India

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Based on a field experiment conducted on maize (*Zea mays*) in a semi-arid alfisol at Hyderabad in India with 18 fertilized and 3 unfertilized treatments of N, P_2O_5, K_2O and vermicompost (VC) in *kharif* 2012, a statistical basis for deriving soil test based optimum fertilizer doses for attaining different yield targets has been developed. The study was conducted in a Randomized Block Design with 3 gradients. The fertilizer treatments were selected based on 4 levels each of N @ 0, 60, 120, 180; P_2O_5 @ 0, 30, 60, 90; K_2O @ 0, 20, 40, 60 kg ha^{-1} and VC @ 0, 2.5 and 5 t ha^{-1}. Significant correlation was found between soil, plant uptake and applied fertilizer nutrients with maize grain and dry matter yield. Based on the effects of fertilizer treatments on maize grain and dry matter yield, soil and plant uptake of N, P_2O_5, K_2O nutrients, estimates of nutrient requirement (NR, kg q^{-1}) from all the 63 plots (54 fertilized and 9 unfertilized), contribution from soil (CS,%) from 9 unfertilized plots and contribution from fertilizer (CF, %) from 54 fertilized plots were derived. Using the basic data of NR, CS, CF and CO, fertilizer adjustment equations of N, P_2O_5 and K_2O were derived for prescribing optimum fertilizer doses based on soil test values for attaining maize yield targets of 40, 50 and 60 q ha^{-1}. The nutrient requirement was 2.67 kg N, 1.64 kg P_2O_5 and 2.27 kg K_2O for attaining one quintal of yield. The CS was 21.6% for N, 85.2% for P_2O_5 and 11.3% for K_2O, while the CF was 69.8, 1001.1 and 239.9% for the 3 nutrients respectively. The contribution from VC was 47.5% for N, 59.0% for P_2O_5 and 51.1% for K_2O. The analysis indicated that we could attain a response of 15.6 kg of maize yield kg^{-1} of nutrient application in semi-arid alfisols. The optimum fertilizer doses based on soil test values could be used for attaining yield targets under similar soil and agro-climatic conditions.

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Phosphorus Availability and Uptake as Influenced by Various Management Practices under Groundnut Cultivation in Calcareous Vertisols

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The availability and uptake of phosphorus either derived from soil and/or applied fertilizers in calcareous vertisols were examined in groundnut cultivation using various management practices like irrigation, nutrients and land management options during *kharif* 2012 at research farm of Directorate of Groundnut Research, Junagadh. The soil and plant samples were collected at different growth stages up to harvest and analyzed for P-availability in the soil and uptake by the plants. Management practices like organic and integrated nutrient management and raised bed with polythene mulch (PM) were found most effective for enhancing availability of soil P consistently with plant growth. Further, the application of saline irrigation water appreciably increased the P availability for specific period of time and subsequently reduced the availability in calcareous soils. The availability of soil phosphorus (*i.e.* Olsen's P) decreased with plant growth under all the management options except organic nutrient management which might be absorbed by the plants. In contrary, the resin P (labile P) increased with plant growth and ranged between 40-60% of Olsen' P under various management practices except organic nutrient management (>100%) indicating that resin P would derive P from the labile P weekly bound in the rhizosphere which needs for further characterization of different P fractions.

Although, irrespective of management options these two estimates for available P represents different pools of soil phosphorus which are only indicative and do not have definite relationship with P uptake by the plants. Highest P uptake was observed under raised bed with PM followed by nutrient management through inorganic fertilizers which was highly correlated with biomass accumulation. However P-inflow rate was found higher under inorganic P supply only. These results indicated that phosphorus requirement of the groundnut plants could be efficiently met by adopting appropriate management options.

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Response of Rock Phosphate Enriched Organics on the Yield and Quality of Potato (*Solanum tuberosum* L.)

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To carry out field evaluation of enriched organics by integrating their use with chemical fertilizers (N, P and K) in terms of potato tuber yield and quality, a field experiment was conducted at the experimental farm of Department of Soil Science, CSK HPKV, Palampur. The soil of the study area was acidic in reaction (pH=5.6), medium in available N (270 kg ha^{-1}), P (16.7 kg ha^{-1}) and K (180 kg ha^{-1}) having P-fixing capacity of 600 mg kg^{-1} of soil and falls in the order 'Alfisol' and sub group 'Typic Hapludalf'. The four manurial products were prepared from farm yard manure and locally available plant biomass, presented as FYM, compost (FYM + Biomass), rock phosphate enriched FYM and rock phosphate enriched compost. These organic manurial products were evaluated individually and in integration with different proportions of inorganic fertilizers consisting of 12 treatments which were tested in RBD with 3 replications. The treatments consisted of recommended application of NK, PK, NP and NPK through chemical fertilizers, alone application of above mentioned four organic manures @ 20 t ha^{-1} and integrated use of P-enriched manurial products along with 50 and 75% of recommended N and K through chemical fertilizers. At harvest the tuber yield was recorded from net plot area and tuber quality was determined by standard analytical procedures. On pooled mean basis of two years, it was found that the increase in the yield to the tune of 15.5 and 13.3% was recorded through application of enriched FYM and compost alongwith 75% of recommended NK, respectively over application of recommended NPK only. Application of enriched compost alongwith 50% of recommended NK remained statistically similar to application of recommended NPK treatment and was the next best in recording significantly higher potato tuber yield through significantly improving the uptake of P and K. Corollary to yield, application of P-enriched organics @ 20 t ha^{-1} along with 75 percent of recommended N and K recorded higher values of potato quality parameters expressed in terms of crude protein, crude fat, ascorbic acid (Vitamin C), β-carotene, starch and minerals. The mean concentration of calcium, magnesium, sulphur and sodium varied between 22-32, 14-24, 10.8-15.4 and 3.5-6.2 mg 100^{-1} g dry weight, respectively. However, their concentrations were higher in the treatments where 20 t of P-enriched organics were integrated with 50% or 75% of recommended N and K when compared with standard treatment where recommended N, P, K were applied through chemical fertilizers. The mean concentration of Fe, Mn, Zn and Cu was found in the range of 99-161, 50-90, 14.8-19.6 and 2.4-5.9 ppm, respectively. When compared with standard treatment where recommended N, P, K were applied through chemical fertilizers, the concentration of these mineral elements was higher in the treatments where P-enriched organics @ 20 t ha^{-1} were added in conjunction with 75% of inorganic N and K.

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Impact and Assessment of Long-term Fertilization on Productivity of Crops and its Sustainability on a Mollisol with Rice-Wheat Cropping System

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The study was carried out in a long-term fertilizer experiment which incepted since *kharif*, 1971 at Norman Borloug Experiment Station, G.B. Pant University of Agriculture and Technology, Pantnagar. Results showed that application of optimal dose of NPK (100% NPK) through mineral fertilizers along with 5.4 t ha^{-1} FYM (Farm Yard Manure, dry weight basis) gave maximum and most sustainable yields of both rice and wheat crops even after 40 years of cropping cycle. Balanced use of NPK fertilizers with correction by application of deficient nutrients gave more or less sustainable yields of both crops even after 40 years of rice-wheat cropping system. The potassium application along with NP+Zn enhanced significantly the rice and wheat production over 100% N and NP treatments. Application of optimal (100% NPK) and super optimal (150% NPK) dose of fertilizers without Zn addition showed remarkable reduction in crop yields and soil properties *viz*; organic carbon, bulk density, mean weight diameter, hydraulic conductivity, microbial population *etc.* The maximum available N, P and K in soil was observed by application of optimal dose of fertilizers (100% NPK) along with 5.4 t ha^{-1} FYM. Organic carbon declined from 1.48 to 0.59% under the unfertilized control after 40 years of rice-wheat cropping cycle. Under fertilized treatments, it decreased up to 1.14% only. At the time of inception of this experiment, zinc was applied as two foliar sprays to rice only but due to severe incidence *Khaira* disease in rice in other treatment also, foliar spray was converted as basal application of 50 kg ha^{-1} Zn SO_4 at an interval of 4-5 years (on soil test basis). Maximum improvement in soil quality parameters was observed with application of 100% NPK through mineral fertilizers along with farm yard manure @ 5.4 t ha^{-1} (dry wt basis) but these were with sole application of chemical fertilizers. Indirect application of sulphur (through SSP) showed marginal response on crop yields over regular use of sulphur free fertilizers.

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Nutrient Recommendation to Pigeonpea Crop-based on Soil Fertility Ratings in North Eastern Dry Zone of Karnataka

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A field experiment on "Revalidation of Soil Fertility Ratings in Pigeonpea crop (var.TS-3R)" in North Eastern Dry Zone (Zone-2) of Karnataka state was conducted in a Chromic Haplustert (Black soil) during *kharif* seasons of 2010-11 and 2011-12 at farmers field, Gulbarga having a latitude of 16° 2″, longitude of 76°.42″ East at an altitude of 443.88 m above mean sea level. The experiment was laid out in a Randomized block design, with three replications. The pooled data revealed that the application of NPK ± 25% based on soil test value recorded significantly higher seed yield of 1294 kg ha^{-1} as compared to recommended NPK as per the package of practice (941 kg ha^{-1}). The increase in seed yield over control was 37.50%. Application of NPK ± 25% based on soil test value could be recommended to obtain the maximum net return per hectare (Rs. 37368) with a B: C ratio of 3.10.

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Response of Raya to the Application of Boron in Alluvial Alkaline Soil of Punjab

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Boron deficiency is observed in about 30% soils of the India and 10-15% soils of Punjab. Furthermore, its deficiency in plants is more wide-spread in soils, which are coarse textured, low in organic matter and high in calcium carbonate content. The range between B toxicity and deficiency being narrow, poses a great difficulty to maintain appropriate B levels in soil solution. A field experiment was conducted at the experimental farm of Department of Soil Science, Punjab Agricultural University, Ludhiana to study the response of raya (*Brassica juncea*. L) to six levels of soil applied B (0, 0.5 0.75, 1.0, 1.5 and 2 kg ha^{-1}) as granubor ($Na_2B_4O_7.5H_2O$; 15%B) in a randomized block design with three replications. Recommended doses of N, P and K were applied. The experimental soil was loamy sand having a pH of 7.8., EC 0.25 dSm^{-1}, $CaCO_3$ 1.5%, organic C 2.5g kg^{-1}, available P 18 kg ha^{-1}, available K 110 kg ha^{-1} soil. The crop was harvested at maturity. Total B content of the plant was determined by dry ashing in a muffle furnace at 550^o C. The ash was dissolved in 10 ml of 6 *N* HCl and heated to dryness and was transferred to 25 ml volumetric flask and the volume was made with de-ionized water. After filtration, B in the extract was determined by using Azomethine–H as proposed. Application of B increased the grain yield of raya at all rates of its application over control. The crop, though, did not show any visual symptoms of B deficiency in control plots, the growth of the crop was poor compared with B treated plots. This was expected because of the low content of available B in the soil. But the significant increase in grain yield was obtained with the application of B at the rate of 0.75 kg ha^{-1} which resulted in 13% increase in grain yield. However, the maximum increase was observed with application of 1 kg B ha^{-1}. Further, the differences among the grain yields observed with application rates of 0.75, 1.50 and 2 kg B ha^{-1} were non-significant. The application of B at the rate of 1.5 and 2 kg ha^{-1} rather decreased the grain yield compared to application of B at the rate of 1.0 kg ha^{-1}. All the yield attributes like plant height, branches plant^{-1}, siliqua plant^{-1}, length of siliqua and straw yield exhibited similar trend. Boron content in grain, straw as well as uptake showed an increasing trend over control with the application of B at all levels.

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Status of Plant Available Macro,Micro and Secondary Nutrients in District Hoshiarpur of Punjab

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Six hundred forty two soil samples were georeferenced from different blocks of District Hoshiarpur and analyzed to judge the status of macro, micro and secondary nutrients. Available nitrogen status of surface soils varied from 31.4 to 141.1 kg ha^{-1} with a mean value of 77.6 kg ha^{-1} indicating that soils were invariably deficient in N. Phosphorus status were found to be high in 60.3% soils and 32.4% soils had medium P status and only 7.30% soils were falling in low category. Potassium status of 49.8 and 44.9% of the soils were high and medium respectively while remaining 5.30% were low. Percent samples for available S under low, medium and high categories were 36.7, 30.2 and 33.1% respectively. Nearly half of the soils (48.3%) have medium Zn status followed by 33.8% soils with low and only 17.9% soils have high Zn status. The deficiency of Cu was prevalent in 4% soils while 47.3% soils were in high and 48.3% were in medium status. It was observed that in case of iron, deficiency was observed in only 7.3% soils while 62.5 and 30.2% soils exhibited high and medium Fe content, respectively. More than half of the soils were medium in Mn (56.7%) followed 30.2 and 13.1% soils which were low and high in Mn content, respectively. Overall 12.9% soils were deficient in B in this district. Besides Zn, higher percentage of soils were also deficient in Mn and S indicating that these elements will be the limiting factors in crop production. Zinc deficiency was still prevalent in nearly 1/3 of soils indicating thereby that farmers of this district are not practicing regular use of Zn fertilizers.

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Soil Test Based Fertilizer Adjustments for Bt Cotton-Wheat Sequence

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The advent of genetically modified cotton, Bt cotton, that allowed better bollworm control brought in a renewed interest in cotton production. Newer cultivars of Bt cotton with higher yield potentials need to be tested for their nutrient use efficiency and subsequently for their fertilizer requirements. Alleged adverse environmental impact, high carbon footprint and high cost of production of excessive fertilizer use necessitate the precise fertilizer need-assessment under integrated plant nutrient supply (IPNS) environments. Soil test crop response (STCR) methodology develops fertilizer calibration linear relationships by factoring in nutrient requirement for attaining a particular yield goal, fertilizer nutrient efficiency and soil nutrient supply. Keeping this in view, a field experiment on Bt cotton-wheat cropping system was conducted on three fertility gradient strips at the PAU Soil Science Research Farm, Ludhiana. The three fertility gradient strips were created by applying graded amounts of fertilizer nutrients and farmyard manure (FYM). The experimental design was Latin Square with three fertility strips, three rates of FYM (0, 5 and 10 t ha^{-1}), three N rates (100, 150, and 200 kg N ha^{-1} for Bt cotton, and 90, 120, and 150 kg N ha^{-1} for wheat), three P rates (15, 30 and 45 kg P_2O_5 ha^{-1} for Bt cotton and 45, 60, and 75 kg ha^{-1} for wheat) and three K rates (15, 30 and 45 kg K_2O ha^{-1} both for Bt cotton and wheat). A control plot was kept with each rate of FYM application. Each fertility strip accommodated 24 different NPK combinations. After the imposition of FYM and other treatments, Bt cotton (var. RCH 134) was planted during May 2011. The cotton stalks were pulled out after the last picking operation in November 2011. Late sown wheat (var PWB 509) was sown in the last week of December 2011 on the same plots without fresh FYM. Surface (0-15 cm) soil samples were drawn from each plot before sowing of Bt cotton and wheat. The samples were analyzed for organic C, available N, P, and K by standard methods. At harvest, cotton seed and stover yields and wheat grain and straw yields were recorded and the samples were taken for total N, P and K analysis. Fertilizer adjustment linear relationships were worked out by factoring in the total nutrient requirement for an economic yield goal, fertilizer use efficiency and potential soil nutrient supply and organic source nutrient supply. Results evidenced a substantial requirement of N for Bt cotton. Relatively diminished NPK requirement of wheat could be ascribed to late-sown nature of the crop. A comparison of STCR methodology with soil test category based recommendation approach for P and K suggested the supremacy of STCR approach. Failure to compute a fertilizer calibration equation for wheat crop under IPNS environment calls for a re-look into the methodology.

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Requirement and Time of Nitrogen Application to Hybrid Maize Crop and its Influence on P Use Efficiency

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Field experiments were conducted for 2 years on a black soil at Hyderabad to find out the dose and phasing amounts of N application to hybrid maize crop (BH-40625). Phosphorus (P-32) use efficiency was also determined as influenced by rates and time of N application in the crop. Pooled data revealed that N applied @ 160 kg ha^{-1} resulted in highest mean grain yield of maize (4.15 t ha^{-1}). Higher N levels (200 kg ha^{-1}) resulted in decrease in yield of the crop. However, when the ratios of N applied in different splits is considered, N supplied in the ratios of 33:33:33 resulted in highest grain yield of 4.34 t ha^{-1}. The mean phosphorus fertilizer use efficiency by maize crop ranged from 8.05 to 10.63% due to N application and from 9.32 to 10.26% due to different ratios of 3 or 4 splits of N supply. Significantly highest P-use efficiency (11.04%) was recorded by maize crop when N was applied @160 kg ha^{-1} and supplied in the ratios of 50:25:25 at basal, 35 DAS and 65 DAS.

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Effect of Soil and Foliar Application of Micronutrients on Soil Nutrients Status and Yield of Hybrid Maize

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The present investigation was undertaken during three years (2010-11 to 2012-13) at Micronutrient Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri to study the effect of soil and foliar application of micronutrients on soil nutrients status and yield of hybrid maize. The experiment was laid out in randomized block design with twelve treatment combinations and three replications. The initial status of soil was pH 8.23, EC 0.22 dS m^{-1} and available N and K were 212, 15.7 and 513 kg ha^{-1} respectively. Maize hybrid variety Rajarshi was taken as test crop with twelve treatment combination *viz.*, Control (water spray) (T_1), Foliar spray 0.1% Fe EDTA (T_2), Foliar spray 0.2% Fe EDTA (T_3), Foliar spray 0.1% Zn EDTA (T_4), Foliar spray 0.2% Zn EDTA (T_5), Foliar spray 0.1% Fe EDTA + 0.1% Zn EDTA (T_6), Soil application Fe EDTA @ 5 kg ha^{-1} (T_7), Soil application Zn EDTA @ 5 kg ha^{-1} (T_8), Soil application on $FeSO_4$ @ 20 kg ha^{-1} + cow dung (T_9), Soil application of $ZnSO_4$ @ 20 kg ha^{-1} + cow dung (T_{10}), Soil application of Fe EDTA @ 2.5 kg ha^{-1} + Zn EDTA @ 2.5 kg ha^{-1} (T_{11}), Soil application of $FeSO_4$ @ 10 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} (T_{12}) with GRDF (120:60:40 N:P_2O_5:K_2O kg ha^{-1} + 10 Mg ha^{-1} FYM) Foliar spray was done at vegetative stage (30 DAS) and at knee high stage (45 DAS) and soil application was done at the time of planting and 30 DAS.

The available DTPA Fe and Zn was significantly increased in T_{12} treatment of soil application of $FeSO_4$ + $ZnSO_4$ each @ 10 kg ha^{-1} with GRDF over control and foliar application of Fe and Zn treatments. Total uptake of N, P, K and Fe, Zn, Mn were significantly increased in T_{12} over control. Total chlorophyll content in fresh tissue of maize leaves was significantly increased in T_{10} followed by T_{12} and T_7 over treatments of T_1 to T_4. The pooled mean of three years in respect of grain yield of maize was significantly increased in T_{12} (79.40 q ha^{-1}) which was at par with T_{11} (76.66 q ha^{-1}), T_{10} (74.44 q ha^{-1}) and T_8 (73.54 q ha^{-1}). The highest gross and net monetary returns were recorded in T_{12} (Rs. 104564/- and Rs. 64466/- respectively) which reflected in higher B:C ratio (2.61) in T_{12}. Thus it is concluded that soil application of $FeSO_4$ + $ZnSO_4$ @ 10 kg ha^{-1} each at sowing and 30 DAS with recommended fertilizer dose to hybrid maize in Fe and Zn deficient Entisols of Western Maharashtra for higher yield, monetary returns and increase in Fe and Zn in soil.

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Effect of Zinc and Boron Application on Wheat Productivity and Nitrogen Use Efficiency in an Acid Alfisol

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The present investigation was carried out to attain reasonably higher yield levels and at the same time to enhance nitrogen use efficiency in an acid soil. The field experiment was conducted on wheat crop (HPW155) under irrigated conditions at experimental farm of Department of Soil Science, College of Agriculture, CSK HPKV, Palampur during *rabi* 2010-11. The soil of was *Typic hapludalf* and acidic in reaction with pH value of 5.3 silty clay loam in texture, medium in organic carbon, low in available N, medium in available P and K. The contents of DTPA extractable Fe, Mn and Cu were adequate whereas DTPA Zn was marginally adequate and hot water soluble B was insufficient. Sixteen treatment combinations were replicated three times in factorial RBD and were comprised of four levels of N [0, 50,100 and 150% of recommended dose (RD)], two levels of Zn (0 and 10 kg ha^{-1}) and two levels of B (0 and 1 kg ha^{-1}). Graded levels of N increased grain and straw yields significantly. The increase was significant upto 150% of RD. Application of N at the rate of 50, 100 and 150% of RD increased grain yield by 47.5, 65.9 and 84.8% over no N application, respectively. The corresponding values in straw yield were 15.4, 28.7 and 36.1%. Application of Zn @ 10 kg ha^{-1} increased grain and straw yields significantly, the increase being 9.7 and 5.7%, respectively. The increase in grain and straw yields of wheat with the application of 1 kg B ha^{-1} was also significant and the extent of increase was 8.1 and 5.3%, respectively. Graded levels of N/B applications increased the total uptake of N, P, K, Zn, Fe, Mn, Cu and B by wheat significantly. Application of Zn resulted in significant increase in total uptake of N, P, K, Zn and B. Partial factor productivity (PFP), agronomic efficiency (AE), physiological efficiency (PE) and apparent recovery (AR) decreased in wheat with increasing levels of N. Application of Zn increased partial factor productivity (PFP), agronomic efficiency (AE), physiological efficiency (PE) by 9.1, 3.1 and 5.2% over no Zn application but apparent recovery (AE) decreased by 1.9% by its application. Boron application increased partial factor productivity (PFP), agronomic efficiency (AE), physiological efficiency (PE) and apparent recovery (AE) by 9.4, 12.0, 4.6 and 5.7% respectively, over no boron application.

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Long Term Effect of Prescription Based Fertilizer Application on Yield and N, P and K Uptake by Wheat in an Acid Soil

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A field experiment was conducted during *rabi* 2009-10 on wheat crop at the Experimental Farm of CSKHPKV, Palampur. The study was a part of an ongoing long-term experiment in maize-wheat cropping sequence. The experimental soil was silty clay loam in texture, pH 5.2, organic carbon 7.2 g kg^{-1}, and available, N, P and K status was 236, 41 and 272 kg ha^{-1}. The treatments were control, general recommended dose (GRD), soil test based, farmers' practice, fertilizer doses for 25, 35, 25 q ha^{-1} with FYM @ 5 and 35 q ha^{-1} with FYM @ 5 q ha^{-1}. The study revealed that the target yield of 35 q ha^{-1} with FYM resulted in highest wheat grain (36.8 q ha^{-1}) and straw (52.4 q ha^{-1}) yield, plant height (73.63 cm), number of tillers $plant^{-1}$ (4.8), number of grains $spike^{-1}$ (49.8) and 1000 grain weight (38.4 g). There was a significant increase in plant height, number of tillers $plant^{-1}$, number of grains $plant^{-1}$, and 1000 grain weight under the influence of both the target yield treatments (25 q ha^{-1} and 35 q ha^{-1}) as compared to soil test based and GRD. Soil test crop response correlation based fertilizer applications for target yields of 25 and 35 q ha^{-1} with and without FYM gave significantly higher yield attributes and grain and straw yield as compared to soil test based and general recommended dose of fertilizers. Targeted yield treatment (25 and 35 q ha^{-1}) with and without IPNS (Integrated plant nutrient supply system), significantly increased the N, P and K uptake over control. Farmers' practice also enhanced the NPK uptake over control.

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Survey and Characterization of Ground Water Quality of Bharthana and Takha Blocks in District Etawah of Uttar Pradesh

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To assess quality of underground irrigation waters, samples from tube wells in Bharthana and Takha blocks of Etawah district of Uttar Pradesh were collected according to standard procedure. These samples were analyzed for electrical conductivity (EC), carbonate ($CO3^{2+}$), bi-carbonate (HCO^{3-}), calcium and magnesium (Ca^{2+}+Mg^{2+}), chloride (Cl^{-}) and sulphate (SO_4^{2-}) and residual sodium carbonate (RSC). The quality of ground water samples indicates that pH, EC, SAR and RSC ranges from 7.4 to 9.0, 0.53 to 5.23 dS m^{-1}, 0.4 to 26.6 (mmol $l^{-1})^{1/2}$ and nil to 14.0 meq l^{-1} in Bharthana and 7.6 to 9.1, 0.7 to 10.0 dS m^{-1}, 2.3 to 31.3 (mmol $l^{-1})^{1/2}$ and nil to 11.8 (meq l^{-1}) in Takha block, respectively. After analysis, 49% samples could be classified under good quality class, 6.2% as saline and 44.7% comes under alkali class in Bharthana block. Whereas, in Takha block 42.3% good, 20.5% saline and 37.2% alkali waters are found. Saline waters were further categorized under marginally saline (4.2%), saline (1.0%) and high SAR saline (1.0%) in Bharthana, whereas in Takha block, the waters were categorized as marginally saline (1.3%), saline (nil) and high SAR saline (19.2%). The alkali waters are again sub-grouped under marginally alkali (28.1%), alkali (1.0%) and high alkali (15.6%) in Bharthana, whereas in Takha block, the quantum of such classes are maginally alkali (15.4%), alkali (2.6%) and high alkali (19.2%). The waters are of HCO_3>SO_4>CL>CO_3 types. Of the two blocks, the poor quality waters exist more in Takha block, further the alkali problem is more in Bharthana block.

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Effect of Saline Water in Drip and Surface Irrigation on Okra *(Abelmoschus esculentus)*

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A field experiment was conducted on sandy loam soil during 2009 and 2010 at Agricultural Research Farm, R.B.S. College, Bichpuri, Agra in Uttar Pradesh to asses the salinity tolerance of okra crop in drip and surface irrigation. The treatments were comprised of three levels of salinity (Control, EC_{iw} 4 and EC_{iw} 8 dS m^{-1}) and three levels of IW/CPE ratios (0.75, 1.00 and 1.25) for both drip and surface irrigations. The study revealed that the fruit yield of okra was significantly decreased at EC_{iw} 4 and EC_{iw} 8 dS m^{-1} over control. In drip irrigation, the okra fruit yield reduced at EC_{iw} 4 and EC_{iw} 8 dS m^{-1} over control was 53.4 & 72.8% in 2009 and 53.7 and 78.4% in 2010, respectively. In case of surface irrigation system okra fruit yield reduced by 60.0 & 98.8% in 2009 and 79.4% in EC_{iw} 4 and EC_{iw} 8 okra fruit yield is zero in 2010. The IW/CPE ratio significantly increased with increasing IW/CPE ratio in drip irrigation of both the years. While in surface irrigation, IW/CPE ratio were non-significant. The interaction effect between EC and IW CPE^{-1} ratio was found to be non-significant in both the years. On an average, at harvest of okra crop, the EC_e of surface layer (0-10 cm) ranges between 2.5 to 3.0 in control, 12.5 to 13.0 in EC_{iw} 4 and 21.0 to 22.0 dS m^{-1} in EC_{iw} 8 dS m^{-1} in plant distance from 5 to 25 cm. In surface irrigation system, the EC_e vale is 4.2 in control, 13.0 in EC_{iw} 4 and 24.0 dS m^{-1} in EC_{iw} 8 dS m^{-1}. The water use efficiency was higher in drip irrigation as compared to surface irrigation with 35% water saving in drip method. In control, EC_{iw} 4 and 8 dS m^{-1}, the water use efficiency in okra crop was 203.7, 101.1 and 53.0 (in drip irrigation) and 138.8, 41.5 and 0.1 kg ha cm^{-1} (in surface irrigation), respectively. Results revealed that in drip irrigation the yield and water use efficiency were higher than surface irrigation.

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Refinement of Phosphorus Fertilizer Recommendations for Maize-Wheat Sequence in Punjab State

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Phosphorus (P) is one of the key nutrient elements for achieving the high yield potential of crops like maize, wheat and potato. Continuous P fertilization in the quest for higher yields has resulted in P build up. As a result, a considerable acreage in Punjab state qualifies for 'high' and 'very high' soil test based classification for phosphorus. Rising fertilizer subsidy expenditure especially of phosphatic fertilizers calls for economy in P fertilizer use. The objective of the present study was to refine the existing P fertilizer recommendations in maize-wheat sequence under high P environments by further segmenting the existing critical limits and graduating the P fertilizer dose accordingly. A field experiment on maize-wheat sequence was conducted by planting maize followed by wheat on three artificially created soil test P gradients, namely, 'medium', 'high', and 'very high' during 2011-12 and 2012-13. The five basal P fertilizer levels (0, 30, 60, 90 and 120 kg P_2O_5 ha^{-1}) were randomized on each P fertility strip for both maize and wheat. The results suggested that both the crops, especially maize, did not respond to fertilizer P application beyond initial soil test P levels of 40 kg ha^{-1}. This assumes significance in the light of the current limit of 50 kg soil test P ha^{-1} beyond which P fertilizer additions are said to generate no yield response. Under 'very high P' environments the response to P fertilizer did not show up initially. Beyond this period, a 30 kg fertilizer P ha^{-1} application to wheat crop was able to sustain economic yields of both the crops. Therefore, the study holds a great promise in effecting much desired fertilizer P economy in Punjab state.

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Effect of Different Levels of Sulphur and Boron on the Yield of Mustard *(Brassica juncia)* in South-West Region of Punjab

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A field experiment was carried out to find the effect of different doses of sulphur and boron application on the yield of mustard (*Brassica juncia*) in loamy sand soil at Punjab Agricultural University, Regional Research Station, Bathinda. The experimental field was non-saline and alkaline in reaction having EC 0.25 ds m^{-1} and pH 8.70, low in organic carbon (0.34 %), medium in available phosphorus and high in available potassium. The $CaCO_3$ content of the field was 4.35%. The experiment comprises of different doses of sulphur as 0 and 40 kg ha^{-1}, and boron 0, 0.25, 0.50, 0.75 and 1.00 kg B ha^{-1} were applied through soil application in different eight treatments combinations in randomized block design with three replications. The PBR 91 cultivar was taken as test crop for the study. The crop was supplied with the recommended doses of fertilizers. Results indicated that the yield of mustard crop improved with increasing application of S and B application as compared to control. The maximum yield (28.09 kg ha^{-1}) was observed in treatment with highest level of S along with B @ 1.0 kg ha^{-1} kg which was at par with 40 kg S ha^{-1} and 0.75 kg ha^{-1} of B application whereas minimum yield (21.94 kg ha^{-1}) was observed in the control.

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Effect of Nutrient Management and its Residual Effect on the Production Potential of Cluster bean (*Cyamopsis tetragonoloba*)-Cumin (*Cuminum cyminum*) Cropping systems in Arid Region

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Cluster bean (*Cyamopsis tetragonoloba* (L) Taub.) and cumin (*Cuminum cyminum* L.) both are important commercial crops grown during *kharif* and *rabi* season, respectively in western region of Rajasthan. The region stands first in production of cluster bean and second in cumin in the country. Owing to high demand and market value of the seeds of both the crops in the international market, country has earned Rs 16356.75 crore during 2011-12 from the export of cluster bean gum and Rs 400 crores from the export of cumin seed during 2010-11. But productivity of cluster bean (390 kg ha^{-1}) and cumin (318 kg ha^{-1}) in the region is major concern. Inherent poor status of organic matter, nitrogen and other nutrients coupled with inadequate and imbalanced supply of nutrients are the important reason for low productivity. Further, growing crops in sequence require adequate nutrient management, as it removed large quantities of nutrients from the soil. Application of nutrients through organic and inorganic sources in combination assures the sustainable production in cropping systems as it improving physical properties of soil and increased applied nutrient use efficiency as well as beneficial effect on the succeeding crop. Keeping this in view, the present study was carried out to study the effect of nitrogen management in cluster bean and its residual effect and direct nutrient management in succeeding crop (cumin) in cluster bean-cumin cropping system in the arid region of Rajasthan.

Field experiments was conducted for 3 consecutive years (2008-9, 2009-10 and 2010-11) at Central arid Zone Research Institute Jodhpur. The experimental soil was sandy loam with pH 7.9, organic C 0.18, available N 126 kg ha^{-1}, available P 12.4 kg ha^{-1} and available K 248 kg ha^{-1}. Six different N management treatments consisted of control, 100% N through FYM, 100% N through urea, 75% N through FYM + 25% N through urea, 50% N through FYM+ 50% N through urea and 25% N through FYM + 75% N through urea were replicated 3 times in randomized block design in cluster bean during *kharif* season maintaining level @ 20 kg ha^{-1}. The phosphorus was also applied at the sowing time through single super phosphate to maintain the level of recommended dose *i.e.* 40 kg P ha^{-1} in all the treatments except control. During *rabi* season each plot was divided into 4 subplots and nutrient management treatments viz. control, 100% RDF (40 kg N +30 kg P_2O_5 ha^{-1}), 75% RDF and 50% RDF were superimposed in factorial randomized block design with 3 replications. Integrated application of 50% N through FYM+50% through urea registered significantly higher growth and yield attributes of cluster bean and recorded 13.9, 12.2 and 34.7% increase in seed yield over 100% N through FYM, 100% N through urea and control, respectively. However, application of 100% N through FYM alone in cluster bean had maximum residual effect on the succeeding crop (cumin) and being at par with 75% N through FYM+25% N through urea and 50% N through FYM+50% through urea increased significantly higher seed yield of cumin compared to other treatments. Direct application of 100% RDF and 75% RDF to cumin, being at par, recorded significantly higher seed yield of cumin over 50% RDF and control. Significantly highest mean cumin equivalent seed yield (CESY) of the cropping system (1024.6 kg ha^{-1}), net returns (Rs 60231 ha^{-1}), benefit: cost (1.43), crop profitability (Rs 286.81 ha day^{-1}) and crop productivity (4.88 kg ha day^{-1}) were also recorded with the application of 50% N through FYM+50% through urea in cluster bean. Amongst nutrient management in cumin, application of 100% RDF resulted in highest CESY (1032.50 kg ha^{-1}), net returns (Rs 42478 ha^{-1}), B:C ratio (1.43), crop profitability (Rs 289.39 ha day^{-1}) and crop productivity (4.92 kg ha day^{-1}) followed by 75% RDF. However among all the treatment combinations, integrated application of 50% N through FYM+50% through urea in cluster bean along with application of 100% RDF in cumin found most effective for obtaining highest CESY (1113.67 kg ha^{-1}) and net return (Rs 69013 ha^{-1}) in cluster bean-cumin cropping systems under arid region of Rajasthan.

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Chemical Properties and Concentration of Heavy Metals in Sewage and Tube-Well Water During Summer Season in Ludhiana District of Punjab

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Ludhiana is the most industrialized city of Punjab. This city is famous for bicycle industry, woolen and hosiery goods, and electroplating, dying, machine tools *etc.* which generate large volume of industrial effluents. Irrigation is one of the best use for sewage effluent because it does not require high quality water that is of value to crops. So, the present study was carried out with the objective to assess the suitability of sewage water around the Ludhiana city for irrigation purposes. Twenty samples of irrigation water were collected in summer season from the 20 sites. Samples were used for determination of major anions (Cl^-, CO_3^{2-} and HCO_3^-), physical and chemical parameters like pH, EC (dS m^{-1}), Residual Sodium Carbonate (meq L^{-1}) using prescribed methods and for Ca, Mg, Na, K, Cu, Fe, Mn, Cd, Pb, Ni, Cr and Zn using ICAP-AES.

There was wide variation in the concentration of the metal ions and the other physical properties. The pH of the sewage water ranged from 6.90-7.38 and the tube-well water from 7.01-8.0 with an average of 7.21 and 7.47, respectively. The pH of both the (sewage as well as tube-well) water samples was within the permissible limit. The mean value of EC in sewage water was significantly higher than that of tube-well water. On an average, sewage water contained 144, 9.74 and 323% higher amount of carbonates, bicarbonates and chlorides, respectively as compared to the tube-well water. The mean concentration of the Ca^{2+}+ Mg^{2+} was 94.08% higher in the sewage water as compared to the tube-well water. The RSC ranged from 4.45-11.35 meq L^{-1} with a mean value 7.42 meq L^{-1} in the sewage water which was 110.11% higher as compare to the tube-well water. On an average tube-well water categorizes as marginal (*i.e.* 2.5-5.0 meq L^{-1} safe limit for irrigation water in Punjab) and sewage water RSC values exceeds the maximum limits for irrigation, and is unfit for irrigation. The concentration of Cd, Ni, Pb, Cr, Fe, Mn and Zn were significantly higher in sewage water as compared to the tube-well water. The mean concentration of Cd, Ni, Pb, Cr, Fe, Mn and Zn in sewage water were 4.25, 40, 6.59, 155.5, 185.8, 66.6 and 9.15 times higher over their respective concentration in tube-well water. In comparison with the standard guideline of irrigation water it was found that mean concentration of Ni, Pb, Cr, Cu, Fe and Zn in sewage water exceeded the recommended level while Cd and Cu concentration were within safe limits. Continuous application of there sewage water to the soil may lead to higher concentration of heavy metals in the soil.

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Effect of Integrated Nutrient Management on Yield and Nutrient Uptake in Pigeon Pea and Wheat Crop Rotation

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Now a days there is a belief to grow the crops by using only organic manures instead of chemical fertilizers but it needs to be studied the effect of organic manures alone or in combination with chemical fertilizers on crop yield and nutrient uptake. Therefore, a field experiment was planned to study the effect of recommended dose of N and P through chemical fertilizers and FYM on yield and nutrient uptake in pigeon pea and wheat crop rotation. The experiment was conducted at the research farm, Department of Soil Science, CCS Haryana Agricultural University, Hisar ($29^0 05'$N, $75^0 38'$ E, 222 m elevation) with the following treatments: (1) Control (2) Recommended dose of N and P through fertilizers (3) 75% RDF N and P through fertilizers + 25% N through FYM (4) 50% RDF N and P through fertilizers + 50% N through FYM (5) 25% RDF N and P through fertilizers + 75% N through FYM (6) 100% N through FYM. Soil of experimental site was sandy loam in texture, having pH 8.0, EC 0.59 d Sm^{-1}, OC 0.36%, available N, P and K as 140, 14 and 280 kg ha^{-1}, respectively. In all, six treatments were maintained in randomized block design with four replications. All the N and P were applied through urea and SSP at the time of sowing in pigeon pea and in case of wheat, all P and half of N was applied at sowing and remaining half was applied at first irrigation. FYM was applied at the time of field preparation before sowing of both the crops. Application of recommended dose of N and P increased grain yield of pigeon pea from 4.39 to 12.37 q ha^{-1} over control and was significantly higher than all the other treatments where some amount of recommended dose of N & P was substituted by FYM (T3, T4, T5 and T6 treatments). Similar trends were obtained in case of straw yield. Similarly, in succeeding crop of wheat, the grain and straw yields were significantly higher where recommended dose of N and P was applied through chemical fertilizers as compared to integrated nutrient management. However, grain and straw yield increased significantly with integrated nutrient management over control and yield was about 50 to 100% higher under various treatments. The N, P and K uptake by pigeon pea varied from 28.83 to 84.18, 5.19 to 16.65 and 27.47 to 79.86 kg ha^{-1} and highest uptake was obtained where recommended dose of N and P was given by chemical fertilizers. It appears that the dose of chemical fertilizers cannot be saved by using FYM in pigeon pea-wheat crop rotation.

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Direct and Residual Effect of Heavy Metals (Cd, Ni and Pb) in Indian Mustard and Maize Grown in Soils Irrigated with Untreated City Sewer Water

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The screen house study was conducted in the Department of Soil Science, CCS HAU, Hisar to evaluate the direct and residual effect of heavy metals *i.e.* Cd, Ni and Pb on Indian mustard and maize (fodder). The crops were grown in soils irrigated with untreated city sewer water. The treatment combination consists of Cd_{60}, Ni_{60} and Pb_{60} spiked soil with 60 mgCd kg^{-1}, 60 mgNi kg^{-1} and 60 mgPb kg^{-1} soil; separately taking $CdCl_2$, $NiCl_2$ and $PbCl_2$ salts. The EDTA was taken as 0, 0.5 g kg^{-1} soil, 1.0 g kg^{-1} soil as disodium salt. Two test crops, Indian mustard (*Brassica juncea* L) and maize (*Zea mays* L) were grown to maximum vegetative stage. The chelating agent (EDTA) was applied at blooming stage in five split doses. No treatment combination was repeated in second crop (Maize). The dry matter biomass of Indian mustard was increased at 0.5 g kg^{-1} soil level of chelating agent and decreased at 1.0 g kg^{-1} soil (EDTA) level in Cd, Ni and Pb spiked soil. In maize, dry biomass increased with increasing levels of chelating agent in Cd spiked soil, however, it decreased in Ni and Pb spiked soil. The concentration as well as uptake of Cd, Ni and Pb in dry biomass (root and shoot) of both the crops increased with increasing levels of chelating agent. As a result, all these three metals have direct and residual effects on both the crops. Since the untreated sewage water which is coming from city wastes containing lot of heavy metals and synthetic chelating agents is absorbed by the vegetables grown in and around the city; this enters in the human-animal-plant chain.

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Interactive Effects of Chromium and Phosphorus on Dry Matter, Yield and Their Distribution in Grain and Straw of Wheat

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Heavy metal pollution is a worldwide problem. Technological advancement due to economic activities of mankind during recent years such as transportation, mining, installation of industrial units, disposal of power generating plants and municipal wastes, and intensive farming has led to broad dispersion of several heavy metals into the biosphere potential. Due to its wide spread and varied industrial applications, chromium happens to be one of the heavy metal pollutant being discharged through industrial effluents and sewage water. The present study was undertaken on wheat (*Triticum aestivum* Cv. WH-542) raised in earthen pots filled with 5 kg of sandy soil with a requisite amount of Cr (VI) (0, 1, 2, 4, 8, 16 mg kg^{-1}) in a naturally lit net house. Yellowing of leaves from tips started at 16 mg kg^{-1} Cr at 25 days after sowing. A general decline in growth after 4 mg kg^{-1} Cr was observed in pots with and without P. A very poor growth of wheat was observed at 16 mg kg^{-1} Cr at all levels of P. After 40 crop days of sowing at 8 mg kg^{-1} Cr with all levels of P, growth is drastically reduced and at 16 ppm Cr with all levels of P, plants were much stunted. Higher doses of Cr (VI) induced International chlorosis in young leaves which turns to necrosis at later stages of growth.

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Soil Test Based Low Input Nutrient Management Strategy for Cassava in an Ultisol of Kerala: Experience from a Long-Term Fertilizer Experiment

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Tuber crops constitute the most important food crop after cereals and grain legumes. Among them, cassava (*Manihot esculenta* crantz) holds promise for 700 million people globally in terms of food, nutritional and economic security cassava is high input crop having good response to manures and fertilizers. Escalating fertilizer prices, its marginal availability, high tuber yield and good market price coupled with concern on human health necessitated precise prescription of manures and fertilizers based on soil nutrient availability and plant requirement. Hence, an attempt was made from 2005 onwards under the LTFE in progress at (CTCRI) (since 1977) by including one of the treatments as soil test based application of manures and fertilizers (STBF). The rate of application of organic manure as farm yard manure (FYM) and chemical fertilizers as N, P and K was arrived following the methodology suggested by Susan John *et al.,* (2010) and Aiyer and Nair (1985). The experimental data over 7 years indicated the superiority of STBF over package of practices (POP) recommendation with complete avoidance of P and reduction in the dose of FYM, N and K to the tune of 20-60, 9-22 and 6-75%, respectively, during all these years. These in turn resulted yield on par with POP where FYM @ 12.5 t ha^{-1} + NPK @ 100:50:100 kg ha^{-1} was applied. Organic carbon status of the soil during 2005, 2006, 2007, 2008, 2009, 2010 and 2011 was 0.71, 0.90, 0.92, 0.78, 0.94, 0.93 and 1.01%, respectively. The P and K status was 56.3 and 145.6, 158.0 and 206.0, 139.9 and 232.9, 80.7 and 192.6, 56.4 and 267.0, 82.3 and 400.3 and 53.8 and 93.5, respectively. The rate of application of FYM was 10, 10, 7.5, 7.5, 7.5, 7.5 and 5 t ha^{-1} and the N:K dose was 91:94, 91; 71,91:71, 91:83, 91:60, 78:25 and 84:106, respectively. The tuber yield recorded during these years under STBF and POP were 20.4 and 22.8, 23.5 and 23.7, 15.8 and 12.6, 31.0 and 30.9, 26.1 and 31.0, 26.2 and 29.2 and 27.1 and 32.1 t ha^{-1}, respectively which in turn was non significant during all these years. A comparison of the tuber yield data between STBF and a higher dose of NPK @ 125:50:125 kg ha^{-1} along with FYM @ 12.5 t ha^{-1} also indicated non significance with an yield advantage of 8, 3, 17, 0, 22 and 24, respectively for the higher dose. The tuber quality parameters *viz.,* cyanogenic glucosides and starch did not show any significant difference among STBF, POP and the higher dose. The soil P status showed a gradual reduction in P to the range of 5-25% from 2005 till 2012. This investigation thus necessitated the need for the adoption and popularization of a soil based INM strategy under the Indian scenario.

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Evaluation of Improved Practices for Fertilizer Applications under Farmers' Field Conditions

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Amount, method and timing of fertilizer application in crops are critical to get maximum use efficiencies of applied fertilizers. Improved practices of fertilizer application have been recommended by research institutions. However, these practices need to be evaluated and demonstrated at farmers' fields. A total of 52 demonstrations were conducted at farmers' fields during the period of 2009 to 2012 in Hoshiarpur district of Punjab. Soil test based fertilizer application resulted in saving of 60 kg P ha^{-1} under very high available soil P conditions in case of wheat without any yield loss as compared to the farmers' practice. This saving in P was 10 to 15 kg ha^{-1} under medium to high available P soil conditions. Keeping in view the build-up of P in soils, skipping of P in *kharif* season for maize and paddy crops, if its recommended dose has been applied in preceding *rabi* crop, helps in saving significant amount of P fertilizer. This practice saved 30 kg P ha^{-1} without any yield loss in case of paddy and maize crops as compared to farmers' practice. Application of 30 kg K ha^{-1} in K deficient soils resulted in 5% higher grain yield both in case of wheat and paddy crops. Use of leaf colour chart for nitrogen application in case of paddy crop resulted in saving of about 30 kg N ha^{-1} as compared to farmers' practice and about 15 kg ha^{-1} as compared to soil test recommended dose without any yield loss. In case of wheat, crop, this saving was about 35 kg ha^{-1} as compared to farmers' practice and 15 kg ha^{-1} as compared to soil test recommended dose of fertilizer N. Therefore, improved practices of fertilizer applications not only have significant monetary benefits for farmers but are also congenial for environmental safety.

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Effect of N, P and S Fertilization on Yield, Quality and Chemical Composition of Soybean in Middle Gujarat Condition

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Field experiments were conducted on soybean during 2008-12 to study the effect of N, P and S fertilization on yield, quality and nutrient content of soybean at TRTC, AAU, Devgadhbaria. The results revealed that the effect of nitrogen application on seed yield of soybean was significant in 1st year. Maximum seed yield (927 kg ha^{-1}) was recorded under 40 kg N ha^{-1}. Similarly during second and 3rd year, significantly higher yield (623 and 759 kg ha^{-1}) were recorded by treatment with 45 kg N ha^{-1}. However, the pooled result revealed that the effect of N application on seed yield was non-significant. The highest seed yield of soybean 893, 595 and 791 kg ha^{-1}, respectively in all the three years were recorded by the application of 60 kg P_2O_5 ha^{-1}. Effect of sulphur on seed yield of soybean were also significant in 1st and 3rd year and as well as in pooled. Application of 40 kg S ha^{-1} recorded significantly highest seed yield 893 and 757 kg ha^{-1} during 1st and 3rd year, respectively. In case of pooled, application of S @ 40 kg ha^{-1} gave significantly higher yield (745 kg ha^{-1}) followed by 20 kg S ha^{-1} application. The interaction effect of N, P and S was found significant in pooled analysis. The result revealed that combined application of 45 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} recorded significantly highest seed yield (855 kg ha^{-1}).

The uptakes of N, P and K by soybean seed, straw and total uptake were significantly influenced by N application. The 1st year, the N application 45 kg ha^{-1} significantly affected to N, P and K uptake by soybean seed, straw and the total uptake. In 2nd year, similar result was obtained with 45 kg N ha^{-1} application. However, the uptakes of N, P and K by soybean seed, straw and total uptake were non significant in 3rd year as well as in pooled. The results showed that the effect of phosphorus application on nutrient uptake by seed, straw and total uptake were significantly influenced in individual year as well as pooled basis. In 1st year, the result revealed that the effect of 60 kg P_2O_5 application was significant to N, P and K uptake by soybean seed and total uptake. In case of pooled, higher level of P application significantly increased N, P and K uptake by seed and total uptake. Sulphur application significantly increased the uptake of N, P and K by seed and total uptake in 1st year. While in 2nd year, S application did not show any significant effect on nutrient uptake except K uptake by straw. In 3rd year, the data showed the effect of S application N uptake by seed, P uptake by straw and total K uptake were increased at 20 & 40 kg S ha^{-1} levels. The result revealed that the application of 40 kg S ha^{-1} found significantly affected to N uptake by seed, P uptake by straw and NP uptake on pooled base analysis. On the basis of pooled analysis, the application of 45 kg N, 60 kg P_2O_5 and 40 kg S ha^{-1} produced significantly higher soybean yield and net realization.

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Minerals Availability from Grazing Resources to Livestock in Arid Soils

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Study was conducted to estimate the mineral contents of grazing resources grown on arid soils for their availability to livestock. The grazing/ browse resources were mostly weeds, grasses, shrubs and trees. Under this study, 10 plant samples, comprising 7 weeds and 3 grasses, most commonly preferred for grazing by the livestock were collected by hand-plucking from arid part of western Rajasthan. Weeds species collected were Kagio (*Tetrapogon tenellus*), Santo (*Trianthema monogyma*), Lolaru (*Digera muricata*), Bekario (*Indigofera cardifolia*), Kanthi (*Tribulus terrestris*), Aandripatha (*Achyranthes aspera*) and Jhingali (*Eremopogon foveolatus*). The Grasses species collected were Moda Dhaman (*Cenchrus setigerus*), Dhaman (*Cenchrus ciliaris* CAZRI-358 and CC-CAZRI-392) and Sewan (*Lasiurus sindicus*). Earlier studies had shown that Ca, Mg and S contents in most arid zone soils are generally adequate for plant growth. However, soil content of Fe, Zn and Cu are area specific and varies within arid region.

These weeds and grasses were analyzed for minerals namely Ca, Fe, Zn, Cu, Co, Mn, Cr, Pb and Mo. The mineral content in weeds range between 197.5 (*Trianthema monogyma*) and 268.1 (*Achyranthes aspera*) for Ca, 107.03 (*Indigofera cardifolia*) and 133.9 (*Trianthema monogyma*) for Fe, 289.2 (*Digera muricata*) and 583.3 (*Achyranthes aspera*) for Zn, 100.3 (*Eremopogon foveolatus*) and 168.9 (*Trianthema monogyma*) for Cu, 27.2 (*Achyranthes aspera*) and 104.9 (*Digera muricata*) Co, 39.2 (*Eremopogon foveolatus*) and 77.9 (*Digera muricata*) for Mn, 90.8 (*Trianthema monogyma*) and 289.3 (*Digera muricata*) for Cr, 38.3 (*Eremopogon foveolatus*) and 67.11 (*Tetrapogon tenellus*) for Pb and 59.7 (*Eremopogon foveolatus*) and 113.9 (*Tribulus terrestris*) for Mo mg 100g. The mineral contants range in grasses were between 105.6 (*Cenchrus setigerus*) and 209.1 (*Cenchrus ciliaris*) for Ca, 91.7 (*Cenchrus ciliaris*) and 135.8 (*Cenchrus setigerus*) for Fe, 202.4 (*Cenchrus ciliaris*) and 477.8 (*Cenchrus setigerus*) for Zn, 61.5 (*Lasiurus sindicus*) and 92.9 (*Cenchrus ciliaris*) for Cu, 49.9 (*Cenchrus setigerus*) and 107.2 (*Cenchrus ciliaris*) for Co, 42.9 (*Lasiurus sindicus*) and 84.6 (*Cenchrus setigerus*) for Mn, 42.8 (*Cenchrus ciliaris*) and 93.3 (*Lasiurus sindicus)* for Cr, 19.1 (*Lasiurus sindicus*) and 42.7 (*Cenchrus setigerus*) for Pb and 0.13 (*Lasiurus sindicus*) and 1.4 (*Lasiurus sindicus*) for Mo mg $100g^{-1}$. Thus, as compared to grasses, weeds contain higher quantity of Ca, Fe Cu, Cr, Pb and Mo, however, Zn and Mn were more in grasses, while Co was more or less with same range. Study showed that weeds are more efficient to supply the available mineral nutrients from the rhizosphere in arid soils to livestock.

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Growth and Yield of Mustard Under Varying Levels of Chemical Fertilizers in Simarouba (*Simarouba glauca*) Based Agrisilviculture System

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An experiment was conducted on loamy sand soil at the Agroforestry Research Farm, Centre for Agroforestry, Forage crops and Green Belt, SDAU, Sardarkrushinagar (Gujarat) to examine the growth and productivity of trees and crop in the agroforestry system *i.e.* simarouba (*Simarouba glauca*) with mustard crop during 2010-11. The simarouba tree has more height (3.98 m) and DBH (12.48 cm) under tree crop interface treatment than the tree alone at 7 years age. The fruit yield (903 kg ha^{-1}) and oil yield (515 kg ha^{-1}) of simarouba seed was significantly higher when the trees were intercropped with mustard crop along with full dose of chemical fertilizers (N and P). The increased plant height, number of branches and 1000 seed weight of mustard crop contributed significantly towards higher seed and stover yields of mustard in open with chemical fertilizer. Mustard yield was higher (19.24 q ha^{-1} seed and 44.25 q ha^{-1} stover yield) with full recommended dose of chemical fertilizer (50 kg N ha^{-1} and 50 P_2O_5 ha^{-1}) followed by 18.05 seed yield q ha^{-1} and 44.25 stover yield q ha^{-1} under simarouba tree and mustard crop interface with chemical fertilizer.

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Studies on Zinc Fortification of Fodder Maize

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Surveys conducted for forage quality evaluation by IGFRI in Jhansi clearly indicated deficiency of Ca, P, Cu and Zn to lactating cows from the feed and forage being served. So far the emphasis has been to supplement the soil with the major nutrients, while crop requirement for secondary and micro-nutrients could be met from soil reserve. Use of high analysis fertilizers limited recycling of plant residues and gap between removal and supplementation of secondary and micro-nutrients have resulted in multiple nutrient deficiencies. When nutrient deficient milk is consumed, it cannot provide complete nourishment to humans, rendering nutrient deficiencies even in humans. Little work has been conducted on fodder supplementation of nutrients to avoid their defiencies in lactating cattle.

Fodder maize is the most promising fodder crop owing to its animal preference and suitability to all seasons. An experiment was conducted to fortify fodder maize with Zn through a set of possibilities including soil application, foliar sprays and a combination of both at two important stages of crop growth *viz.,* knee high stage and tasselling stage. The study indicated highest green fodder yield (51.0 t ha^{-1}) in treatment receiving 50 kg $ZnSO_4$ through soil application. The tissue concentrations were also highest with 50 kg soil application at all stages of the crop. The fodder quality parameters were also influenced by Zn application. At knee high stage, the crude fibre % was highest in 25 kg $ZnSO_4$ soil application + foliar sprays at knee high stage, while the NDF was significantly highest when 12.5 kg $ZnSO_4$ was soil applied + foliar sprays at KH and Tasselling. At tasselling, the NDF was highest with 25 kg $ZnSO_4$ soil application + foliar sprays at knee high stage. At harvest *i.e.,* at early dough stage of the cob, the CF% was highest when $ZnSO_4$ applied at 25 kg ha^{-1} + foliar spray at KH and tasselling. The fortification of Zn was found to the extent of 28% in treatment receiving 50 kg $ZnSO_4$ ha^{-1}, significantly superior than all other combinations. It could be concluded that soil application of 50 kg $ZnSO_4$ ha^{-1} recorded highest fodder yields of maize.

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Effect of Integrated Nutrient Management Under Sorghum-Wheat Cropping Sequence in Vertisol on Soil Properties

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A long-term field experiment on integrated nutrient management in sorghum-wheat cropping sequence is being conducted since 1984-85 to study its effect on soil properties and yield sustainability of sorghum and wheat crops. The present data pertain to the last five years, 2006-07 to 2010-11. The clay textured soil of the experimental plot was slightly alkaline in reaction, with pH 8.15 and EC 0.35 dS m^{-1}. The organic carbon content was 0.64%. The soil was low in available N, P and very high in available K status (153, 14 and 705 kg ha^{-1}, respectively). Various sources of organic manure *viz.,* wheat cut straw, FYM and glyricidia leaves were incorporated in different treatments, with substitution of inorganic fertilizers by 25 and 50%.

Highest grain yields of sorghum and wheat were achieved in the treatment of 50% recommended NPK through fertilizers + 50% N through FYM. Soil reaction and electrical conductivity were not affected much due to application of various treatments involving inorganic fertilizers alone or in conjunction with organic sources like FYM, wheat cut straw and green manuring. The organic C and soil available N and P were increased in the treatments where organic sources were used and were highest in the treatment comprises 50% recommended NPK through fertilizers + 50% N through FYM (0.68%, 238 and 19 kg ha^{-1} respectively). The micronutrients status *viz.,* Fe, Mn, Zn and Cu was also highest in the above treatment. The bulk density was the lowest in the same treatment, indicating an improvement in soil aeration and porosity, which was reflected in increase in hydraulic conductivity. The microbial population in respect to bacteria, fungi and actinomycetes was also highest in this treatment. which may be attributed to the high organic C status. The application of N dose through 50% FYM and 50% NPK through inorganic fertilizers proved useful to obtain higher yields of sorghum and wheat in sequence, by maintaining soil health and fertility.

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Effect of Different Fertilizer Management Practices on NPK Assimilation and Grain Yield in Basmati-Wheat Sequence

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A long-term field experiment was selected to study the effect of fertilizer management practices on NPK assimilation and grain yield in basmati-wheat sequence which was started since *rabi* 2006-07. Objective of the experiment was to study the effect of different nutrient management strategies on crop yield. A known weight of ground plant sample was digested with concentrated H_2SO_4 in presence of catalyst mixture containing $CuSO_4$, K_2SO_4, Se and HgO for estimation of total nitrogen. For estimation of total P and K content, a known weight of grain and straw was digested with HNO_3 and $HClO_4$ in the ratio of 4:1. These digested samples were used for determining total N, P and K content in grain and straw according to procedure outlined by Jackson (1967). Nutrient uptake was worked out by multiplying nutrient content with yield. Treatments applied to wheat were control, chemical fertilizer (recommended fertilizer, RF), integrated nutrient management {75% RF+FYM (INM1), 100% RF+FYM (INM2)} and organic manure (400 kg N ha^{-1} applied through FYM, vermicompost (VC) and rice straw compost (RSC). Fertilizer treatments applied to basmati rice were control, RF and sunhemp green manure. Data revealed that grain and straw yields of basmati ranged from 30.3 to 36.5 and 75.3 to 98.1 q ha^{1}. Highest grain and straw yields were obtained where fertilizer according to INM2 was applied to wheat followed by green manuring. The N, P and K content in basmati grain and straw varied from 0.75 to 1.34, 0.11 to 0.31, 0.49 to 0.65 and 0.17 to 0.63, 0.10 to 0.22 and 0.63 to 1.71% in different treatments. The N, P and K uptake in basmati grain and straw varied from 22.7 to 48.8 kg N ha^{-1}, 3.2 to 11.3 kg P ha^{-1} and 14.8 to 23.7 kg K ha^{-1} and 5.1 to 24.6 kg N ha^{-1}, 3.0 to 8.7 kg P ha^{-1} and 47.7 to 168.0 kg K ha^{-1} in different treatments. Highest nutrient uptake in basmati grain and straw was observed in INM2 treatment. Grain and straw yield of wheat ranged from 13.9 to 42.9 and 18.0 to 69.5 q ha^{-1} in different treatments. N, P and K content in wheat grain and straw varied from 1.07 to 1.68, 0.20 to 0.39 and 0.65 to 0.95 and 0.20 to 0.68, 0.02 to 0.10 and 0.60 to 0.90% in different treatments. N, P and K uptake in wheat grain and straw ranged from 14.8 to 72.0 kg N ha^{-1}, 2.7 to 16.7 kg P and 9.0 to 40.8 kg K ha^{-1} and 3.6 to 47.5 kg N, 0.30 to 6.69 kg P and 10.8 to 62.6 kg K ha^{-1}. Highest NPK uptake in wheat grain and straw was observed in INM2 treatment.

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Soil Test Crop Response Correlation Approach for Dryland Rabi Sorghum Grown on Inceptisols

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A field experiment on nutrient requirement of *rabi* sorghum based on Soil Test Crop Response Correlation Approach was conducted on Inceptisols at STCRC Research Farm during 2012-13. The experiment was divided into three equal strips as F_0, F_1 and F_2 by applying 0, 2.5 and 5 t ha^{-1} FYM, respectively one month before sowing. Eighteen treatments (Fourteen treatment combinations of NPK and four controls) were laid in each FYM block. The treatment combinations consisted of 25, 50 and 100 kg N ha^{-1} and 12.5,25 and 50 kg ha^{-1} each of P_2O_5 and K_2O, respectively. The initial soil samples from each 18 treatment plots were carried before fertilizer application to dryland *rabi* sorghum. The basal full doses of N, P_2O_5 and K_2O were applied at the time of sowing. The grain and stover yield data was recorded. The grain and stover analysis was carried out for NPK uptake. The nutrient requirement was calculated on the basis of yield and total nutrient uptake. The initial soil analysis and nutrient uptake was used to generate basic data *viz.* contribution of soil, fertilizer and FYM for supplying the N, P and K. The contribution of soil for supplying the NPK to dryland *rabi* sorghum were 9.26, 20.39 and 1.78%, respectively. The contributions of fertilizer for NPK without FYM were 27.75, 14.30 and 54.93% and with FYM were 32.18, 17.29 and 86.38%, respectively. Whereas, the contribution of FYM for NPK was 13.52, 3.56 and 3.12% respectively. These basic data were used to derive the fertilizer prescription equations for nutrient requirement of dryland *rabi* sorghum with and without FYM.

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Crop Nutritional Survey and Nutrient Indexing in Bengal Gram Grown Soils of Prakasam District of Andhra Pradesh

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Bengal gram is one of the major crops grown in Prakasam district of Andhra Pradesh. Even though it was introduced in recent years only, it could replace traditional tobacco crop of this area. Mean annual rainfall of this district is 790 mm and most of it received from north east monsoon (October to January). Hence during *kharif* season, land will be left fallow and Bengal gram will be sown from October onwards. These soils are deeep black and very frequently affected by saline-alkaline preoblems. Their nutritional status was not well studied previously. With this view a suryey was conducted in the major Bengal gram grown mandals and soil properties were studied. Leaf samples at peak flowerig stage were also analysed for their major nutrient compositions. A total of 163 surface soil samples were collected from the mandals of Parchur, Inkollu, Addanki, Martur, Koresipadu and Eddanapudi ansd analysed for various soil properties. The results indicated that most of the soils are slightly alkaline to moderately alkaline, non-saline and low in organic carbon status. Only 11 samples are medium in available N and the remaining are low. Hence the nutrient index for available N in these mandals is low and ranged from 1.0 to 1.27. The available P_2O_5 status was low in 24 samples, medium in 44 samples and high in 95 samples. The nutrient index for available P_2O_5 in these mandals is medium to high and ranged from 1.8 to 3.0. The nutrient index for available K_2O is high and ranged from 2.86 to 3.0. Out of 163 samples ony 5 samples were low to medium and all the remaining were high in available K_2O status. Analysis of leaf samples at flowering stage indicated that percent N ranged from 1.06 to 2.99, percent P ranged from 0.10 to 0.19 and percent K ranged from 1.75 to 3.20. These results indicate that the soils require soil organic carbon improvement and addition of 2-50% enhanced doses of N. Build up of P and K in soils was also noticed.

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Effect of Zinc Application with Different Saline Waters on Soil Properties and Wheat (*Triticum Aestivum* L.) Yield

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A pot experiment was conducted during *rabi* season of 2010-2011 at Rajasthan College of Agriculture, Udaipur (Raj.) to study the efficiency of zinc application on the performance of wheat (*Triticum aestivum* L.) irrigated with different saline waters. Influence of Zn in saline water irrigation was judged on physico-chemical and chemical properties of soil, number of tillers, grain and straw yield and nutrient uptake by wheat (var. Raj 3077). The experiment was laid out in CRD with four (W_0, W_1, W_2 and W_3) qualities of irrigation water and four levels of Zn (0, 5, 10 and 15 mg Zn kg^{-1} soil). The results indicated that the increased levels of EC_{iw} significantly increased the EC, ESP and SAR of soil while decreased available pH and P. High EC_{iw} significantly reduced the grain and straw yields, phosphorus, potassium and zinc contents in grain and straw while sodium content increased. Zinc application to soil had favorable effect on grain and straw yield of wheat. The Zn application increased the contents of N, K, Zn significantly in both grain and straw whereas, phosphorus content was decreased significantly. The comparative reduction in grain and straw yield of wheat as well as contents of P and Zn of grain and straw was less at higher doses of $ZnSO_4$ when the level of EC_{iw} increased in irrigation water. Hazardous effects of saline water on wheat can be mitigated to some extent by applying $ZnSO_4$ 15 mg Zn kg^{-1} soil.

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Effect of Vermicompost and Fertility Level on Yield of Pearl Millet (*Pennisetum glaucum* L.) in Semi-arid Eastern Plain Zone of Rajasthan

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A field experiment was conducted at agronomy farm of S.K.N. College of Agriculture, Jobner (26^{o} 05' N latitude, 75^{0} 28' E longitude) district of Rajasthan during *khraif*, 2010. The soil was loamy sand, having low in organic carbon (0.13%), available nitrogen (128.3 kg ha^{-1}), and medium in phosphorus (16.10 kg ha^{-1}) but high in available potassium (154.3 kg ha^{-1}). Four levels of vermicompost (0, 2, 4 and 6 t ha^{-1}) and fertility levels (0, 50, 75 and 100% RDF) fertilizers were applied in RBD with three replications and recommended dose of fertilizers for pearl millet was 60 kg N and 20 kg P_2O_5 ha^{-1}.

The results revealed that vermicompost application @ 6 t ha^{-1} significantly increased grain yield of pearl millet by 51.4, 20.1 and 7.3% over control, 2 and 4 t ha^{-1}. It also recorded the maximum stover yield by 42.4, 19.3 and 6.8% and biological yield by 44.6, 19.8 and 6.7%, respectively, over control, 2 and 4 t ha^{-1}. Successive increasing levels of fertilizers upto 100% RDF (60 kg N + 30 kg P_2O_5 ha^{-1}) significantly increased grain, stover and biological yields. Application of 100% RDF significantly increased grain, stover and biological yield by 37.7, 33.9 and 34.9, 16.4, 16.2 and 16.0 and 6.5, 6.53 and 6.4% over control, 50% and 75% recommended levels, respectively. Application of 4 t ha^{-1} vermicompost with 75% recommended level of fertility gave significantly higher grain yield (1924 kg ha^{-1}).

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Soil Test Based Fertilizer Prescription for Sunflower in Alfisol Soils

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A Sunflower experiment was conducted in an Alfisol at ARS, Utukur, YSR Kadapa district with 24 NPK and vermicompost treatments during *rabi* 2010-11 and 2011-12 for deriving soil test based fertilizer doses for attaining yield targets. Multiple regressions have been calibrated for predicting sunflower yield through soil and fertilizer nutrients and their interactions. In targeted yield approach for calibrating and formulating fertilizer recommendations, the basic data computed were (i) nutrient requirement of N, P and K in kg per 100 kg of produce, (ii) the per cent contribution from soil available nutrients, (iii) the per cent contribution from the applied fertilizer nutrients and the per cent contribution from the applied vermicompost nutrients. Based on the study, the estimates of nutrient (kg) required for obtaining 100 kg yield of sunflower were found to be 2.24 for N, 0.51 for P and 1.35 for K. The soil, fertilizer and vermicompost nutrient contributions (%) were found to be 21.41, 19.00 and 29.22 for N, 22.70, 12.63 and 15.19 for P and 10.12, 60.42 and 11.63 for K, respectively. The response yard stick (kg output kg^{-1} input) was found to be 5.53 based on the targeted yield coefficients. Using the above basic data, fertilizer prescription equations and a fertilizer ready reckoner have been developed for interpolating soil test based optimal fertilizer doses for attaining different sunflower yield targets of 20 and 22 q ha^{-1} in Alfisol soils of Andhra Pradesh.

Fertilizer Prescription Equations

$FN = 11.81\ T - 1.13\ SN - 1.54\ VC\ N$

$FP_2O_5 = 4.04\ T - 1.80\ SP - 1.20\ VC\ P$

$FK_2O = 2.23\ T - 0.17\ SK - 0.19\ VC\ K$

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Prescription of Soil Test Based Fertilizer Recommendations for Specific Targeted Yield of BT Cotton in Alfisol Soils of Andhra Pradesh

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Soil Test Crop Response (STCR) field experiment was conducted on Bt cotton during *kharif* 2011-12 and 2012-13 in Alfisols of Utukur, YSR Kadapa district, with an objective of developing soil test based fertilizer recommendations for attaining yield targets under IPNS. With the help of nutrient uptake, soil test values and average basic data (*i.e.* nutrient requirement of N, P and K, per cent contribution of N, P and K from soil, fertilizer and vermicompost) required for making fertilizer recommendations for different BT cotton production levels (25 and 30 q ha^{-1}) were calibrated. The basic data were transformed into simple workable fertilizer prescription equations for calculating fertilizer doses based on initial soil test values. Based on the study, the estimates of nutrient requirement (kg) for obtaining 100 kg kapas yield of BT cotton were found to be 2.37 for N, 0.20 for P and 1.02 for K. The nutrient contributions from soil, fertilizer and vermicompost were found to be 16.52, 29.12 and 11.23 for N, 18.61, 6.65 and 8.54 for P and 11.46, 17.30 and 13.32 for K, respectively. The response yard stick (kg output kg^{-1} input) was found to be 5.88 based on the targeted yield coefficients. Using the fertilizer prescription equations, a fertilizer ready reckoner was developed for interpolating soil test based optimal fertilizer doses for attaining desired BT cotton yield targets of 20 and 25 q ha^{-1} in alfisol soils of A.P.

Fertilizer Prescription Equations

$FN = 8.15\,T - 0.57\,SN - 0.39\,VC\,N$

$FP_2O_5 = 2.95\,T - 2.80\,SP - 1.28\,VC\,P$

$FK_2O = 5.92\,T - 0.66\,SK - 0.77\,VC$

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Soil Test Crop Response Approach for INM to Okra (*Abelmoschus esculents* L.) Moench. in Mollisols of Uttarakhand

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A field experiment was conducted during spring 2012 in a Aquic Hapludoll at Norman E. Borlogue Crop Research Centre of the G.B. Pant University of Agriculture and Technology, Pantnagar (29^o N latitude and $79^0 29'$ E longitude), as per the technical programme of All India Coordinated Research Project on Soil Test Crop Response Correlation. The experiment was conducted in two phases. In the first phase soil fertility gradient was created by dividing experimental field into three strips and applying graded doses of fertilizers in them and growing of exhaust crop fodder oat (var. UPO-212). In the second phase *i.e.* next season test crop okra (var. *Parbhani kranti*) was grown by diving each strip in 24 plots having 23 treated and one control plot. Response to selected combinations of three levels of FYM (0, 10 and 20 t ha^{-1}), four levels (0, 50,100 and 150 kg ha^{-1}) of nitrogen, phosphorus (P_2O_5) and potassium (K_2O), respectively at different fertility levels of okra was studied. The values of organic carbon, alkaline $KMnO_4$ extractable N, Olsen's P and neutral normal ammonium acetate extractable K in the experimental field ranged between 0.67-1.05%, 112-275% and 21.2-32.9 and 143-258 kg ha^{-1}, respectively. Total N, P and K uptake by okra ranged from 40.64-140.20, 11.10-53.70 and 38.10-132.80 kg ha^{-1}, respectively. In the present investigation the total fresh fruit yield ranged from 37.89-202.77 q ha^{-1}, Ascorbic acid (fresh) ranged from 4.2-11.1 mg 100 gm^{-1}, crude fiber ranged 1.69-2.03% and protein ranged from11.38-16.4% in different treatments. The nutrients requirement for production of one quintal of okra (fresh) was found to be 0.70 kg of N, 0.21 kg of P_2O_5 and 0.72 kg of K_2O. Percent contribution of N, P and K was 35, 72 and 29, respectively, from soil, 5.50, 11.90, 7.00, respectively, from FYM, 26, 19, 51, respectively, form chemical fertilizer and 29, 20, 58, respectively, from conjoint using chemical fertilizer & FYM, Using above basic data fertilizer adjustment equations were developed (FN= 2.4T- 1.20 SN-0.19FYM-N, FP= 1.05T-3.6 SP- 0.95FYM-P, FK= 1.24 T-0.5 SK-0.12 FYM-K) for integrated nutrient management to okra. These equation can be used for conjoint use of mannure and fertilizer recommendation as per yield expected by the farmers and his resource constraints. Findings of this investigation may successfully we used for the larger parts in Mollisols of Uttarakhand for efficient and balanced fertilizer use for quality production of okra in this region.

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Evaluation of Quality of Soils in a Long-Term Fertility Experiment (24 years) with Rice-Wheat Cropping System under Inceptisols

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Soil quality indicators (SQIs) can be used to evaluate sustainability of land use and soil management practices in long-term cropping systems. The quality is assessed integrating physical, chemical and biological attributes of soils. We evaluated soil quality for a long-term fertility experiment with rice-wheat cropping system under Inceptisols in Indo-Gangetic Plains. Soil samples were collected at 0-0.20 m depth and analysed for a large number of physical (bulk density and mean weight diameter and aggregate stability), chemical (soil pH, cation exchange capacity, easily oxidisable carbon by 24N, 18N and 12N H_2SO_4, total soil organic C, available N, P, K, Ca, Mg, B and cationic micronutrients) and biological (microbial biomass carbon, microbial biomass nitrogen, mineralizable carbon, mineralizable nitrogen, and a few enzymes (dehydrogenase, β-glucosides, acid and alkaline phosphatase) attributes. Result showed that higher values of aggregate indices were recorded in fallow soils followed by NPK+ farmyard manure (FYM) > NPK+ paddy straw (PS) > NPK+ green manure (GM) > NPK > farmers' practice > control treatments in decreasing order. Allocation of organic C in passive pool was highest in NPK+PS followed by fallow > NPK+FYM > NPK+GM > NPK > farmers' practice > control in decreasing order. Application of NPK+FYM and NPK+GM and NPK fertilization caused a significant increase in N_{min} not only over the control but also over the fallow for both the systems. Organic amendments significantly increased the activities of enzymes related to C, N, P and S cycles over the NPK, control and fallow treatments. For developing quality index of soils equivalent rice yield (ERY) was used as a goal variable and all analysed attributes were considered as independent variables for computing linear correlation, principal component analysis (PCA) and multiple regression. β-glucosides activity, very labile organic C, aggregate stability and hydraulic conductivity were the key indicators of soil quality in the 24-year old long-term fertility experiment with rice-wheat cropping system in Inceptisols.

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Organic Farming for High Value Crops and its Impact on Soil Health under Hill Ecosystem of North Western Himalayas

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A field experiments were conducted for three years at FSR farm, Chatha of SKUAST-Jammu with high value crops like paddy (Pusa-1121)-potato (Kufri Badshah)-French bean (contender) cropping sequence to evaluate organic sources vis-s-vis farming with integrated nutrient in terms of yield, quality and soil health for raising high value crops. The climate at the site is hot and humid with annual rainfall of about 1100 mm, major portion of which is received during July to September, the rice growing period. The highest yield of paddy (37.03 q ha^{-1}), potato (133.65 q ha^{-1}) and French bean (39.32 q ha^{-1}) after 3rd year of study period was recorded in treatment, where 100% recommended N through different organic source each equivalent to 1/3rd of N through FYM + vermicompost + non-edible neem cake + VAM were applied then followed by integrated nutrient management treatment, while 100% recommended dose of NPK through fertilizer treatment was found at par with INM treatment, respectively. After 3rd year cropping sequence, soil organic carbon content was recorded higher and range varied from 0.53 to 0.56% in all the plots where organic practices were adopted over initial value of 0.51%. Similarly, soil bacteria (55×10^5 CFU g^{-1}) and fungi (28×10^5 CFU g^{-1}) was recorded higher in treatment, where 50% recommended N through vermicompost + biofertilizer + rock phosphate to substitute the P requirement + PSB were applied to each however, the population of actinomycetes in the soil was higher (17×10^5 CFU g) under the treatment where different organic sources FYM + Vermicompost + non-edible neem cake) + VAM were applied to each crop. There is ample scope for organic farming in hill ecosystem under sub tropical condition, where there is little or no use of fertilizers and other agro chemicals.

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A Comparison of the Effects of Copper Seed Priming and Soil Fertilization on Yield and Copper Nutrition of Wheat (*Triticum aestivum* L.) under Field Condition

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Seed priming with nutrient solutions provides a simple and inexpensive method for improving plant nutrition. In this investigation, two concentrations of 0.03 and 0.06% $CuSO_4.5H_2O$ solution and a soaking interval of 6 h standardized in the laboratory study for Cu seed priming along with soil application (4.5 mg kg^{-1} soil as $CuSO_4.5H_2O$ in pots and 10 kg Cu ha^{-1} in field), foliar application (0.1% $CuSO_4.5H_2O$ + lime), seed coating (3g $CuSO_4.5H_2O$ kg^{-1} seed) alone and in combination (Total 10 treatments) were used to evaluate their effect on Cu nutrition of wheat (cv PBW 550 and PDW 233). Germination initially increased significantly but as the concentration of Cu in priming solution and the duration of soaking increased, The germination percentage decreased which may be due to an elevated level of Cu in seeds. The effect of 0.03 and 0.06% $CuSO_4$ solution used for soaking of wheat seeds up to 8 h on the germination of both the cultivars was not significant as compared to soaking in plain water for 2 h duration. But thereafter, germination percentage of both the varieties decreased significantly over 8 hours duration as well as for 2 h duration. Therefore, the concentration of 0.03 and 0.06% $CuSO_4$ solutions and a soaking time of 6 h duration were selected to evaluate its effect on Cu nutrition of wheat crop.

Mean Cu content of Cu-primed wheat seeds increased significantly from 4.1 to 174 mg g^{-1} as the concentration of $CuSO_4$ solution used for soaking increased from 0 to 0.4% irrespective of soaking duration for PBW 550 cultivar. The corresponding values for PDW 233 varied from 4.3 to 151.5 mg g^{-1}. The content of Cu in wheat seeds of PDW 23.3 was considerably lower as compared to PBW 550, which may be due to the reason that durum wheat is harder than the bread whet and it may be difficult to penetrate into its seed.

Grain and straw yields increased significantly by 6.86 and 5.41% with soil application and by 11.5 and 12.3% with Cu seed priming wiith 0.03 $CuSO_4.5H_2O$ + foliar application over control, respectively. Copper concentration and its removal by root, shoot, grain and straw increased significantly over control by Cu fertilization. The differences in the yield, Cu concentration and its uptake by wheat with soil application and Cu seed priming with 0.03% $CuSO_4.5H_2O$ with or without foliar application were not significant, thereby indicating that both these treatments were equally effective for Cu fertilization of wheat. Significant positive correlation of grain (r=0.372*) and straw Cu uptake (r=0.414*) with leaf Cu concentration was observed. Furthermore, the yields, Cu concentration and its removal by PDW 233 were significantly lower than that of PBW 550. These results indicated that either the Cu requirements of durum wheat may be lower than that of bread wheat or the translocation of Cu from root to shoot of PDW 233 may be affected due to lower production of root biomass. In the absence of any visual symptoms of Cu deficiency, an increased activity of ascorbate peroxidase in the leaves as a result of Cu fertilization suggested that wheat might have suffered from hidden hunger of Cu under the conditions where these investigations were undertaken.

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Effect of Integrated Nutrient Management on the Forms of Sulphur in Pearl Millet – Mustard Cropping Sequence

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Sulphur is one of the essential elements for plant growth. Mostly sulphur in the soil can be grouped into four forms *viz.* total-S, organic-S, non-sulphate-S, and available-S. In these different forms of sulphur-organic-S dominantly control the levels of plant available sulphur. The important factors which influences the content and availability of S in soils are-organic matter and texture of soil. Sulphate-S represents plant available-S, which is immediate supplier of sulphate ions to the roots for absorption by plants. Heavy removal of S by high yielding varieties, particularly oil seed crops, under intensive cropping with high S requiring crops and continuous use of sulphur free fertilizers. Under these contexts, a study on the distribution of different forms of S in the soils of pearl millet-mustard cropping sequence already in progress since 1998 is Inceptisols of Gwalior district of M.P. was undertaken and samples were collected from sixteen treatments after the harvest of mustard in 2008. Result indicate that the application of 150% NPKS or supplement application of FYM with different levels of NPK support the build up of different forms of S in soil and is maximum under 150% NPKS which also maintained satisfactory level of water soluble and available S in soil. In general, surface soil contained higher amount of water soluble and available S as compared to sub-surface soil in all the treatments. The organic carbon status showed highly significant positive correlation with different forms of S (*i.e.* water soluble, available, organic and total) in surface as well as in sub surface soils respectively, indicating that organic matter played a vital role in the maintenance of applied S fertilizer through its exchange sites. A highly positive significant relationship existed between different forms of S (*i.e.* water soluble, available, organic and total) in surface as well as in sub-surface soils. Thus, there existed equilibrium between different forms of S and depletion of one is instantly replenished by other forms of sulphur.

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Status of Available Sulphur and DTPA-Extractable Micronutrient Cations in Mustard Growing Areas of Northern Madhya Pradesh

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Mustard (*Brassica juncea* L.) is one of the major *rabi* season oil seed crop of Morena, Bhind and Gwalior district of northern Madhya Pradesh. There are reports of reduction in yield even due to constant use of NPK fertilizers. The reduction in the yield is generally traced due to deficiency of secondary (sulphur) and micronutrients. Keeping in view, in present study, one hundred fifty (150) composite surface soil samples (0-15 cm) were collected from irrigated and non- irrigated mustard growing fields of 30 villages covering Gwalior, Morena and Bhind districts (10 villages of each district). The processed soil samples (<2mm) were analyzed for different physico-chemical properties, available-S and DTPA-extractable Zn, Cu, Fe and Mn by standard procedures.

The available-S and DTPA- extractable Zn, Cu, Fe and Mn contents ranged from 4.36-19.58, 0.18 – 2.56, 0.12 - 4.62, 1.25 -18.65 and 0.36 -16.65 mg kg^{1} with the mean values of 15.31, 0.69, 1.14, 5.55 and 4.36 mg kg^{1}, respectively. About 25.0% samples were found deficient and 75.0% medium and none of samples under sufficient category of available S. Whereas, available Zn and Fe were deficient in 46.0 and 35.3% soil samples, respectively, while Cu and Mn were adequate in all the soil samples. The S, Zn and Fe deficiency increased with an increase in pH and calcium carbonate content whereas it decreased with an increase in organic carbon content in mustard growing fields of northern Madhya Pradesh.

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Soil Fertility Status, Quality and Yield of Mustard as Influenced by Integrated Nutrient Management in an Alluvial soil

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Mustard (*Brassica juncea* L.) is the second important oil seed crop in India after groundnut in area and production. Nitrogen, phosphorus and potassium as the major nutrients and sulphur among the secondary nutrients play an important role in the yield and quality of mustard. In view of emerging micronutrient deficiencies in recent years, integration of inorganic, organic and bio-fertilizer is essential for maintaining productivity. Keeping these points in view, experiments were conducted with integrating the sources of nutrients like inorganic fertilizer, FYM and bio-fertilizer on mustard in three consecutive rabi seasons of 2007-08 to 2009-10 with sixteen treatments and three replications on an Inceptisol at Research Farm, College of Agriculture, RVSKVV, Gwalior. Mean results of three years indicated that the application of balanced fertilizer at optimum level (100% NPKS) recorded significantly higher yield of mustard by 47.14, 15.52 and 11.70% over 100% N, 100% NPS and 100% NPK-S treatments, respectively. Maximum seed yield (22.36 q ha^{-1}) recorded in 100% NPKS alongwith 10 t ha^{-1} yr^{-1} FYM, Azotobacter and PSB inoculation; however yield was at par with 150% NPKS applied alone. Uptake of nutrients more or less followed the content and yield pattern, as content and yield of crop were higher, so was the uptake, total uptake of nutrients (NPKS) increased with their application to the crop. A linear significant increase was observed in oil content in mustard seed upto 150% NPKS level. Balanced nutrition of NPKS at optimum level (100% NPKS) also showed significantly higher oil content as compared to nutrients applied alone (100% N & 100% NP). Treatments containing FYM and seed inoculation with Azotobacter and PSB were superior in increasing the organic carbon content compared to NPKS applied alone. Application of NPKS with FYM and PSB recorded significantly higher available P than NPKS applied alone. Declining trend in available K status over initial was observed in the treatments which did not receive K. The decline in available-S status was in all the treatments except 150% NPKS level or with additional application of FYM with 75 and 100% NPKS.

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Effect of Foliar Feeding of 19:19:19 and Potassium Nitrate (KNO_3) Water Soluble Fertilizers on Yield and Quality of Byadgi Chillies in a Vertisol

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A field experiment was conducted during *kharif* 2011-12 in the farmer's field at Agadi village (Taluk: Hubli) in Dharwad district to investigate the Effect of concentrations and time of foliar spray of 19:19:19 and KNO_3 water soluble fertilizers on yield and quality of Byadgi chillies in a Vertisol. Experiment consisted of 13 treatments and three replications. Results showed that foliar spray of one per cent 19:19:19 water soluble fertilizer at 60 and 90 DAT recorded highest fruit yield (10.19 q ha^{-1}) closely followed by treatment that received one spray of 19:19:19 (1%) at 90 DAT (9.33 q ha^{-1}) and two sprays of one per cent KNO_3 (9.24 q ha^{-1}). Foliar spray of one per cent KNO_3 at 60 and 90 DAT recorded significantly highest colour value (264.93 ASTA units) and the treatment (T_{13}) that received two sprays of 19:19:19 fertilizer (1%) recorded highest capsaicin (0.14%) which was on par with treatments T_7 and T_{12}. Highest oleoresin (18.32%) was recorded in treatment (T_7) which was on par with treatments T_6 (17.03%) and T_{13} (16.83%). Highest nitrogen (2.30%) and phosphorus contents (0.41%) in chilli fruits was recorded in treatment T_{13}, while highest potassium (3.81%) was recorded in treatment T_7. Nitrogen content of red fruit bears significant positive relationship with capsaicin (r= 0.99**) while potassium content bears significant positive relationship with colour value (r=0.95**) and oleoresin content (r=0.88**). The B:C ratio was highest (2.68) in treatment T_7, closely followed by T_{13}. Foliar application of water soluble fertilizers at both concentrations (0.5 and 1%) significantly increased the uptake of major nutrients as well as sulphur. Available nitrogen and phosphorus contents in soil at harvest were not much influenced by concentrations as well as time of foliar spray of 19:19:19 and KNO_3, but available K content in soil was significantly reduced due to foliar spray of both fertilizers.

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Status on Ferrous Sulphate and Zinc Sulphate Application on Yield and Quality of Byadgi chillies in Calcareous Vertisol of Northern Transitional Zone of Karnataka

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A field experiment was conducted during *kharif* 2012 in the farmer's field at Agadi village in Dharwad district to study the response of Byadgi chillies to ferrous sulphate and zinc sulphate application in calcareous Vertisol in northerm transitional zone of Karnataka. The experiment consisted of ten treatments with three replications. Results showed that application of ferrous sulphate @ 25 kg ha^{-1} to soil on 30th DAT + foliar spray of 0.5% $FeSO_4$ on 60th and 90th DAT recorded highest fruit yield (17.17 q ha^{-1}) closely followed by treatment that received soil + foliar application of $ZnSO_4$ (16.60 q ha^{-1}). Ferrous sulphate applied treatments recorded comparatively higher fruit yield than $ZnSO_4$ applied treatments. Highest colour value (274.23 ASTA units) and oleoresin content (18.07%) in red chillies were recorded with soil (25 kg ha^{-1}) + foliar (0.5%) application of $FeSO_4$. Foliar spray of $ZnSO_4$ (0.5%) on 60th and 90th DAT produced minimum per cent discoloured fruits (5.26%) and treatments receiving only $FeSO_4$ application recorded comparatively higher discoloured fruits than treatments receiving $ZnSO_4$ application (T_3 and T_5). Control recorded maximum per cent discoloured fruits (6.12%). Combined foliar spray of $FeSO_4$ and $ZnSO_4$ (each 0.5%) at 60 and 90 DAT resulted in marginal decreased colour value (230.11 ASTA units) but numerical increase in discoloured fruits (5.54%) compared to individual foliar spray. Highest Fe (196.6 mg kg^{-1}) and Zn (86.5 mg kg^{-1}) contents in red fruits were noticed in treatments receiving soil+foliar application of $FeSO_4$ (T_6) and $ZnSO_4$ (T_7) respectively. Potassium content of whole red fruits had a significant positive correlation with colour value (r=0.79**) and oleoresin content (r=0.81**). Fe and Zn contents of whole red fruits were positively correlated with colour value (r=0.65* and r=0.63* for Fe and Zn, respectively). Zinc content of whole red fruit possessed significant negative relationship with per cent discoloured fruits (r=-0.84**). Per cent discoloured fruits possessed significant positive relationship with leaf N content (r=0.66*), while K, Fe and Zn contents possessed significant negative relationship. Highest B : C ratio (5.31) was obtained due to soil + foliar application of $FeSO_4$ (T_6).

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Integrated Nutrient Management for Rubber (*Hevea brasiliensis*) in Tripura : Influence of FYM and Inorganic Fertilizer on Growth and Soil Properties

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A field experiment was conducted at Pathalia, Sepaijhala district of Tripura during 2007-13 to study the effect of integrating organic manures with chemical fertilizers on growth of young rubber (*Hevea brasiliensis*), its nutrient uptake and soil properties. The treatments comprised of farmyard manure (FYM) with 50% recommended dose of inorganic fertilizer, 100% recommended dose of inorganic fertilizer (RDF) with no fertilizer as control and the experiment was laid out in a block design with 125 plants block^{-1}. Significant increase in girth and height were recorded for plants receiving FYM @ 20 kg plant^{-1} with 50% of RDF and its influence was more pronounced in the beginning years. At the end of 6th year, mean girth of the plants receiving FYM @ 20 kg plant^{-1} with 50% of RDF was 48.3 cm and 68.3% attained tappable girth. The corresponding mean girth values for plants receiving 100% inorganics at the RDF and without fertilizer were 44.7 cm and 35.8 cm and the tappable plants were 57.6% and nil, respectively. Integrating FYM with inorganic fertilizer increased the soil nutrient status particularly available N (226.3 kg ha^{-1}) significantly compared to application of inorganics alone (201.3 kg ha^{-1}). Significant increase in leaf nutrient content of plants was also observed due to combined application FYM and inorganics indicating higher uptake of applied nutrients. DTPA extractable micronutrients particularly Zn and Mn were also significantly increased due to combined application of FYM and inorganic fertilizer. Result from the experiment revealed that application of FYM @ 20 kg plant^{-1} with 50% RDF could reduce the gestation period of rubber plants at least by six months to one year besides improving soil health, when grown in the denuded lands in Tripura.

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Effect of Silica on Rice (*Oryza sativa* L.) Yield and its Uptake under Different Levels of Nitrogen Application

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Silicon is considered as quasi-essential element for healthy plant growth and sustainable production. Application of nitrogenous fertilizers increase rice yield, but excess of N may limit crop yield because of lodging, shading and susceptibility to insects and diseases. However, these effects could be minimized by the use of Si, which is reported to raise the optimum level of nitrogen. Keeping this in view, an investigation on the effect of silica on rice (*Oryza sativa* L.) yield and its uptake under different levels of nitrogen application was carried out during *kharif* 2010 and 2011 to study extensively various aspects of Si nutrition in rice. During *kharif* 2010, index leaves and soil samples were collected from rice section varietal display plots of Telangana region. Out of all the 133 genotypes evaluated, two promising varieties, one with high Si (JGL-3855) and the other with low Si (RNR-2354) contents were selected for further field verification during *kharif* 2011 at RARS, Jagtial. Among the genotypes, a positive and significant correlation (r = 0.55) existed between Si content of index leaf and grain yield.

The experiment was laid out in strip-plot design consisting of sixteen treatmental combinations with four levels of Si (0, 200, 400 and 600 kg ha^{-1}) and four levels of N (0, 80, 120 and 160 kg ha^{-1}) with 3 replications. Nitrogen and silica were applied as per the treatmental combinations and the recommended doses of P_2O_5 (60 kg ha^{-1}) and K_2O (40 kg ha^{-1}) fertilizers were applied uniformly to all the treatments. Results indicate a positive response in yield and other yield parameters determined with conjunctive application of Si and N. Among the varieties, JGL-3855 showed significantly higher grain and straw yields (6779 and 8949 kg ha^{-1}) compared to RNR-2354 which recorded grain yield of 6460 kg ha^{-1} and straw yield of 8530 kg ha^{-1}. The combination of N and Si application of 160 kg N + 600 kg Si ha^{-1} (T_{16}) recorded significantly higher grain and straw yields (7180 and 9693 kg ha^{-1}) over control and was on par with other treatments which received N @ 120 and 160 kg ha^{-1} along with silica 200, 400 and 600 kg ha^{-1} except T_9 (N 120 + Si 0) and T_{13} (N 160 + Si 0). The silica and nitrogen contents of index leaves and their uptakes at harvest were increased correspondingly with increased levels of their application. Conjunctive use of Si and N significantly increased the nutrient concentration and their uptake by straw and grain except in the treatments which received N @ 120 and 160 kg ha^{-1} alone. Considering all aspects, application of Si @ 200 kg ha^{-1} along with N @ 120 kg ha^{-1} can be recommended for rice crop grown in three agro climatic zones of Telangana region of Andhra Pradesh.

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Impact of Soil Salinity on Differential Accumulation of Phosphorus by Groundnut Cultivars

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Groundnut (*Arachis hypogaea* L.) is an important leguminous oilseed crop, extensively grown in the semi-arid Saurashtra region of Gujarat. In these areas salinity is a common problem both in terms of saline soil and high level of total dissolved solids (TDS) in irrigation water affecting groundnut production by hindered growth and nutrient uptake. An experiment was conducted at farm of Directorate of Groundnut Research during *kharif*, 2011 to assess the change in phosphorus (P) uptake pattern in different plant parts at various levels of soil salinity in calcareous black clay soil having in-built soil salinity developed over a period of ten years. Four levels of salinity were imposed through irrigation water (EC_{iw}) [0.5 (control), 2.0, 4.0 and 6.0 dS m^{-1}] assigned to main plots and eight Spanish groundnut cultivars (TPG 41, GG 6, GG 8, SG99, GG 7, TG 37A, R 2001-3 and Girnar 3) were assigned in sub plots in a split plot design. Being a key element to determine crop growth, nutrition and economic yield was found to accumulate variably under saline condition in different plant parts in these cultivars. Root-P showed an increasing trend of accumulation with increase in EC_{iw} upto 6.0 while leaf-P increased only upto 4.0 EC_{iw} with a concomitant rise in soil EC and available P. Among the cultivars, GG 6 and TG 37A were found superior for root-P accumulation under saline condition. Whereas, higher leaf-P content was observed in GG 8, TG 37A and GG 7 over four applied salinity levels. (Root $leaf^{-1}$) ratio-P emerged to be an important parameter for interpreting the P-distribution in roots over leaves as the values differed significantly among the cultivars. Ratio-P was observed higher for R 2001-3 (1.054) at 2.0 EC_{iw}, followed by TG 37A (0.958) at 6.0 EC_{iw}. However, across the cultivars, the P-uptake (g $plant^{-1}$) was reduced under the influence of salinity. The reduction was significant when the applied EC_{iw} was 6.0 dS m^{-1} while it did not show significant variations at lower salinity levels. Further, these P accumulation parameters correlated with the yield and yield attributes of groundnut crop and it was found that root-P (r= -0.67, -0.72) and ratio-P (r= -0.69, -0.50) had a negative correlation with pod yield and haulm yield at 6.0 EC_{iw}. The study concludes that P uptake of groundnut affected at a certain salinity level, although that indicates a luxury consumption of P as evidenced by increasing P content in leaves and roots.

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Effect of Fly Ash on Yield and Nutrient Accumulation by Rice in Iron Toxic Alfisol

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A field experiment was conducted in low land iron toxic soil (Aeric Haplaqupt) of Central Farm, OUAT, Bhubaneswar during 2010-12 to study the effect of fly ash on rice yield, nutrient content, heavy metal accumulation in plant and soil as well as change in soil properties. The experiment was conducted with 8 treatments consisting 100% RDF, 100% RDF + Fly ash @ 10 t ha^{-1}, 100% RDF + Fly ash @ 20 t ha^{-1}, 100% RDF + Fly ash @ 40 t ha^{-1}, 50% RDF + Fly ash @ 10 t ha^{-1}, 50% RDF + Fly ash @ 20 t ha^{-1}, 50% RDF + Fly ash @ 40 t ha^{-1}, 50% RDF + Fly ash @ 10 t ha $year^{-1}$. The recommended dose of fertilizer for rice was 80-40-40 N-P_2O_5-K_2O kg ha^{-1}. The soil of the experimental site was sandy loam in texture, acidic (pH 4.27), low in available P and K but medium in nitrogen. The fly ash from NALCO, Angul used in the study was slightly alkaline in reaction (pH 7.5) and contains appreciable amount of available P, K, S, B, Ca, Zn, Cu and Mn. The content of total Cr, Pb and Cd was higher than the soil. The fly ash was applied to the first crop of rice during 2010 and its effect was studied on third crop during 2012. The results revealed that application of fly ash significantly increased the grain yield of rice over three seasons. Addition of fly ash @ 40 t ha^{-1} resulted in 29.4% higher grain yield and 30.1% straw over control. Fly ash has significant positive effect on biometric characters like plant height, panicle length, no. of tillers and chaff percentage. The chaff percentage was reduced significantly by 28.64 to 42.25% when fly ash was applied @ 20-40 t ha^{-1}. Accumulation of P and K in fly ash treatment at PI stage of the rice crop was increased over control by 46 and 4%, respectively. Fly ash has significant effect on Fe reduction might be due to high silica content. Accumulating of Fe at PI stage was reduced from 4% to 2.8% in root and 3798 to 3010 ppm in shoot when the crop received fly ash @ 20 t ha^{-1}. However, the accumulation of Mn, Zn and Cu in both root and shoot was increased with fly ash application. Accumulation of heavy metals like Pb, Cd and Cr in root and shoot were higher in fly ash treatments as compared to control. Fly ash has no beneficial effect on content of P, K and Ca in both grain and straw. However its application enriched the content of Fe, Mn, Zn and Cu in grain by 7.0, 23.0, 25.0 and 93%, respectively, over control. Content of Pb, Cd and Cr in both grain and straw were below the critical limit. The uptake of P and K by rice varied between 6.87-9.67 and 50.22-68.42 kg ha^{-1} in fly ash treatments as against 6.36 and 58.49 kg ha^{-1}, in control, respectively. The uptake of Ca, Fe, Mn, Zn and Cu by rice was increased with fly ash application. The post harvest soil properties indicated that fly ash addition increased the percentage of clay in surface and sub surface soil. There was decrease in oxidizable organic carbon and P status of soil after harvest of third crop. However, there was build up in available K. Thus fly ash application @ 40 t ha^{-1} to the first crop increased the grain yield, nutrient accumulation and uptake. There was no toxic effect of Cd, Pb and Cr on third crop of rice and post harvest soil.

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Screening of Maize Hybrids for Salt Tolerance in Andhra Pradesh

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The cropping pattern in Andhra Pradesh has been changed to maize due to severe Yellow Mosaic Virus (YMV) infestation in pulses. In Andhra Pradesh the area (8.56 Lakh ha^{-1}) under maize crop is increasing over years but the productivity (2.54 t ha^{-1}) is decreasing in some areas which might be due to salinity of water. Many of the promising maize hybrids are not salt tolerant. The experiment was carried out for three years (in *rabi* seasons of 2010, 2011 and 12) at Saline Water Scheme, Bapatla with 3 hybrids of maize *viz.,* 30V92, Sandhya and DHM 117 (ANGRAU) at different salinity levels of irrigation water (Best Available Water, EC_{iw} 2, 4, 6 and 8 dSm^{-1}). Initial soil (0-15 cm) had pH 7.17, EC 0.34 dS m^{-1}, available N 247 kg, P 35.8 kg and K 483 kg ha^{-1}. The highest germination percentage was noticed in Sandhya hybrid (96%) in best available water treatment but with increasing EC levels of irrigation water the germination percentage has decreased drastically. However, 30V92 hybrid has shown highest germination percentage with increasing the EC level of irrigation water compared to Sandhya and DHM 117 hybrids.

The soil EC values with different be levels increased with increasing EC level of irrigation water compared to the initial values. This may be due to salt buildup in the soil as a result of application of irrigation water. Available N, P and K values decreased compared to initial values. This may be due to removal of nutrients from soil as it is a heavy exhaustive crop. Among hybrids, 30V92 hybrid has significantly performed (6008 kg ha^{-1}) well compared to Sandhya and DHM 117. Irrespective of the hybrids used for cultivation, the highest yield was recorded with the application of best available water and significant reduction in yield was noticed with each increment of salinity level from 2 to 8 dS m^{-1}. There was significant interaction between yield of different hybrids and EC levels of irrigation water.

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Response of Cotton (*Gossypium arboreum* L.) to Boron under Sodic Water Irrigation in a Calcareous Soil

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In Punjab, 42% of the groundwater show high incidence of residual alkalinity. Long-term use of such waters results in increased soil pH, and accumulation of soluble salts and exchangeable Na, creating a hostile environment in the soil rhizosphere. Due to intensive cropping in absence of proper replenishment of nutrients except macro nutrients such as N, P and K, deficiencies of S, Zn, Cu and B are increasingly being observed in soils. Among these, B deficiency is gaining importance as it is indispensable for the normal growth and development of plants. Several factors like soil pH, calcium carbonate content, aridity, and organic matter affect B availability in the soil. Boron availability to plants decreases with increasing soil pH. In arid areas, B uptake can be reduced due to adsorption of a great portion of soluble B on the $CaCO_3$ surface. Keeping these facts in view, a field experiment was conducted during *kharif* season for three years (2010-2012) in calcareous soil at research farm of Punjab Agricultural University, Ludhiana to study the response of cotton (*Gossypium arboreum* L. cv. MRC 7017) to sodic water irrigation and B levels in presence and absence of gypsum. Important physico-chemical characteristics of the experimental site were pH 7.9 - 8.5, electrical conductivity 0.22 -0.27 dS m^{-1}, organic C 3.0 -3.5 g kg^{-1}, $CaCO_3$ 28 - 44 g kg^{-1}, ESP 3.4 - 4.5% and available B content of 0.408 mg kg^{-1} soil. The treatments comprised of five levels of irrigation water *viz.* canal water (CW), sodic water (SW, RSC 12.5), SW + 12.5% of gypsum requirement (GR), SW + 25% GR and SW + 50% GR and four levels of B *viz.* 0 (B_0), 0.5 ($B_{0.5}$), 1 ($B_{1.0}$) and 2 kg B ha^{-1} ($B_{2.0}$). Sodic water were synthesized by dissolving 1.05 g of commercial grade $NaHCO_3$ for 12.5 $mmol_c$ L^{-1} in 180 L of CW in large steel drums and it was conveyed through a rubber hose pipe (6 cm diameter). Results revealed that the individual effects of irrigation treatments and B applications were significant; however, their interaction was not significant. Irrigation with SW significantly declined the seed-cotton yield by 10.3% compared to CW. Gypsum amended treatments recorded significantly higher mean seed-cotton yield compared with SW irrigation, however, gypsum application rates did not differ significantly. Significant difference in response to B application was recorded for $B_{1.0}$ (16%) and $B_{2.0}$ (22.4%) but not for $B_{0.5}$ treatment (4.6%) over B_0 treatment. Mean yield increased by 4.6, 16.0 and 22.4%, respectively, in B treated plots compared to control. Hence, B application B @ 1 kg ha^{-1} is beneficial in sustaining seed-cotton yields in calcareous soils irrigated with canal water or sodic water with/without gypsum.

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Response of Direct Dry–seeded Rice (*Oryza sativa* L.) to Phosphorus Fertilization on Different Soils Varying in Available P and Texture

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Most of the rice in Asia is cultivated by transplanting 25- to 30- day-old seedlings into puddled soil. Due to looming water crisis and shortage of labour during transplanting, farmers in north western India are considering the option from puddle transplanted rice to direct dry -seeded rice (DSR). Next to N, phosphorus (P) deficiency is a key constraint in the cultivation of DSR. Cultivation of DSR after wheat is likely to encounter the lower availability of P compared to puddled transplanted rice. Keeping this in view, a greenhouse experiment was conducted to study the effect of three levels of P (0, 6.5, 13 mg P kg^{-1} soil) application on biomass accumulation and P uptake of DSR at maximum tillering, panicle initiation and flowering stages on ten different soils varying in texture, available P and pH. Significant soil P level interaction effects on shoot dry matter yield of DSR at all the growth stages was observed. Low P soils (< 5 mg kg^{-1} soil) showed significant response to P application in terms of biomass yield and P uptake up to 6.5 mg P kg^{-1} soil. In medium and high P category soils, P uptake was significantly higher compared with low P soils. Textural difference in high P status soils did not register any significant difference on the response of DSR to applied P as the higher content of Olsen-P over shadowed the impact of texture. A critical limit of Olsen-P for DSR, below which the crop is likely to suffer yields, was determined by Cate-Nelson graphic model and it was 6.75 mg kg^{-1} soil.

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Characterization of Soils around the City Solid Waste Dumping Sites in Haryana

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The unmanaged and unsafe disposal of municipal solid waste represent a potential source of pollutants and contaminants released into the soil and environment. To assess and characterize the soils around the city solid waste dumping sites, a study was conducted at three locations in Haryana, India *viz.,* Rohtak, Jind and Karnal. The sites invariably represented different kinds and duration of waste being deposited. Soil samples were collected from different depths at different interval distances from the dump sites and after processing analyzed for certain physicochemical properties and contents of potentially toxic metals. The pH of soil samples near to the dump sites was found lower than that from the cultivated indicating the release of some organic acids by the dumping material which ultimately helps in bringing down the soil pH. In case of EC, there were not many variations among different depths and locations irrespective of the distance adjoining the dumping site. The organic carbon content at different depths and interval distances showed a variation from 0.08 to 1.12% in Rohtak, 0.11 to 1.38% in Jind and 0.11 to 0.58% in Karnal samples. The nearby-cultivated field samples varied from 0.03 to 0.27, 0.09 to 0.24 and 0.09 to 0.84 at Rohtak, Jind and Karnal sites, respectively. The higher OC content in samples around the dumping sites was due to the mixing/migration of the fine waste material especially in the upper horizons. Overall, the organic carbon content at each site decreased with depth and spatial distance from the dumpsite. Except Cd, most of the toxic metals (Pb, Ni, Cr, Co) were found well below the toxic limit in the soil. However, it may be noted that all soils in the vicinity of these sites contained low but measurable quantities of potentially toxic metals. The maximum concentration was observed in the surface samples (0-15 cm), suggesting that there might have been some complexation of these metals either with clay or organic matter thereby restricting their movement to the downward depths.

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Micronutrients Status in Soil Profile under Different Tree Species of Arid and Semiarid Region

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Block plantation (of one hectare) of five multipurpose tree species of arid and semi arid region *viz. Prsopis cineraria, Dalbergia sissoo, Acacia nilotica, Eucalyptus tereticornis* and *tamarix aphylla* of about 15-20 years old were selected for determining the micronutrients (Zn, Fe, Cu, Mn) status in soil. Soil samples of the depth of 0-4, 4-15, 15-30, 30-60, 60-90, 90-120 and 120-150 cm were collected from the soils under each tree species and also from the soil which were devoid of trees. The micronutrients and organic carbon content of these soil samples were determined by adopting standard procedures. In general, micronutrient status in soil was more under surface horizon in control as well as under all tree plantations and decreased gradually but significantly with the increase in depth. In comparison to control, the micronutrient concentration was significantly higher in soils under all tree species and among tree species, higher amount of micronutrient was found under *Dalbergia sissoo* followed by *Prosopis cineraria* and *Acacia nilotica*. The higher amount of micronutrients under above species might be due to higher biomass production and accumulation of leaf litter in soil under these tree species.

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Utilization of Treated Effluent from Fertilizer Industry for Crop Production on Vertisols

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Diverse nature of effluents from various industries are disposed off to soil and water bodies, which has been causing major pollution problem. To economize the irrigation water industrial effluents are commonly used for irrigation. So it is relevant to understand the response of industrial effluents to crops dependent on it. Analysis of effluents from urea, ammonium nitrophosphate (Narmada PHOS), calcium ammonium nitrate (Narmada CAN) plants of the Gujarat Narmada Valley Fertilizer Company Ltd., indicated that effluents produced were less toxic as their chemical constituents were within acceptable limits. These plants produced about 2000 m^3 of effluents per day. In view of its sub-lethal nature and the same are being used by farmers of nearby villages for irrigation purpose, an experiment was conducted during 2006-2009 with crops like castor, cotton, wheat and dill on Vertisols with the treatments comprising application of effluent irrigation as such and in combination with water. Data on initial soil analysis showed that the experimental soils were neutral to slightly alkaline in reaction and soil salinity ranged from 0.8 to 4.2 dS m^{-1}, ESP from 2.2 to 5.6%, organic carbon from 0.2 to 0.4%, $CaCO_3$ from 4 to 9% and SAR from 0.9 to 3.4. Cation exchange capacity varied from 40 to 48 cmol(p^+)kg^{-1} with 48-51% montmorrillonitic clay, available N content from 70 to 114 kg ha^{-1}, Fe from 8.1 to 13.6 ppm, Mn from 9.7 to 13.4 ppm, Zn from 0.3 to 0.44 ppm and copper 2.4 to 2.8 ppm. Treated effluent was also analyzed for its various characteristics like pH, EC, BOD, COD, TSS, chloride, sulphate, SAR and ammoniacal N and found that the values were below the threshold values recommended for irrigation. Result indicated that application of treated effluent has not brought any changes in soil salinity and soil pH under all the crops indicating its non deleterious effect on soil characteristics. Analysis of post harvest soil samples indicated that there was an increase in available N under the effluent treatment and also an increase in the concentration of all the micronutrients in the treated plots over the control plot. However, the concentration of these micronutrients was well below the toxic limit and thus their increase in concentration within the limit will help in the metabolic activities of the plant which in turn help in increase in the productivity. Gradual increase in the quantity of available N from BAW to pure effluent and its accumulation is more in 0-15 cm depth compared to 15-30 cm depth indicating effluent application meets the N requirement partially for the crops. Use of effluent irrigation resulted in significant increase in plant height and straw yields of crops suggesting the beneficial effects of N fraction of the effluent in biomass production of wheat though effluent irrigation has resulted in higher biomass production, the relative partitioning of photosynthates into economic component *i.e.,* grain is only marginal. The straw yield under the diluted effluents and pure treated effluent was found non-significant, suggesting the dilution has resulted in less impact of nitrogen component present in the effluent. Data on growth and seed yield of dill indicate effluent enhanced seed yield. Effluent application resulted in increased growth by 17% test weight by 15% and seed yield by 15% over the fresh water treatments. The data indicated that water productivity of wheat and dill were higher under the pure effluent treatment while in castor the diluted effluent gave higher water productivity. Similar trends were observed in terms of net returns gained for the unit of water used. The studies clearly indicated the beneficial effects of effluents in terms of crop production and economic returns. In wheat, the diluted effluent was found even better than the surface water in enhancing water productivity.

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Impact of Long-term Application of Sewage Water on Soils around Hubli City in North Karnataka

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Water is a severely limited resource in most of the developing countries. The population increase has not only increased the fresh water demand but also increased the volume of waste water generated. Use of sewage water for growing crops has been practised for years by the peri-urban farmers around Hubli city. A study was conducted with the objective of understanding the impact of long-term application of sewage water on soils around Hubli city in North Karnataka. The sewage water samples were collected from three villages Gabbur, Mavanur and Katnur located at 2, 5 and 6 km from the Hubli city close to the stream carrying sewage water. The sewage water were analyzed for different parameters like pH, EC, BOD, COD, TSS, TDS, cations, anions and heavy metals. In each village, five soil samples were collected from three depths (0-20, 20-40, 40-60 cm) at distances of 50, 150, 250 m off the stream course and analyzed for pH, EC, Organic carbon and composition of exchangeable cations.

From the study it was observed that all parameters of the sewage water decreased with increase in the distance from the sewage outlet. The pH of the sewage water is slightly alkaline in reaction (7.31 to 7.44) and that of EC in the range of 1.19 to 1.23 dS m^{-1}. The BOD and COD values ranged between 410-640 mg L^{-1} and 524 -695 mg L^{-1}, respectively. The alkalinity of the sewage water seems be due to bicarbonates (7.6 - 8.4 ppm) only because carbonates were not observed. It had appreciable amounts of chloride and sulphate contents (7.8 – 8.7 meq L^{-1} and 7.22-7.55 ppm, respectively). The total solids content in sewage water ranged between 1090- 1130 mg L^{-1}. The sodium concentration (5.13- 5.49 meq L^{-1}) was above the safer limits prescribed by FAO (1985) and the other cations were within the safer limits and the heavy metals were also below the detectable limits in the sewage water. The pH and EC of the sewage irrigated soils increased with the depth ranged from 7.72-8.24 and 0.28 – 0.70 dS m^{-1}. The EC in the soils was slightly higher in soils sampled close to the stream (50 m) at Gabbur than those sampled away at all the depths. No such trend was observed in respect of other two villages. Despite of long-term irrigation with sewage water the EC build up is not appreciable in all three depths in all villages. Whereas, pH showed a slight increase with depth in all three villages the EC remained nearly uniform in majority of the cases except for a slight increase at the surface in sites closer to the stream at Gabbur. The available N content was higher in soils of Gabbur village, especially in soils 50 and 150 m away from the stream compared to other two villages. The organic carbon content in the sewage irrigated profiles ranged from 0.55 to 0.79% in the surface layers and it decreased with depth (0.21 to 0.40%). The exchangeable sodium content was in the range of 0.26-1.23 meq L^{-1} in the surface layer and there were no drastic variation in the sodium content in the subsurface layers. The exchangeable cations like Ca and Mg were increased with the depth in the range of 24.9-28.2 meq 100 g^{-1} soil.

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Investigation on Alkalinity of Biochars Produced from Different Feedstocks at Different Temperatures

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Soil application of biochar is being considered as new vista for sustainable crop production and carbon sequestration by effecting major soil properties like pH, EC, organic carbon and plant available nutrients. A laboratory analysis was conducted to investigate the alkaline properties of biochar, which is considered as main reason to increase soil pH when biochar is applied to soil. Different biochars were prepared from Rice (RC), Wheat (WH), Maize (MA) and Pearl Millet (PM) residues at three different highest treatment temperatures (HTT) *i.e.* 400, 500 and 600 ^oC. Biochar pH and electrical conductivity (EC) was measured by suspending 1 g of biochar in 20 mL of distilled water. Calcium carbonate equivalent (CCE), water soluble carbonate ($CO_3^=$) and bicarbonate (HCO_3^-) contents of all 12 biochars were also measured by a titrimetric procedures. For all biochars pH, EC, CCE and CO_3= increases an while HCO_3^- decreases with increase in HTT. Highest pH value *i.e.* 10.75 was recorded for PM biochar produced at 600^{o}C. Among all biochars, PM biochar showed highest pH value (10.52) followed by RC biochar (10.18), MA biochar (10.12) and WH biochar (10.04). EC values ranges from 4.48 to 2.79 dS m^{-1} among the biochars. The RC biochar showed highest EC (4.10 dS m^{-1}) and CCE (43.3). The $CO_3^=$ and HCO_3^- content decreases in the order: PM > WH > RC > MA and RC > MA > WH > PM, respectively. For investigating alkalinity of these biochars XRD and water soluble K, Ca and Mg contents were further analyzed. XRD analysis of biochar showed presence of inorganic minerals in the biochar. Important minerals which were identified in the biochar are sylvite (KCL), calcite ($CaCO_3$), dolomite ($CaCO_3.MgCO_3$) and quartz (SiO_2) along with other minerals in minor amounts. Water soluble K, Ca, Mg and Cl content confirm the presence of above stated mineral in the biochar.

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Characterization of Underground Irrigation Water of Jalore District

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Water is a basic human need and a precious national asset. The quality of water is more important compared to quantity in any water supply planning, especially for drinking purposes. Increasing population growth and limiting natural resources have increased problems associated with the disposal of waste water and also exploitation of groundwater for domestic, industrial and agricultural applications. The main objective of the present research work is to characterize the underground water in Jalore District and its suitability for irrigation purpose. Geo-referenced underground water samples (107) were collected from different parts of Jalore district. These water samples were analysed by using standard methods of analysis and interpretation by using RSC and SAR. Jalore district being a part of arid region has ground water of varying salinity and chemical character. The water table of the tube wells in Jalore district varied 10 to 77.70 m. Deep water levels (>50 m) are observed in parts of Bhinmal, Raniwara, Soyla and east of Sanchore blocks. The EC and pH of water samples ranged between 0.54 to 12.08 dS m^{-1} and 7.05 to 10.41, respectively. Soluble $CO_3^{=}$ and HCO_3^- in these waters varied from 0.0 to 5.9 and 1.4 to 28.6 me L^{-1}, respectively. The concentration of Cl^- and SO_4^{2+} varied from 1.6 to 87.0 and traces to 25.9 me L^{-1}, respectively. The concentrations of Ca^{2+} and Mg^{2+} varied from 2.8 to 120.0 me L^{-1}. Sodium is the dominant cation concentration ranged from 1.21 to 197.7 me L^{-1}. SAR and soluble sodium percentage of the water samples varied between 0.6 to 33.1 and 13.7 to 88.7, respectively. The residual sodium carbonate (RSC) of these waters ranged between nil to 5.7 me L^{-1}.

The results clearly indicates that about 20.6, 38.3 and 41.1% water samples showed EC in the range of 0-2, 2-4 and > 4 dS m^{-1}, respectively. About 26.2, 56.1, 15.9 and 1.9% water samples showed (SAR) as permissible, moderately safe, moderately unsafe and unsafe. According to Richard's classification, about 67.3, 9.3 and 23.4% water samples showed RSC as permissible, moderately safe and unsafe. Thus, groundwater quality is gradually getting deteriorated. The EC, SAR and RSC values hinted out that one third water samples belong to either moderately saline or moderately unsafe for irrigation purposes and its continuous use may lead to salinity/ alkalinity development in soil. Highly saline waters, however, cannot be recommended for all the crop categories (except salt tolerant) either due to high value of RSC or SAR. Water having high amounts of RSC may also be used, but along with the required quantity of gypsum to neutralize the excess RSC.

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Effect of Different Amendments on Soil Properties, Berry Yield and Quality Parameters of Grapes Irrigated with Saline-sodic Water

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An experiment was conducted at research farm of PAU Regional Station, Bathinda from 2008 to 2013 to investigate the effect of poor quality groundwater in relation to different amendments on grape vine (*cv. Perellete*) yield, qualitative characteristics and soil properties. Different water quality treatments *viz.* canal water (CW); poor quality groundwater (GW); alternate irrigation of canal and groundwater (CW-GW); GW with 50% gypsum requirement (GW+GR_{50}); GW with 75% gypsum requirement (GW+GR_{75}) and GW with pressmud @ 10 t ha^{-1} (GW+PM). The experiment was conducted in a randomized block design with four replications. The experimental soil was sandy loam in texture, low in organic carbon, medium in available P and high in available K. The poor quality groundwater used in the experiment was having EC 2200 micromhos cm^{-1} and residual sodium carbonate 6.4 meq L^{-1}. The pooled mean of 5 years research data revealed that treatments CW-GW, GW+GR_{50}, GW+GR_{75} and GW+PM significantly increased the berry yields by 28.3, 11.3, 21.2 and 31.0% respectively, compared to GW. Application of amendments along with poor quality groundwater showed a significant increase in total soluble solids (TSS) compared to groundwater alone. Irrigation with groundwater caused detrimental effect on soil quality as it resulted in highest pH (9.35), EC (0.6 mmhos cm^{-1}), SAR (11.01) and low organic carbon content (2.0 g kg^{-1}) of the soil. Application of amendments *i.e.* pressmud, gypsum (GR 75%) and cyclic use of canal and ground water exerted considerable influence in decreasing the pH and SAR of the soil. Organic carbon content of the soil improved with the application of pressmud. Maximum water expense efficiency 3.99 q ha-cm^{-1} was observed in CW treatment followed by 3.93, 3.72 and 3.68 q ha-cm^{-1} in GW+PM, CW-GW and GW+GR_{75} treatments, respectively.

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Long-term Effect of Irrigation Water Quality in Conjunction with Different Amendments on Soil Properties and Productivity in Cotton-Wheat Cropping System

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A field experiment was conducted in a light textured soil using brackish water in permanent plots at Punjab Agricultural University Regional Research Station, Bathinda to study the effect of different amendments on soil properties and yield of cotton and wheat from 2004-12. The treatments were canal water (CW); poor quality tube well water (TW); CW and TW alternately, pre-sowing irrigation (PSI) with CW (CW/TW); TW, PSI with CW (flat sowing of wheat and furrow planting of cotton); TW + Zinc (Zn); TW + Gypsum(G); TW + farm yard manure (FYM); TW + Zn + FYM + G and CW + Zn + FYM + G. The experiment was conducted in a randomized block design with four replications. The experimental soil was loamy sand in texture, alkaline in reaction, low in organic carbon, medium in available P and high in available K. The residual sodium carbonate and electrical conductivity of the tubewell water used was ranged from 6.0- 6.4 meq L^{-1} and 2000- 2200 μmhos cm^{-1}, respectively. The corresponding values for canal water were 0.5 meq L^{-1} and 450 μmhos cm^{-1}, respectively. Zinc sulphate, FYM and gypsum were applied once in a year before sowing of wheat @ 62.5 kg ha, 25 t ha^{-1} and 12.5 q/ha/4 irrigations, respectively. Pooled analysis of the data suggests that conjunctive use of poor quality tube well water with canal water (CW/TW) and amendment application along with tube well water (TW+G, TW+FYM, TW+Zn+FYM+G) significantly increased seed cotton yield over tube well water alone (TW). However, wheat grain yield was not affected with the use of either brackish water alone or in combination with amendments. The pH, EC and SAR of soil increased and organic carbon content decreased with the application of tube well water irrigation. Conjunctive use of canal water with tubewell water, TW with gypsum application alone and TW with gypsum + FYM + Zn decreased the pH and SAR of surface soil. The organic carbon content of the soil improved with the application of FYM + Gypsum + Zinc in both canal and tubewell irrigated treatments.

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Amelioration of Iron Deficiency in Aerobically Grown Rice on Alkaline Soil

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Iron (Fe) deficiency is one of the serious nutritional disorders, which lead to a decline in productivity in aerobically-grown rice on upland alkaline and calcareous soils. A pot experiment was conducted with four surface soil samples (alkaline soil of IARI; acid and lime-treated acid soils of Ranchi; calcareous soil of Birauli KVK, Pusa, Bihar) to evaluate the relative efficacy of soil, seed treatment and foliar application of Fe in alleviating its deficiency. Two used rice (*Oryza sativa* L.) cultivars were: IR-64 (Fe-inefficient) and Pusa Sugandh-3 (Fe-efficient). Four levels of Fe applied included *(i)* control, *(ii)* soil application of 67 mg $FeSO_4.7H_2O$ kg^{-1} at the time of sowing, *(iii)* three foliar sprays (at 40, 60 and 75 DAS) of 3% $FeSO_4.7H_2O$ solution, and *(iv)* 0.05*M* Fe-EDTA used as seed treatment. Thus, in all, 32 treatment combinations were laid out in a completely randomized design (CRD) with three replications.

Results showed that, three foliar sprays of 3% $FeSO_4.7H_2O$ produced highest grain yield to the tune of 18.9 g pot^{-1} followed by soil application (17.5 g pot^{-1}) and seed treatment (16.1 g pot^{-1}), whereas lowest grain yield was recorded under control (15.7 g pot^{-1}). The mean responses of rice in terms of grain yield were 11.9, 20.5 and 3.0% under Fe application by soil, foliar and seed treatments, respectively, over control. Among the soils, acid soil (without lime) produced highest yield of aerobic rice followed by alkaline, calcareous and lime-treated acid soils. Interactive effect of soil type and applied Fe on grain yield was significant, indicating that efficiency of applied Fe on yield varied with the soil type. Pusa Sugandh-3 performed better under aerobic condition compared with IR-64. The Fe^{2+} content in Pusa Sugandh-3 was invariably higher across the soils compared with that of IR-64. Unlike total Fe, the Fe^{2+} content of IR-64 was lower in the lime-treated acid soil (35.8 mg kg^{-1}) than alkaline (37.4 mg kg^{-1}) and calcareous (32.7 mg kg^{-1}) soils. These results indicate that Fe^{2+} content is a better indicator of iron nutrition status of rice plants as compared with total plant Fe and chemically extractable soil Fe.

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Impact of Waste Water Irrigation on Heavy Metals Accumulation in Soil and Plants

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Environmental pollution with toxic heavy metals has increased dramatically due to rapid industrialization and surge in population. In Bhopal, the waste water of the patra naala is used as the main source of irrigation for the crops and is being utilized for daily needs by the people living in its vicinity. Thus, the aim of this study wals to assess the toxic level of different heavy metals and micronutrients in the soil, water and the plant samples collected from patra naala and surrounding areas. To achieve the objectives, samples were collected and analyzed in the laboratory of Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal (M.P.), during Jan-June 2013. It was summarized that the waste water collected from the patra naala is highly contaminated with cadmium, nickel, iron and manganese. Similarly, tube well water upto 2 km periphery of patra naala is also having high concentration of cadmium, lead, copper and manganese. Soil samples collected from near naala, 1km away from naala and 2 km away from naala showed that the concentration of heavy metals and micronutrients were well within the permissible limits. Hence, the soil is not contaminated may be due to its buffering capacity. But irrigation with waste water from patra naala influenced the heavy metal level in plant samples. All plant samples collected from near naala, 1 km away and 2 km away from naala have high concentrations of cadmium, lead and nickel. It was recorded that the Cd concentration was around 10 times higher, Pb was 8-12 times higher and Ni was about 5 times higher than the safe limits given by FAO.

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Effect of Sewage Sludge on Yields, Heavy Metal Content and Soil Fertility under a Rice-Wheat System

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Large scale urbanization as a consequence of economic development is leading to production of huge quantities of effluents in India and posing serious environmental problems for their disposal. Sewage sludge is a product of sewage treatment plant and results from removal of solids and organic matter from the sewage. It is a rich source of organic matter, nutrients and heavy metals. The present study was conducted to assess the impact of sewage sludge on yields, soil fertility and heavy metals buildup under rice-wheat system. The experimental soil (0-15 cm) had pH 7.95 (1:2.5), EC 0.219 dS m^{-1}, organic carbon 0.24% and available N, P and K to the tune of 62.72, 16.1 and 139.3 kg ha^{-1}, respectively. DTPA extractable Fe, Mn, Cu, and Zn were found to be 32.4, 9.58, 6.14 and 1.59 mg kg^{-1}, respectively. Five levels of sewage sludge as 0 (S_0), 10(S_{10}), 20(S_{20}), 30(S_{30}) and 40(S_{40}) t ha^{-1} and 100% recommended dose (N: P_2O_5 : K_2O :: 120 : 60 : 60) of fertilizer (RDF) was applied. After harvesting of rice, wheat (*Triticum aestivum* L. cv. Malviya 234) was grown in the same pot without application of sewage sludge (SR_0, SR_{10}, SR_{20}, SR_{30}, SR_{40}) and chemical fertilizers to study the residual effect of sewage sludge applied in rice crop and one level of recommended dose (N: P_2O_5 : K_2O :: K_2O : 120 : 60 : 60) of fertilizer (RDF) was also taken. The yield of rice grain increased by 3, 15, 23 and 45% over control at 10, 20, 30 and 40 t ha^{-1} application of SS. However, corresponding increase as residual effect of SS was 37, 47, 63 and 68% in wheat. The soil pH increased with the application of sewage sludge in rice while it decreased in post harvest soil of wheat. With increase in sewage sludge doses, increase in soil available nutrients (N, P, K, S and micronutrients) was recorded. Although application of sewage sludge improved the fertility status of soil it caused heavy metal accumulation in soil and plants. Land application of sewage sludge increased organic carbon and nutritional content of soil and due to its slow release nature; it has potential to fulfill the nutritional need of crop for prolonged time. Application of sewage sludge gave significantly higher grain yield due to more number of tillers and significantly higher test weight both in rice and wheat crops. But the higher doses of SS increased heavy metal contents in grain. Hence, application of sewage sludge is good for improving crop production and build up of nutrients in soil. A regular monitoring of metal concentrations in soil and plant parts should be taken up while its continuous use.

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Influence of Water Quality on Exchange Phase-Solution Phase Behaviour of Texturally Different Salt Affected Soils

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The influence of total electrolyte concentration (TEC) and sodium adsorption ratio (SAR) of water on ESR-SAR relationships of normal clay loam, saline silty loam and sodic loam soils was studied in a laboratory experiment. Sixteen solutions, encompassing four TEC levels *viz*., 25, 50, 75 and 100 me L^{-1} and four SAR levels *viz*., 5, 10, 20 and 30 $mmol^{1/2}$ $L^{-1/2}$ were prepared to equilibrate the soil samples using pure chloride salts of calcium, magnesium and sodium at Ca: Mg = 2:1. SAR of equilibrium solution decreased compared to the equilibrating solution and more so in waters of low salt concentrations and high SAR. At all electrolyte concentrations, SAR values were not attained to the equilibrium solution because of addition of Ca and Mg from the mineral dissolution from the exchange sites. A positive interaction of TEC and SAR influenced the ESP build-up and CEC played a major role in the visual disparity in sodification of these soils. At higher TEC levels, considerable increase in ESP was observed when it was correlated for anion exclusion and more so in sodic loam followed by saline silty loam and normal clay loam soils. The soils exhibited differential affinity for Ca^{2+}, Mg^{2+} and Na^{+} under different quality waters. Regression coefficient of ESR-SAR relationships was maximum for sodic loam followed by saline silty loam and normal clay loam soil. The exchange equilibrium was strongly affected by TEC of the solution phase. Variation in soil pH was gradual with respect to TEC and SAR of equilibrating solution and a sharp change was observed.

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Validation of Oryza 2000 Model under Nitrogen Limited Conditions of Transplanted Rice in Southern Telangana Region of Andhra Pradesh

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An experiment was carried out at college farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif* 2012 to validate ORYZA rice model under variable nitrogen levels of transplanted rice (*Oryza sativa* L.) using BPT 5204 variety. The experiment was laid out in randomized block design with six N levels replicated four times. The treatments include N a levels from 90 to 240 kg ha^{-1} at an increment of 30 kg ha^{-1}. The soil was neutral in reaction, non-saline and medium in organic carbon content, low in available N and medium in available P_2O_5 and K_2O. The results revealed that application of 180 kg N ha^{-1} (5892 kg ha^{-1}) recorded the highest grain yield, number of tillers m^{-2} (345), number of panicles m^{-2} (319) and number of grains per panicle (179) over all other N levels. The highest straw yield was observed with the application of 240 kg N ha^{-1} (7415 kg) followed by 210 kg and 180 kg ha^{-1} (7303, 7043 kg ha^{-1} respectively). However, increase in straw yield, leaf area index, chlorophyll content and dry matter production were increased with each successive increment of N dose from 90 to 240 kg ha^{-1}. Crop growth parameters were generated and calibrated at variable N levels using ORYZA 2000 rice model. The results revealed that the dry biomass was underestimated at initial stage of crop growth upto 60 DAT. The RMSE ranged from 102 to 356 and correlation coefficient ranged from 0.96 to 0.98 between actual and predicted values of grain yield. Significant differences between observed and simulated grain yields were not observed in‘t’ values (paired ‘t’ test) and was supported by low RMSE value of 37 and normalized RMSE value of 1.27%. The results showed that the model is an excellent tool to predict transplanted rice grain yield under variable N levels in Southern Telangana region of Andhra Pradesh.

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Assessment of Groundwater Quality in Jhajjar Block of District Jhajjar (Haryana)

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Groundwater is the most important source of water in arid as well as semiarid regions of India and its quality plays an important role to plan the proper irrigation strategy. Thus, a study has been carried out for the quality appraisal of the groundwater of Jhajjar block of district Jhajjar, Haryana. Groundwater samples were collected from running tubewells in the area and analyzed for electrical conductivity (EC), pH and ionic concentrations of CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+ and K^+. According to AICRP classification, it was found that 20.7% waters were of good quality, 39.0% saline and 40.3% alkali in nature. Out of the saline water, 18.3, 1.2 and 19.5% were marginally saline, saline and high SAR saline, respectively. In alkali group, 7.3, 4.9 and 28.1% were marginally alkali, alkali and high alkali, respectively. The study revealed that 81.7% of the samples showed EC upto 4 dS m^{-1} and the maximum value of EC (13.3 dS m^{-1}) was found as in village Kheri Asara. Residual sodium carbonate (RSC) and sodium adsorption ration (SAR) varied from nil to 10.3 me L^{-1} and 3.23 to 29.97 (m mol $l^{-1})^{1/2}$, respectively. Cl^- and HCO_3^- were found in appreciable quantities, whereas, CO_3^{2-} were in traces. Contour maps of EC, SAR, RSC and water quality of groundwater used for irrigation in the block were plotted to study spatial variability of these parameters. The average values for CO_3^{-2}, HCO_3^-, Cl^- and SO_4^{-2} were found to be 0.33, 5.10, 20.49 and 1.11 me L^{-1}, respectively, and the anions were in order of $Cl^- > HCO_3^- > SO_4^{-2} > CO_3^{-2}$. Average values for Na^+, Mg^{+2}, Ca^{+2} and K^+ were 20.55, 4.28, 1.34 and 0.59 me L^{-1}, respectively and the cations were in order of $Na^+ > Mg^{+2} > Ca^{+2} > K^+$.

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Assessment and Categorization of Groundwater Quality for Irrigation of Bahadurgarh Block, Jhajjar District, Haryana

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Water is most vital input in agriculture and has made a significant contribution in providing stability to food grain production and self-sufficiency. This resource can be optimally used only when quality of water is assessed at micro level. The present study was aimed to assess and categorise the quality of groundwater of Bahadurgarh block of Rohtak district by focusing on spatial variability of electrical conductivity (EC), pH, cationic and anionic composition of the groundwater. It was revealed that 65.4% of the samples showed EC values less than 4 dS m^{-1} and the maximum value of EC was found as 12.24 dS m^{-1} in village Kanaunda. Residual sodium carbonate (RSC) and sodium adsorption ration (SAR) varied from nil to 7.6 me L^{-1} and 2.50 to 21.87 (mmol L^{-1})$^{1/2}$, respectively. The concentration of Na^+, Ca^{2+} and Mg^{2+} --ions generally increased with increase in EC of the water samples. Cl^- and HCO_3^- were found in appreciable quantities, whereas, CO_3^{-2} were in traces. Contour maps of EC, SAR and RSC of groundwater used for irrigation in the block were plotted to study spatial variability of these parameters. According to AICRP classification, the maximum samples were found in high SAR saline category (34.6%) followed by good (25.9%). Percent samples in saline classes *i.e.* marginally saline, saline and high SAR saline classes were 19.8, 2.5 and 34.6, respectively. Percent samples in alkali classes *i.e.* marginally alkali, alkali and high alkali classes were 0.0, 4.9 and 12.3, respectively. Good quality and marginally saline waters can be successfully used for crop production. Rest of the waters requires special management and reclamation practices for use in irrigation. For alkali waters it includes application of amendments (gypsum) depending upon the water applied and RSC of the waters.

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Mapping Soil Salinity and Crop Indices using Remote Sensing and GIS in South West Haryana

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Spatial variability of soil salinity is a major factor hampering crop production and agricultural productivity. Satellite imagery and ground sensors are increasingly being used to study spatial variability. IRS P-6 LISS-III and 2.5 mtr Quickbird satellite imageries were used to identify salt affected sites in Village Waiser, Jagsi and Kahni in districts Panipat, Sonepat and Rohtak in South West Haryana. All three sites have varying manifestations of saline-alkali and saline soils and this in field spatial variability of salinity gets reflected in crop production. Hand held sensors such as the Greenseeker, Plant canopy analyser and the ASD spectro-radiometer were used to study this variability over a period of three years 2009 to 2012. Soil samples collected from 75 points from each site at 0-1 cm and 0-15 cm depth were analyzed for estimating pHs, ECe, cations and anions. The analytical results were transferred into the GIS environment for creating a digital database and examine spatio-temporal variability. Image processing models and sensor derived NDVI, LAI, reflected the status of the crop during the growing season. The IDW interpolation algorithm was used to prepare maps showing variability in salinity and crop growth parameters. It was observed that the variation in pHs ranged from 6.06 to 9.26 in 0-1 cm and 7 to 9.2 in 0-15 cm depth at all village sites. The ECe in the top 0-1 cms ranged between 0.2-114 dS m^{-1}. The ECe at 0-15 cm depth was 0.22 to 130 dS m^{-1} and was highest at village Kahni followed by Jagsi and Waiser respectively. The exchangeable Na and K^+ was 1.6 to 1535 meq L^{-1} and 0.014 to 255 meq L^{-1} respectively at 0-1 cm soil depth whereas, it was 1 to 1105 meq L^{-1} and 0.014 to 98 at 0-15 cm soil depth. The Ca+Mg and SO_4 was 0.8 to 499 meq L^{-1} and 0.5 to 536 meq L^{-1}, respectively at 0-1 cm depth whereas, it was found 0.5 to 370 meq L^{-1} and 0.3 to 396 meq L^{-1}, respectively at 0-15 cm soil depth. The OC was low at each of the three villages which ranged from 0.1% to 0.60%. The variability between fields was maximum at Kahni in comparison to Jagsi and Waiser, respectively. It was found that the pHs, ECe, cation and anion increased at all sites post wheat harvest in comparison to Rice. Vegetation indices for wheat were obtained from the ASD hyperspectral spectroradiometer over the growing seasons. All vegetation indices had a poor relationship with soil EC. It was observed that the area with ECe 2-6 dS m^{-1} had an average NDVI of 0.75. The area with a higher ECe of more than 6 dS m^{-1} had comparatively lower NDVI. NDVI, LAI, CARI and GI all exhibit a negative correlation with ECe; however crop parameters GI, LCI and CARI were all closely correlated to NDVI indicating that hyperspectral data is useful for monitoring crop parameters over the growing season at different salinity. Integration of these data with prediction modeling could play an important role in determining the impact of soil spatial variability on crop yield.

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Characterization of Irrigation Water Quality, Nutrient Load and Heavy Metals in Musi Project Canal Water

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An investigation was carried during 2012-13 to study the canal water quality of Musi project which was constructed across Musi river, a tributary of the Krishna River, in Andhra Pradesh. The river flows through the city of Hyderabad carrying heavy load of pollutants. The Musi project with a live storage of 130.31 Mm^3 (4.6 TMC) intended to irrigate cultivable command area of 13,360 during *rabi* season, having major crops of rice, cotton and pulses. The crops are grown by conjunctive use of surface water and ground water of the command. Water samples from two main canals of Musi project were collected at every 2 km length along the canal and distributaries in the Musi command area, in three sets during first release of canal water i.e., November third week (50 No), third release i.e., February 1st week (92 no) and last release i.e., March last week (110 samples). The samples were collected in different sets to monitor, how the water quality is changing from beginning of *rabi* season to end of season. In all the three sets collected at different intervals (November 2012, January and February 2013), the canal water was alkaline with a mean pH of 8.65, 8.45 and 8.21 during I, II and III sets, respectively. The conductivity class was C_3, ranged from 0.90 to 2.01, 0.09 to 1.48 and 1.04 to 2.02 dS m^{-1} with a mean of 1.12, 1.08 and 1.23 dS m^{-1} in I, II and III sets, respectively. However as per CSSRI classification they were grouped as A1 category. Sodium Adsorption Ratio class was S_1. It ranged from 4.61- 9.49, 3.71 – 4.99 and 3.74 – 9.60 with a mean of 5.37, 4.36 and 5.60 in I, II and III sets respectively. Residual Sodium Carbonates ranged from safe to unsafe. It ranged from -5.796 to 1.528, -4.299 to 9.41 and -5.00 to 5.60 with a mean of -0.198, -0.024 and 0.00 in I, II and III sets respectively. During II set (February) 3 % of samples were under unsafe category which increased to 11% by III set (March). Chlorides contents were slight to moderate to unsafe. Chlorides increased from no samples under unsafe during I set (November 2012) to 10 % during III set (March 2013). It ranged from 6 to 8.4, 6.4 – 12.4 and 5.2 – 13.6 me L^{-1} with a mean of 7.08, 8.76 and 9.3 me L^{-1} in I, II and III sets, respectively The Nitrates were slight to moderate to severe. It ranged from 2 to 50, 20 – 30 and 10 – 50 with a mean of 25.24, 25.60 and 30.5 mg $NO_3 L^{-1}$ in I, II and III sets, respectively. During I set (November 2012) 4 % samples were under unsafe category which increased to 23 % by III set (March, 2013). The Floride contents are just on the boarder of safety limit. It ranged from 0.2 to 1.0, 0.9 – 1.0 and 0.8 – 2.0 with a mean of 0.98, 1.0 and 1.0 in I, II and III sets, respectively. The nutrient loads were worked out for rice crop based on the nutrient contents of canal water, assuming the water applied to rice as 1200 mm. The P contents were less but the canal water is contributing considerable quantity of N, K and S. In different sets, the mean N load ranged from 303 to 366 kg N ha^{-1}, mean P load from 15 to 23.6 kg P_2O_5 ha^{-1}, mean K load from 102 to 174 kg K_2O ha^{-1}, mean Ca load from 36.4 to 53.8 kg Ca ha^{-1} and mean Mg load from 46.7 to 61.2 kg Mg ha^{-1} and mean S load from 271 to 317 kg SO_4 ha^{-1}. Among the micronutrients, the Fe contents ranged from traces to 0.445, Mn from traces to 0.689, Cu from traces to 0.128 and Zn from traces to 0.083 mg L^{-1}. As per the guidelines suggested by FAO, 1985 adopted from National Academy of Sciences (1972), except Mn during II set, Fe, Cu and Zn in all sets and Mn in I and III sets were below the recommended maximum concentration. In II set, only 4% of water samples were found to have Mn contents above the recommended maximum concentration. Among heavy metals, the Cd appears to be main pollutant element. The Pb contents ranged from traces to 1.12, Cd from traces to 0.071, Co from traces to 0.093, Ni from traces to 0.216 and Cr from traces to 0.5 mg L^{-1}. The Pb content was within permissible limits in all the three sets collected. The Cd and Co were within permissible limits in I and II set but in unsafe limits in 79 and 11% samples, respectively, in III set samples. In contrast, the Ni and Cr were within permissible limits in II and III set samples and 6 and 8% samples were in unsafe limits respectively in I set water samples. Canal water (C_3S_1) can be used to raise rice with good drainage facility and management practices successfully. Gypsum may be recommended for soil application @ 40 kg/irrigation ha for each milliequivalent of RSC to be neutralized. Leaching is the only practical way to reduce and control Cl and SO_4 ions toxicity in the crop root zone. High N levels may be beneficial during early growth stages but may cause yield losses during the later stages. It will stimulate nuisance growth of algae and aquatic plants in canals and drainage ditches. To what extent the N, P and K fertilizers can be reduced in this area to compensate the nutrient loads carried by Musi project water need to be further investigated.

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Application of Municipal Solid Waste and Gypsum Enriched Compost Reduces the Salinity Impact and Improves Mustard Yield

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Use of municipal solid waste compost (MSWC) and gypsum enriched compost (GEC) as soil organic amendments in normal as well as salt affected soils is economically and environmentally sustainable. However, little is known about the effectiveness of MSWC and GEC in Indian agriculture. We assessed the impact of different organic amendments and mineral fertilizers on mustard yield, soil physical and chemical properties. Mustard grain as well as stover yield was enhanced with all amendments except untreated plot. Application of 50% recommended dose of N and P fertilizers (RDF) along with MSWC (@ 4 t ha^{-1}), GEC (@ 3.5 t ha^{-1}) and rice straw compost (@ 3.5 t ha^{-1}) resulted in significantly higher grain (24.7 q ha^{-1}) and straw (87 q ha^{-1}) yield of mustard over control. Significantly higher amount of Walkley and Black organic carbon (4.2 g kg^{-1}), alkaline $KMnO_4$-N (141 kg ha^{-1}), Olsen-P (37 kg ha^{-1}) and NH_4OAc-K(269 kg ha^{-1}) were observed under treatments receiving integrated application of MSWC, GEC, RSC (Rice straw compost) and 25 % RDF of N and P than unfertilized plot. In the first year of the study the integrated use of composts and 25% RDF is effective in reducing soil pH and EC compared to sole application of 100% RDF of N and P. The results clearly showed that MSWC and GEC could be an alternative and cost effective option for mitigating the adverse effects of soil salinity on crop yield and as a source of plant available nutrients these amendments have the potential to partly replace the costly chemical fertilizer for crop production as well as maintaining soil fertility.

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Effect of fertigation on Movement, Availability and Uptake of Nutrients and Yield of Banana in an Inceptisol

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A field experiment was conducted for three years from 2008-2011 at Inter faculty Department of Irrigation Water Management, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra), India to find out the response of drip fertigation on nutrient mobility, nutrient availability, nutrient uptake and yield of Banana, Cv. *Grand naine* in an Inceptisol. The experiment was laid out in randomised block design with nine treatments consisting of 100, 80 and 60 per cent water soluble fertilizers (WSF) applied through drip in two schedules (schedule A- application of nutrients in 18 equal splits and schedule B- application of nutrients in 18 spits as per crop growth stages), drip irrigation with only N through drip, drip with conventional fertilizers through soil and surface irrigation as control. The movement of nutrients was found to be influenced by sources and schedule of fertilizer. The NPK mobility was found to be varied considerably with period in all treatments. The maximum movement of nutrients was found in 100 and 80% fertigation using water soluble fertilizers. The N was moved upto 45 cm horizontally and upto 60 cm vertically. P was moved upto 30 cm horizontally and 40 cm vertically. K was moved upto 45 cm horizontally and 60 cm vertically during the crop growth. The available NPK content in the soil was maximum just beneath the dripper. The NPK availability was increased with period from planting in all treatments. The minimum availability was found at 3 months after planting (MAP) and was increased upto 9 MAP and afterwards it decreased at harvesting stage. The nutrient availability was more in treatment T_4 where fertilizers were applied as per growth stages (schedule B) than equal splits (schedule A). The treatment T_4 recorded significantly maximum availability of NPK (174.96, 16.44 and 539.85 kg ha^{-1}, respectively) at 9 MAP. The drip irrigation improved the availability of nutrient compared to surface irrigation method. The uptake of nutrients was also relatively more in fertigated treatments than rest of the treatments. The total nutrient uptake of banana was the sum of nutrient uptake by shoot, leaves and fruit. The T_4 treatment was significantly superior over other treatments in total N, P and K uptake (392.3, 88.65 and 946.9 kg ha^{-1}, respectively) by banana and treatment T_9 (surface irrigation) recorded lowest nutrient uptake (316.5, 67.8 and 786.7 NPK kg ha^{-1}, respectively). The drip irrigation was proved beneficial than surface irrigation and resulted into 46.22% increase in yield with 45.30% water saving in banana and almost 40% fertilizer saving. The 100% RD of fertilizer through drip as per schedule B showed maximum banana yield 82.94 t ha^{-1} over surface irrigation (57.4 t ha^{-1}). However, it was at par with treatment T_1 (100% WSF in uniform 18 splits) and T_5 (80% RD as per schedule B). The study also indicated that the yield of banana can also be increased sizably by applying N through drip irrigation.

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Reclamation of Abandoned Aqua Ponds

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Aqua culture has spread fast in coastal region of Andhra Pradesh during last two decades. But due to erratic distribution of rainfall and adverse effects of climate, the aqua culture has been failed. Heavy losses incurred by aqua farmers due to failure of crops and become non-remunerative, thereby farmers were forced to abandon these ponds and ready to take rice. In this situation, there is a need for reclamation of abandoned aqua ponds and techniques were developed (based on the research conducted by CSSRI, Karnal and subcentres) to reclaim the abandoned aqua ponds.

To create awareness among the farmers, the study was carried out in different villages from 2007-08 to 2012-13 in Guntur district of Andhra Pradesh. During the first year, 2007-08, a village of Kothapalem of Nizampatnam mandal, Guntur district where aqua culture is practised was selected. Later two more villages *viz;* Gokarnamatam of Nizampatnam mandal, Guntur district and Ganapavaram of Karlapalem mandal, Guntur district were included. An area of about 20 ha land was leveled and irrigation and drainage channels were prepared. Farmers were supplied with green manure seed (dhaincha) and also gypsum @ 1.5 t ha^{-1} (mostly based on gypsum requirement). After incorporation of green manure and gypsum, the fields were puddled and water was drained. Paddy variety NLR-145, relatively tolerant for salinity was grown with increased population and higher doses of N, P and Zinc sulphate @ 50 kg ha^{-1} was applied as basal.

During 2011-12, the initial EC ranged from 3.02 to 20.6 dS m^{-1} with a mean of 11.81 dS m^{-1}. The final soil analysis indicated that the EC ranged from 1.18 to 10.50 dS m^{-1} with a mean of 5.84 dS m^{-1}. During 2011-12, initial pHs ranged from 7.20 to 7.97 with a mean of 7.58. Final pHs ranged from 7.3 to 7.85 with a mean of 7.5. The rice grain yield obtained ranged from 4.01 to 5.6 t ha^{-1} with an improvement of 39% during 2011-12. With the implementation of reclamation practices, the salts which are accumulated in the pond surface layer, get dissolved, diluted and drained out through drainage channel. So, the EC levels of abandoned aqua ponds drastically decreased. pH levels also get neutralized. Whenever the EC and pH values were decreased and neutralized the availability of nutrients are increased and yields are also increased compared to earlier.

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An Innovative Approach "Activated Carbon" Converting Industrial Effluents to Good Quality Irrigation Water, Reducing Soil Pollution

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Industrialization has lead its impact on each and every field of life. Industries generate several types of pollutant affecting the environment. It has been known that heavy metal ions are among the most important pollutants in several industrial wastewaters. The common methods available to remove heavy metal ions from wastewaters are coagulation, chemical precipitation, ion-exchange, adsorption and reverse osmosis. Among these processes, adsorption technique employing solid absorbents are well established for treating industrial wastewaters containing heavy metals. Currently, activated carbon is the most popular adsorbents. Activated carbon, also called activated charcoal, activated coal, or *carbo activatus*, is a form of carbon processed to be riddled with small, low-volume pores that increase the surface area available for adsorption or chemical reactions.

Due to its high degree of micro-porosity, just one gram of activated carbon has a surface area in excess of 500 m^2, (as determined by adsorption isotherms of carbon dioxide gas at room or 0.0 °C temperature). An activation level sufficient for useful application may be attained solely from high surface area. However, further chemical treatment often enhances adsorption properties. Activated carbon with properties of thermo-stability, high performance, high adsorptive effect, large specific surface area and well-developed pore structure, has been proved to be an excellent adsorbent for removing organic or inorganic pollutants. Activated carbon can be prepared by carbonaceous materials under different conditions. In the process of preparation, physical activation and chemical activation are the two main patterns. The physical activation method performs under steam or CO_2 at high temperature, while the chemical method involves soakage of raw material with chemical activator. In chemical activation, the commonly activator are phosphoric acid, potassium hydroxide and zinc chloride. Phosphoric acid is often preferred due to its environmental effect. Comparisons between adsorption capacities of activated carbon made from various low cost materials were analyzed. Adsorption capacity of activated carbon from sewage sludge, *Eichhornia crassipes*, Typha were also analyzed. Sewage sludge derived activated carbon has affinity for non polar adsorbates and heavy metals as nickel, cadmium. *Echhornia* is capable of adsorbing chromium efficiently. Activated carbon have immense potential for adsorbing the pollutants, making water safe for disposal and even make it a source of irrigation water thus preventing deterioration of soil fertility. Thus, activated carbon may prove a solution for reducing secondary problems generated by untreated industrial effluents.

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Assessment of Salt Affected Soils in Central Haryana for Reclamation and Management

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IRS LISS III (Resourcesat) imageries for March, May and October seasons (2005-06) were used for mapping salt affected soils in the Indo-Gangetic plain of Central Haryana covering Karnal, Kurukshetra, Panipat and Sonepat district. Salt affected soils appeared as barren surface and as white patches amidst the cropped and forest cover areas (red to dark red color), along the Ghaggar, Markanda, also Yamuna plains. The carbonate and bicarbonate salts of sodium caused soil alkalization in the undrained areas. Soil salinity is found in the arid/semiarid areas underlain by saline ground water. It is also found in the irrigated areas, showing high water table depth (sub-surface waterlogging) with poor natural drainage. The calcium carbonates concretions are found at a depth below the soil surface. The iron and manganese mottling are found under the anaerobic conditions. The blocky structures are found in the alkali soils due to poor physical conditions and dispersion of soil particles. The sub-surface clay loam /silty clay loam soil texture in Ghaggar plain caused low internal drainage and waterlogging. The natric horizon is found at sub-surface layers in strongly sodic soils under forestry. The high water table depth, high clay content and calcium carbonate concretion layer in the low-lying plains caused waterlogging and soil salinization in irrigated areas of Western Yamuna Canal command (Block Gohana) of Sonepat district. In the imageries, these areas are appearing as gray to dark gray tone due to higher water absorption in the infrared range (SWIR). The irrigation with poor quality (saline /sodic) ground water caused development of soil salinity/ alkalinity along the Chautang plain (Assandh block) of Karnal district. The installation of sub-surface drainage is suggested for waterlogged saline soils with poor internal drainage in Sonepat district. The use of sodic ground water for irrigation in Ghaggar plain (Block Pehowa) caused soil alkalization. The sodic ground water need treatment with gypsum for use in arable crops and saline ground water may be used in cyclic or mixed mode for irrigation. The complex saline-sodic soils underlain by saline ground water in Yamuna plain (Block Israna) of Panipat district is a major concern for reclamation and management.

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Assessment of Soil Quality Degradation due to Salinity and Sodicity in Mula Command Area of Ahmednagar District (M.S.)

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Detailed soil survey was carried out in distributory No. 2 of Mula command area in Ahmednagar district of Maharashtra during 2007-08. The study area comprises of Kendal Bk, Kendal Kd and Chandkapur villages in Rahuri tahsil and located between $19^{o}51'$ to 19^{o} $54'$ N latitude and 74^{0} $21''$ to 74^{0} $25'$ E longitude covers and a total area of 688.53 ha. It is suited about 15 km East to Rahuri town on both sides of distributory No.2 of Mula right bank canal. Soil survey interpretations revealed that the soils in Mula command area are mainly developed due to the fluvial action from the basaltic alluvium and the major soils were Inceptisol and Vertisols. Taxonomically soils were classified as Typic Haplustepts (P_1 and P_3), Vertic Haplustepts (P_2, P_4 and P_5), Sodic Haplusterts (P_6, P_7 and P_9) and Sodic Calciustert (P_8). The physical and chemical properties of soils varied greatly and the soils in general were very high in clay (52.0 to 71.0%), high in bulk density (1.42 to 1.83 Mg m^{-3}) and low in the hydraulic conductivity (0.08 to 1.52 cm hr^{-1}). The soils were moderately to strongly alkaline (pHs 8.10 to 9.16) with ECe ranged from 1.4 to 7.4 dS m^{-1}, and ESP from 6.6 to 27.2. These soils were highly calcareous in nature. The area affected due to soil salinity and sodicity in the command area under study was 22.4%, out of which 6.1% was saline, 6.2% saline-sodic and 10.1% was sodic in nature. The effect of levels of ESP and application of gypsum, spent wash and pressmud compost were assessed on yield of wheat. The results revealed that based on degree of degradation, the wheat yield at different ESP levels were increased due to application of gypsum, spentwash pressmud compost and FYM over application of recommended dose of fertilizer. The highest grain yield was recorded under the treatment of ESP level <5.0 (yield 36.33 q ha^{-1}) whereas, highest yield reduction (48.66%) was recorded in the ESP level of 20 to 25. The soils associated with Sodic Haplustept pedons (P_6, P_7, P_9) and Sodic Calciustert (P_8) were unsuitable (N_1) for sugarcane and soybean but marginally suitable (S_3) for wheat and cotton due to variabililty in ESP, hydraulic conductivity and low fertility status of soil. The soil quality index was high (1.25) for soils of midland region, while it was low (0.79) in the tail region owing to soil degradation due to salinity and sodicity. The exchangeable Ca:Mg ratio was found to be the most predominant soil quality indicator followed by organic carbon, ESP, CEC/clay and EMP in controlling of soil quality. Thus, the tail region of the Mula command area was severely degraded due to salinity and sodicity compared to head and mid regions.

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Comparative Phytoremediation Potential of Lemon Grass, Vetiver and Raya for Decontamination of Cadmium in Soil

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Environmental pollution due to industrial and agricultural activities had resulted in considerable increase in heavy metals in all compartments of environment, especially in soils. Identification of Hyper-accumulator plants can provide a solution for remediation of polluted soils. Aromatic grasses are known to accumulate nutrient and toxic elements in large amount. Hence, phyto-remediation potential of lemon grass and vetiver are compared with raya. Among the pollutant elements, cadmium, a commulative poison, is recognized as an extremely significant pollutant due to its high toxicity and relatively larger solubility in water. To find out the best phytoremediating crop, screen house studies were conducted with Cd (0, 5, 10, 20, 40, 80 and 160 mg kg^{-1} soil) and EDTA (0 and 1 g kg^{-1} soil) on alkaline loamy sand soil. It was observed that increasing rates of Cd application resulted in significant increase in DTPA-Cd which was further enhanced by EDTA application. Increasing phyto-toxic effect of Cd with its increased application, consequently caused reduction in dry matter yield of each crop. Among these crops, vetiver contained highest content of Cd in both shoots and roots, thus showing its highest accumulation/phyto-remediating potential. The roots in all crops were found to accumulate higher content of Cd compared with shoots. The yield reduction at 80 mg Cd kg^{-1} soil was 65.9, 21.5 and 19.8% in raya, lemon grass and vetiver, respectively, suggesting vetiver to be the most tolerant crop while raya to be least tolerant whereas lemon grass showed moderate tolerance. The upper critical toxic levels of DTPA-Cd in soil was 10.3, 21.4 and 24.5 mg kg^{-1} soil for raya, lemon grass and vetiver, respectively. In shoots, these were 40.7, 138.2 and 180.3 μg Cd g^{-1} dry matter for 20% reduction. The interaction of Cd with Cu and Mn was antagonistic while with Fe and Zn, it was synergistic at lower levels but antagonistic at higher levels.

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Effect of Saline Water in Drip and Surface Irrigation on Okra (*Abelmoschus esculentus*)

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A field experiment was conducted on sandy loam soil during 2009 and 2010 at Agricultural Research Farm, R.B.S. College, Bichpuri, Agra in Uttar Pradesh to assess the salinity tolerance of okra crop in drip and surface irrigation. The treatments were comprised of three levels of salinity (control, water with EC_{iw} 4 and EC_{iw} 8 dS m^{-1}) and three levels of IW/CPE ratios (0.75, 1.00 and 1.25) for both drip and surface irrigation. The study revealed that the fruit yield of okra was significantly decreased in EC_{iw} 4 and EC_{iw} 8 dS m^{-1} over control. In drip irrigation, the okra fruit yield reduction at EC_{iw} 4 and EC_{iw} 8 dS m^{-1} over control was 53.5 & 72.8% in 2009 and 53.7 & 78.4% in 2010, respectively. In case of surface irrigation system, okra fruit yield reduced by 60.0 & 98.8% in 2009 and 79.4% in EC_{iw} 4 and EC_{iw} 8 okra fruit yield is zero in 2010. The IW/CPE ratio was found significantly increased with increasing IW/CPE ratio in drip irrigation of both years. While in surface irrigation IW/CPE ratio were found non-significant. The interaction effect between EC and IW/CPE ratio was found to be non-significant in both the years. On an average at harvest of okra crop, the EC_e of surface layer (0-10 cm) ranged between 2.5 to 3.0 in control, 12.5 to 13.0 in EC_{iw} 4 and 21.0 to 22.0 dS m^{-1} in EC_{iw} 8 dS m^{-1} in plant distance from 5 to 25 cm. In surface irrigation system, the EC_e vole is 4.2 in control, 13.0 in EC_{iw} 4 and 24.0 dS m^{-1} in EC_{iw} 8 dS m^{-1}. The water use efficiency was higher in drip irrigation compared with surface irrigation with 35% water saving in drip method. In control, EC_{iw} 4 and 8 dS m^{-1} on an average the water use efficiency in okra crop was 203.7, 101.1 and 53.0 in drip irrigation and 138.8, 41.5 and 0.1 (kg ha cm^{-1}) in surface irrigation, respectively. Results revealed that in drip irrigation the yield and water use efficiency were higher than surface irrigation.

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Change in Plant Available Nutrients under Successive Rubber Cultivation in Traditional Rubber Growing Tract in Comparison to Adjacent Virgin Forest

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Large scale rubber cultivation started in India more than a century ago and currently most of the rubber plantations are in third cycle of planting. Limited extent of area is now in the forth cycle also. The present study was conducted to investigate the change in plant available nutrients over successive rubber cultivation in three regions in traditional rubber growing tract *viz;* Nilambur (11^0 12' N and 76^0 21' E), Punalur (9^0 02' N and 76^0 55' E) and Kulasekaram representing North Kerala, South Kerala and Kanyakumari district (8^0 25' N and 77^0 117' E) of Tamil Nadu. 72 soil samples each were collected from both surface (0-30 cm) and sub surface (30-60 cm) soil from 1st, 2nd and 3rd cycles of rubber cultivation and from adjacent virgin forest at Nilambur. At Punalur, 45 soil samples each were collected from 2nd and 3rd cycles of rubber cultivation and from adjacent virgin forest and at New Ambadi 20 number of soil samples were collected from 1st and 2nd cycles of rubber plantation. The soil samples were air dried at room temperature and sieved through 2 mm sieve and subjected to chemical analysis. The samples were analyzed for bulk density, soil pH, organic carbon and available phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca) by standard analytical procedures. The data were subjected to analysis of variance.

Results indicated that bulk density of soil was significantly higher in all the cycles at both depths in comparison to adjacent forest at Nilambur. At Punalur also, same trend was observed, but the difference was significant during 3rd cycle only. Soil pH was lower in rubber plantations compared to forest, and the difference was significant during the 3rd cycle. There was a decreasing trend in all three locations with progressive cycles also. Organic carbon status was significantly higher in forest compared to 3rd cycle of rubber. Between the cycles also, there was a decreasing trend at both the depths. There was no significant change in available P status compared to forest or between the cycles, though an increasing trend was observed. However contrary to the earlier observation, available K status showed a significant decrease in rubber plantation compared to forest at Nilambur. No significant difference was observed at the other two locations. Available Ca and Mg was significantly low compared to forest and decline was significant in the 3rd cycle at Nilambur at both depths. At Punalur also, significantly lower status of available Ca and Mg was observed at both depths in rubber plantations compared to forest. However, between cycles, there was no significant difference at New Ambady. The results confirm the earlier observations that soil pH, organic carbon and available Ca are Mg lower in rubber plantations compared to forest.

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Effect of Integrated Nutrient Management on Soil quality and Crop Productivity under Sorghum-wheat Cropping Sequence in Inceptisol

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The present investigation was carried out to study the long-term effect of integrated nutrient management on soil quality and crop productivity under sorghum-wheat cropping sequence. The 26th and 27th cycle of the long-term experiment initiated during 1984-85 on the Inceptisol at the Research Farm, Integrated Farming System Research, PDKV, Akola. The treatments comprised of unfertilized control, chemical fertilizers alone and their combinations with organics *viz.* FYM, wheat straw and Leucaena loppings and farmers practice in randomised block design with four replications. The long term use of organics *viz.* FYM, wheat straw and green manuring with leucaena loppings in conjunction with chemical fertilizers recorded improvement in physical, chemical and biological properties resulting into enhancement in soil quality. The use of only chemical fertilizers without organics for a long term period caused nutrient mining and deterioration in soil physical properties. Application of FYM (50% N) alongwith chemical fertilizers over a long-term showed highest soil quality index as well as sustainability yield index. However, wheat straw and green manuring in conjunction with chemical fertilizers although improved the soil quality over a long term did not sustain the yields under cereal-cereal cropping system. The Sustainability yield index for sorghum and wheat were higher under integrated nutrient management involving use of chemical fertilizers with FYM as compared to only chemical fertilizers. The lowest sustainability yield index was noticed in control with no manure, no fertilizer. Application of 50% N through FYM in conjunction with chemical fertilizers recorded highest soil quality index and it was found as the promising practice from the view of sustainability maintaining crop yields year after year under intensive cropping system. Continuous cropping with the use of only chemical fertilizers without addition of organics showed depletion of micronutrients and sulphur. The predominant soil quality indicators most influenced by the management practices were hydraulic conductivity, organic carbon and dehydrogenase activity. The declining trend of soil available potassium under only chemical fertilizers indicated mining of soil potassium under continuous cropping. The bulk density values of less than 1.40 Mg m^{-3}, hydraulic conductivity more than 1.00 cm hr^{-1} and mean weight diameter more than 1.00 mm could be used as minimum thresholds indicating base line values for deciding management practices for enhancing soil quality in swell-shrink Inceptisols of Deccan plateau in central India.

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Variation in Quality Parameters of Sewage Water and Sludge: A Case Study of Ludhiana STP

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Buddha Nullah, literally, means *Old rivulet or watercourse*, a 16 Km long narrow unlined channel runs parallel to the Sutlej river on its south for a fairly large section of its course in the Ludhiana district. It was free from pollution during sixties. However, with rapid industrialization and urbanization of Ludhiana city, there has been a tremendous increase in the production of liquid and solid wastes. A study was conducted during 2010-11 to monitor the quality of untreated waste water (carrying untreated/partially treated domestic sewage and industrial effluents in it) of Ludhiana city supplied to Bhattian Sewage treatment plant (STP) through a narrow unlined channel (Buddha Nullah), and change in different quality parameters after the treatment during different seasons of the year. The Buddha Nullha waste water analysis has shown that quality parameters BOD, COD, TS, TDS and TSS of Buddha Nullah water were outside the maximum permissible limits (MPL), however, after its treatment at Bhattian STP all these parameters approached well within their respective MPL The BOD of untreated waste water supplied to Bhattian treatment plant varied from 112 to 212 mg L^{-1} with a mean value of 145 mg L^{-1}. The major sources of high BOD in Buddha Nullah sewage water are two dairy complexes located at Tajpur Road & Humbran Road, hotels/ restaurants, and slaughter houses *etc.* The values of TDS of raw influent to Bhattian STP ranged from 440 to 1320 with a mean of 799 mg L^{-1}. After treatment, TDS values improved to 160 to 1280 with a mean of 472 mg L^{-1}. Variations in heavy metals concentration in the untreated wastewater samples were observed during different times of the year. The metal concentrations in raw water (influent to Bhattian STP) were higher during August to January. This could be due to the fact that during this period, all the industries work at their peak and hence the quantity of industrial effluents produced is more. After treatment, the different heavy metals concentration such as Cr, Ni, decreased in the effluent of Bhattian STP. All heavy metals tested in the sewage sludge samples collected from the Bhattian STP got concentrated in sludge but highly varying, which corresponds with wastewater metal concentrations variability.

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Use of Solid Industrial Waste in Comparison to Vermicompost for Production of Wheat and Chickpea on Vertisol

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Field experiments were conducted on Vertisols at CSSRI, RRS, Bharuch (Gujarat) during 2010-11 with wheat and chickpea to ascertain the response of solid industrial waste (bio-sludge: BS) alone and in combination with vermicompost (VC) to test the efficacy of bio-sludge in supplying nutrients and its effect on crop growth and yield as well as on soil properties. The bio-sludge is the solid waste generated from fertilizer plant of GNFC-NCPL, Bharuch (Gujarat) and there is problem for its disposal. The application of bio-sludge increased the grain yield of wheat (KRL 238) to the extent of 26.2% over control. The wheat variety NW 3087 showed increase of 9.0% in grain yield when bio-sludge was applied with NPK over NPK alone. Application of bio-sludge in combination with vermicompost and NPK showed increase of 46.4% in KRL 238 while 29.4% in NW 3087 over NPK alone. In chickpea, application of bio-sludge along with NPK resulted in increase of number of pods plant^{-1} to the extent of 16 pods plant^{-1} which further got enhanced to the magnitude of 30 pods plant^{-1} when BS+VC were applied in conjunction with NPK. Similarly, number of seeds per plant was increased by 210% in NPK+VC treatment and by 115% in BS+VC treatment as compared to 70% in NPK+BS treatment over control. The weight of 100 seeds was maximum of 16.05 g which obtained in treatment BS+VC were applied while minimum in control (NPK). The seed yield of chickpea was increased by 16 and 26% over control when BS alone and BS along with VC was applied. The effect of bio-sludge on soil bio-chemical properties was found to be pronounced in terms of supply of additional N and S as well as improving microbial activity. However, the effect was much higher when VC was added in conjunction with bio-sludge. The studies conducted thus indicated that the use of biological sludge can be an alternate source for sustainable management of lands for production of crops.

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Soil Health Assessment under Protected Cultivation of Vegetable Crops in Mid Hill Zone of Himachal Pradesh

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The change in soil health indicates whether the management practices being adopted are sustainable or not. Sustainability of intensive agriculture system is intimately linked to maintenance or enhancement of soil health. Therefore, present study was undertaken during 2012-2013 to investigate the impact of intensive cultivation on soil health under polyhouses of Himachal Pradesh. The soil samples were collected from polyhouses of three districts (Solan, Mandi and Sirmour). From each district ten polyhouses were selected randomly for the study of different soil health indicators. The bulk density ranged from 1.16 to 1.29 g cc^{-1} and the soils were good for root proliferation and plant growth. The particle density ranged from 2.07 to 2.21 g cc^{-1}, whereas the porosity ranged from 40.86 to 47.65%. Amongst the chemical properties, chloride content ranged from 0.04 to 0.07 mg kg^{-1}, bicarbonate content 1.02 to 2.01 mg kg^{-1} and CEC 13.52 to 15.85 mg kg^{-1}, are in normal range without any adverse effect on soil health. The soil pH ranged from 6.58 to 6.89 and the EC values were in safer range. The organic carbon (OC) content varied from 1.40 to 1.66 percent and was categorized as high. The available N, P and K ranged from 253.48 to 352.42, 40.41 to 87.6 and 453.94 to 495.06 kg ha^{-1}, respectively. The exchangeable Ca was found to be adequate, however soils show low levels of exchangeable Mg. Sulphur (62.47 to 72.14 kg ha^{-1}) was also high in the soils. Amongst the micronutrients, available Zn, Fe, Cu and Mn were found to be medium to high in availability. The microbial biomass ranged from 377.13 to 459.89 μg g^{-1} soil, which fell under medium to high range for categorizing soil health. The soil indicators like OC, P, S, chloride and microbial biomass had more influence on soil health, while, other had less effect on soil health under polyhouse conditions. The results indicated that the majority of the soils in polyhouse conditions were high (57%) in soil health condition, followed by the very high (40%) and medium health soil (3%). Soil health was found to be affected by the management practices adopted by the farmer and the extent of fertilizer use over a period of time.

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Influence of Management Practices on Greenhouse Gas Emission from Soybean-Wheat Cropping System in Vertisols

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Adoption and use of best and improved management practices is imperative to achieve higher and sustainable food grain production and is important to improve and maintain soil health. However, the management practices (conservation tillage in conjunction with application of manure and inorganic fertilizer) also affect the emission of greenhouse gases (GHG) from soil. Keeping the above in view the present study was conducted to compare the GHG emission from different tillage and nutrient management practices in the black soil region of India. The effect of different manure and tillage treatments on emission of GHG from soil was studied in two long-term experiments under soybean-wheat cropping system during *kharif* and *rabi* seasons of 2012-13. The gas samples were collected by static chamber method at about one month interval using chambers of 71 cm × 56 cm × 15 cm (length × width × height) placed between crop rows. The average CO_2, CH_4 and N_2O emissions of different treatments varied from 2.7–25.4 mg C m^{-2} h^{-1}, -35.27 to 1.21 µg C m^{-2} h^{-1} and 20.50 to 81.8 µg N m^{-2} h^{-1}, respectively during the experiment. Averaged over tillage treatments, the GHG emission was higher under organic as compared to inorganic treatments. The emission of CO_2 was relatively higher in no tillage compared to reduced tillage and conventional tillage. However the N_2O emission was found to be higher in conventional tillage followed by reduced tillage and no tillage. Substitution of 100% inorganic N by organic sources lead to a 30% and 77% increase in N_2O and CO_2 emission respectively.

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Assesment of Suitability, Nutrition and Quality of Selected Forage Crops Raised Through Sewage Water

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An experiment was laid out at live stock research station, Rajendranagar with four different perennial fodder crops *viz;* bajra napier hybrid (APBN-1), guinea grass (CO-GG-3), para grass (local collection) and lucerne (CO-1) raised under sewage irrigation. Sewage water of Budwel village was used for crop production. Five variable doses of recommended NPK *i.e.,* without NPK, 25% of recommended NPK, 50% recommended NPK, 75% recommended NPK and 100% recommended NPK were imposed. Samples of soil were collected initially before raising the experiment and after every of study, while plant samples were collected at each cut. Initial analysis of sewage indicated that concentration of chromium (Cr), cobalt (Co), nickel (Ni), and cadsmium (Cd) in toxic limits for irrigation. Initial soil was neutral in reaction, non-saline, low in N and high in available P_2O_5 and K_2O and also indicated magnitude of all micro and heavy metals were within safe limits. Among the four studied crops, the establishment percent was highest in para grass *i.e.,* 92% better than all other crops studied. After three years of study it was concluded that paragrass produced the highest green fodder yields of 93.9 t ha^{-1} and dry fodder yields of 15.27 q ha^{-1} which is much superior to those observed in APBN-1 and guinea grass (66 and 65 t ha^{-1}, respectively) which are on par with each other. The highest dose of NPK *i.e.,* 100% showed significantly highest green fodder yields in all crops. The crude protein yield was however, highest in lucerne (1.4 t ha^{-1}) owing to its leguminous nature with 26% protein percent despite low green fodder yields. The mean crude fibre percent of bajra napier hybrid (26.39%) and guinea grass (28.17%) is significantly higher than that of para grass (20.38%) and lucerne (9.90%). Nevertheless the effect of sewage irrigation was not observed in quality parameters. The concentration of N, P and K and micronutrients were found within the optimum range in fodder crops. These four crops exhibited preferential accumulation of these four heavy metals. Guinea grass had high affinity towards accumulation of Cr para grass accumulated comparatively higher doses of Co, copper and manganese; lucerne accumulated highest concentration of Ni and Fe while Cd and Pb accumulation was highest in APBN-1, though fortunately most of these metal concentrations did not cross the toxic limits. The accumulation of some heavy metals *viz.,* Fe, Cr and Cd in soil was also alarming with more than 250%, 180% and 209% increase in magnitude, respectively by end of three years of study. Comprehensively, among the different doses of NPK 100% of NPK was found most promising. The uptake of all nutrients was high, in most of the cases significantly, in 100% NPK. Hence it could be recommended to continue applying 100% RDF for a few more years as crop removal of NPK and micronutrients is also very high owing to perennial nature of the crops. The economics indicated a B:C ratio of 4.94 in para as compared to all other crops which reported below 3.00 values.

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Enhancing Quality of Municipal Solid Waste Compost through Removal of Heavy Metals

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Municipal solid waste composts (MSWC), particularly those prepared from unsegregated mixed wastes, contain very high amount of heavy metals posing threat to ecosystem when used as soil amendment in agriculture. In India, majority of the MSWC is prepared from mixed wastes, mainly due to less manpower requirement in processing of wastes for segregation. A low cost technology for removal of heavy metals from MSWC is desired to maximize their recycling and enhancing agricultural production while minimizing threat of soil pollution. We investigated various chemical extraction as well as physical fractionation methods for their efficacy in removing different heavy metals from MSWC. The extractants investigated in the experiment included chelating compound, organic acids, inorganic acid, effluent from distillery industry (DE). It has been found that heavy metals were mainly concentrated in finer size fractions of MSWC prepared from mixed wastes. Inorganic acid (HCl) and chelating compound (EDTA) were more efficient in removing heavy metals, particularly Cd, Cu, Pb and Zn. Extraction efficiency of metals increased with increasing concentration of EDTA. Although EDTA is less soluble in acidic medium, it increased extraction efficiency from HCl and DE considerably. A separate experiment was carried out to quantify the extent of removal of heavy metals from MSWC by employing combination of EDTA (with varying concentrations), acidic liquid extractants (DE or HCl) and wet sieving. Different combinations of these methods removed, on average 23% As, 66% Cd, 20% Cr, 67% Cu, 24% Ni, 44% Pb and 58% Zn from MSWC prepared from mixed waste. As considerable volume of liquid would be required for extraction of metals and removal of fine fractions from MSWC, we recommended use of acidic effluent from molasses based distillery industry (with EDTA dissolved in it) for this purpose.

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Biochar - An Alternative Towards Increased Soil Carbon Sequestration

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Many types of soil additives and fertilizers are used to improve the structure and functions of soil. Biochar has emerged as one of issues towards improving the soil conditions and plant growth for the past few years with lots of ifs and buts. In the initial phase we need to understand the basic questions before jumping into the pool. Questions such as how much biochar should be used in soils? How should biochar be applied? What types of biochar fit specific types of soils? How does it actually helps to retain nutrients and water? The questions can vary with person to person and focus of each individual. In addition to use as a soil amendment, biochar may also be used for remediation and/or protection against particular environmental pollution and as an avenue for greenhouse gas (GHG) mitigation. Biochar, a solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment is thought to yield a fine-grained, highly porous charcoal. Before looking at new research on biochar in soils, it is important to examine the nature of biochar developed at different pyrulytic conditions. An attempt was made to prepare and characterize the biochar of subabool loppings at varying pyrulytic conditions as it is found in abundant and does not have any fodder value for animals. Pyrolysis conditions were standardized for preparation of biochar from different feedstocks. Preparation of biochar was done at 1, 2 and 3 hr duration at temperature ranging between 250 to 400°C for subabool (*Leucenea leucocephala*). Subabool recovery for three different size classes did not vary much at similar temperatures. However there was a sharp decline in the recovery of biochar from subabool feedstock with increase in temperature. At 350 ^{0}C temperature the recovery declined with increase in duration. With three hours heating the recovery was between 47 and 50%. At 400 °C temperature the recovery of biochar varied between 30.43 and 32.34%, respectively across all the sizes of subabool. The total carbon content in biochar decreased from 47.48 g 100 g^{-1} in raw material to a mean of 32.29, 29.77, 27.39 and 24.09 g 100 g^{-1} at 250, 300, 350 and 400 °C respectively. Thus a decrease of 32.02, 37.32, 42.33 and 49.29% was observed with increase in temperature from 250, 300, 350 and 400^{0}C. Therefore, keeping other issues aside the higher proportion of total carbon that may be converted into resistant fraction through biochar could be obtained at lower temperature. Total N content in biochar prepared from subabool feedstock varied widely with temperature and duration of pyrolysis. The mean N content of N increased with duration of pyrolysis for first two size categories but there was sharp decline in respect of feedstock having diameter more than 3 cm. Total N recovery from the biochar at different temperatures varied between 40.6 and 64.5 percent of the original N with a decline at incremental temperatures. Total phosphorus content in biochar increased from the original level of 0.090% to a mean of 0.08, 0.10, 0.11 and 0.11% when the biochar was prepared at 250, 300, 350 and 400 °C. Total P recovery from the biochar varied between 0.028 and 0.045 g 100 g^{-1} feedstock. P recovery at 250, 300 and 350 °C was almost similar and further decreased at 400 °C. Total potassium content in subabool biochar increased from its original content of 0.465 percent to a mean of 0.66, 0.70, 0.69 and 0.70%. The potassium recovery from feedstock varied from 0.22 to 0.38 g 100 g^{-1} against the 0.47% in the raw material. The mean recovery was highest at 250°C temperature which decreased with increase in temperature to 0.22 g 100 g^{-1} feedstock. This indicates that the K recovery of the feedstock can be up to 54.8 and 47.0% at 350 and 400 °C temperatures. Hence the biochar prepared under these temperatures would supply at least half of the potassium contained in the original subabool feedstock which is otherwise not being recycled into the soil.

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Protocol for Fixing Maximum Allowable Limit of Sludge Addition to Agricultural Lands

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Limited information is available on maximum permissible limit of sludge addition to agricultural lands in relation to transfer of metals to human food chain. Thus, in the present study an attempt has been made i) to predict metal uptake by Indian spinach (*Beta vulgaris*) grown on sludge amended soils using different chemical extractants and solubility-free ion activity model and ii) to assess maximum permissible limit of sludge addition to agricultural soils in relation to transfer of metal to human food chain using spinach as a test crop. For this purpose, a greenhouse pot experiment was conducted to study the effect of sludge application on Zn, Cu, Fe, Mn, Ni, Cd and Pb uptake by spinach grown on acid and alkaline soils. Sludge was added @ 0, 1.12, 2.24, 4.48, 8.96, 17.9, 35.8, 71.6, 142, 285 g kg^{-1} of soil. Results indicate that spinach responded positively to the applied sludge in both acid and alkaline soils. Among the chemical extractants EDTA extracted the highest amount of all metals from sludge amended soil followed by DTPA and $CaCl_2$. Substantial increase in the content of Zn, Cu, Fe, Mn, Ni, Cd and Pb in the shoot of spinach was recorded as a result of sludge application. Application of sludge was more effective in enriching the spinach with metals grown on acid soil than alkaline soil. Solubility-free ion activity model as a function of pH, organic carbon and extractable metal was far superior in predicting metal uptake by spinach grown sludge amended soils as compared to chemical extractant alone. Risk in terms of hazard quotient (HQ) to human health for intake of metals through consumption of spinach grown on sludge treated soils ranged from 0.05 to 0.23 for Zn, 0.01 to 0.02 for Cu, 0.20 to 0.56 for Fe, 0.07 to 1.18 for Mn, 0.01 to 0.03 for Ni, 0.06 to 0.23 for Cd and 0.04 to 0.12 for Pb. Safe rates of sludge application were worked out as 4.46 and 71.4 g kg^{-1} (10 and 160 t ha^{-1}, respectively) for acid and alkaline soil, respectively as far as transfer of metals from soil to human food chain is concerned.

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Essential Elements and Heavy Metals in Soil and Plant as Affected by Mining and Industrial Activities

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An investigation was undertaken to study the effect of mining and industrial activities on essential element and heavy metals content in soil and plant around Subarnarekha river command area of Ghatsila (East Singhbhum), Jharkhand. Majority of area covered were very strongly acidic to slightly acidic with low fertility status and crops generally suffering from toxicity due to heavy metals. Fifty nine soil and seventy seven plant samples were collected during January 2012 from adjoining area of the selected water resources showed following observations. pH varied from 7.05 (Bore well) to 8.48 (river) in water collected from different water resources, while EC was in decreasing order 0.66, 0.44, 0.43, 0.32 and 0.22 dS m^{-1}, in well, bore well, canal, river and tank respectively, indicated more salt concentration in underground water as compared to surface water due to high leaching in coarse texture. Content of Zn, Cu, Fe & Mn in soil varied from 0.77 to 1.74, 3.61 to 5.87, 18.73 to 24.82 and 14.70 to 16.06 mg kg^{-1}, while Pb, Ni, Co and Cd varied from 2.31 to 2.87, 1.30 to 2.51, 1.30 to 1.60 mg kg^{-1} respectively in soil around different water resources. pH and EC in soil varied from 5.83 to 6.81 and 0.04 to 0.41 dS m^{-1} around different water resources, respectively. Phosphorous content around well was found much higher (64.48 kg ha^{-1}) as compare to other water resources due to the intensive cropping of vegetables. Similarly potash content was also higher in soil around well and bore well water resources. Content of Zn, Cu (Well), Fe, Mn (Tank), Pb, Ni (River), Co (Well) and Cd (River) in plant was higher 57.03, 64.50.448.14, 197.20, 56.28, 54.02, 47.66 and 11.54 mg kg^{-1}, respectively, when grown around the water resources. In different plant family groups, Zn and Cu content was higher in Allianceae, while Fe and Mn content was higher in Rubiaceae and Gramineae family. Heavy metals Pb and Ni was higher in Alliaceae while Co & Cd was higher in Rubiaceae. Trace metal content in edible parts of vegetable showed wide variation. Zn, Cu, Fe, and Mn were higher in radish (64.80 mg kg^{-1}), brinjal (64.20 mg kg^{-1}) radish (304.8 mg kg^{-1}) and cucumber (94.75 mg kg^{-1}) respectively while lower content of Zn, Cu, Fe and Mn was in tomato (10.60 mg kg^{-1}), radish (32.70 mg kg^{-1}), brinjal (93.40 mg kg^{-1}) and cowpea (77.65 mg kg^{-1}), respectively. Lead content among different vegetables showed a wide variation with higher content in potato (82.40 Pmg kg^{-1}) and lower in cowpea (0.30 mg kg^{-1}). Nickel content was in narrow range varied from 42.30 (radish) to 56.26 mg kg^{-1} (bottle guard). Cobalt and Cd content in different edible parts of vegetable showed not much variation and varied from 27.30 (radish) to 48.50 (potato) mg kg^{-1} and 8.90 (radish) to 11.68 (bottle gourd) mg kg^{-1}, respectively.

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Effect of Fly Ash with Graded Levels of Soil Test Based K on Yield and Uptake of Si and K in Rice under Drought Stress

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Rice (*Oryza sativa* L.) is the staple food for three billion people of Asia, which accounts for the production and consumption of 90% of world rice. At accelerating current growth rate of 1.8% of population in India, if rice requirement is to cope with population, the yield level of rice has to be triggered by 25 to 30% from the present level of 1.9 t ha^{-1} if the country is to remain self-sufficient by 2020. Rice is a silicicolous plant that absorbs Si in the form of monosilicic acid (H_4SiO_4) through active aerobic respiration. The epidermal cell walls contain deposition of Si that act as effective barriers against disease, pest incidence and also mitigate biotic and abiotic stress in rice. Under water deficit conditions K nutrition increases crop tolerance to water stress by using soil moisture more efficiently than in K-deficient plants. Potassium maintains the osmotic potential and turgor of the cells. Fly ash is a major industrial waste in India. It is a by-product of thermal power station where electricity is produced by burning finely powdered coal. Fly ash contain considerable amount of Si and K which can used as its source.

In view of the above, the present investigation was carried out at Agricultural Engineering College and Research Institute, Kumulur, Trichy district during 2011-12 by conducting field experiment with fly ash @ 25 t ha^{-1} with Farm Yard Manure (FYM) @ 12.5 t ha^{-1} and Silicate Solubulizing Bacteria (SSB) @2 t ha^{-1} with graded levels of soil test based potassium (STBK) in split plot design with two replication. The drought stress was imposed for 20 days during tillering stage of the rice cultivar BPT 5204 by cutting the irrigation. The results revealed that the yield of rice was positively and significantly increased by the addition of fly ash @ 25 t ha^{-1} with FYM @12.5 t $ha^{-1}$and SSB @ 2 kg ha^{-1} with 100% STBK by registering 6.01 and 7.63 t ha^{-1} of grain and straw respectively over control which recorded only 3.15 and 4.72 t ha^{-1} of grain and straw respectively. The maximum uptake of Si in grain (70.25 kg ha^{-1}) and in straw (281.74 kg ha^{-1}) was observed by the application of fly ash @ 25 t ha^{-1} with SSB and FYM with 100% STBK. The K uptake of 103.87 kg ha^{-1} in straw and 40.09 kg ha^{-1} in grain was recorded by the application of fly ash @ 25 t ha^{-1} with FYM @12.5 t ha^{-1} and SSB @ 2 kg ha^{-1} with 100% STBK. Thus fly ash along with FYM and SSB play effective and positive role in enhancing the yield and uptake of Si and K in rice as it acts as a source of Si and K under drought condition.

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Assessment of Soil Properties under Long-term Weed and Nutrient Management in Rice-Rice Cropping Sequence

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Autumn rice and winter rice is one of the major rice-based cropping systems followed under specific soil type and land situations in Assam. Transplanted rice faces diverse weed flora and intensity while use of both organic and chemical fertilizers is critical for long-term sustainability of production. The soil physical, chemical and biological properties of a long-term trial, being conducted since 2001 at ICR Farm of Assam Agricultural University, Jorhat, were evaluated after completion of tenth crop cycles of the cropping sequence. Application of herbicide with rotation of pre-emergence herbicide significantly increased grain yield in both the crops. The physical properties, except water holding capacity, were not affected by the treatments. The pH of the soil increased and fractions of soil acidity decreased significantly, while the cation exchange capacity, exchangeable cations, *viz.* Ca, Mg and NH_4 increased significantly with application of organic manure for partial N-fertilizer substitution. The available nitrogen and phosphorous content in soil differed significantly after winter rice due to organic manure addition, while the effect on available potassium was not significant. Organic carbon content in soil increased significantly due to organic manure addition and was implicated for consequent changes in some chemical and biological properties of the soil. The microbial biomass carbon, activity of urease were unaffected by herbicide application but were enhanced by organic manure addition. Application of herbicide significantly reduced the acid phosphatase activity in soil while it had a positive effect on dehydrogenase activity and the effect was pronounced by organic manure application. The effect of rotation of herbicide was not obvious and was limited to a few biological properties.

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Challenges and Opportunities in Soil Carbon Research in India

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Carbon sequestration can be defined as the capture and secure storage of carbon that would otherwise be emitted to or remain in the atmosphere. Increasing carbon content in the soil, through better management practices, produce a number of benefits in terms of soil ecology, fertility and soil water storage capacity and ultimately crop productivity. Soil carbon sequestration through the restoration of soil organic matter can further reverse land degradation and restore soil health through restoring soil biota and other associated ecological processes. However, it is still not clear about soil threshold carbon content for providing optimum soil related processes. Hence, there is a need to develop a methodology to compute minimum carbon content of each soil type which is required for providing optimum ecosystem services and soil processes. Furthermore, globally, there is problem of computing soil carbon stock due to prevalence of Walkley-Black method which gives only an approximation of soil organic carbon content. Adequate correction of Walkley-Black measurements is the most important aspect for the accurate and comparative total organic carbon measurements. Regardless of soil carbon sequestration potential, the amount of carbon a soil can actually hold is limited by factors such as rainfall, temperature and sunlight, and can be reduced further due to factors such as low nutrient availability, poor management factors and diseases. The term maximum attainable carbon content is defined and is suggested as the preferred term for carbon sequestration in mineral soils, being more relevant to management than "potential" and thereby of greater practical value. Therefore, there is a need to develop maximum attainable carbon content of soil for different agro-ecological regions of the country. Such determination may help the researchers, policy makers and farmers for devising suitable strategies for attainment of desired carbon level. Most soil carbon models assume a linear increase in C content with C input; suggesting that C sequestration can continue regardless of the amount of organic carbon already contained in each SOC pools. In contrast, many long term experiments soil rich in C have not shown any further increase in SOC following an enhanced C input. This suggests that there is an upper level of soil carbon beyond which carbon content of soil could not be increased. The proportion of carbon stabilized would be greater in samples with larger carbon saturation deficits and the relative stabilization efficiency would decrease as carbon input level increased. Hence, determination of soil carbon saturation level for different soil type may further help in judicious allocation of meager organic resources. Further a soil from saturation level, the greater the soil carbon storage potential. Therefore, it is not very well known if and how quickly newly incorporated C is stabilized by different mechanisms. The restoration of wastelands, degraded/desertified soils and ecosystems and adoption of improved farm management practices can enhance soil organic carbon and improve soil quality and soil health. Such management practices include organic agriculture, conservation tillage, mulching, cover crops, integrated nutrient management including use of manure and compost, and agro-forestry.

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Effect of Tannery Effluent Irrigation on Heavy Metal Accumulation and Physico-chemical Properties of Soil and Ground Water in Kanpur

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With the growing competition for water and the declining freshwater resources, utilization of marginal quality water for agriculture has posed a new challenge for environmental management. Use of tannery effluent, without treatment or with treatment, accumulated significant amount of heavy metals in agricultural soils and plants. Further, consumption of heavy metals accumulated plants may affect human and animal health. There are many numbers of tannery industries distributed in Kanpur city and generate huge volumes of effluents. These effluents are used for irrigation in *peri urban* areas of the city for cultivation of crops and vegetables production. Continuous application of tannery effluent for irrigation may change the physico-chemical properties of soil and water in that region. Keeping in view of the above, the study was conducted to measure the extent of heavy metal contamination and physico-chemical changes in the soils and water of Kanpur. The Geo referred effluent, soil and ground water samples were collected from the Kanpur region. Physico-chemical properties (pH, EC, organic carbon) of effluent, soil and ground water were determined as per the standard method and the potential toxic elements *viz*. Zn, Cu, Pb, Ni, Cr, As and Cd in soil and tannery effluent samples using ICP-OES. The pH of effluent samples at source point varies 7.91 to 8.76 with an average of 8.2, EC (dS m^{-1}) of effluent varies 2.35 to 13.15 and total heavy metal concentration (ppm) in samples was measured Cd varies from 0 to 0.019, Pb (0 to .074), Cr (1.53 to 57.35), Ni (0.0 to 0.116) and Zn (0 to 0.480) and As (0.0 to 0.03). Treated effluent having pH 7.66 to 7.97, slightly in alkaline range, while EC (dS m^{-1}) was varies 3.69 to 4.70 and total heavy metal concentration (ppm) was Cd 0.006-0.016, Cr 0.77 to 2.16, Ni 0.012-0.019, Zn 0.8 to 0.282 and As 0, 0.003. The effluent used for irrigation purpose found to have pH 7.46 to 8.26, EC 2.48 to 3.15 and total heavy metal concentration (ppm) was Cd 0.006-0.016, Cr 0.77 to 2.16, Ni 0.012-0.019, Zn 0.8 to 0.282 and As 0-0.003. Heavy metal concentration in ground water industrial area samples were Cu.0 to 0.057, Pb 0 to 0.012, Cr 0.022 to 0.038, Ni 0 and Zn 0.164 to 0.181. Soil samples collected from agricultural field where tannery effluent is using as an irrigation purpose (polluted) during crop cultivation. The pH (1:2.5) of polluted soil varies 7.15 to 8.33, EC (dS m^{-1}) 1.23 to 3.56, OC (%) 0.72 to 1.52. Total heavy metal concentration (ppm) was Cu 35.3 to 82.80, Cd 2.30 to 14.10, Pb 23.7 to 58.80, Cr 252.4 to 971.7, Ni 22.9 to 30.3, Zn 138.7 to 338.1 and As 6.8 to 11. Proper use of tannery effluent after treatment can be a good option to full fill water need for crop production.

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Poor Quality Water Use in Agriculture – A Concern

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Use of poor quality water in agriculture is growing because of scarcity of fresh water. Poor quality water comprises of wastewater as well as surface and groundwater contaminated due to geogenic or anthropogenic reasons. Being a cheap source farmers prefer to use it extensively in vegetables to provide life saving irrigation during moisture stress condition especially during *rabi* and summer season. These waters contain undesired materials like high salinity, magnesium hardness, nitrate content, heavy metals *etc.* that has negative environmental impact which is of concern and source of contamination may be urban sewage, industrial effluent or return flow from agriculture.

The impact of different sources of poor quality water use in irrigation on soil and plant under different agro-climates were studied and possible measures suggested for reducing the adverse effect. It has been observed that groundwater with high salinity can be effectively used to grow wheat in conjunction with surface water. The surface water with high alkalinity and hardness can be used with amendments in acid soil to grow groundnut. Moreover it has been observed that vegetables grown with urban sewage assimilates heavy metals especially in leafy and root crops. Microirrigation, incorporation of organic matters and suitable amendments are some of the measures suggested to minimise the assimilation. Management of poor quality water use in agriculture is the real challenge Indian agriculture is going to face in the near future.

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Effect of Urban Wastewater Irrigation on Paddy Productivity

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The urban wastewater (untreated or partially treated) availability round the year, is a resource used by many peri-urban farmers and has a significant impact on their livelihoods worldwide. Due to the proximity to urban centers, vegetables are important crops in peri-urban areas and have important contribution to the urban food basket Thereby, scientific studies investigating the use of untreated wastewater reuse were more focused on vegetable production systems. While, the cereal that provides household food security and wastewater-dependent livelihood activities in many countries is inadequately studied. An attempt was made to study the impact of long-term urban wastewater irrigation on paddy productivity and soil properties. Paddy and soil samples were collected in selected peri-urban villages of Bhubaneswar, India, from fields receiving contrast irrigation sources (urban wastewater and river water) under similar agro-climatic and socioeconomic conditions. Major plant nutrients were higher in wastewater irrigated soils, whereas pH was lower. Wastewater irrigation increased grain and straw yield. Concentrations of Zn, Fe, Cr, Mn and Cu were higher in soil, paddy grain and straw with wastewater irrigation. Response to wastewater irrigation varied with paddy variety. The ANOVA with the inclusion of pH as covariate revealed that the efficient management of soil pH would increase grain yield of rice by 318 kg ha^{-1}. Wastewater irrigation also saves about INR 3200 ha^{-1} towards the cost of fertilizer for growing paddy.

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Effect of Tank Silt Application on Soil Quality and Productivity of Marginal Land in Osmanabad District, Maharashtra

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Study area located in between 18^{o} 17’52’’ N latitude and 76^{0} 05’00’’ E longitudes at an altitude of 660 m above mean sea level (MSL) in basaltic area of College of Agriculture Farm, Osmanabad in Osmanabad district. Experiment was conducted on four ha area marginal land. These area were split in to four equal plots, deep ploughed, make free from rocks and applied the tank silt @ 0, 500,1000 and 1500 cum ha^{-1} *i.e.* 0, 5, 10 and 15 cm thick layer of tank silt on very shallow soil. This investigation indicated wide variability in growth and yield of soybean crop. This may be due to variation in application of different depth of tank silt layer. The application of tank silt @ 1500 cum ha^{-1} under very shallow soil were found two fold increase in the clay content, CEC and moisture retention whereas three fold decrease in the hydraulic conductivity of these soils over control (without application of tank silt). The maximum yield of soybean was recorded at application of 15 cm depth of tank silt layer (29.3 q ha^{-1}) and was nearly three fold increase over control (10.2 q ha^{-1}). On the basis of correlation analysis, it was observed that yield of soybean significantly and positively correlated with depth of tank silt layer (r= 0.98), clay content (r = 0.98), moisture content at flowering (r = 0.98), moisture content at harvesting (r= 0.98) and CEC (r = 0.97) and significantly and negative correlation with hydraulic conductivity (r = - 0.99). This is suggested that the application of tank silt improve the soil quality and productivity of marginal land. From the above discussion it is inferred that the tank silt application will be a good option to bring nearly 20 m ha of marginal land under cultivation with improved productivity.

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Impact of Sole and Conjunctive Use of Wastewater and Saline Groundwater on Soil Quality and Productivity of Indian Mustard (*Brassica juncea* L.)

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Wastewater use in agriculture is a profitable business for urban and peri-urban farmers but its unplanned, unmanaged and improper use in agriculture leads to a number of risks, including public health, agronomic, and environmental risks. Conjunctive use of wastewater with groundwater can be a new opportunity for comparatively safe and sustainable use of wastewater in agriculture. Therefore, field experiments was conducted for two consecutive crop seasons (2010-11 and 2011-12) at Indian Agricultural Research Institute (IARI) research farm, New Delhi, India. Indian mustard (*Brassica juncea var.* Pusa Jagannath) was taken as a test crop. The main objective of experiment was to assess the effect of sole and conjunctive use of wastewater and groundwater (saline or non saline) on soil quality status and crop productivity. Three sole irrigation treatments (*viz.* irrigation with 100% tubewell water (T_1), irrigation with 100% wastewater (T_2), irrigation with 100% synthetic saline water of EC-8.0 dS m^{-1}, T_3) and three conjunctive application of tubewell, wastewater and saline waters (*viz.* irrigation with 50% tubewell water + 50% wastewater (T_4), irrigation with 50% saline water + 50% tubewell water (T_5) and irrigation with 50% saline water + 50% wastewater, T_6) were undertaken. These were tested under randomized block design (RBD) with four replications. Results indicated that the physical properties of soil such as bulk density and saturated hydraulic conductivity were not significantly changed due to application of wastewater in two consecutive years. Whereas a significant improvement was occurred in available NPK, organic carbon and microbial biomass carbon contents in soil under the treatment of wastewater irrigation as sole (T_2) and conjunctively applied with groundwater as compared to 100% groundwater and 100% saline water. The bio-metrical observations such as number of branches plant^{-1}, dry matter accumulation plant^{-1}, number of siliqua plant^{-1} and seed siliqua^{-1}, seed yield and straw yield were significantly higher in the irrigation with 100% wastewater and significantly lowered under irrigation with 100% saline water. The above parameters were also significantly higher in case of conjunctive use of saline and wastewater (T_6 - 50% saline water + 50% wastewater) as compared to conjunctive use of saline and tubewell water (50% saline water + 50% tubewell water; T_5). Presence of higher organic matter and nutrients in wastewater and their capacity to dilute saline waters, when applied in conjunction, appears to be the main reason for the dampening of adverse effects of saline water applications. Thus application of wastewaters in sole or in conjunctive with saline waters appears to be a feasible strategy for enhancing mustard yields. However, its long term effects need to be further evaluated.

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Soil Physical Resilience as Influenced by Various Soil Amendments in Vertisols of Central India

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Vertisols most prominent in Central India, having expansive clays possess low strength and undergo excessive volume changes. It can be plastic, compressible and expand when wetted and shrink when dried. An incubation study was carried out to evaluate the effect of various soil amendments such as FYM, poultry manure, biochar, fly ash either alone or in combination on physical resilience/index properties of Vertisol. Study showed that the plasticity parameters such as liquid limit, plastic limit and plasticity index exhibit favourable changes (23-37%) with the addition of fly ash. The compaction characteristics like the maximum dry density increases with the corresponding decrease in optimum moisture content. The behaviour of vertisol is controlled by diffused double layer. The addition of fly ash results in increased flocculation due to increased availability of free lime content of fly ash. This increases the repulsive forces of soil particles, thereby increasing the resistance to compactive effort and hence the density of mix starts decreasing. Californian Bearing Ratio (CBR) and Resilient modulous values were highest in the treatments with FYM + fly ash (2.79% and 28.88 MPa, respectively) followed by poultry manure + fly ash (2.25% and 23.28 MPa, respectively) depicting their higher strength due to addition of fly ash. In other treatments, these values varied in between 1.76 to 2.12% and 18.19 to 21.93 MPa, respectively. Simultaneously, organic manures increase the microbial growth (84% increase as compared to control) and enzymatic activities (78% increase against control) so as to increase organic carbon content (71-80% increase among various treatment combinations against 34% increase in sole fly ash treated soil) in the soil. Study suggested that fly ash along with organic amendments like FYM or poultry manure can be used for better physical resilience in Vertisols of Central India.

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Soil Organic Carbon Stocks as the Most Reliable Land Quality Indicator of Red and Lateritic Soils of West Coast of Karnataka

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West coast of Karnataka experiences humid tropical climate with heavy rainfall, high temperature and dry spell, on Western Ghats to Arabian Sea, where, forests and commercially important crops like rubber, cashew, coconut, arecanut, banana, vegetables and paddy are grown. High and low hill ranges, elongated ridges, undulating uplands, lateritic mounds, plateau summits, and coastal landform constitutes the major physiographic divisions. By virtue of climate and topography, red and lateritic soils prevail here with acidification, low cation exchange capacity (CEC) and base saturation (BS), sheet erosion, crusting and compaction, iron stone capping and vegetative degradation. A study was undertaken to estimate horizon-wise soil organic carbon stocks in two transects comprising of a total of 7 soil profiles representing all major physiographic divisions, along with other physical and chemical parameters to study its impact on land quality. Organic carbon was estimated through standard procedure and soil organic carbon stocks were studied in kg m^{-2} soil using Grossman equation for top 30 cm, 30-100 cm and 0-100 cm. Soil organic carbon stocks upto 100 cm ranged from 1.7 to 14.2 kg m^{-2} and the highest in Kollur (14.2 kg m^{-2}) indicated high land quality, followed by Beltangadi (8.60 kg m^{-2}) and Brahmavar (8.0 kg m^{-2}) with moderate land quality. For top 30 cm, Kollur stood first with 10.9 kg m^{-2} followed by Beltangadi (5.6 kg m^{-2}) and Brahmavar (4.1 kg m^{-2}). For 30-100 cm, highest was in Brahmavar (3.91 kg m^{-2}) followed by Kollur (3.4 kg m^{-2}) and Beltangadi (2.9 kg m^{-2}) and least were noticed in Molahalli at 100 cm depth (1.71 kg m^{-2}), top 30 cm (0.99 kg m^{-2}) and at 30-100 cm also (0.72 kg m^{-2}) indicating poor land quality. Soil organic carbon was high in surface horizons and it decreased with the depth and helps the soil for better aggregation, buffering capacity, soil fertility and beneficial microbes. Low organic carbon leads to crusting and compaction, impeded structure and poor soil permeability and water retention capacity. Increase in soil organic carbon through C sequestration into the pedosphere enhances the soil quality and regulatory capacity. Soil organic carbon status is an indicator of quality of land and how best it can sustain crop production at profitable and sustainable level. Soil organic carbon stocks in rubber and cashew production systems ranged from 7.98 to 8.56 kg m^{-2}.

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Effect of Inorganic and Organic Manures on Soil Enzyme Activities in Relation to Yield and Quality of Colocasia in Acid Alfisols

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A field experiment was conducted for two years during 2011-13 to study the effect of integrated use of lime, biological, inorganic and organic manures on soil enzyme activities in relation to yield and biochemical constituents of colocasia (*Colocasia esculenta* L.) in acid Alfisols of Odisha. The experimental soil is sandy loam, acidic (pH 5.51), non saline (0.58 dS m^{-1}) and having 0.33% organic carbon, 0.075% total N, 142, 12.32 and 218 kg ha^{-1} of available N, P and K, respectively. The microbial populations were relatively lower in these acid soils in which fungi are dominant over that of bacteria and *Actinomycetes*. Integrated application of lime + FYM + ½ NPK + $ZnSO_4$ has recorded highest dehydrogenase activity (2.012 µg TPF h^{-1} g^{-1} soil) followed by 150% NPK (1.981 µg TPF h^{-1} g^{-1} soil). Highest Fluorescein Diacetate Activities (FDS) (1.986 µg g^{-1} h^{-1}) as well as acid and alkaline phosphatase activities (78.19 and 52.16 µg PNP g^{-1} soil h^{-1}, respectively) were observed due to fungal inoculation with VAM in combination with lime + FYM+½ NPK.

Significantly highest mean cormel yield (14.13 t ha^{-1}) was recorded due to application of super optimal doses of NPK at par with FYM + 100% NPK (14.12 t ha^{-1}). The yield response was highest due to application of K rather than N and P, whereas combined application of NK showed higher yield response over that of NP. The starch and dry matter contents in the cormels varied from 14.82-18.53 and 20.86-24.63%, respectively. Organic carbon showed highly significant relationship with cormel yield ($r = 0.53^{**}$) and dry matter ($r = 0.89^{**}$) of colocasia. Dehydrogenase activity had highly significant relationship with yield and bio-chemical constituents of colocasia. Soils receiving inputs of organic residues through amendments or with higher levels of plant residues have shown greater FDA, dehydrogenase, and acid phosphatase activities than soils received inorganics alone. Acid phosphatase showed significantly higher relationship with starch content as well as cormel yield, whereas alkaline phosphatase showed significantly higher relationship with dry matter content of colocasia. Since majority of soil biochemical transformations are dependent on presence of microorganisms and microbial activities, conjunctive use of lime, balanced chemical fertilizers and organic manures sustain the soil quality in order to realize higher crop yields of colocasia in acid Alfisols.

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Delineation of Potassium Deficiency in Oil Palm Growing Areas of Andhra Pradesh

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Oil palm (*Elaeis guineensis*) is a nutrient demanding crop and nutrients are removed largely in the harvested fresh fruit bunch (FFB) and also immobilized in the trunk. The potassium is the main nutrient element, which plays a significant role in oil palm production (FFB yield) and its resistance to the dry season. One can observe 30% decrease of the production in case of potassium deficiency. Therefore the target of high oil yields cannot be realized without adequate supply of this nutrient. The present study has been undertaken to delineate potassium deficient areas in three major districts of oil palm growing areas of Andhra Pradesh and to evaluate their present status and to understand the effect of potassium fertilization on FFB yield and leaf K-status using On-farm data sheets. Soils of one hundred twenty nine oil palm orchards from nineteen Mandals representing three districts of Andhra Pradesh (14 Mandals from West Godavari, 3 from Krishna and 2 from Khammam districts) were collected by compositing and studied for K status.

It was observed that the soils were very acidic to slightly alkaline in nature. The values of electrical conductivity of the soils were low, varying from 0.015 to 0.352 dS m^{-1} with an average value of 0.102 dS m^{-1}. The organic carbon content in general was very low and the contents varied from 2.2 to 12.1 g kg^{-1} with a mean value of 5.2 g kg^{-1}. The cation exchange capacity (CEC) of the soils varied from 5.21 to 19.05 cmol (p^+) kg^{-1}. The available phosphorus and potassium ranged from 4.2 to 161.9 kg ha^{-1} and 45 to 1008 kg ha^{-1} respectively. The potassium content in these soils varied widely with in Mandals irrespective of the district and variability in phosphorus and potassium status in West Godavari district. Levels of low status of potassium were highest in Devarapalli (83%) followed by Jangareddygudem (60%) Mandals of West Godavari and most Mandals in Krishna District. Low organic matter, phosphorus and potassium status coupled with low CEC in these districts suggests that they are subject to decline in fertility and require specific potassium management measures with sufficient organic manure application. The overall nutrient index value of potassium is 1.85. Increased potasssium fertilization increased oil palm yield (FFB yield, bunch size and bunch number on many soils) and also improves the K leaf content in all the studied area.

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Soil Quality Assessment of Vertisol of AESR 10.1 using Principal Component Analysis and Expert Opinion Method

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Soil quality assessment has been suggested as a tool for evaluating sustainability of soil and crop management practices. Expert opinion (EO) method and statistical method approach of data reduction through principal component analysis (PCA) were tested for choosing a minimum data set (MDS), indicator transformation, indices calculation and its suitability for soil quality assessment for the region AESR 10.1 covering largely of Vertisol (Sehore and Vidisha district). After choosing the MDS indicators through PCA, each MDS indicator were converted into score between 0-1 by following a linear scoring technique. Once transformed, the MDS variable for each observation was weighted using the PCA results. In case of expert opinion method the minimum data set of indicators (15 attributes of soil comprising of physical, chemical and biological indicators) were identified that best represent soil function for that particular region (AESR 10.1) with uniform weight-age and scoring value. Soil quality index (SQI) value for each observation was derived by summation of the product of weighted MDS variables and scores for each observation. Further, relative soil quality index (RSQI) was computed by dividing observed SQI value of a site by maximum SQI value derived from EO method.

The results showed that linear regression of the soil quality indices derived from respective MDS indicators (as independent variables) against the end point measures like percent relative yield of *kharif* crop, *rabi* crop and mean relative yield of the cropping systems as dependent variables showed no significant differences between the EO (EORSQI) ($y= 1.042x – 4.933$; $R^2 = 0.484$**) and PCA (PCASQI) ($y= 55.77x – 10.25$; $R^2 = 0.533$**) techniques in their abilities to explain variability of management goal (Yield) for Sehore + Vidisha district (combined). Further the relationship between PCA derived SQI (PCASQI) and Expert opinion derived SQI (EORSQI) is highly significant with R^2 value of 0.589**. The relationship was in the form of $y = 0.016x + 0.199$ and indicated very high degree of relationship ($r = 0.767$). From the study it is concluded that these indices derived from MDS of PCA and EO is reliable for assessing the quality of Vertisols in AESR 10.1. However, soil health assessment through PCASQI is a tedious and cumbersome method because it involves identification of soil health indicators and rational judgment of screening of indicators through principal component analysis. Therefore, EORSQI methodology appears to be very simple and can be easily adopted by soil testing laboratories for assessing soil health of Vertisols in AESR 10.1.

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Dissemination of Productivity Enhancement Technologies of Micro Nutrient Application in Oilseed and Pulse Crops

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Assessment of technologies and frontline demonstrations on micro nutrient application for oilseed and pulse were carried out during the year 2010-11 and 2011-12 at farmer's field in Rajgarh district. The treatments and technologies were application of Zinc in Soybean as foliar and soil application and Mo with Rizobium in Gram as seed treatment for enhancement in N-fixation. The OFTs in the year 2010-11 and then FLDs in the year 2011-12 were conducted at five farmer's field in each OFT, FLD and in each treatments and technologies. The results of both years showed that the 37.88 percent and 39.41 percent increase in average yield in Zn as soil application & foliar application respectively in Soybean and 13.45 percent in increase in yield in Mo + Rizobium as seed treatment in Gram. The treatments and technologies assessed and demonstrated were NPKSZn 20:60:20:40:5 kg per ha as soil application in Soybean in light to medium soil, NPKS - 20:60:20:40 kg per ha soil application + 0.5 per cent $ZnSO_4$ foliar application in Soybean in heavy soil and NPK - 20:60:20 kg per ha + Amonium molybdate 1 g + Rizobium 5 g per kg seed as seed treatment in Gram. Horizontal spread of the technologies demonstrated showed the wider adoption of the tested technologies in the district.

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