NATIONAL SEMINAR

ON

DEVELOPMENTS IN SOIL SCIENCE – 2011

ABSTRACTS

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Indian Society of Soil Science
16-19 November 2011

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Abstracts

Indian Society of Soil Science

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Characterization of Some Aquepts in Lower Mahanadi Delta of Orissa for Land Use Planning

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Aquepts are the Inceptisols having aquic moisture regime and characteristic redoximorphic features like gleying and mottles. They are normally developed in low lying areas periodically inundated with water. The lower Mahanadi delta occupies an area of 0.55 m ha representing 3.76 per cent of the total geographical area of Orissa and nearly level low lands constitute 60 per cent of this tract. Aquepts are the dominant suborder in this region and the informations on these soils are scanty. The present study is an attempt to characterize these soils for developing suitable and sustainable land use options. Soils from the representative pedons of these Aquepts at Kakuria (Pipili), Nalibasanta (Satyabadi), Deosahi (Puri) and Narasinghaballabh (Puri) series under lower Mahanadi delta have been studied for the purpose. The Aquepts occurring in these areas belong to great groups Epiaquepts and Endoaquepts. The Epiaquepts are imperfectly drained, yellowish brown in the surface and grayish brown down the depth. The texture was coarse loamy over fine loamy (clay 29.3%) in the control section. The strong gleying was evident from chroma of 2 at the depth of 26-48 cm, 71-90 cm, 90-130 cm and the redoximorphic features present were redox concentration (Fe and Mn concretion) at the depth of 48-71 cm and 71-90 cm, redox depletion (mobilization of Fe and Mn out of the horizon) at the depth of 26-48 cm and 90-130 cm and presence of high chroma mottles in the lower horizons. Saturated conditions at the depth zone of 26-48 cm and again at 71-90 cm and 90-130 cm indicated the characteristics of episaturation. The Endoaquepts are poorly drained, dark brown in the surface, grayish brown in between and dark gray in the bottom. The texture is fine (clay 42%) in the control section and clayey in the surface. Low matrix chroma of < 2 in the subsurface horizons, presence of redoximorphic features such as gleying, redox depletion in the lower horizons and redox concentration (Fe and Mn concretions) at the depth zone of 30-75 cm indicated aquic environment in these soils. These soils have endosatuation as the groundwater fluctuated from nearly level to below a depth of 50 cm. Wide variation in sand / silt ratio (0.1 to 12.6) suggested fluvial activity in these soils. The soils are well saturated with bases (69-94%) with moderate CEC. Alternate land use plans developed through soil site suitability for Epiaquepts are transplanted rice in *kharif* and pulses in *rabi* season. The Endoaquepts can be used to grow deep water rice/boro rice in *kharif*/ pre *rabi* season followed by pulses. Dugout farm pond technology can be a viable option in these low lying Endoaquepts.

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Studies on Morphological and Chemical Properties of the Soils of Agriculture College Farm, Kolhapur

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Studies on morphological, chemical properties and nutrient status of the soils of Agriculture College Farm, Kolhapur was carried out during the year 2010-11. Representative pedons were studied for various morphological characteristics. The soils under Entisols were developed on upper pediment, shallow, gravely sandy clay to sandy clay texture. Soils under Inceptisol order were moderately alkaline, texturally classified as sandy clay to clay with strong coarse subangular blocky to medium moderate angular blocky structure. Soils of Vertisol order were developed on lower piedmont. Soil pedons exhibit the colour very dark brown (10 YR 2/2 D) to very dark grey (10 YR 3/1 D), sandy clay to clay in texture, strong subangular blocky structure at surface and angular blocky peds at subsurface horizon showing pressure faces with intersecting slikenslides .Status of micronutrients indicated deficiency of Fe in 91% and Zn in 93% soil samples . Parker's Fertility Index for College farm was 1.27 (low) for organic carbon, 0.94 (very low) for available N, 1.67 (medium) for available P and 1.66 (medium) for available K. Soils of the College Farm were classified as Lithic ustorthents ,Vertic haplustepts and Typic haplusterts . Correlation among chemical parameters and nutrient content of surface soil samples were studied, in case of surface soil pH showed correlation with EC, available P, CEC and Ca. Organic carbon showed positive relation with available N. Available N showed positive relation with available P and available S, while $CaCO_3$ showed negative correlation with micronutrients like Fe, Mn, Zn and Cu.

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Studies on Soil Morphological, Physical and Chemical Properties of Important Soil Series of Kolhapur District

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Important benchmark soil series of Kolhapur district were assessed for morphological, physical and chemical characters. This series comes under Entisol, Inceptisol, Vertisol and Alfisol orders which are derived from basalt, basaltic alluvium and slightly conditioned by topography. The dominant structure were coarse to medium, moderately strong to strong sub angular blocky type, but angular blocky structure is a common feature in slickenside zone of Vertisol soil series and some Inceptisol soil series. Few $CaCO_3$ concretions along with slight to violent effervescences were mostly observed in Inceptisols and Vertisols. Soils showed gravely sandy clay (Ghot, Sathesai series) to clay loam (Majnal series) to clay texture. Hydraulic conductivity ranged from 0.16(Rastapur series) to 3.95(Shirawali series) cm hr^{-1} and bulk density from 1.06 (Barshi) to 1.60 (Udgoan series) Mg m^{-3}. Relatively high smectite content resulted in higher moisture content at 33 kPa and 1500 kPa suction. These soils have moderately acidic (<5.5) to moderately alkaline (8.2) reaction with more soluble salt present in Rastapur soils series. Majority of surface layer having more organic carbon and available phosphorous than underlying ones. Calcium and magnesium were found to be dominant cations on the exchange complex of Vertisols and Inceptisols soil series. The soils are very low to low in available N, very low to very high in available P and very low to high in available K. All the soil series are deficient in sulphur content except Barshi soil series (25 mg kg^{-1}) of Vertisols. Considering the chemical properties of different soil series , all the series needs appropriate nutrient management with respect of nitrogen and potassium except Barshi , Shirawali and Velapur series . Ghot ,Sathesai and Bamburdi soil series needs phosphorous management. In case of micronutrients , management for available Fe should be carried out in all Entisols (except Ghot), Inceptisols and Donoli soil series MANGANESE IN Udgaon ,Sathesai ,Kavhe , Bamburdi series , whereas Zn fertilization needs in Ghot .Sathesai ,MAJNAL ,Kavhe , Bamburdi ,Rastapur and Barshi soil series due to its deficient status .Shirwali soil series showed acidic soil reaction(pH < 5.5) , therefore needs liming for achieving sustainable crop productivity .

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Survey, Delineation and Characterization of Salt Affected Soils of Mandsaur District of Madhya Pradesh Using Remote Sensing Techniques

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The survey, delineation and characterization of salt affected soils of Mandsaur District of M.P using remote sensing techniques was done on the basis of visual interpretation of Resourcesat-1 LISS III data and ground truthing. A map showing salt affected soils was prepared using soil analysis data, features identified showing salinity/ sodicity problem on digital satellite data through visual interpretation of the digital image using Remote Sensing Software (ERDAS IMAGINE 8.7) and ground truth. Geographical position of the identified points was recorded using software. Soil samples were collected from identified points with the help of GPS for ground truthing. During the traversing of the area, soil samples were also collected from locations other than identified one, showing salinity/ alkalinity problem and their geographical positions were recorded. On the basis of degree of salinity and alkalinity, the soils were classified and map of the district was generated. Laboratory analysis of samples collected from different locations showed that the pHs, ECe and SAR ranged from 7.5 to 8.7, 1.2 to 2.7 and 3.4 to 62.2 respectively. Most of the samples exhibited higher pH i.e. > 8.0. Among different cations, Na was the dominant one in all the soil samples and ranged from 6.3 to 12.2 me L^{-1}. This shows that the soils are saturated with Na followed by Ca and Mg. The exchangeable Ca, Mg and Na ranged from 9.3 to 25.0, 5.1 to 13.5 and 5.4 to 28.61 cmol (p^+) kg^{-1} respectively. The exchangeable sodium percentage (ESP) varied from 14.0 to 61.6 respectively. Five samples from Mandsaur, one sample from Suwasara and three samples from Bhanpura tehsils belonged to ESP greater than 50. According to salinity and alkalinity hazards, the soil was classified in to three different categories of salinity (slight (ECe 4-8 dS/m), moderate (EC_e 8-15 dS/m) and high (EC_e >15 dS/m) and Alkalinity (Slight (ESP 15-25), Moderate (ESP 25-40) and High, (ESP > 40). After identification of areas falling under different categories of salt affected soils with the help of band combinations, colour, texture and tone through available software (ERDAS imagine, 8.7) the area was estimated with the help of software and affected villages were identified after opening this map over scanned tehsil maps having village boundaries. The total area of salt affected soils in Mandsaur district is 15437 ha, out of which, 7854 ha area fall under the category of slightly saline and highly alkali (7854 ha) followed by slightly saline and moderately alkali (7006 ha) and slightly saline and slightly alkali (577 ha).

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Weathering and Stability of Minerals of Soils in Different Geomorphic Units of North-Eastern Part of Haryana

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A systematic study of weathering and stability of minerals of soils of different geomorphic units in north-eastern part of Haryana was carried out. Seven pedons representing geomorphic units and subunits, which were already identified and studied for weathering and stability of minerals. The soil minerals are arranged in order of stability or conversely their weatherability is predicted by using the thermodynamic model developed by Rai and Lindsay (1975) to generalize about the behavior of soils i.e. physical properties in relation to clay mineral type present to assess the various environmental conditions on the path of soil formation. The equation of the chemical species as relate to the equilibrium constants were used to plot the mineral solubility lines in terms of activities of the species that are common to minerals under consideration.

According to the methods as illustrated by Rai and Lindsay (1975) equation showing the relationship between log (Al^{+3}) and –log (H_4SiO_4) for the minerals were developed and stability diagrams were constructed. For weathering stability of primary minerals under different environment, the stability order of different minerals of the study area obtained from the models were grouped under following stability (in increasing order) groups.

1) Low albite, anorthite, muscovite, microcline, quartz.
2) Low albite, anorthite, microcline, muscovite, quartz.
3) Anorthite, low albite, microcline, muscovite, quartz.
4) Low albite, muscovite, anorthite, microcline, quartz.
5) Muscovite, low albite, anorthite, microcline, quartz.

The Stability of secondary minerals varied less and order of stability of minerals in different geomorphic unites were (in increasing order) Chlorite, Illite, Kaolinite and Chlorite, Kaolinite, Illite.

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Characterization and Evaluation of Land Resources in Marpaka Watershed of Nalgonda District, Andhra Pradesh Using Geo Spatial Approach

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The land and water resources have optimum interaction and synergistic effect when developed on watershed approach. Therefore, for land use planning based on watersheds, the information on land use / land cover is also important in spatial format because the present land use is the result of different causes and factors which are related to land form, soil physical, chemical and mineralogical properties as well as infrastructure conditions. An attempt has been made to characterize, evaluate and map the land resources of Marpaka watershed.

The study area selected, Marpaka watershed, is located in Nalgonda district of Andhra Pradesh. The Marpaka watershed is located between 16^0 54' 30" to 16^0 56' 45" N latitude and 79^0 19' 20" to 79^0 21' 15" E longitude. It has total geographical area of 868.61 ha. It is located in Southern Telangana Agro-climatic zone of Andhra Pradesh. The soils have Ustic and Hyperthermic soil moisture and soil temperature regimes, respectively. The digital data from Linear Imaging Self Scanner (LISS) – IV sensor on board IRS – P6 data was used in the study of natural resources of the watershed. The resource maps *viz.*, soil resource and land use/ land cover map of 1:10,000 scale were generated using the standard methodologies.

Five major landforms *viz.*, valley, pediplain – lower, middle, upper, and linear ridges and dolerite dykes were identified in the study area. The major land use/land cover identified were single cropped area, marginal land under cultivation and double cropped area. Six soil units were identified and mapped on 1:10000 scale based on landform-soil relationship. The soil of valleys represents very deep soils and belongs to Typic Haplustepts and Vertic Haplustepts taxonomic units. Pediplain shallow was having deep soils and mostly belongs to Typic Haplustepts and Typic Haplustalfs.The middle pediplain contains deeper soils and belongs to Typic Haplustalfs and Typic Ustorthents taxonomic units. The pediment was shallow soils and containing Lithic Ustorthents, Typic Ustorthents and Lithic Haplustepts taxonomic units. Linear ridges and dolerite dykes were shallow soils belongs to Typic Ustorthents.

The soils of Marpaka watershed were grouped into II and IV land capability classes. The soil suitability analysis indicated that soils of Marpaka watershed are marginally suitable to Cotton and Sugarcane and moderately suitable to Tomato and Chilli. Based on the land capability classification, Physiography and soil suitability of the study area instead of existing crop like Cotton; Chilli and Tomato crops are more suitable. Also soil conservation practices like agro forestry, horti pasture and silvi pasture were suggested. Suitable conservation measures and interventions have been suggested to improve the productivity of these soils.

Commission 2.1: Soil Physics

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Management of Soil Physical Environment – An Indispensable Prerequisite for Sustaining Agricultural Production at Higher Level

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The challenging task ahead before the Indian agriculture is to produce more food to feed the burgeoning population from shrinking land and less water without eroding the ecological foundation. It is estimated that by 2025 AD, India would require 350 million tones of food grains to feed its teeming millions. There are two ways to augment food supply; one to increase the cultivated land, which is not possible because our land resources are limited, the only another way is to increase yield/unit area/unit time. The surest mean to tide over this challenge is the efficient management of natural resources of sustainable agricultural growth and development.

Out of the 328 Mha of the total geographical area in India, 173.65 are degraded, producing less than 20 per cent of its potential capacity and out of this 89.52 Mha suffers from one or the other form of physical constraints *viz.*, shallow depth, soil hardening, slow and high permeability, sub-surface compacted layer, surface crusting, temporary water-logging *etc.* Unless the soil physical environment is maintained at its optimum level, the genetic yield potential of a crop cannot be realized even when all the other requirements are fulfilled. Technologies like optimal uses of water, manures and fertilizers, tillage practices, mulching, selection of appropriate cropping system can favourably modify the soil physical parameters like bulk density, porosity, aeration, soil moisture, temperature, soil aggregation, water retention and water transmission properties and soil process like evaporation, infiltration, runoff and soil loss for better crop growth and yield. The improvement of soil health through these eco-friendly site specific technologies will also lead to efficient use of inputs and help in sustaining agricultural production at higher level.

Some of the site specific technologies for ameliorating and managing soil related constraints, *viz.*, compaction and clay addition for highly permeable soils, chisel technology and ridge technology for managing soils with sub-surface mechanical impedance, raised bed and sunken bed and broad bed and furrow technology for managing slowly permeable black soils *etc.* can help in improving the soil health and enhancing crop productivity. The nature and extent of soil physical constraints are however, not static. Mechanization of farm operations, frequent tillage in intensive cropping systems, unscientific and indiscriminate use of inputs and decline in soil organic matter *etc.* are adding new problems to the existing area. Persistent efforts are, therefore, warranted to arrest further aggravation of soil degradation, to alleviate soil physical constraints and also to understand the respective causal processes for the sake of holistic, safe and resilient agricultural production system. Therefore, our sincere efforts must be to improve and maintain soil physical environment at its optimum condition with minimal risks to environment, which in turn will lead to efficient use of inputs and help in sustaining agricultural production at higher level.

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Soil Water Dynamics and Input Use Efficiency by Wheat as Influenced by Levels of Irrigation and Nutrient Management Practices

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A field experiment was conducted on a Typic Haplustept at the Indian Agricultural Research Institute, New Delhi during 2010-11 in a split-plot design with four levels of irrigation (0.4 IW/CPE, 0.6 IW/CPE, 0.8 IW/CPE and 1.0 IW/CPE, IW= 6 cm) and three nitrogen 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 study soil-water dynamics and optimize irrigation schedule for wheat (cv PBW 502) for improving input use efficiency in soybean-wheat system. The temporal variation in the profile water distribution showed that at lower level of irrigation (0.4 IW/CPE), greater depletion of soil water took place from deeper layers compared to higher irrigation levels (1.0 IW/CPE). The maximum soil water extraction took place from 0-30 cm soil depth and it declined with depth. With respect to the nutrient sources, highest soil water was retained in the profile due to FYM application compared to sole urea application. This was mainly attributed to higher soil water retention due to improvement in the physical properties of soil under FYM treatment and lower evapo-traspiration demand under this treatment due to poor biomass production. The wheat crop was showing water stress at later part of crop growth at 0.4 IW/CPE irrigation level and FYM application as indicated by lower relative leaf water content, lower transpiration rate, higher leaf water potential, higher canopy-air temperature difference, and higher water index as measured using hyper-spectral remote sensing technique. The grain yield of wheat at 1.0 IW/CPE level of irrigation was significantly higher than that at 0.4 IW/CPE and 0.6 IW/CPE level. However, there was no significant difference in the grain yield of wheat due to 0.8 and 1.0 IW/CPE irrigation levels. The total biomass production with 1.0 IW/CPE irrigation level was significantly higher than that at lower irrigation levels. Grain yield and biomass production of wheat with sole urea application was significantly higher than that of integrated use of urea and FYM and sole FYM application. Slow release of N from FYM source during *rabi* season might have caused N stress, which might have resulted in the decline in grain yield and biomass production of wheat in this treatment. Since this is the first year of experimentation, the nutrient release from FYM was not sufficient enough to meet the crop demand. This was reflected in significantly lower grain protein percentage with FYM application compared to sole urea application. There was no significant difference among the irrigation treatments with respect to water use efficiency; however the water use efficiency with urea and urea + FYM treatment was significantly higher than that of FYM treatment. The partial factor productivity of nitrogen decreased with decrease in irrigation level, which shows synergistic interaction between water and nitrogen. The partial factor productivity of N with urea application was significantly higher than that with FYM application. Thus from this study it may be concluded that wheat can be grown with 0.8 IW/CPE irrigation level in sandy loam soils of Delhi region but if it is grown with only organic manures, it is likely to suffer from low productivity in the initial years under limited water supply situation.

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Distribution of Carbon in Particle Size Fractions, and Carbon Nitrogen, Phosphorus and Sulphur Status in Macro and Micro Aggregates of a Red Soil under Long-term Fertilization

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Investigation was carried out in a red soil under long-term fertilization at Zonal Agricultural Research Station, GKVK, to study carbon in particle size fractions and, macro and micro aggregates of soil samples, and to assess nitrogen, phosphorus and sulphur status in macro and micro aggregates of soil. Soil samples were collected at two depths *i.e.* 0-15 cm and 15-30 cm, and samples were analyzed using standard procedures. The soil samples were also fractionated into different groups of primary particles without destroying carbon particles and were analyzed for C, N, P and S associated with sand, silt, and clay. Total C, total N and total P contents varied markedly among the treatments. The plots which were applied with NPK at recommended dosage and with FYM along with fertilizers contained higher quantities of total C, total N, total P and total S than the plots treated with lower doses of nutrients or the one not at all treated with fertilizers. Total P and total S amounts were higher in the plots applied with single super phosphate as source of P. The total contents of all the four elements were lower in the second depth as compared to the first depth. Available N, P and S of soil were higher in the plots applied with both fertilizers and manures and also in the plots treated with balanced doses of nutrients. The contents of available N and P were higher in the first depth as compared to the second depth, while, the reverse was the trend in respect of available S of soil. Available phosphorus was very low in the control plot and the plot treated with only nitrogenous fertilizers. The effect of both S containing fertilizers and the FYM was evident in increasing the available S content of soil. Among the soil size fractions, the sand was highest, followed by clay and then silt in the decreasing order of their contents in the soil. Among the different size fractions, clay had the highest content of all the four elements *i.e.* C, N, P and S, followed by silt and sand fractions in both the depths of soil, indicating that most of the C, N, P and S were closely associated with clay. Irrespective of the soil size fraction, the contents of C, N, P and S were higher in the plots treated with 100% NPK+FYM, followed by the plots treated with NPK fertilizers at the recommended dosage and were lower in control plot and the plots treated with imbalanced dosage of nutrients. The contents of all the four elements were relatively higher in the surface soil, irrespective of treatments and the trends in respects of treatment differences in the lower depth were similar to the one observed for the upper layer of soil. Micro aggregates of soil had much higher amount of organic C, and also total and available forms of N, P and S than that of macro aggregates. In both types of aggregates, the trends in respects of treatment differences were similar to the ones observed for whole soil.

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Effect of Subsurface Drip Fertigation on Growth and Yield of Banana cv. Rasthali

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Field experiment was carried out at AICRP- Water Management block, Agricultural College and Research Institute, Madurai during 2010 - 2011 to study the effect of subsurface drip fertigation on growth, yield, quality and economics of Banana cv. Rasthali. There were eleven treatments replicated three times in Randomized block design. Banana cv.Rasthali was used as the test crop. Subsurface drip irrigation was scheduled at 100 per cent PE once in three days and fertigation was given once in six days starting from 15 days after planting to 300 days after planting. For surface method irrigation was scheduled at 5.0 cm depth with IW/CPE ratio of 0.8. The observations on growth characters, yield attributes, yield and quality parameters at periodical intervals were observed. Estimates of total water use, soil available nutrients, nutrient mobility in soil and economic returns were also recorded.

Sub-surface drip fertigation of 100% RDF (50% P and K as basal, remaining N, P and K as WSF) +LBF and subsurface drip fertigation of 100% RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF were equally effective in increasing growth attributes (pseudostem height, stem girth, number of leaves) and physiological parameters of banana (leaf area index, specific leaf weight and chlorophyll content of leaves). The plants treated with subsurface drip fertigation of 100 per cent RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF came to shooting and harvest earlier. As a consequence of better growth, yield attributing characters like number of hands and number of fingers per bunch, fresh finger weight, finger circumference and bunch weight were increased under subsurface drip fertigation of 100 per cent RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF. The highest bunch yield was recorded in subsurface drip fertigation of 100% RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF which accounted to 115 per cent increase over surface irrigation with soil application of recommended dose of fertilizers. In general, subsurface drip fertigation of 100% RDF treatments in combination with liquid biofertilizers maintained higher available NPK in the post harvest soil compared to surface irrigation with soil application of recommended dose of fertilizers. The nutrient mobility study revealed that fertigation treatments maintained higher concentration of available N, P and K around root zone of banana compared to surface irrigation with soil application of recommended dose of fertilizers where most of the nutrients moved to deeper layer due to leaching fraction of applied fertilizers. The resource use efficiency parameter *viz.*, partial factor productivity declined with increasing levels of fertigation. However, the water use efficiency, water productivity and net return were higher under subsurface drip fertigation of 100% RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF. The results of this study clearly indicated that subsurface drip fertigation of 100 per cent RDF as WSF (WSF – Urea, 13: 40: 13, KNO_3) + LBF at six days interval would be an ideal practice to achieve higher income as compared to traditional method of applying fertilizers with surface irrigation.

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Predicting Textural Averages of Saturated Soil Hydraulic Conductivity from Water Retention Data

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Modeling of transport processes in soils relies on predicted values of saturated hydraulic conductivity, Ks. The objective of this work was to derive the parameters of a Ks power-law model from water retention (WR) properties defined at the inflection point of s-shaped WR functions. The proposed model uses water content, θ_{inf}, pressure potential, ψ_{inf}, and the slope, S, at the inflection point to derive an effective porosity, Ψ_{inf}, (air filled porosity at θ_{inf}) and a pore distribution index, λ^*, (estimated from WR data between pressure potential at air-entry and ψ_{inf} or as S/θ_{inf}). The Φ_{inf} is raised to $3\text{-}\lambda^*$ or $3\text{-}S/\theta_{inf}$ and multiplied by C_{inf} D_{inf} where C_{inf} is a constant and pore diameter is defined as $D_{inf} \alpha \psi_{inf}$ "[1]. The model was developed from: A) a dataset containing 374 measurements of Ks together with detailed WR and particle size distribution information, B) a subset of the HYPRES dataset containing 1827 values of *Ks* and their corresponding sand, silt and clay percentages and parameter values from an s-shaped WR model; and tested for consistency with C) a published dataset containing textural averages of parameters of an s-shape WR model and Ks values developed from 2134 and 1036 samples, respectively. Linear regression between 16 (A), 10 (B) and 12 (C) textural averages of *logKs* and their predicted values with C_{inf} = 20 resulted in R^2 values of 0.95, 0.82 and 0.82, respectively. The proposed model is physically sound and except for Cinf all its parameters are derived from one point in the WR curve. This work shows that the inflection points of water retention curves contain information useful for modeling *Ks*. Such an approach provides an alternative to defining effective porosity with fixed pressure potentials, and it could most likely be extended to other transport coefficients such as diffusion coefficient. The *Ks* models require information on at least average values of total porosity, and of water content and pressure potential at the inflection point of water retention curves. Although detailed water retention data near saturation is the best way to derive these parameters, they could also be inferred from average parameter values of water retention functions grouped by texture classes. The variability observed within each texture class and across datasets compromise the predictability of individual *Ks* values. More research is needed to define the best constant which, in turn, could lead to improvements in site predictions of *Ks*. The applicability of the *Ks* models outlined in this work may be extended to include the effect of soil structure on each of their parameters by developing pedotransfer functions to predict the variation around textural-based predictions. Such approach would be in agreement with the concept of textural and structural porosity

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Effect of Soil Moisture Regimes and Nutrient Levels on Productive Performance of Bt Cotton and Profile of Season Long Cry 1 Ac Expression in Deep Vertisols

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The cotton varieties expressing the *Bacillus thuringiensis* (Bt cotton) gene offer improved yield potential grown under different soil conditions. The seed cotton yield differed significantly due to irrigation and nutrient levels. The results indicated that maximum seed cotton yield was obtained with 150 per cent recommended dose of fertilizer (2.95 t ha^{-1}), however it was on par with 100 per cent RDF (recommended dose of fertilizer) (2.85 t ha^{-1}). The per cent improvement in seed cotton yield over 50 and 100 per cent RDF was 14.09 and 3.47 respectively in 150 per cent RDF. Whereas, it was 21.06 per cent higher in 0.8 IW/CPE level compared to no irrigation condition. Soil moisture depletion from different layers of the soil profile also increased with increase in both fertilizer as well as irrigation levels. The water requirement of Bt cotton in no irrigation condition was 34.52 cm ha^{-1} which increased to 138.04 cm ha^{-1} in 0.8 IW/CPE irrigation level. Cry 1 Ac content in square and boll rind marginally increased with increase in recommended dose of fertilizers from 50 to 150 per cent and declined with advancement of crop growth. The average soil moisture content of deep vertisols (0-90 cm) had no impact on Cry 1 Ac protein synthesis.

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Effect of Fly ash on Hydrological Properties of an Alfisol with Groundnut based Cropping System

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Field experiments were conducted for 3 years (2008-11) in Alfisol (upland) of central farm, OUAT, Bhubaneswar to study the effect of fly ash on hydrological properties of soil with groundnut as test crop. There were seven treatments consists of 3 levels of fly ash (10,20 and 40 t ha^{-1})and two levels of fertilizer (100% RDF and 50% RDF) with one fly ash control. Hydraulic properties like saturated hydraulic conductivity, water holding capacity, infiltration rate were studied at beginning and after 3 years of cropping. Different size particles of fly ash (NALCO, Angul) used in the study are; >0.02 mm – 54.4%, 0.002-0.02 mm – 34% and <0.002 mm – 11.6% indicating that fly ash be easily mixed with soil since it's particles size are comparable with size of soil separates. Its bulk density is 0.98 Mg m^{-3} which is lower than the soil (1.54 Mg m^{-3}) but its water holding capacity (49.4%) can be compared with fine textured soil.

Addition of fly ash @ 10, 20, 40 t ha^{-1} alters the physical properties of soil. The bulk density was reduced from 1.61 Mg m^{-3} (control) to 1.44 Mg m^{-3} at surface layer where as it increases from 1.70 Mg m^{-3} (control) to 1.88 Mg m^{-3} at sub surface layer (0.15 – 0.30 m depth). Increase in saturated hydraulic conductivity from 1.76 in control to 5.4 cm hr^{-1} in 40 t ha^{-1} fly ash treatment is attributed due to increase in porosity of soil with addition of different particle fractions of fly ash. Steady state infiltration rate in fly ash control treatment was increased from 2.4 (initial) to 6.0 cm ha^{-1} over 3 years of intensive groundnut cultivation. This is possible might be due to penetration of groundnut roots upto a depth of 45 cm which makes the rhizophere soil porous. Addition of fly ash @ 40 t ha^{-1} further increases the infiltration rate by 83% possibly due to increase in water stable aggregates and porosity of soil. Improvement in volumetric water content at field capacity and wilting point was also observed in fly ash treatments. Direct effect of fly ash @ 40 t ha^{-1} resulted in 23.80% higher ground nut pod yield over control. In subsequent years the yield response was 26 to 48%. Beneficial effect of fly ash was also recorded at half of the recommended fertilizer dose.

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Chick pea Response to Organic Farming under Conserved Soil Moisture

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Chick pea is an important leguminous crop of the central India. Chick peas are relatively easy to produce using organic methods besides their ability to grow under conserved moisture. However, it is important to recognize that organic farms rarely focus on a single crop. Organic chickpeas are best grown in rotation with several other crops that (ideally) complement or compensate for each another. Cropping system is mainly meant for counteracting weather vagaries. Crop rotations primarily serve two purposes: improve soil fertility on one hand and break pest cycles on the other. With regard to fertility management, rotation strategies concentrate mainly on generating and conserving nitrogen. Nitrogen is commonly the most limiting element in organic production, especially for cereals in rotation, which is complemented by soybeans in most crop sequences.

The quest for organic food is increasing day by day in western countries. With this backdrop, Indian Institute of Soil Science (ICAR) located at Bhopal has initiated an organic farming experiment under the ICAR sponsored Net Work Project on Organic Farming (NPOF) during 2004 to compare the suitability of nutrient management options *viz*., organic means of nutrient management, chemical based nutrient management and integrated nutrient management system (50% organic and 50% inorganic management). This was studied in 4 crop rotations *viz*., soybean-wheat, soybean-mustard, soybean-gram and soybean-linseed. The experimental set up remains unchanged till date. The observations during 2010-11 have indicated that chick pea yield under organic crop nutrient management systems were higher than other management systems even under shifting rainfall patterns.

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Water Use Efficiency of a Promising Hybrid JX 576 in Comparison to Some Released Potato Cultivars

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Optimum supply of water is the key factor in production of the potato crop. Potato being a herbaceous plant with sparse and shallow root system, requires readily available water throughout the crop period. Water requirement of the crop varies from 350-550 mm, depending largely upon crop duration, atmospheric conditions, soil type and variety under cultivation. Higher demands for food and fiber by increasing world populations further enhance the importance of water efficient cultivars that are also higher producers. The objective of this study was to evaluate water use efficiency of a promising hybrid JX 576 (now released as cv. Kufri Gaurav by the Institute) in comparison to some released potato cultivars.

Field experiments were conducted during the autumn of 2009-10 and 2010-11 on an alkaline loam deep alluvial soil (Ustochrept) at the Central Potato Research Station, Jalandhar, Punjab. Four potato cultivars/hybrid (Kufri Badshah, Kufri Jyoti, Kufri Pukhraj and hybrid JX 576) in 2009-10 and four (Kufri Badshah, Kufri Jyoti, Kufri Pushkar and hybrid JX 576) in 2010-11 were grown with three irrigation treatments scheduled at 20, 25 and 30 mm cumulative pan evaporation (CPE). Total tuber yields were recorded at harvest. The water use efficiency (WUE) of different cultivars were calculated.

Irrigation at 20 mm CPE produced significantly higher potato tuber yields of all the cultivars/hybrid than irrigation at 30 mm CPE during both the years. Mean reduction in yield was about 8% from 44.6 to 40.9 t ha^{-1} in 2009-10 and about 7% from 35.0 to 32.6 t ha^{-1} in 2010-11. The hybrid JX 576 produced significantly higher tuber yield than other cultivars tested particularly under water stress. It produced 8.4 to 20.3 t ha^{-1} higher tuber yield under water stress (30 mm CPE) in 2009-10 and 2.2 to 17.3 t ha^{-1} higher tuber yield under water stress than other three cultivars tested in 2010-11. The results clearly established that hybrid JX 576 is highly more water stress tolerant than other cultivars and is higher producer at all levels of irrigation.

As far as water use efficiency is concerned, potato cultivars showed considerable variation in water use efficiency. The hybrid JX 576 showed significantly higher water use efficiency than all other cultivars tested during both the years. Mean water use efficiency of hybrid JX 576 was 164 kg tubers/mm water in comparison to 139, 123 and 104 kg tubers/ha-mm water of cvs. Kufri Pukhraj, Kufri Badshah and Kufri Jyoti, respectively in 2009-10 whereas it was 129 kg tubers/ha-mm water in comparison to 117, 103 and 75 kg tubers/mm water of cvs. Kufri Pushkar, Kufri Badshah and Kufri Jyoti, respectively in 2010-11.

Results showed that hybrid JX 576 was the most water use efficient as well as higher producer followed by Kufri Pushkar, Kufri Pukhraj, Kufri Badshah and Kufri Jyoti.

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Studies on Water and Nutrient Requirement of Bt-Cotton Under Vertisols of Malaprabha Command

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A field experiment was conducted at AICRP (Water Management), Water Management Research Centre, Belvatagi, University of Agricultural Sciences, Dharwad, Karnataka, during 2009-10 and 2010-11 in the *kharif* season to determine the response of Bt cotton to higher levels of recommended dose of fertilizer (RDF) at different irrigation levels in a split-plot design. The experimental site was deep black with clayey texture, available N, P_2O_5 and K_2O of the soil were 207.2, 30.0 and 780 kg ha^{-1} respectively, with a soil pH of 8.34, electrical conductivity 0.21 dS m^{-1} and organic carbon content of 0.54%. The values of field capacity and bulk density were 40.0 percent and 1.32 Mg m^{-3} respectively. In the main plots three irrigation levels *viz.*, I_1 = 1.0 IW/CPE, I_2 = 0.8 IW/CPE and I_3 = 0.6 IW/CPE and in sub plots four fertilizer levels *i.e.* F_1 = 100% RDF, F_2 = 125% RDF, F_3 =150% RDF and F_4 = 175% RDF (nitrogen, phosphorus and potassium) were tried.The results of two years indicated that the treatment receiving 175% RDF significantly increased growth parameters *i.e.* plant height, sympodial branches per plant, number of bolls per plant and seed cotton yield and NPK uptake by the cotton plants. Pooled data of two years seed cotton yield indicated that significantly higher seed cotton yield (2.68 t ha^{-1}) was recorded under 175% RDF treatment as compared to rest of the treatments. Among irrigation levels, significantly higher seed cotton yield was recorded at 1.0 IW/CPE ratio (2.54 t ha^{-1}) and was on par with 0.8 IW/CPE ratio (25.13 q/ha). Interaction effects were non significant. Nutrient management significantly influenced the NP and K nutrient tissue concentration (%) and their uptake (kg ha^{-1}). Nutrient uptake (NPK) at 60 DAS, 90 DAS and at harvest of Bt-cotton significantly increased with increase in fertilizer dose. The total uptake of NPK by Bt cotton at harvest were significantly superior with F_4 (N- 99.58 kg ha^{-1}, P-15.19 kg ha^{-1} and K – 43.66 kg ha^{-1}) followed by F_3 (N- 97.29 kg ha^{-1}, P-14.74 kg ha^{-1} and K – 42.11 kg ha^{-1}), F_2 (N- 91.3 kg ha^{-1}, P-13.58 kg ha^{-1} and K 39.70 kg ha^{-1}) and F_1 (N- 86.1 kg ha^{-1}, P-12.92 kg ha^{-1} and K – 37.48 kg ha^{-1}). Effect of irrigation levels on NPK uptake were non significant.

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Effect of Moisture Regimes, NPK and Zinc Levels on Yield, Quality, Nutrient Uptake and Economics of Mustard (*Brassica juncea*)

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A field experiment to identify the effect of irrigation and fertility levels on growth, yield, nutrient uptake, WUE, quality and economics of Indian mustard [*Brassica juncea* (L.) czernj and cosson] was carried out on sandy loam soil at Morena, during winter (*rabi*) season of 2007-08 and 2008-09. The soil of experimental field was sandy loam having low in available nitrogen (134.5 kg ha^{-1}) and zinc (0.43 mg kg^{-1}), medium in available phosphorus (14.2 kg ha^{-1}) and potash (223 kg ha^{-1}) with pH 7.7. The available moisture at field capacity was 23.50%, bulk density 1.4 cm^{-3}, permanent wilting point 7.2%, infiltration rate 14.5 mm hr^{-1} with electrical conductivity 0.32dS/m.. The experiment was laid out in split-plot design with four replications. Twelve treatment combinations, comprising three irrigation schedules viz irrigation at flower initiation stage, siliquae formation stage and flower initiation plus siliquae formation stage in main plots and four fertilizer levels *i.e.* 50% (40:8.8:8.3:2.50), 75% (60:13.2:12.4:3.75), 100% (80:17.6:16.6:5.0) and 125% (100:22:20.7:6.25) NPK and Zn of recommended doses of fertilizer (RDF) in sub plots. Irrigation applied at flower initiation plus siliqua formation stage registered significantly higher growth and yield attributes, WUE, production efficiency, nutrient uptake and oil production and resulted in 11.22% and 33.33% higher seed yield over irrigation applied at flower initiation stage and siliqua formation stage, respectively. Among the fertility levels 125% RDF maintained significantly higher values of yield contributory characters, WUE, production efficiency, nutrient uptake and quality components over other fertility levels. Application of 125% RDF also achieved 19.94, 11.86 and 3.97% higher seed yield of mustard over 50, 75 and 100% RDF. Maximum returns of Rs. 40441 ha^{-1} and 36916 ha^{-1} and benefit cost ratio of 4.37 and 3.82 were realized under to irrigations and 124% RDF, respectively.

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Micro Irrigation in Hilly States: Can Himachal Pradesh Lead the Way?

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Ever since micro-irrigation became popular in Israel and other developing countries, drip and sprinkler irrigation technologies have appealed to progressive technology-savvy farmers. In recent years, attempts have been made by central government to adapt these technologies and promote them as livelihood-creators for the farmers of India. The central government through its different policies provide subsidies to promote it massively amongst the farmers by cutting the costs to be borne by the farmer. Taking a cue from the central government and realizing the importance of water saving in agriculture, number of state governments are also providing subsidies in addition to the central government. Similarly, Government of Himachal Pradesh is also providing subsidy under Pt Deen Dayal Kisan Bagwaan Samridhi Yojana (DDKBSY). Does micro-irrigation offer promise as a poor-friendly technology? Based on the fieldwork of the state of Himachal Pradesh by the author, this paper attempts a first-cut answer to this question; it offers a preliminary, impressionistic assessment of the potential of micro-irrigation technology, its social impacts, and issues involved in 'scaling it up'. In the main, it concludes that: [a] in Himachal Pradesh, DDKBSY micro-irrigation program has responded to two critical but distinct needs: of the poor women to create a new means of income and livelihood; and of farmers in water scarce areas to cope with extremes of water scarcity; [b] the best example of the first is to be found in majority of areas in Himachal Pradesh, where poor/marginal vegetable growers have experienced major improvements in cash income and household food and nutrition security; [c] the best examples of the second are to be found amongst the dry temperate zone of Himachal Pradesh viz. Lahaul and Spiti where vegetables are produced in cold dry lands; water deficit areas of different districts where farmers have gone for diversification from traditional agricutlure [d] in terms of sheer scale of outreach, promoting micro-irrigation as a means to coping with water scarcity offers much greater potential than promoting it to poor women vegetable growers; [e] in doing both, prima facie, it seems that the DDKBSY scheme philosophy of sharing the 80% of the cost of the technology and of ensuring availability of dealers in local markets holds great promise.

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Distribution of Carbon in Particle Size Fractions, and Carbon Nitrogen, Phosphorus and Sulphur Status in Macro and Micro Aggregates of a Red Soil under Long-term Fertilization

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Investigation was carried out in a red soil under long-term fertilization at Zonal Agricultural Research Station, GKVK, to study carbon in particle size fractions and, macro and micro aggregates of soil samples, and to assess nitrogen, phosphorus and sulphur status in macro and micro aggregates of soil. Soil samples were collected at two depths *i.e.* 0-15 cm and 15-30 cm, and samples were analyzed using standard procedures. The soil samples were also fractionated into different groups of primary particles without destroying carbon particles and were analyzed for C, N, P and S associated with sand, silt, and clay. Total C, total N and total P contents varied markedly among the treatments. The plots which were applied with NPK at recommended dosage and with FYM along with fertilizers contained higher quantities of total C, total N, total P and total S than the plots treated with lower doses of nutrients or the one not at all treated with fertilizers. Total P and total S amounts were higher in the plots applied with single super phosphate as source of P. The total contents of all the four elements were lower in the second depth as compared to the first depth. Available N, P and S of soil were higher in the plots applied with both fertilizers and manures and also in the plots treated with balanced doses of nutrients. The contents of available N and P were higher in the first depth as compared to the second depth, while, the reverse was the trend in respect of available S of soil. Available phosphorus was very low in the control plot and the plot treated with only nitrogenous fertilizers. The effect of both S containing fertilizers and the FYM was evident in increasing the available S content of soil. Among the soil size fractions, the sand was highest, followed by clay and then silt in the decreasing order of their contents in the soil. Among the different size fractions, clay had the highest content of all the four elements *i.e.* C, N, P and S, followed by silt and sand fractions in both the depths of soil, indicating that most of the C, N, P and S were closely associated with clay. Irrespective of the soil size fraction, the contents of C, N, P and S were higher in the plots treated with 100 % NPK+FYM, followed by the plots treated with NPK fertilizers at the recommended dosage and were lower in control plot and the plots treated with imbalanced dosage of nutrients. The contents of all the four elements were relatively higher in the surface soil, irrespective of treatments and the trends in respects of treatment differences in the lower depth were similar to the one observed for the upper layer of soil. Micro aggregates of soil had much higher amount of organic C, and also total and available forms of N, P and S than that of macro aggregates. In both types of aggregates, the trends in respects of treatment differences were similar to the ones observed for whole soil.

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On-farm Evaluation of Soil Moisture Conservation in Rice-Wheat System in Punjab

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Water is becoming a limiting factor with the passage of time in the production of agricultural crops in Punjab. The so called assured irrigation water source is depleting at an enormous rates in the region. In central Punjab, the ground water table is falling at the rate of 75-90 cm annually. On-farm studies were carried out to evaluate and demonstrate to the farmers the soil moisture conservation practices so as to reduce the input water use in rice and wheat crops in different districts of Punjab. The alternate wetting and drying practice of irrigation in rice in central Punjab on the basis of soil matric potential of -15 kPa at 15-20 cm soil depth at different farmers fields could help save the irrigation water to the extent of 25 per cent from that of farmers own practice of irrigation. This coupled with laser land leveling of the fields resulted in higher irrigation water saving to the extent of 30-40 per cent. The use of improved seed of recommended wheat cultivars in submontane Punjab resulted in increase in crop yield to the extent of 212-232 per cent compared to the local cultivars. Mulching particularly with the help of locally available material resulted in conserving soil moisture particularly during wheat crop. The studies in the region revealed that about 30-45 per cent of rain water gets lost as runoff water and there is great scope to store this water in dug out or embankment type of reservoirs during monsoon season to be used as supplementary irrigation to wheat which could result in increased wheat yields.

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Response of Date of Sowing to Maize (*Zea mays* L.) and Soil Hydro-physical Properties with Different Scheduling of Fertilizer Application under Rainfed and Irrigated Conditions in Sandy Loam Soil

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Maize is ranked at third position in the list of important cereals in India, after wheat and rice. Knowledge of rainfall pattern, on long-term average basis, may help in deciding the date of sowing, particularly in rainfed areas. Fertilizer application scheduling, especially of N, also depends on moisture condition of the soil and is very crucial. In sandy loam soil of the Indian Agricultural Research Institute, New Delhi, Maize experiment was conducted in kharif 2010, in three replications with split plot design (SPD) taking the date of sowing (SD) as main plot and moisture levels as sub-plot and scheduling of N application as sub-sub plots to study the effect of these treatments on the grain yield (GY), dry matter (DM), water use efficiency (WUE) and soil hydro-physical properties. Three dates of sowing were 15-7-2010 (D_1); 22-7-2010 (D_2) and 29-7-2010 (D_3) and moisture levels were I_0 – Rainfed, I_1 – One irrigation at knee height (KNH), and I_3 - three irrigations – at KNH, teseling (TSL) and grain filling (GRF). Recommended dose of P and K were applied as basal dose, in full. Nitrogen (N @120 kg/ha) in sub-sub plot was applied as M_1 – 40 per cent basal and 60 % at TSL and M_2 – 50 % basal , 25% at KNH and 25 % at GRF. Grain yield of maize was maximum (6.02 t ha^{-1}) under $D_1I_3M_2$ and minimum (4.60 t ha^{-1}) under $D_3I_0M_1$.There was significant reduction in the grain yield when sowing was delayed by 15 days. However there was no significant decreased in the GY between first and second date of sowing. A significant increase in the GY was recorded in I_3 as compared to I_0. GY was reduced by 14 to 18 percent from D_1 to D_3 and 3 to 7 per cent from D_2 to D_3. GY increased by 3.5 to 6 per cent when N was applied in three splits instead of two. Bulk density of soil decreased in D_1 (1.58 g cm^{-3}) as compared to that in D_3 (1.61 g cm^{-3}) under I_0M_1 in 0-15 cm soil layer. Corresponding figures for I_3M_2 were 1.54 and 1.53 g cm^{-3}. Hydraulic conductivity (HC) was recorded maximum (1.63 cm hr^{-1}) under $D_1I_3M_2$ while minimum (1.48 cm hr^{-1}) was recorded under $D_3I_0M_1$. In 15-30 cm layer BD increased to 1.61 g cm^{-3} and HC decreased to 1.45 cm hr^{-1}. There were 36 events of rainfall from July to November, at regular interval, with total rain fall of 883.7 mm. Water use efficiency was minimum (74.37 kg/ha- cm) under D_3 and maximum (81.82 kg/ha-cm) under D_1.

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Moisture Extraction Pattern, Water Use Efficiency and Grain Yield of Wheat (*Triticum aestivum*) under Different Water Regimes and Nitrogen Doses

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Water and nitrogen are two major inputs for production of wheat. The independent effects of these inputs on grain yield of wheat have been evaluated intensively. Therefore, an experiment was carried out at research farm of IARI, New Delhi, in *rabi* seasons 2009-10 and 2010-11, to evaluate the effects of varying levels of water regimes and nitrogen on water use efficiency and grain yield of wheat under maize-wheat cropping system. The soil was sandy loam in texture. Wheat cultivar was HD 2733. The treatment combinations consisted of three water regimes, namely, W_2 (irrigation at CRI and flowering stages), W_3 (irrigation at CRI, jointing and flowering stages) and W_5 (irrigation at CRI, tillering, jointing, flowering and dough stages) in main plots, and four levels of nitrogen *viz*., N_0- control, N_1- 75% of recommended dose of nitrogen N_2- 100% recommended dose of nitrogen N_3- 150% recommended dose of nitrogen in sub plots. Experiment was laid out in split plot design with three replications. Recommended dose of N 120 kg ha^{-1} was applied as urea and P and K as basal doses @ 60 kg ha^{-1} P_2O_5 and 40 kg ha^{-1} K_2O, respectively in all treatments. Nitrogen was applied half as basal dose and half as top dressing in two split doses. The results revealed that the consumptive water use was highest (45.77 cm) in W_5 followed by W_3 (35.30 cm) and W_2 (29.90 cm) irrigation treatments. Among the nitrogen doses, consumptive water use was maximum (39.37 cm) in N_3 treatment and minimum (33.67 cm) in N_0 treatment. Total water uptake i.e. 65 to 70%, average of two seasons, occurred from 0-30 cm soil depth only, under different water regimes. Plant extracted more water from deeper soil layer in the later phase of the crop in all treatments. Water use efficiency was observed 99.02 in W_2, 99.65 in W_3 and 86.81 kg/ha-cm in W_5 treatment, average of both seasons. Water use efficiency increased by 39.28% in N_3 treatment as compared to N_0 treatment. Plant growth parameters such as dry matter, plant height and leaf area index were superior in W_5 treatment as compared to other treatments. Maximum grain yield was recorded in W_5N_3 treatment (5.25 t ha^{-1}) and the minimum in W_2N_0 treatment (2.17 t ha^{-1}). The application of five irrigation (W_5) increased average grain yield significantly by 36.11% and 14.70% over W_2 and W_3 treatments, respectively.

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Effect of Irrigation and Nutrient Management on Seed Yield and Economics of Indian Mustard (*Brassica juncea*) in Alluvial Soils

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In Gird agro-climatic zone, mustard occupies dominant position (2.80 lakh ha) as an oilseed crop. This crop is more sensitive to water availability and more or less at critical growth stages, which adversely influences the yield. Inherited yield potentials of the crop, however, can be realized by providing plant nutrients in balance amount along with suitable agronomic package to crop. Therefore, there is a need of efficient and economic use of irrigation water and plant nutrients, so as to increase the area and productivity of mustard. With this view, a field experiment was conducted during Rabi season of 2007-08 to 2009-10 with mustard variety JM-3 at Morena. The experimental soil had sandy loam to clay loam in texture having 4.5 g kg^{-1} organic carbon, pH-7.5, $KMnO_4$ extractable N-185 kg ha^{-1}, Olsen's P_2O_5-19.5 kg ha^{-1} and 1*N* ammonium acetate extractable K_2O-382 kg ha^{-1}. The experiment was laid out in split plot design with four replications. Twelve treatment combinations, comprising 3 irrigation schedules *viz*., 40 DAS (I_1), 60 DAS (I_2) 40 and 70 DAS (I_3) in main plots and four fertility levels (50, 75, 100 and 125% RDF) in sub plots. The observations were recorded at their critical stages.

The seed and straw yield of mustard increased significantly due to irrigation schedules. The irrigation applied at 40 and 70 DAS resulted in highest seed (3.11 t ha^{-1}) and straw yields (4.73 t ha^{-1}). The lowest values of these parameters were maintained under 60 DAS irrigation treatment. The fertilizer application caused significant variation in seed yield and biological yield of mustard from 50 to 125% RDF. The maximum seedy yield (2.04 t ha^{-1}) and straw yield (4.70 t ha^{-1}) were achieved under 125% RDF.

The nutrient use, water use efficiency and production efficiency of mustard varied significantly due to different irrigation. The significant better response was observed in nutrient use and production efficiency (16.19 kg ha^{-1} day^{-1}) with two irrigations applied at 40 and 70 DAS over one irrigation applied at 40 or 60 DAS. The crop receiving one irrigation at 40 DAS maintained higher WUE. The maximum nutrient use of N, P, K, Zn (40.19, 80.37, 160.8 and 128.62 kg kg^{-1} of seed) was recorded with 50% RDF. The progressive increase in nutrient application from 50 to 125% RDF increased in production efficiency and WUE. The economics viability indicated that the combination of two irrigation at 40 and 70 DAS with 125% RDF was found beneficial for mustard in terms of total net returns and B:C ratio.

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Structural Properties of an Acid Alfisol as Influenced by Continuous Use of Chemical Fertilizers with or without Organics

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The present investigation was carried out in an ongoing long-term field experiment with maize-wheat cropping sequence in an acid Alfisol established during 1972-73 *rabi* season at the experimental farm of Department of Soil Science, CSK HPAU, Palampur. The objective was to study changes in structural properties of soil due to long-term use of chemical fertilizers with or without amendments. The soil structural properties, characterized by soil aggregation, bulk density, total porosity, air-filled porosity, pore-size distribution and soil penetration resistance, were significantly affected by different treatments *viz.* control, N, NP, NPK, NPK + FYM and NPK + lime. The MWD increased with the application of NP, NPK, NPK + FYM and NPK + lime by about 17, 23, 85 and 164%, respectively over control. Nitrogen alone decreased MWD by about 29% over control. Similar trend was observed in case of WSA > 0.25 mm dia. The bulk density of soil was highest in N and lowest in NPK + FYM. The corresponding values were 1.35 and 1.15 Mg m^{-3} for 0-0.15 m and 1.35 and 1.22 Mg m^{-3} for 0.15-0.30 m soil depth. The decrease in bulk density with NP, NPK and NPK + FYM was about 8-14% in 0-0.15 m soil layer and 7-10% in 0.15-0.30 m soil layer. Total porosity increased with the application of NP, NPK and NPK + FYM over control by about 9-15% in 0-0.15 m soil layer and 7-9% in 0.15-0.30 m soil layer. The air-filled porosity at any given moisture content was lowest in N, control and NPK + lime followed by NP and NPK, and highest in NPK + FYM. The 10% air-filled porosity (critical value for most of the upland crops) in 0.06-0.09 m soil layer was attained within a few hours in NPK + FYM, NPK and NP, and in 5 days in NPK + lime, control and N. In 0.15-0.18 m soil layer, it appeared much earlier in NPK + FYM (5 days) followed by NPK, NP, NPK + lime, control and N (9-16 days). The water transmission pores (> 50 ìm) increased, residual pores (< 0.5 ìm) decreased, and the water storage pores (0.5-50 ìm) remained almost the same with decrease in bulk density and improvement in soil structure due to applications of NP, NPK and NPK + FYM, in comparison to N, control and NPK + lime. The SPR in general decreased with the increase in moisture content and decrease in bulk density. It was highest in N, control and NPK + lime followed by NPK and NP, and lowest in NPK + FYM. The results revealed that balanced use of chemical fertilizers improved structural properties of soil compared to control, while N alone through urea showed an adverse effect. Integration of organics with chemical fertilizers further enhanced the beneficial effect, while liming along with NPK had an intermediate effect on structural properties of soil.

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Organic Inputs Influence Aggregate Associated Carbon Concentration under Long-term Rice-Wheat Cropping system

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We evaluated organic carbon concentration within water stable aggregates (WSA) of soils under continuous influence of manuring and fertilization in a 22-year old fertility experiment with rice (*Oryza sativa*)-wheat (*Triticum aestivum*) rotation in Inceptisols. Surface (0-0.15 m) soil samples were collected from twelve treatments with different type of organic amendments such as farmyard manure (FYM), paddy straw (PS) and green manure (GM). The soils were separated by wet sieving technique into >2.0 mm (large macro-aggregates, LMA), 2.0-0.25 mm (small macro-aggregates, SMA), 0.05-0.25mm (fine micro-aggregates, FmA) and <0.05mm (silt+clay size aggregates, SCA) aggregate fractions. Structural indices such as aggregate stability, aggregate ratio, mean weight diameter and geometric mean diameter etc. were found higher in soils receiving organic amendments (NPK+FYM, NPK+PS and NPK+GM) than the minerally fertilized (NPK) soil or the control. Organic C content within water stable aggregates decreased with decreasing size of the aggregates as follows: SMA_{OC} > LMA_{OC} > FmA_{OC} > SCA_{OC}. Such effect was more pronounced in organic amended soils. Within a size class, aggregated C concentrations were in the order of FYM > PS > GM.

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GPS-GIS Based Mapping of Zn, Cu, Fe, Mn and B and their Indexing in Intensively Cultivated Soils of the District Hooghly, West Bengal

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Micronutrient deficiency in Indian soils has emerged as one of the major constraints to crop productivity. A study was conducted to know the availability and indexing of micronutrients *viz*., zinc, copper, iron, manganese and boron in the soils and its content in the kharif rice grain and straw collected from some rice growing soils of the district Hooghly, West Bengal. Two hundred and fifty soil samples were collected at 3.5 km grid from the whole district using global positioning system (GPS) and analyzed for DTPA extractable Zn, Cu, Fe, Mn and hot water soluble B as well as important physicochemical properties like pH and organic carbon were also determined. Randomly 44 rice plants were also collected from the site of soil collection to determine the content of micronutrients *viz*. Zn, Cu, Fe, Mn and B in the rice grain and straw by following the dry ashing method. Results showed that, the soils were mostly acidic to neutral in reaction and soil pH ranged from 4.45 to 7.98 with a mean value of 5.89. The organic carbon content was also fairly high which ranged from 1.5 to 11.8 g kg^{-1} with a mean value of 8.7 g kg^{-1}. The available Zn, Cu, Fe, Mn and B content of the soils ranged from 0.05-13.16, 0.64-18.48, 27.16-454.20, 4.52-207.5 and 0.03-2.37 with the mean values of 1.80, 8.20, 206.28, 45.63 and 0.70 mg kg^{-1}, respectively. About 4.4% and 22.8% of the soil samples were deficient in Zn and B respectively. Fe and Mn content, on the other hand, recorded high values. The simple correlation study showed that there was negative correlation of available soil Zn, Fe, Mn and B with soil pH. Available soil Cu and B showed significant positive correlation with the organic carbon, whereas available Fe recorded significant negative correlation. The content of Zn, Cu, Fe, Mn and B in rice grain was found on an average about 61.43, 3.40, 72.01, 47.91 and 7.72 mg kg^{-1}, respectively and that in rice straw were about 10.41, trace, 46.83, 40.64 and 28.10 mg kg^{-1}, respectively.

The present study revealed that there was a wide variation in available micronutrient status of rice growing soils of district Hooghly, West Bengal, but the soils were low in available B content, medium in available Zn and high in available Fe, Mn and Cu and their nutrient index values were 1.13, 1.84, 3.00, 2.84 and 2.99, respectively. Maps regarding the available soil status of Zn, Cu, Fe, Mn and B were prepared as per the critical nutrient range value. This would be immensely helpful for formulating the area wise programming of micronutrient fertilization.

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Elucidating the Mechanistic Pathways for Carbon Stabilization in Soils under Different Agro-ecological Zones

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Stabilization of organic carbon in soils refers to the processes or mechanisms that lead to its prolonged turnover time. It varies with climate, soil types and biochemistry of organic residues applied as C source. Stabilization of soil organic C (SOC) takes place through three mechanism- physical, chemical and biochemical. Physical stabilization refers to aggregate formation and consequently physical encapsulation and /or shielding of organic matter from microbial and enzymatic attack. Chemical stabilization refers to the associations formed between soil minerals and organic materials. It is based on adsorption and chemical binding of SOC onto mineral surfaces. Clay particles and sesquioxides in soils provide the most extensive reactive surfaces onto which organic carbon is adsorbed. Sorption of negatively charged organic groups through cation bridging is probably the most common mechanism that allows for stabilization of organic matter against biological attack. Stabilization of SOC by biochemical recalcitrance is achieved through the inherent chemical structure of the biomolecule, which is a function of the intra- and inter-structural bond strengths, the degree of regularity of occurrence of structural units and the degree of aromaticity. Chemical recalcitrance can be a property of the primary molecular structure or it can result from changes induced by decompositional processes within the soil environment. This complex chemical composition can be an inherent property of the plant material or be attained during decomposition through the condensation and complexation of decomposition residues, rendering them more resistant to subsequent decomposition. To examine the process of C stabilization, fractionation of C into different pools is of importance. Once it is done, estimation can be made about the amount of carbon stabilized into passive or active pools in soils under different agro-ecological zones of the country. As insight of the whole processes of stabilization of soil organic C is highlighted.

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Spatial Distribution of Soil Moisture and Nutrients under Drip Irrigation and Fertigation and Productivity of Apple (*Malus domestica* Borkh)

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Spatial distribution of soil moisture and nutrients under drip irrigation and fertigation and the productivity of apple (*Malus domestica* Borkh) was studied conducting field trials on seven year old apple plantations, raised on sandy loam soils 'Inceptisol', at Rohru (Shimla) Himachal Pradesh. Two field experiments were conducted simultaneously in the same orchard wherein, three drip irrigation levels (100, 80 and 60 per cent ETc.) and three fertigation levels (100, 80 and 60 per cent of recommended dose) were tried and compared with conventional practices. Soil moisture content under drip irrigation remained higher in the upper soil layers (0-30 cm) whereas, under conventional surface irrigation, deeper soil layers registered higher moisture content. The wetting front extended up to 45 cm horizontally however, the maximum moisture content remained confined near the emitting point. Available N and K content under drip fertigation were significantly higher in the upper 0-30 cm soil layers than conventional soil fertilization plus irrigations, suggesting higher downward movement in the later. Further, N and K was higher below the emitter and decreased consistently with increasing lateral distance from emitter up to 30 cm, thereafter a sharp decline was noticed. Irrespective of treatments, available P remained confined within 0-20 cm distance from the point of application, both vertically and laterally. Both drip irrigation and fertigation resulted in significantly higher tree growth and yield apple, compared to conventional practices. Fruit yield was about 13 and 33 per cent higher under drip irrigation and fertigation compared to conventional irrigations and soil fertilization, respectively. Thus**,** a saving of about 20 per cent fertilizers and about 40 per cent irrigation water can be achieved through drip irrigation and fertigation besides appreciable improvement in fruit yield

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Effect of Integrated Nutrient Management by Using Crop Residue on Yield of *Rabi* Sorghum and Soil Properties under Dryland Condition

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A field experiment was conducted on medium deep black soil (Vertic Ustropepts) at dry farming research station, Solapur during *rabi* 2010-11 to study the feasibility of use of crop residues in field and its subsequent effect on *rabi* sorghum yield and soil health. The experiment was laid out in randomized block design with ten treatments replicated three times. Among the various treatments the substitution of 25 kg N ha^{-1} through crop residue + 25 kg N ha^{-1} through *Leucaena* lopping gave significantly highest sorghum grain and stover yield, gross monitory returns and B:C ratio, total N uptake, moisture use efficiency (MUE) by *rabi* sorghum. The organic carbon and soil available N content were also increased at harvest of *rabi* sorghum. The next best treatment 25 kg N through FYM + 25 kg N through urea the total microbial count of bacteria, fungi, actinomycetes were more in FYM or crop residue addition. Whereas N fixer and P solubilizers count was more under *Leucaena* application either alone or with crop residue or urea.

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Leaching of Soil Nutrients with Poor Quality Irrigation Water Use and its Impact on Groundnut (*Arachis hypogaea*) Grown in an Acid soil

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Fresh-water resources are getting polluted due to discharge of effluents from industry and urban sewage in them and also to a limited extent due to the leaching and runoff of chemicals used in agriculture. Such polluted waters when used for irrigation showed mixed reactions to crops. The impact varied with quality of irrigation water, soil characteristics and type of crops grown. Location specific studies are required to protect the soil and crop quality when irrigated with poor quality water. In Bhubaneswar, most of the urban effluents are discharged in Daya River which is extensively used for irrigation during rabi season. An attempt has been made to study the impact of poor quality Daya River water on soil characteristics and crop yield grown in an acid soil and suitable measures were suggested. Extent of gain and loss of soil nutrients in leachate and leached soil were analysed through soil column study and overall suitability index was developed based on ranking system and restriction was categorized as none, slight to moderate and severe. The long term impact on the yield and nutrient uptake and oil content of groundnut was estimated from farmers' field and suitable measures were suggested.

The important chemical parameters tested for ascertaining the water quality of irrigation water were pH, EC TDS (total dissolved solid), total hardness, chlorides, sulphates, phosphate, carbonates, bicarbonates, nitrates, ammonium, calcium, sodium, potassium, magnesium, iron, manganese and zinc and moderate to severe restriction was recommended for the river water as per the guidelines provided by Ayers and Westcot 1985. Based on the soil column study leachate analysis the river water was found to be restricted severely for irrigation. The suitability index of the irrigated soils revealed that the river water is slight to moderately restricted for irrigation as it shows diversified effect on retention and removal of soil nutrients which affect the fertility status of the soil adversely for all the soil depths up to 0-45 studied. The pH of river water was beyond the permissible limits (6.5-8.5) and causes nutritional imbalance in the soil. The Ca and Mg ratio lowered which affected the soil structure as well as the texture and the nutrient holding capacity of the soil. At the same time it shows ameliorative effect and increases the pH of the acid soil and also solubilises phosphorus for plant use.

In addition, the higher water pH, alkalinity due to low Ca/Mg < 1 accompanied with high bicarbonate content interferes with other ion uptake and affected the yield and Ca uptake of groundnut adversely. Application of gypsum @2.5 t ha^{-1} lowered the Mg/Ca ratio and improved the Ca uptake, root growth and crop production. The less Ca concentration as well as the Ca uptake in the groundnut, when irrigated with Daya River water got corrected with the application of gypsum @2.5 t ha^{-1}.

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Residual effect of Crop Residues on Soil Properties and Yield of Wheat (*Triticum aestivum* L.) in Rice-based Cropping System

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We studied the residual effects of crop residues alongwith green manure, microbial culture and inorganic fertilizer on the yield of wheat grown after rice. The following treatments such as control, straw burn (5 t ha^{-1}), straw incorporation (5 t ha^{-1}), straw (5 t ha^{-1}) + 25%N of recommended dose, straw (5 t ha^{-1}) + green manure (5 t ha^{-1}) and straw (5 t ha^{-1}) + microbial culture (a cocktail of *Aspergillus*, *Trichoderma*, *Pleurotus* and *Phanerochaete*) were imposed on rice and their residual effects on the yield of wheat and nutrients content in soils were evaluated. Result showed that application of straw (5 t ha^{-1}) + green manure (5 t ha^{-1}) recorded the highest yield of wheat followed by the straw (5 t ha^{-1}) + 25%N of recommended dose > straw (5 t ha^{-1}) + microbial culture > straw incorporation (5 t ha^{-1}) >straw burn (5 ton/hectare) > control. Availability of soil nutrients particularly N, P, K and organic carbon also increased following the above trend.

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Persistence and Degradation of Chlorpyrifos in Coffee Growing Regions of Karnataka

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Chlorpyrifos, [O, O-diethyl O-(3,5,6-trichloro-2-pyridyl) phosphorothioate] is the world's leading insecticide being consumed in large volume and is effective against a wide range of plant feeding, household and soil insects. Karnataka is a major commercial coffee growing state of India with Chikmagalur and Madikeri being the major producing areas. Incidence of white stem borer is a serious threat to Arabica coffee productivity for which chlorpyrifos 20 EC was recommended by Coffee Board in 2004.

A study was undertaken to know the persistence and degradation of chlorpyrifos at two different moisture conditions (field capacity and submergence), lime treatments (4 and 8 t ha^{-1}) and fortification levels of 10 and 25 μg g^{-1} in both Chikmagalur and Madikeri soils. Higher persistence of chlorpyrifos was noticed at higher fortification level. The degradation of chlorpyrifos was faster in Chikmagalur soil compared to Madikeri soil at both the moisture regimes irrespective of fortification levels. Degradation of chlorpyrifos decreased with increased moisture content from field capacity to submergence. The order of chlorpyrifos degradation observed in lime treated soil was 8 t ha^{-1} > 4 t ha^{-1} > 0 t ha^{-1}. Half-life of chlorpyrifos ranged from 11.1 to 22.8, 9.6 to 20.2 and 7.4 to 11.8 days at the lime treatment rates of 0, 4 and 8 t ha^{-1} in Chikmagalur and 14.7 to 27.5, 10.9 to 23.6 and 8.2 to 14.7 days in Madikeri soils, respectively at field capacity.

Study on the effect of chlorpyrifos on dehydrogenase and phosphatase enzyme in soil indicated a slight inhibitory effect on both the enzymes. Residue analysis of chlorpyrifos in selected coffee orchard soils, water and soils of nearby rice fields showed the persistent nature of chlorpyrifos even in field condition.

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Sulphur Sorption under Maize-Wheat Cropping System as Influenced by Long-term Effect of Chemical Fertilizers and Soil Amendments

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A study on sulphur sorption under maize-wheat cropping system as influenced by long-term effect of chemical fertilizers and soil amendments was carried out in randomized block design with eleven treatments replicated thrice, during *rabi* (2007-08) and *kharif* (2008) in the ongoing long-term fertilizer experiment at the farm of College of Agriculture, CSK HPKV, Palampur. The soils of the experimental site were acidic and classified taxonomically as Typic Hapludalfs. Soil samples taken from surface soils (0-15 cm), after the harvest of wheat (*rabi* 2007-08) were analyzed for pH, OC and CEC using standard methods. Besides, different forms of sulphur, adsorption-desorption behaviour of sulphur were also worked out in the soil samples taken after the wheat harvest. The maize (*kharif* 2008) grain and stover yield and sulphur uptake data were correlated with different forms of sulphur. Addition of FYM and lime along with inorganic fertilizers has improved the soil quality as well. Imbalanced use of inorganic fertilizers on the other hand, reduced the crop productivity and deteriorated the soil health in terms of increased soil acidity and high sulphate adsorption. Continuous cropping with heavy doses of sulphur free fertilizers resulted in a substantial decrease in total, organic, heat soluble, available and water soluble sulphur by 22.8, 22.4, 9.34, 31.5 and 13.7 per cent, respectively, over unfertilized control plot. Zero fertilization and use of N alone led to decline in the levels of all the forms of sulphur, while addition of sulphur increased total sulphur and inorganic sulphur fractions. Maximum sulphate adsorption in 100% NPK without sulphur treatment revealed that continuous cropping without sulphur application leads to deterioration of soil sulphur status and also decrease in yield and uptake of sulphur by the crops. An increase in the rate of long-term sulphur fertilization thus caused considerable reduction in the sulphate adsorption. With the increase in desorption of sulphur in soil, the concentration of sulphur in soil solution was found to be increased.

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Adsorption Kinetics of Zinc in the Major Soil Series of the Rubber Growing Tract of South India

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In India, the traditional belt of rubber cultivation is confined to a narrow tract in the western side of the Western Ghats mainly in Kerala and Kanyakumari district of Tamil Nadu. The soils of this tract are highly weathered acid soils with pH ranging from 4.5 –6.0. These soils were characterized as per modern soil taxonomy into 62 soil series of which 51 were under Ultisols, nine under Inceptisols and two under Entiisols.

The adsorption of nutrients is one of the most important solid and liquid phase interaction determining the release and fixation of applied plant nutrients and the efficiency of fertilization. Study was conducted to characterize the Zn sorption in the nine major soil series in the traditional belt of rubber cultivation. The data on adsorption were interpreted in terms of Langmuir and Freundlich equations. The derivatives of Langmuir equation (adsorption maxima and bonding energy) as well as that of Freundlich equation (sorption capacity and rate of sorption) were correlated with soil properties.

The Zn adsorption by the different soil series as a function of the Zn concentration of the equilibrating solution was depicted through linear relationships. The amount of Zn adsorbed varied with the soil and the initial Zn concentration. Though all the soil series depicted linear relation between Zn concentration in the solution and the amount of Zn adsorbed, only five series *viz.*, Kanjirappally, Lahai, Kunnathur, Kaipuzha and Panachikkad showed significant regression coefficient. Both Langmuir and Freundlich models were equally fitting for these five soil series. The highest adsorption maxima was recorded by the Kaipuzha series. Similarly, Panachikkad series also recorded high value. Lowest adsorption was recorded by Kanjirappally and Lahai series. These two series were extremely deficient in available Zn. Wide variation in the bonding energy between series was recorded. The rate of sorption, a derivative of Freundlich equation also showed wide variation between series. The rate of sorption was low for Kaipuzha and Panachikkad soils, though these series recorded the highest adsorption maxima. A negative relation was observed between adsorption maxima and the rate of sorption. The sorption capacity was high for Panachikkad and Kaipuzha series and the same series recorded the highest adsorption maxima.

Wide variation on adsorption behavior was recorded among the series. The variation in the organic carbon and clay content might have contributed for the wide variation in the adsorption behavior of these soils.

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Evaluating Lime Requirement of Acid Soil by Calcium Hydroxide

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Exactly 10 g of soil were taken in each of three polythene beakers of 50 mL capacity. The soil was equilibrated for half an hour with intermittent shaking after addition of 0, 2, and 4 mL of 0.022 *M* $Ca(OH)_2$ solution and required amount of distilled water so as to maintain a soil and solution ratio of 1:2.5. The pH of the soils was determined with pH meter. The buffering capacity of the soil was computed from the reciprocal of the slope of the graph of pH versus the amount of base added, and the lime requirement of the soil was also computed by deviding the difference in initial pH of the soil from the target pH by the buffering capacity of the soil. In order to validate the procedure 10 types of acid soils differing in texture from course to fine were tested for their buffering capacity and lime requirement. The relationships between changes in pH to base added were found to be linear for these soils from pH 5 to 7. The buffering capacities of their soils were found to vary from 0.88 to 1.43 cmol OH^- kg^{-1} pH^{-1} whereas the lime requirement (LR) varied from 1.2 to 3.3 t ha^{-1} so as to raise the pH of soil to 7. The lime requirement of these soils so determined was found to be 42% of the values (1.5 to 6.2 t ha^{-1}) determined by modified Woodruff method and appeared to exclude the overestimation of lime requirement by latter method. The present method is simple, less costly and could be used by soil testing laboratories as an alternative method for routinely determining the LR of the soils.

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Distribution and Availability of Iron, Manganese, Zinc, and Copper in Soils of Cuddalore District of Tamil Nadu

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A study of the micronutrient status of soils of the Cuddalore district was made covering all the blocks of Cuddalore district of Tamil Nadu. A total of 1941 surface soil samples from 0-15 cm depth were collected from all thirteen blocks of Cuddalore district and analyzed for DTPA-extractable micronutrients and other soil properties. The availability of nutrients ranged from 1.04 to 137.80 mg kg^{-1} for DTPA-Fe, 0.16-11.95 mg kg^{-1} for DTPA-Zn, 0.86-127.51 mg kg^{-1} for DTPA-Mn, 0.07-10.11 mg kg^{-1} for DTPA-Cu and 0.10-3.0 mg kg^{-1} for HWSB. Cuddalore district is found to be deficient in DTPA-Zn (49.9%) followed by DTPA-Cu (32.2%). The fertility status of the district was in the order of Mn>B>Fe>Cu>Zn. Among the micronutrients, DTPA-Fe is negatively correlated with pH and DTPA-Cu, while DTPA-Cu, Mn and Zn are positively correlated with pH. DTPA-Zn and DTPA-Mn is positively correlated with organic matter. Micronutrients show positive correlation with $CaCO_3$ except DTPA-Fe. HWSB is positively correlated with DTPA-Cu. DTPA-Mn is positively correlated with DTPA-Zn. Comparing data of previous analysis, copper deficiency is found to be increased alarmingly but zinc deficiency is reduced to about 40 per cent from 67 per cent during 1980-2000.

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Sulphur Status and Their Relationship with Soil Properties of Gird Region of Northen Madhya Pradesh

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Sulphur an essential element is becoming deficient due to continuous use of S-free fertilizer, being used for growing high yielding crop varieties and intensive cropping with high sulphur requiring crops. Inadequate and imbalance use of fertilizer (organic and inorganic) also further leads to abnormal distribution of nutrients, particularly in mustard growing area. There is a need to evaluate sulphur status of soil of intensively cultivated area so that a picture regarding depletion and build-up of various forms of sulphur may be obtained. One hundred fifty surface soil samples were collected from Gwalior, Morena and Bhind District (10 villages from each district) of northern Madhya Pradesh (where mustard were growing since last 5 years) and analysed for their physical and chemical properties and different fractions of sulphur namely total-S, organic-S, water soluble-S and available-S by using standard methods.

The results indicated that soils of all the three districts were sandy clay loam to clay loam in nature. The pH and electrical conductivity of all the three districts were in normal range and status of organic carbon and total-N was observed in the range 0.12-0.81% and 0.032-0.165% under different villages with the average value of 0.41% and 0.079%, respectively. Results revealed that the different forms of sulphur *i.e.* water soluble, available, organic and total sulphur were observed in the range of 1.02-7.44, 4.36-19.58, 84.25-201.35 and 188.21-465.26 mg kg^{-1} under different villages of investigated area with the average value of 3.76, 15.31, 135.42 and 317.91 (mg kg^{-1}), respectively. About 25.0% samples were found under deficient and 75.0% under medium and none of the samples under sufficient category. The maximum deficiency was observed in Gwalior district as compared to other districts. Different forms of sulphur *i.e.* water soluble, available, organic and total showed a highly significant and positive correlation with organic carbon, clay content and total-N of the soils. A highly significant and positive relationship was observed between different forms of S. The step down multiple regression equation revealed that organic carbon had greater impact on different forms of sulphur followed by soil textures. It suggests that organic matter was the main contributing factor which affect sulphur availability in the soil.

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Status of DTPA-extractable Micronutrient Cations under Mustard Growing Area of Northern Madhya Pradesh

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Soil samples from mustard growing areas of Madhya Pradesh were collected and status of DTPA-extractable micronutrient cations was determined for identification and monitoring of micronutrient status for efficient nutrient management. One hundred and fifty soil samples from thirty locations were collected to explore the availability of cations under varying soil conditions. The soil samples were analysed for pH, EC (1:2 soil:water ratio), $CaCO_3$ and organic carbon following standard procedures. The available Zn, Cu, Fe and Mn were extracted with 0.005*M* DTPA, 0.01 *M* $CaCl_2$ and 0.1 *M* TEA (pH 7.3) solution and determined with the help of AAS.

The results indicated that the soils were neutral to alkaline in nature with electrical conductivity of 0.1-0.97 dS m^{-1}, organic carbon (0.11-0.81%), calcium carbonate (0.5-9.5%). The DTPA-extractable Zn, Cu, Fe and Mn in different soil samples varied from 0.18-2.56, 0.12-4.62, 1.25-18.65, 0.36-16.65 mg kg^{-1}. The correlation study of DTPA extractable micronutrients and soil properties showed that the pH and calcium carbonate content are negatively correlated and organic carbon and clay content are significantly positively correlated with all the micronutrient cations. Considering the critical level of Zn, Cu, Fe and Mn as 0.6, 0.2, 4.5 and 1.0 mg kg^{-1} 46, 6.6, 35.3 and 6.6 per cent soil were found deficient in Zn, Cu, Fe and Mn, respectively, under mustard growing fields of Northern Madhya Pradesh.

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Status of Micronutrient Cations in Soils of Jorhat District of Assam

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An investigation was carried out to study the status of micronutrient cations in soils of Jorhat district of Assam. Two hundred twenty three (223) Surface soil (0-15 cm) samples were collected at an interval of 2 km from representative sites of Jorhat district and analysed for important soil physicochemical properties and micronutrient cations following standard procedures. Relationships were worked out between various soil properties and micronutrient cations.

The soil texture varied from sandy loam to silty loam ranging from 5.40-80.25 per cent sand, 8.00-62.00 per cent silt and 8.50-39.25 per cent clay respectively. Soils of the district were found to be strongly acidic to near neutral in reaction (3.89-7.38) with a low to high organic carbon content (0.33-1.01per cent). The CEC [5.00-9.10 cmol(p^+)kg^{-1}] and EC (0.01-0.21dS m^{-1}) of the soil was found to be low. The soils of Jorhat district were found to be sufficient in DTPA-Fe and DTPA-Mn while 33.2 per cent, 17.50 per cent and 1.3 per cent of DTPA-Zn, HWS-B and DTPA-Cu were found to be deficient in soils of Jorhat district. Sandy loam soils accounted for about 68.9% for DTPA-Zn, 56.4% for HWS-B and 100% for DTPA-Cu deficiency while loamy sand accounted for about 31.0% for DTPA-Zn and 43.6% for HWS-B deficiency. Blockwise, DTPA-Zn deficiency was found to be the highest in Majuli and Ujjani Majuli block with 40% each and the lowest deficiency was found in Sipahikhula and Titabar block with 26.9% each. Selenghat block showed the highest deficiency in HWS-B with 24% and the lowest deficiency was found in Dekargorah block with 12%. DTPA-Cu deficiency was found only in Selenghat and Majuli block with 3.8 and 3.3% each.

Micronutrient cations correlated positively and significantly with soil organic carbon, CEC, per cent clay and silt but negatively and significantly with soil pH and per cent sand content of the soil. Except HWS-B, DTPA-extractable micronutrients correlated negatively and significantly with soil EC. Micronutrient cations also correlated positively and significantly amongst each other. Regression analysis revealed that soil pH, organic carbon, CEC and per cent clay were the main factors contributing to the variability in micronutrient cations.

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Evaluation of Some Chemical Extractants for Testing Copper Availability to Wheat in Punjab Soils

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A pot culture experiment was conducted using fifteen bulk surface (0-15 cm) soil samples collected from Ludhiana, Ferozepur, Muktsar and Bathinda districts of Punjab having 0.119 to 1.253 mg DTPA extractable Cu kg^{-1} soil, to study the response of wheat to Cu application (0 and 5 mg Cu kg^{-1} soil as Cu-EDTA). The plants were harvested at three stages (30 days after germination, 60 days after germination and at maturity). The soil samples were extracted for available Cu by different extractants (DTPA, AB-DTPA, DTPA+0.1*N*HCl, 0.1*N*HCl, AB-EDTA, Mehlich-1 and Mehlich-3). The relative dry matter yield at 30 and 60 days varied from 70.8 to 96.7 and 71.3 to 96.5 per cent whereas relative grain and straw yield varied from 70.7 to 97.1 and 73.3 to 95.8 per cent, respectively. The relative Cu uptake by wheat at 30 and 60 days varied from 37.3 to 94.0 and 42.7 to 93.7 percent whereas relative uptake by grain and straw varied from 33.9 to 92.6 and 30.2 to 89.1 per cent, respectively.

The amount of soil Cu extracted by different extractants decreased in the following order: AB-DTPA > AB-EDTA > Mehlich-3 > DTPA-HCl > Mehlich-1 > 0.1*N* HCl > DTPA. The critical levels of Cu extracted by DTPA, AB-DTPA, AB-EDTA, DTPA+0.1*N*HCl, 0.1*N* HCl, Mehlich-1 and Mehlich-3 to produce 90 per cent of the maximum dry matter yield at 30 and 60 days, and grain and straw at maturity varied from 0.19 to 0.25, 0.56 to 0.69, 0.52 to 0.68, 0.35 to 0.45, 0.23 to 0.32, 0.28 to 0.46 and 0.50 to 1.01mg kg^{-1} soil, respectively as estimated by Mitscherlich model. The corresponding values of soil Cu measured by Cate and Nelson were 0.23 to 0.25, 0.60 to 0.65, 0.60 to 0.62, 0.50 to 0.50, 0.36 to 0.45, 0.26 to 0.28, 0.35 to 0.35 and 0.56 to 0.57 mg kg^{-1} soil, respectively. The critical value of Cu in dry matter at 30 and 60 days and in grain and straw at maturity to produce 90 per cent of the maximum yield was observed to be 16.50, 11.50, 4.20 and 3.00 µg g^{-1}, respectively as measured by Cate and Nelson (graphical) procedure. The corresponding values of Cu concentration to produce 90 per cent of the maximum yield estimated by Mitscherlich model were observed to be 14.17, 12.55, 4.09 and 2.37 µg g^{-1}, respectively. Of all the extractants used to extract available Cu in soils, the amount of Cu extracted by the most commonly used DTPA was highly significantly and positively correlated with relative grain yield ($r=0.688^{*}$), grain Cu concentration ($r=0.914^{**}$) as well as relative Cu uptake by wheat grain ($r=0.720^{*}$).

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Nano-Particles Characterization and Their Effect on Plant Growth

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Application of nano-particles in agriculture, an emerging concept, is receiving increasing attention with the fast development of nanotechnology. Thorough research is needed to study the influence of environmental factors including natural organic matter characteristics on the colloidal stability and transport of the engineered nano-particles in the environment. Against this backdrop, an investigation was carried out to study the interaction effect of humic acids with different nano-particles. A parallel solution culture study was also conducted to investigate the bioavailability of copper nano-particles to maize plant. Seeds of maize crop were germinated in moist rock mass for about 12 days after sterilization and water soaking. Uniform seedlings were selected and transplanted to 1500 mL pots containing 1500 mL of nutrient solution. Roots of the seedlings were submerged into the nutrient solution. The seedlings were allowed to grow in the nutrient solution for three weeks. Due to their small size and huge surface energy, nano-particles are prone to aggregation in aqueous phase, which may influence their bioavailability. CuO nano-particles aggregated in the nutrient solution with a colloid size up to several hundred nanometers. The aggregate would deposit quickly without stirring solution. The mean size of CuO nano-particle aggregates in the nutrient and the rhizosphere solution with initial CuO concentration 0.25 ppm was 90±10 nm. The seedling biomass was increased with the application of CuO nano-particles and its spray. The different enzymatic activity like glucose-6-phosphate, dehydrogenase activity, succinate, superoxide dismutase, catalase, guaiacol peroxidase was measured. It could be depicted from the experimental results that application of CuO nano-particles through spray affected the pentose phosphate pathway.

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Long-term Effect of Manures and Fertilizers on Quantity/Intensity Relations of Potassium in Rice Soils

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The effect of 21 years of continuous rice-rice cropping, fertilization and manuring on potassium supplying power of the Inceptisols was studied by employing quantity/intensity approach from a permanent plot experiment conducted since 1988 at College of Agriculture, Rajendranagar. Twelve treatments comprising of chemical fertilizers alone and in conjunction with FYM, rice straw and *gliricidia* at 50 and 25% substitution levels of nitrogen during *kharif* and with 100 and 75% 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, whereas in 25% substitution treatments only 75% RDF through fertilizers was applied in *rabi*. Six elective treatments comprising of control, 75% NPK, 100% NPK during both the seasons, 75% NPK + 25% N substituted through organic manures (FYM, rice straw and *gliricidia*) during *kharif* and uniformly 75% NPK during *rabi* were studied for this purpose. The ARKe value, a measure of availability or intensity of potassium was highest in treatment receiving 75% NPK + 25% N substituted through rice straw followed by 75% NPK + 25% N through *gliricidia*, 75% NPK + 25% N through FYM, 100% NPK at the end of annual cycle during 2008-09. The lowest ARKe was recorded in the control. Potassium held in nonspecific sites (K_0) and the labile potassium (K_L) was harvest when 75% NPK + 25% N through *gliricidia* was applied. The cumulative removal of potassium for 21 years was also highest with this treatment followed by 100% NPK > 75% NPK + 25% N through FYM > 75% NPK + 25% N through rice straw > 75% NPK > control. Ammonium extractable potassium was lowest in the 75% NPK + 25% N through *gliricidia* treatment and was highest in 75% NPK + 25% N through rice straw however the status in all the treatments was lower than the initial status. Despite of the low low ARKe and K_L value deficiency symptoms were not expressed by the rice crop indicating the release of potassium of nonexchangeable source.

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Appraisal of Available Micronutrients Status in soils of Central Brahmaputra Valley Zone of Assam

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Available micronutrients status and their relationship with different soil properties were studied in different blocks of Nagaon and Morigaon Districts of Central Brahmaputra Valley Zone of Assam during 2010-11. Six hundred surface soil samples from 18 blocks of Nagaon and two hundred fifty samples from 5 blocks of Morigaon district were collected with the help of GPS and analyzed for DTPA-extractable micronutrients and hot water soluble boron. The DTPA-extractable iron, copper, zinc, manganese and hot water soluble boron ranged from 62 to 278, 0.16 to 8.34, 0.21 to 1.80, 3.21 to 43.5 and 0.33 to 0.96 mg kg^{-1}, respectively in Nagaon District, while in Morigaon, these contents ranged from 78 to 339, 0.16 to 12.08, 0.36 to 1.39, 16.2 to 42.4 and 0.41 to 0.89 mg kg^{-1}, respectively. Based on the critical levels, all the soils from both the districts were adequately supplied with DTPA-extractable Fe, Mn and Cu. Available Zn was found deficient in 23.9%, marginal in 69.3% and sufficient in 5.5% in Nagaon soils while, in case of Morigaon soils, these categories ranged 25.7, 72.2 and 0.8%, respectively. Block-wise per cent deficiency of Zn in Nagaon district followed the order: Batadrava (31.1 %) > Binakandi (28.7%)> Pakhimoria and Udali (26.5 %) > Juria (26.0%) > Pachim Kaliabar (23.5 %)> Jugijan and Lawkhowa (20.1 %)> Dolonghat (19.6 %)> Lamding (19.6 %) > Baziagaon (18.8 %)> Raha (18.2%), indicating highest coverage of deficiency in Batadrava and lowest in Raha block. In Morigaon district, highest Zn deficiency was found in Bhurbandha block (32.2%) followed by Lahorighat (29.8%), Mayang (28.5%), Kapili (26.4%) and Moirabari (25.7%) In respect of hot water soluble boron, both the districts exhibited deficiency in their B content and percent deficiencies of the nutrient ranged from 10.3 to 21.1% in Nagoan and 19.7 to 21.3%, in Morigoan district, respectively. Irrespective of the district, organic carbon content showed significant and positive correlation with available Fe, Cu, Zn, Mn and B (0.351**, 0.318*, 0.611**, 0.345* for Nagaon district and 0.697**, 0.217*, 0.545**, 0.791**, 0.254* for Morigaon district. Both the district exhibited significant negative correlation between pH and micronutrients. Significant and negative correlation of Mn and Zn was further noticed with the available N, P and K in both the districts.

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Nitrogen Transformations in the Soils under Different Multipurpose Tree species in Semi-arid India

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In order to study the effect of different tree species on N transformation in the soil profile five blocks of different tree plantations native of arid and semi-arid area *viz.*, *Prosopis cineraria*, *Dalbergia sissoo*, *Acacia nilotica*, *Eucalyptus tereticornis* and *Tamarix aphylla* which were about 15-20 years old were selected. Soil profiles up to 150 cm were dug and seven soil samples were taken from 0-4, 4-15, 15-30, 30-60, 60-90, 90-120, 120-150 cm depth of each soil profile. The soil samples were then analyzed for different forms of N *i.e.* total N, organic N, NH_4^+-N, NO_3^--N, available N. Concentration of all the forms of nitrogen in the soil samples observed the same trend and the concentration decreased gradually with the increase in soil profile depth. Highest concentration of total N, organic N, NH_4^+ -N, NO_3^- -N, available N was observed under the plantation of *Dalbergia sissoo* followed by *Acacia nilotica* and *Prosopis cineraria* because these three spp. are N-fixers, therefore, produce more biomass which consequently accumulates as leaf litter on soil and gradually mineralize on decomposition. Whereas, *Eucalyptus tereticornis* and *Tamarix aphylla* being non-nitrogen fixer and evergreen in nature shed comparatively less amount of biomass resulting in low N availability in the soil.

It may be concluded that tree litters falling from *Acacia nilotica*, *Dalbergia sissoo* and *Prosopis cineraria* was stabilized enough and improved the nitrogen status in soil as compared to *Eucalyptus tereticornis* and *Tamarix aphylla*. In case of *Eucalyptus tereticornis* and *Tamarix aphylla*, more time is needed for stabilization and decomposition of litters for their better management and high returns.

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Fractions of Soil Boron and their Relationship with Boron Uptake by Wheat in Different Soils as Influenced by Long-term Fertilization and Manuring

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In Indian context, deficiencies of boron (B) are no longer confined to acid soils, owing to excessive removals under intensive cropping systems and continued neglect of its replenishment. In order to understand the distribution of B in different fractions as influenced by nutrient management, soil samples collected after wheat (2009-10) from three sites of AICRP on Long Term fertilizer Experiments (LTFE) *i.e.* Delhi (Typic Haplustept), Junagadh (Vertic Ustochrept) and Ranchi (Typic Haplustalf) were subjected to sequential fractionation. Soils of Delhi and Junagadh were mildly alkaline, and those of Ranchi were acidic in reaction. Averaged across the treatments, organic C (0.78%) and CEC (35.7 cmol(p^+)kg^{-1}) of Junagadh were the highest and those of Ranchi were the lowest (0.45% and 9.8 cmol(p^+)kg^{-1} respectively). Soils of Junagadh were calcareous with average $CaCO_3$ content of 39.9%, whereas free sesquioxides were relatively higher at Ranchi. Total B content was highest (130 mg kg^{-1}) at Junagadh, followed by Delhi (39.2 mg kg^{-1}) and Ranchi (21.7 mg kg^{-1}). Among different B fractions, residual B was the major contributor to total B in all the LTFEs. The other fractions collectively shared on average 15.5, 5.3 and 6.9% of total B at Delhi, Junagadh and Ranchi, respectively. Distribution of total B among different fractions was in the order: readily soluble < specifically adsorbed < oxide bound < organically bound < residual. At Ranchi, however, oxide bound B was greater than organically bound B. Total and residual B generally remained unaffected due to nutrient supply options at different sites. Whereas, application of N alone depleted readily soluble and specifically adsorbed B bringing the contents even below unfertilized-control, conjoint use of NPK and FYM increased significantly ($p<0.05$) these fractions as well as organically bound B over other treatments. Organically bound B was positively correlated ($p<0.01$) with specifically adsorbed B at all sites, and with readily soluble B at Delhi and Junagadh, whereas it showed negative correlation ($p<0.01$) with oxide bound fraction at Ranchi. Available (hot $CaCl_2$ extractable) B was positively correlated with readily soluble, specifically adsorbed and organically bound fractions at all sites indicating the significance of these pools in controlling B availability in soil. Specifically adsorbed, oxide bound and organically bound fractions were correlated well ($p< 0.05$ or <0.01) with B uptake by wheat.

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Iron Toxicity Management in Laterite Derived Paddy Soils using Nonconventional Sources of Calcium

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The major constraint in crop production in laterite derived paddy soils of Kerala are low soil pH and high concentration of soluble iron in reduced ferrous form. This creates stress and also affects plant health and potential yield. Plants suffer from acute nutrient deficiencies induced by high soluble iron and aluminum ions in soil solution. The present recommendation of 600 kg lime per ha for paddy, is not sufficient to correct soil acidity and reduce the Fe and Al toxicities. Moreover the cost of conventionally used shell lime is high and inhibitive and so farmers limit its use to the bare minimum quantity. Hence the present study was conducted with cheaper nonconventional sources of calcium with an objective to evaluate their effectiveness in wet land paddy soils.

A field experiment was conducted during 2010 at farmers field in laterite soil of Kasargode Kerala. The soil in the experimental plot was red clay loam with pH 4.35, EC 0.43 dS m^{-1}, Organic C 2.42%, available P 20.3 kg ha^{-1} and available K 92.5 kg ha^{-1}. The aim of the study was to evaluate the efficacy of non-conventional sources of calcium like phosphogypsum and dolomite on yield of paddy variety Athira in comparison with conventional shell lime. The treatments include application of phosphogypsum (600 kg ha^{-1}), dolomite (600 kg ha^{-1}), shell lime (600 kg ha^{-1}), phosphogypsum 300 kg ha^{-1} + dolomite 300 kg ha^{-1} and control (no lime).

The study revealed that the soil acidity was significantly reduced due to the application of various amendments. The soil pH values obtained in the different treatments were phosphogypsum + dolomite (5.08), phosphogypsum (5.0), shell lime (4.98), dolomite (4.8) and control (4.23).The treatments were also effective in reducing 0.1 N HCl extractable iron. Similar trend of result was obtained in the case of HCl extractable iron wherein the values were phosphogypsum + dolomite (41.6 ppm), phosphogypsum (42.7 ppm), shell lime (47.6 ppm), dolomite (45.5 ppm) and control (49.5 ppm).

The growth parameters and yield attributes like plant height, number of tillers and 1000 grain weight were highest in the phosphogypsum + dolomite treatment. Highest grain yield of 6.25 t per ha was obtained in phosphogypsum + dolomite treatment followed by shell lime (5.8 t per ha), phosphogypsum (5.75 t per ha), dolomite (5.6 t per ha) and control (4.75 t per ha). The results indicate the possibility of replacing shell lime with dolomite , phosphogypsum and their blends in managing soil acidity and iron toxicity in laterite derived paddy soils of Kerala.

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Physicochemical Properties and DTPA-Zinc Status of Surface and Sub-Surface Soils in Traditional Arecanut Growing Soils of Karnataka

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A survey study was conducted at the Agricultural college, Shimoga, Karnataka to assess the physico-chemical properties and status of DTPA extractable zinc in surface (0 – 20 cm) and sub-surface (20 – 40 cm) soils of traditional arecanut growing belts of Karnataka during 2007-08. Twenty representative soil samples from 0-20 cm depth and twenty soil samples from 20-40 cm depth were collected from each of five taluks *viz.*, Sagar, Thirthahally, Koppa, Sringeri and Kundapur representing two agro-climatic zones *viz.*, hilly zone and coastal zone for characterization. Standard procedures were adopted for analysis of particle size distribution, pH, EC, OC, CEC and DTPA extractable Zinc.

The data emphasized that no wide variations are observed with respect to particle size analysis either for different taluks studied or for 0-20 cm and 20-40 cm depths. Sand was the dominant fraction in both 0-20 cm and 20-40 cm depths *i.e.*, 64-75 and 63-75 per cent, respectively. This was followed by clay content that ranged from 16 – 28 per cent in 0-20 cm and 15-27 per cent in 20-40 cm depth. In a nutshell it was observed that these soils were texturally belonged to sandy loam to sandy clay loam.

The soils studied were strong to slightly acidic in reaction. The pH of the soils varied from 4.62 to 6.23 and 4.69 to 6.23 in 0-20 cm and 20–40 cm depths, respectively. The total soluble salts content was in the range of 0.03 to 0.13 dS m^{-1} for 0 – 20 cm and 0.01 to 0.10 dS m^{-1} for 20–40 cm depth soils.

Among the different taluks studied, higher organic carbon content was identified in 0–20 cm depth (5.21- 27.82 g kg^{-1}) as compared with 20–40 cm depth (except for Kundapur soils). The organic carbon content was noticed higher in Kundapur taluk for both the depths (27.82 g kg^{-1} for 0–20 cm and 29.20 g kg^{-1} for 20–40 cm) wherein Thirthahally taluk recorded lower value (5.21 g kg^{-1}) for 0 – 20 cm and Sagar taluk for 20–40 cm (4.5 g kg^{-1}) depth soils.

The higher CEC value for 0-20 cm depth soils was observed in Sringeri taluk (35.20 cmol(p^+)kg^{-1} whereas soils from Sagar taluk recorded lower value (11.34 cmol (p^+) kg^{-1}). In 20-40 cm depth soils the higher CEC value was indicated in Kundapur taluk (34.60 cmol (p^+) kg^{-1}) and lower value in Sagar (10.20 cmol (p^+) kg^{-1}) taluk soils.

Higher DTPA extractable zinc content was observed in soils of 0-20 cm depth as compared to 20 - 40 cm depth. In 0-20 cm depth the value ranged from 0.69 mg kg^{-1} (Kundapur) to 2.24 mg kg^{-1} (Sringeri) whereas in 20-40 cm depth it varied from 0.65 to 2.04 mg kg^{-1}. Among the different soils studied, the higher available zinc content was recorded in Sringeri taluk irrespective of 0-20 cm and 20-40 cm depth. Further, the DTPA extractable zinc was positively and significantly correlated with organic carbon content (>0.43) and CEC (>0.43) in Koppa and Kundapur taluks for both the depths.

Thus, from the above study it can be concluded that in the above taluks studied; the surface soils (0-20 cm depth) contains higher organic carbon and DTPA extractable zinc contents compared to subsurface soils (20-40 cm depth) and DTPA- zinc showed positive significance with OC and CEC.

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Persistence and Degradation of Antracol 70WP (Propineb) in Rice (*Oryza sativa* L.)

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A study was conducted during summer 2008 at Ramagundanahalli, Bangalore to study the persistence and degradation of Propineb residues following application of Antracol 70WP (Propineb) in rice straw and grain and cropped soil when applied at two different doses (700 g a.i. ha^{-1} and 1400 g a.i. ha^{-1}) and stages 20 and 30 days after transplanting (DAT). Rasi was used as rice variety in the present investigation. There were five treatments and the design of the experiment was RCBD. The initial deposition of Propineb residues ranged from 21.69 to 58.9 μg g^{-1} irrespective of doses and crop stages. The Propineb residues resulting from the foliar applications of Antracol 70WP were found to persist longer on paddy leaves when applied at 20 DAT compared to 30 DAT. The initial residue levels of 28.7 μg g^{-1} and 58.9 μg g^{-1} were higher when applied at 700 g a.i. ha^{-1} and 1400 g a.i. ha^{-1} on 30 DAT but dissipated faster than the treatment receiving 700 g a.i. ha^{-1} and 1400 g a.i. ha^{-1} on 20 DAT. Although, higher residues was found, the dissipation was relatively faster with a half-life of 1.2 (700 g a.i. ha^{-1}) and 1.6 (1400 g a.i. ha^{-1}) days when applied at 30 DAT than applied at 20 DAT being 2.0 (700 g a.i. ha^{-1}) and 2.3 (1400 g a.i. ha^{-1}) days respectively. More than 90 per cent of Propineb residue was dissipated within 14 days irrespective of doses and crop stages. The dissipation of Propineb in the present investigation followed the first order kinetic reaction for all the doses of application (R^2= >0.914). Propineb residues on paddy leaves dissipated with a half-life of 2.0 and 2.3 days when applied at 20 DAT and 1.3 and 1.6 days when applied 30 DAT at 700 g a.i. ha^{-1} and 1400 g a.i. ha^{-1}, respectively. The results suggested that there was slower dissipation of propineb when it was applied at 20 DAT as compared to 30 DAT. The results also revealed higher degradation rate of Propineb 555.5×10^{-3} days and 436.5×10^{-3} in the treatment receiving 700 g a.i. ha^{-1} and 1400 g a.i. ha^{-1} respectively at 30 DAT compared to that of 20 DAT being 353.5×10^{-3} and 303.0×10^{-3} at both the application rates. The paddy straw, grains, husk and soils were found to notice below detectable limit (0.19 μg g^{-1}) of Propineb residues after the harvest. Propineb has a very short half-life besides faster rate of degradation. Therefore, it can be safely incorporated in the plant protection programme without posing hazard to the environment.

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Profile Distribution of Forms of Potassium in Some Salt-Affected Soils of Punjab

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The accumulation of salts and sodium is a common feature of the alluvia soils with imperfect drainage especially in the drier regions. Out of the total geographical area 5.0362 million hectares, about 0.06 million hectare of land is still affected with problem of salinity and sodicity in Punjab. The problems of alkalinity and sodicity go hand in hand, and are more pronounced in fine-textured soils. These soils are difficult to take into agricultural due to high salts, toxicity of sodium, high pH and poor physical condition. The soils suffer from limited availability of micronutrients due to low organic matter content, and high pH and calcium carbonate. Though the soils are high in sodium, however, they need to be investigated for potassium content and its forms in profile.

Five salt-affected soils from different parts of Punjab were investigated for potassium and its different forms. Water soluble K content in the salt-affected soils ranged from 7.0 to 790.0 mg kg^{-1} having lowest content in Langrian soils (WM= 28.4 mg kg^{-1}) and highest content in Balluana soils (WM= 302.6 mg kg^{-1}). Balluana salt-affected soils (WM= 824.4 mg kg^{-1}) contained highest content of exchangeable K whereas Langarian salt-affected soils (WM= 58.7 mg kg^{-1}) had lowest content. Non-exchangeable K was highest in Balluana salt-affected soils (WM=17472 mg kg^{-1}) and lowest in Langrian soils (WM=6690.3 mg kg^{-1}). All the soils under study belong to very high (very high > 1200 mg K kg^{-1}) non-exchangeable K status. Non-exchangeable K of the salt-affected soils of Balluana, Bheela, Dagru, Ramgarh and Langrian varied from 14787 to 19875 mg kg^{-1}, 5372 to 12987 mg kg^{-1}, 9717 to 10905 mg kg^{-1}, 8227 to 11767 mg kg^{-1} and 2542 to 9685 mg kg^{-1}, respectively. The highest content of total K was observed in salt-affected soils of Balluana (WM= 2.79 %) and lowest in Dagru soils (WM= 2.05 %). The salt-affected soils had the highest contents of water soluble K, exchangeable K, available K, non-exchangeable K and 1*M* HNO_3 K in Balluana soils and the lowest in Langarian soils. The Balluana soils being under aridic moisture regime showed accumulation salts causing higher soluble and other forms of K. The difference in finer fractions particularly clay is responsible for variation in total K content in the soils.

Commission 2.3: Soil Biology

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Interaction of Dual Inoculation of N Fixers and PSB alongwith Chemical Fertilizers in Sorghum-Chickpea Cropping System

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Field experiments were conducted for three successive years (2008-09, 2009-10 and 2010-2011) to evaluate the interaction effect of dual inoculation of nitrogen fixers and phosphorus solubilizing bacteria (PSB) alongwith graded doses of chemical fertilizers in sorghum-chickpea sequence at research farm, MKV, Parbhani. The experimental soil was moderately alkaline in reaction, EC was in safe limit. The organic carbon, available N and P were moderate and potassium was in high range. The experiment was laid out in factorial randomized block design using sorghum hybrid CSH 16 in *kharif* and chickpea variety BDN 9-3 in *rabi*. *Azospirillum*, *Rhizobium* and PSB as per treatment were applied @ 250 g kg^{-1} seed with 100% RDF, 75% RDF and without chemical fertilizers. The recommended dose of fertilizers @ 80:40:40 kg N, P_2O_5 and K_2O ha^{-1} to sorghum and 25:50:00 kg N, P_2O_5 and K_2O ha^{-1} to chickpea were applied through urea, single super phosphate and muriate of potash. Standard procedures were adopted for soil, plant sampling and analysis.

The results revealed that in sorghum-chickpea cropping system seed inoculation of *Azospirillum* and phosphate solubilizing bacteria in sorghum and *Rhizobium* + PSB in chickpea alongwith 100% RDF significantly influenced the growth and yield attributes of sorghum as well as chickpea and produced maximum seed yield, fodder yield of sorghum and had more nutrient availability in soil after harvest as compared to single inoculation or no inoculation of biofertilizers. There was improvement in soil nutrient balance with dual inoculation of biofertilizers + 100% RDF after harvest of chickpea but population of bacteria, actinomycetes and fungi was found more in 75% RDF treated soil over 100% RDF and control. However, significantly more number of bacterial abundance was recorded with dual application of bioinoculants over single inoculation and control. In monetary returns maximum benefit was recorded in treatment receiving 100% RDF + dual inoculation in both the crops.

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Use of Phosphate Solubilizing Microorganisms for Increasing Phosphate Utilization by Rice in Coastal Region of Maharashtra

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Phosphorus is a limiting macronutrient next only to nitrogen for plant growth and makes about 0.2% of plant dry weight. The water soluble form of phosphate which is absorbed by the plant remains in the soil in extremely small quantities. Though, water soluble phosphate fertilizers are applied to the soil they are converted to insoluble forms like ammonium taranakite, variscite, struvite, *etc*. The P fixation capacity of soils from coastal region of Maharashtra state is very high and that these soils are deficient in available phosphorus even under waterlogged conditions. Many fungi, bacteria and actinomycetes are potential solubilizers of bound phosphates in soil. Use of P solubilizing microorganisms has been found to dissolve insoluble forms of phosphates (Fe-P, Al-P, Ca-P, *etc*.) and make available to the crop plant. Use of P solubilizing organisms increased the P use efficiency of phosphate fertilizers reported increased availability and rice yields due to use of phosphate solubilizing microorganisms in soils of coastal Maharashtra.

In view of this, the experiment was conducted in medium black soil from north Konkan coastal zone during *kharif* seasons of 2008 to 2010 with rice (var.KJT-3) as a test crop. The soil from experimental field (RARS, Karjat) was sandy clay loam with pH-6.65, EC- 0.11, OC -0.99%, available N 105 kg ha^{-1}, available P_2O_5- 18 kg ha^{-1} and available K_2O- 113 kg ha^{-1}. There were eight treatments *viz*. T_1-Control (No fertilizer), T_2- Recommended dose of fertilizers (10:50:50), T_3-5 t ha^{-1} glyricidia leaves +*Azospirillium* + PSM, T_4- 100 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + PSM, T_5-50 kg N ha^{-1} + 25 kg P_2O_5 ha^{-1} + *Azosprillium* + PSM, T_6- *Azospirillium* + PSM, T_7-Only *Azospirillium* and T_8-Only PSM. The roots of rice seedlings were dipped in 10% suspension of *Azospirillium*/PSM or both for half an hour as per the treatment. Ten tonnes per hectare of FYM was applied to all the treatments except the treatments T_1. Muriate of potash was applied to rice crop @ 50 kg K_2O ha^{-1} in all the treatments except control. The treatments were replicated three times. Twenty one days old seedlings were transplanted in puddled soil at 20 x 15 cm^2 spacing. All the cultural practices were scrupulously followed during the crop growth.

The pooled data indicated that the treatment T_5 recorded the highest grain yield of rice (4.50 t ha^{-1}) which was significantly higher than treatments T_1, T_7, T_8 and T_9 but was at par with the treatment T_2 (4.17 t ha^{-1}) and was significantly superior over the treatment T_1 (2.59 t ha^{-1}). The lowest straw yield was received in control treatment (3.11 t ha^{-1}).The treatment T_5 was at par with the treatments T_2, T_3 and T_4 in respect of straw yield. The application of PSM saved 50% dose of phosphate fertilizers thereby decreasing the fertilizer cost of rice by 26% with 8% increase in grain yield. The highest C: B ratio (1.66) was recorded by the treatment T_5. The phosphorus uptake by rice increased with the application of PSM alone or in combination with phosphate fertilizer. The increase was from 11 to 67% in comparison to the respective treatment without PSM.

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Effect of Organic Manure and Microbial Inoculants on Dynamics of Microbial Community in Lentil Rhizosphere

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A microplot field experiment was conducted in acid Alfisol with lentil *(Lens esculanta* L.) var. BR-25 during *rabi* season (2005-06) to determine the change in microbial community in lentil rhizosphere as influenced by *arbuscular mycorrhiza* (AM) and *Rhizobium* inoculation in presence of FYM.

Result indicated that dual inoculation supplemented with FYM @ 10 t ha^{-1} improve the bacterial ($56x10^6$ g^{-1} soil), fungal ($49.3x10^4$ g^{-1} soil) and actinomycetes ($14.6x10^6$ g^{-1} soil) population. The maximum respiration *i.e.* 70.58 mg CO_2 evolved 100 g^{-1} soil with combined inoculation and FYM @10 t ha^{-1} followed by use of *Rhizobium* inoculation (61.49 mg 100 g^{-1} soil). The highest biomass of 56.64 mg 100 g^{-1} soil was observed with dual inoculation with FYM @10 t ha^{-1} fallowed by 53.63 mg 100 g^{-1} soil with 5 t ha^{-1} of FYM. The least microbial biomass 52.40 mg was found without organic manure. A better establishment of mycorrhizal fungi was indicated with maximum spore of (241.7 spore/50 g^{-1} soil) with 10 t ha^{-1} of FYM and AM x *Rhizobium* inoculations.

Use of *Rhizobium* sp. and AM alone and in combination resulted in a significant increase in number of nodules. Maximum nodules 15.7 $plant^{-1}$ were observed when the test plant received combined inoculation with FYM @ 10 t ha^{-1}. Application of combined inoculation with FYM @ 10 t ha^{-1} significantly increased the grain yield (8.10 q ha^{-1}). Similar trend was noted in case of straw yield. Based on the experimental finding it may be concluded that a better plant growth of lentil with increased soil and crop productivity is possible with combined inoculation with specific *Rhizobium sp*. with *Arbuscular Mycorrhiza* in conjunction with FYM @ 10 t ha^{-1} in acid Alfisol of Ranchi.

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Impact of Conservational Practices on Crop Yield and Urease and L-Asparaginase Activities in an Ustochrept of Indo-Gangetic Plain in Rice-Wheat System

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An investigation was carried out on an Ustochrept of Indo-Gangetic plain at Project Directorate for Farming Systems Research, Modipuram, Meerut research farm in split plot design having main plots as direct seeded rice (DSR), system rice intensification (SRI) for rice cultivation, conventional method of rice cultivation (TPR) and control plots without addition of manure and fertilizers. After harvest of rice, four sub-plots treatments were super imposed on main plot *viz.,* zero tillage (ZT), tillage with happy seeder (HS), conventional tillage for wheat sowing (CWS) and furrow irrigated raised bed system (FIRB) for sowing wheat crop. The investigation was carried out for three consecutive years *viz*., 2008-09, 2009-10 and 2010-11 in the same plot during both rainy and winter seasons for cultivation of rice and wheat, respectively. Crop yield, soil properties and enzymatic activities like urease and L-asparaginase was recorded to study the suitability of various conservational practices in rice-wheat system.

Highest grain yield of rice (5.42 t ha^{-1}) was recorded under SRI during rainy season and wheat (5.12 t ha^{-1}) in subsequent winter season where SRI method of rice cultivation was made (average of three years). Among sub-plot treatments, highest grain yield of wheat was recorded under FIRB at 5.68 t ha^{-1}. Per cent yield increase in rice grain was 10.14% compared to TPR whereas that of wheat was 32.7% compared to CWS. Root and shoot biomass accumulation in rice were highest (2.02 and 17.5 t ha^{-1}) at harvest under SRI. Wheat root biomass was highest (1.93 t ha^{-1}) in plot receiving SRI treatment for rice, whereas among sub-plots, FIRB recorded highest root biomass (7.59 t ha^{-1}). Soil properties in terms of organic carbon was highest (0.59%) under happy seeder seeded wheat cultivated plots. Available N, K and MBC were highest (300.3, 486.0 kg ha^{-1} and 186.6 µg g^{-1} soil) under SRI among main plots and available P was highest (41.99 kg ha^{-1}) under DSR. Among sub-plots, happy seeder seeded wheat plot recorded highest available N, P, K and MBC being 249, 37.9, 472.3 kg ha^{-1} and 171.3 µg g^{-1} soil. L-asparaginase and urease activities were highest in soil under SRI whereas among sub-plots, soils collected from FIRB exhibited highest performance. These enzymatic activities were highly correlated with biomass production in wheat at crown root initiation stage and physiological maturity stage under SRI. Among sub-plots, urease activity was highly correlated with wheat biomass under ZT and that of L-asparaginase under happy seeder seeded wheat biomass.

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Soil Characteristics of Jute Growing Areas of South Bengal

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Jute (*Chorchorus olitorius* L.) is the important cash crop of eastern India and West Bengal in particular. The average national productivity of Jute fibre is about 2.3 t ha^{-1}. West Bengal is the largest producer of jute fibre in India and the productivity varies from place to place within West Bengal. In general, the productivity of South Bengal comprising the district of Nadia, Murshidabad, Hooghly and North 24 Parganas is much higher than the productivity of North Bengal comprising the districts of Cooch Behar, Jalpaiguri, North and South Dinajpur. The jute fibre productivity of a region depends mainly on the soil fertility status and the availability of good retting water. Hence a study was undertaken to have a clear idea about the important soil characteristics of jute growing districts of South Bengal. Ten soil samples were collected from high, medium and low productivity zones of four districts. The soil samples were analysed for pH, organic C, available N, P and K, dehydrogenase, urease and soil microbial biomass carbon and fluorescein diacetate hydrolysing activity following standard procedure. The Physicochemical analysis of soils revealed that, the soils of North 24 Parganas district are less fertile compared to other three districts and according to soil fertility status the districts were in the order of Nadia > Murshidabad > Hooghly > North 24 Parganas. The soils of North 24 Parganas district had soil available N, P and K in the range of 200-285, 8.30-39.5 and 100-356 kg ha^{-1} compared to respective N, P and K status (358-444, 68.9-86.3 and 209-297 kg ha^{-1}) of Nadia district. The same had direct effect on the average jute fibre productivity of these districts. A great variation was also found in the microbial population and soil enzymatic activities of the different districts. The soil microbial properties also found to vary in the same manner as that of soil fertility status. The dehydrogenase activity of Nadia, Murshidabad, Hooghly and North 24 Parganas districts ranged between 0.7 to 3.0, 0.6-2.7, 0.8-2.5 and 0.5-2.0 µg TPF g^{-1} oven dry soil h^{-1} at 37^0 C, respectively. The other enzymatic activities also followed the same trend as that of dehydrogenase activity in the jute growing districts of South Bengal.

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Composting of Weed Biomass using Earthworms: Effect of Partial Substitution with Rice Stubble

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The left over stubbles after harvest of rice crop undergo natural decomposition in most of the sole cropped areas of Assam resulting in considerable loss of nutrients. In areas where succeeding crop is grown, their efficient management either through *in-situ* incorporation or use as a substrate in traditional composting poses a challenge owing to many factors. Use of earthworms for composting weed biomass proves to be a feasible way of recycling them into quality manure. Partial substitution of weed biomass with rice stubble without affecting quality will provide an avenue for the latter's better utilization. Accordingly, an experiment was conducted in concrete tanks (1m x 1m x 0.8 m : l x b x h) during summer 2010 with 2 species of weed biomass *viz*., *Eichhornia crassipes* and *Ipomoea carnea* with 0, 10, 20 and 30% substitution of rice stubble and complete randomization of the treatments. The tanks were filled with sun-dried substrates weed biomass with or without rice stubble (9 kg) and cow dung (6 kg) on dry weight basis. One hundred grams each of two different earthworm species *viz*., *Eisenia foetida* and *Eudrilus eugeniae* were released in respective tanks and the residue was composted following standard method. The various parameters studied did not show any significant variation due to substitution of weed biomass by rice stubble up to 20%. Irrespective of weed species, substitution by rice stubble up to 30% significantly decreased the compost yield. However, the earthworm yield, composting period and recovery percentage are significantly affected by 30% substitution with rice stubble only in case of *Eichhornia crassipes*. The total carbon content did not show any significant variation either due to weed species or rice stubble substitution. The total nitrogen and potassium contents significantly decreased due to 30% substitution by rice stubble, the trend for total phosphorous was erratic. The earthworm species had no significant effect in the parameters, irrespective of the treatments.

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Effect of Fertilizer, FYM and *Azotobacter* on Growth and Yield of Mustard and Soil Fertiltiy

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A field experiment was conducted at Khargone (MP) on mustard cv. Rohini during 2007-18 to assess the effect of fertilizer, FYM and Azotobacter on growth, yield and yield attributing characters of mustard and soil fertility. Integrated application of 75% NPK + 5 t FYM + *Azotobacter* inoculation gave the highest test weight (6.53 g), seed yield (19.5 kg ha^{-1}), stover yield (64.2 kg ha^{-1}), oil content (40.3%) net return (12,732.00 ha^{-1}) and B/C ratio (2.2), which was at par with 100% NPK + 5 t FYM + *Azotobacter* inoculation and other. Increase in the levels of chemical fertilizers (NPK) showed significant impact on yield attributing characters but the maximum impact on yield attributing characters were recorded under 75% NPK + 5 t FYM + *Azotobacter* treatments. Maximum net return and B/C ratio were also obtained with 75% NPK + 5 t FYM + *Azotobacter*.

However, saving of 25% NPK could be possible due to application of FYM and *Azotobacter*. Incorporation of FYM and *Azotobacter* with optimal and suboptimal levels of NPK increased the uptake of N, P and K besides improving soil properties.

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Soil Carbon Stability as Affected by Long-term Chemical Fertilization and Manuring

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Carbon (C) stabilization in soil is a critical process influencing global C cycle. Hence, understanding the factors affecting the soil carbon storage and turnover would be helpful in devising the strategy for soil carbon sequestration. Furthermore, present knowledge of carbon turnover in terrestrial ecosystem could not explain the complex relationship between nutrient availability and soil carbon storage. Globally, results on long-term application of chemical fertilizer and manuring on organic matter stability are inconsistent. Long-term fertilizer experiments conducted at several locations of India provide an opportunity for assessing the influence of chemical fertilizer and manuring on soil carbon stability and nitrogen dynamics. Long-term application of either NPK+ farm yard manure (FYM) or FYM alone increased the carbon content of resistant pool (biochemically stabilized carbon) of soil organic matter (SOM) with concomitant increase in total carbon content of soil in all kinds of soil. Biochemically stable carbon pool (resistant pool) of soil increased with the increase in silt+clay content. In Alfisol, long-term application of chemical fertilizer (NPK alone) did not influence the carbon content of resistant pool of SOM whereas carbon content of slow pool of SOM was significantly increased. Carbon stability affected the N dynamics in soil. Long-term fertilization and manuring significantly increased the total N content of soil. We observed that availability of N in soil is governed by the amount of carbon in acid hydrolysable pool rather than total soil organic carbon content. The information would also be useful for global biogeochemical carbon models for simulation of long-term carbon dynamics.

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Integrated Effect of Vermicompost and Nitrogen Fertilizers on Soil Urease Enzyme Activity and Yield under Onion – Radish Cropping System

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A field experiment was conducted at Hyderabad on a sandy loam soil during *kharif* (onion) and *rabi* (radish) seasons of 2007-08 with a view to study the effect of integrated use of vermicompost and nitrogen fertilizers on soil urease enzyme activity and yield of onion-radish cropping system. The experiment was laid out in randomized block design with factorial concept consisting of twelve treatment combinations taking 3 levels of vermicompost (0, 5 and 10 t ha^{-1}) and four levels of nitrogen (0, 60, 90 and 120 kg N ha^{-1}). In *rabi* (radish) season, all the plots were divided into two equal halves. Fertilizers were not applied to one half to know the residual effect on radish grown during *rabi* after harvest of onion crop. In another half a common dose of 75% of recommended dose of N, P and K fertilizers were applied to radish crop for all the treatments to study the cumulative effect.

The results of the experiment revealed that, application of 10 t vermicompost ha^{-1} + 120 kg N ha^{-1} (V_2N_3) recorded significantly highest fresh onion bulb yield (24.5 t ha^{-1}). However, the bulb yield at V_2N_3 was on par with the yield obtained at V_2N_2 (23.43 t ha^{-1}). The radish crop grown during *rabi* responded favorably to the residual and cumulative treatments and the highest radish yield of 18.5 t ha^{-1} and 23.4 t ha^{-1} was recorded in residual and cumulative treatments at V_2N_3 level. The soil urease enzyme activity at different growth stages of onion and radish revealed that there was increase in enzyme activities up to active growth stages (30 days after transplanting for onion and 15 days after sowing for radish) of crops and later showed a decrease. The results showed that integrated application of 10 t vermicompost ha^{-1} + 120 kg N ha^{-1} (V_2N_3) recorded significantly highest urease activity at 30 (90.8 µg of NH_4^+-N released g^{-1} soil h^{-1}), 60 (75.3 µg of NH_4^+-N released g^{-1} soil h^{-1}), 90 days after transplanting (63.6 µg of NH_4^+-N released g^{-1} soil h^{-1}) and at harvest (38.72 µg of NH_4^+-N released g^{-1} soil h^{-1}) of onion. The cumulative and residual effects at different growth stages of radish revealed that the urease activity was higher in cumulative treatments than residual treatments.

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Comparative Assessment of Enzyme Activities in Vegetable Market Waste during Conventional Composting and Vermicomposting

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The biological decomposition of organic matter is mediated by a variety of biochemical processes in which enzymes play a key role. The quantification of enzyme activity during composting can reflect the dynamics of composting process in terms of decomposition of organic matter and mineral transformation. Therefore, in the present study, the investigation was carried out to determine and compare the different enzyme activities *i.e.* urease, dehydrogenase, acid and alkaline phosphatase and cellulose at different stages of vermicomposting and conventional composting of vegetable market waste at Regional Agricultural Research Station, Anakapalle during 2009. In both the composting methods the urease activity decreased with increasing the composting period. However per cent decrease from initial to a particular period of time was more in vermicomposting than conventional composting and maximum activity was recorded in vermicomposting than conventional composting. The urease activity during vermicomposting of vegetable market waste ranged between 512 and 415 µg NH_4^+ released g^{-1} h^{-1} at 30 and 60 days of composting. In case of conventional composting at 30 and 110 days, it was 325 and 280 µg NH_4^+ released g^{-1} h^{-1}. Dehydrogenase activity also decreased from initial to final composting in both methods of composting and followed the similar trend like urease during decomposition period. The dehydrogenase activity was 79 and 44 mg TPF produced g^{-1} h^{-1} at 30 and 60 days of vermicomposting, whereas in conventional composting at 30 and 110 days it was 36 to 29 mg TPF produced g^{-1} h^{-1}. The acid and alkaline phosphatase activity (µg PNP released g^{-1} h^{-1}) was not significantly changed with incubation in both the composting methods. However, more phosphatase activity was recorded in vermicomposting than conventional composting and it was 48 and 26% increase of acid and alkaline phosphatase activity in vermicomposting than conventional composting. In matured composts, the acid phosphatase activity was 810 and 390 µg PNP released g^{-1} h^{-1} in vermicomposting and conventional composting, respectively. Alkaline phosphate activity due to vermicomposting at 30 and 60 days was 1390 and 1405 µg PNP released g^{-1} h^{-1}. In conventional composting at 30 and 110 days it was 980 and 990 µg PNP released g^{-1} h^{-1}. Cellulase which is responsible for hydrolysis of cellulose, studied to understand the degradation of different organic residues. The cellulose activity (µg glucose released g^{-1} h^{-1}) decreased with incubation in both the composting methods. In vermicomposting the cellulose activity reduced from 845 (30 days) to 760 µg glucose released g^{-1} h^{-1} (60 days), whereas in conventional composting it was reduced from 400 (30 days) to 365 µg glucose released g^{-1} h^{-1} (110 days). The high initial activity of enzymes in both the composts was due to availability of easily degradable substances which resulted in high microbial activity. The decrease in the later stages lead to decrease in microbial biomass. In the maturity stage due to lack of suitable carbon compounds for microorganisms the enzyme activity might have reduced. The present study revealed that the vermicomposting of vegetable market waste recorded higher enzyme activities than conventional method of composting and high enzyme activity at maturity compared to initial stages of composting.

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Effect of Biochar, FYM and Lime on Microbial Resilience of Degraded Acid Soil under Copper Stress

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In the recent years, land degradation has emerged as an important issue due to increasing pressure on land resources caused by rapidly increasing population. This has prompted discussions on sustainability of systems. Sustainable system may be established on these soils. However, an unanswered question is the ability of the soil to be restored to its previous performance level (soil resilience). A research investigation under laboratory condition was undertaken to understand the microbial resilience capacity of degraded acid soil amended with various amendments (biochar, FYM and lime). The soil samples used for incubation studies were collected from a marginally degraded acidic soil at Korba district, Chhattisgarh. The treatment details includes: soil amended with i) FYM, ii) biochar, iii) biochar + FYM, iv) lime and v) soil without amendment (SWA). The biochar and FYM were applied at the rate of 5 g kg^{-1} soil, each as per the treatment details. The Cu stress @ 500 ppm of Cu kg^{-1} soil was given after 10 days of treatment imposition through copper sulphate solution. Periodic soil sampling was drawn at 0, 4, 8, 12 and 16 weeks after copper stress and analyzed for acid phosphatase, alkaline phosphatase, dehydrogenase activity (DHA) and microbial biomass carbon (MBC).

The result from the incubation studies revealed that Cu stress showed significant reduction in all the enzymatic activities and MBC over the control (without Cu stress). The greater reduction in the enzymatic activity during first 8 weeks after Cu stress and thereafter the recovery in acid phosphatase, alkaline phosphatase and microbial biomass carbon were observed in our study. The result also indicates that the per cent reduction in the microbial activity over control (without Cu stress) was the highest in dehydrogenase activity (85.2%), followed by MBC (60.0%), alkaline phosphatase activity (55.9%) and acid phosphatase activity (24.0%), respectively. Among the various amendments, application of biochar + FYM showed greater resistance to Cu stress followed by biochar, FYM and lime at the end of 0 weeks (24 h after Cu stress) with respect to acid phosphatase, alkaline phosphatase, dehydrogenase and MBC, respectively. The resistance and resilience index was also calculated. An index value of 1 at the time of measurement indicates full recovery (maximal resilience), and the lower value indicates a slower rate of recovery. Among the various treatments, soil without amendment (0.62, 0.35, 0.14, and 0.25) showed the lowest resistance index followed by lime (0.69, 0.35, 0.17 and 0.27), FYM (0.72, 0.39, 0.21 and 0.31), biochar (0.74, 0.41, 0.22 and 0.33) and biochar + FYM (0.80, 0.46, 0.27 and 0.39) with respect to acid phosphatase, alkaline phosphatase, DHA and MBC, respectively. The highest resilience index for acid phosphatase enzyme activity was observed in the soil amended with FYM (0.40). Whereas, the highest resilience index for alkaline phosphatase activity, MBC and dehydrogenase activity, was observed in biochar + FYM treatment (0.50, 0.25 and 0.21).

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Optimum and Threshold levels of Different Soil Organic Carbon Pools of Vertisol of AESR 15.1

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Soil organic carbon content has been recognized as one of the important indicators of soil health/ soil quality. In order to work out the threshold and optimum level of different organic carbon pools of Vertisol in AESR 15.1, geo-referenced soil samples (0-15 cm) were collected in 2008 (before the sowing of winter crops) from the farmers fields of Sehore (n=120) and Vidisha (n=156) districts. These soil samples were analyzed for total oxidizable organic C (SOC) by wet digestion method of Walkly and Black (1934) and total organic C (TOC) by CHN – analyzer. The TOC was apportioned into different pools by the modified Walkly and Black method using 5, 10 and 20 mL of concentrated H_2SO_4 that resulted in 3 acid-aqueous solution ratio of 0.5:1, 1:1 and 2:1. The amount of C, thus determined, allowed the apportioning of TOC into very labile C (organic C oxidizable by 12.0 *N* H_2SO_4), labile C (the difference in C oxidizable by 18.0 *N* and that by 12.0 *N* H_2SO_4), less labile C (the difference in C oxidizable by 24.0 *N* and that by 18.0 *N* H_2SO_4) and non-labile C (difference in C between TOC and SOC). Also crop yields during the following winter season (wheat) and rainy season from the geo-reference fields were recorded and the yield data were transformed to % relative yield.

It was observed that SOC (y) was related to TOC (x) in the form of $y = 0.825x - 0.086$ ($R^2 = 0.958$, $n = 276$), indicating that SOC contributes to 82.5% of variation in the TOC in the Vertisol of AESR 15.1. Among the four C pools, very labile C was highly correlated (r = 0.940) with TOC followed by labile C (r = 0.897), less labile C (r = 0.840) and non labile C (r = 0.7877). The mean crop productivity was better related to SOC (r = 0.494) as compared to TOC (r = 0.454). Among the different pools, less labile C was highly correlated (r = 0.559) with the crop productivity, followed by very labile C (r = 0.347), labile C (r = 0.325) and non labile C (r = 0.177). Between the active (very labile + labile C) and passive (less labile + non labile C) pools of C, the passive pool of C was found to have significantly marked influence on crop productivity (r = 0.500) as compared to active pool of C. The threshold (where yields are likely to be < 50% of the recorded maximum yield) and optimum (where yields are likely to be > 80% of the recorded maximum yield) of different C pools were calculated from the regression equation relating % relative yield (y) and different pools of C (x). The threshold and optimum values of SOC were 0.32% and 1.12%, respectively, whereas the same values for TOC were 0.38% and 1.41%, respectively. Since less labile C was found to have better relationship with crop productivity, the computed threshold and optimum value for less labile C were 0.15% and 0.52%, respectively.

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Effect of Long-term Fertilization with and without FYM or Green Manures on Soil Ecology in a Reclaimed Sodic Soil

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A field experiment was established in 1994 on a reclaimed sodic soil at the Central Soil Salinity Research Institute, Karnal involving use of NPK fertilizers with and without FYM or green manures (*Sesbania aculeata*) on rice-wheat cropping sequence. Soil samples obtained in 2009 (*i.e.*, after 15 years), after the harvest of rice, were assessed for microbial groups and their activities. The results have revealed the distinct advantage of addition of FYM or green manuring in rice along with NPK to enhance the biological and biochemical indicators. The application of full recommended amount of inorganic fertilizers (120 kg N, 26 kg P and 42 kg K ha^{-1}) and its combined use with green manure or 10 t/ha FYM and 150% recommended amount (180 kg N, 39 kg P and 63 kg ha^{-1}) significantly enhanced the MBC, dehydorgenase activities and microbial groups. The MBC varied from as low as 120 mg in control to as high as 260 mg kg^{-1} in FYM treated soil followed by 200 mg kg^{-1} in treatment with green manure. With respect to dehydrogenase activity in soil, impact was conspicuous, being 400% increase due to application of FYM or GM along with NPK. Higher MBC and dehydrogenase activities associated in these soils have also shown increased microbial and metabolic quotients. High nitrate reductase activity and population of denitrifiers in the FYM or green manure treatments, however, indicated high potential of dnitrification loss of N. Application of super-optimal NPK (150%) showed depressing effect on some of the enzyme activities in soil. Except fungi, population of bacteria, *Azotobacter*, a free living N fixers, and *Pseudomonas* was higher in the FYM treated soils than rest of the treatments. The data on bacteria-to-fungi ratio showed three distinct patterns: group – 1: Control, NP, and NPK were almost similar ratios and highest values; group – 2: NPK + GM showed lowest ratio; and group – 3: NPK + FYM and 150% NPK were at par and in between group-1 and 2. It was concluded from this study that in a reclaimed sodic soil, higher ecological benefit could be sustained when inorganic fertilizer was combined with organic manures.

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Integrated Effect of Bioinoculation and Chemical Fertilization on Yield of Onion (*Allium cepa*)

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Onion is an important commercial vegetable cum spice crop cultivated extensively and is mainly used for its flavour and pungency. In Orissa the productivity of onion is around 60.45 t ha^{-1} which is comparatively very low. The low productivity of onion is mainly associated with poor nutrient management and more particularly nitrogen whose deficiency limits synthesis of chlorophyll, enzyme and proteins. However, the area under onion cultivation is increasing day by day and hence improved management practices are necessary to give a good yield with qualitative, quantitative and marketable parameters. Therefore, the present investigation was carried out with the sole objective of studying the effect of biofertilizers, inorganic fertilizer levels and organic amendments on the growth, yield and quality of onion and to recommend the most appropriate combinations, which could be considered for the commercial cultivation of onion under Bhubaneswar agroclimatic condition.

Application of recommended doses of inorganic fertilizers in different levels along with biofertilizers and organic amendments increased the yield of bulbs significantly over all other treatment combinations. Maximum yield (9.31 t ha^{-1}) of bulbs was recorded using 75% of recommended dose of inorganic fertilizers along with biofertilizers and organic amendments which was nearly 80% more than the treatment receiving recommended dose of fertilizers (RDF) only. The highest yield under the former treatment may be attributed to the sum of yield attributing characters *viz.*, plant height, number of leaves per plant, bulb diameter, number of rings per bulb, root count *etc*.

Yield per unit area also increased significantly over control by the application of inorganic fertilizers or biofertilizers alone but the combined effect of chemical fertilizers along with the biofertilizers and organic amendments yielded the highest as the biofertilizers boosted the yield attributing characters.

Integration of biofertilizers with inorganic fertilizers help reduce the use of recommended dose of inorganic fertilizers by 25% while maintaining the desired yield level. Results further showed that microbial biomass carbon (MBC) and microbial biomass respiration (MBR) where significantly influenced by the balanced and integrated application of biofertilizers with chemical fertilizers and organic amendments.

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Effect of AM Fungi (VAM) Cultures from Different Farming Situations on Root Colonization, Productivity and Soil Fertility in Soybean in P-Deficient Acid Alfisol of North Western Himalayas

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A pot experiment was conducted at the Soil Science Department Greenhouse of CSK HPKV Palampur with the aim of identifying the most suitable AM fungi culture for rain-fed soybean production under P deficient Alfisol of north western Himalays. Experimental material consisted of cultures belonging to 5 farming situations existing in the university campus itself. The cultures were screened out from the soils of maize harvested field, vegetable field, tea and citrus orchards. The experiment was conducted in CRD with four treatments replicated five times. The soil used in pot experiment had 110, 5, 278 kg $ha^{-1}$of available N, P and K, respectively. The soil pH was 5.2 whereas, organic carbon content was 3.5 g kg^{-1} soil. Respective VAM spore counts of above cultures were 160, 170, 200, 160, 160 and 240 per 250 g of dry soil. A basal dose of 2 t FYM on dry weight basis was applied in all the pots. While full recommended doses of N and K were applied, only half of recommended P was applied. Seven kg of sterilized soil was thoroughly mixed with 2 kg FYM and 1 kg mycorrhizal soil collected from different locations and packed in the pots. The crop was raised up to maturity. Results revealed that the culture from vegetable cultivation dominated fields gave the highest seed yield (14.1 g pot^{-1}) of soybean. Root infectivity observations at maximum flowering stage gave the highest values (28%) in case of cultures from vegetable and soybean fields whereas, lowest values were found under cultures from tea and orchard soils. Soil fertility assessment after crop harvest indicated lowest NPK availability in pot soils inoculated with cultures hailing from vegetable fields indicating more nutrient solublization/ availability to plants through concerned VAM culture which also reflected in enhanced seed and straw yields of soybean crop. It can be inferred from above study that VAM culture screened out from vegetable fields proved to be the most efficient for production of rain-fed soybean under P deficient acid Alfisol of north western Himalayas.

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Effect of Quantity and Frequency of Vermicompost Application on Physicochemical Properties of Soil under Maize-Wheat Cropping System

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A field experiment was conducted at Agriculture Research Station, Banswara at fixed site with 16 treatment combinations comprised of two fertility levels *i.e.* 100 and 75% RDF, Four vermicompost levels *i.e.* 0, 5, 7.5 and 10 t ha^{-1} and two frequency of vermicompost applications *i.e.* every year and in alternate year. Experiment was laidout in split plot design with fertility levels as main treatment and vermicompost levels and frequency in subplots with three replications *at Agriculture Research Station Borwat farm, Banswara at fixed site during 2009-10 and 2010-11*. Results indicate that application of vermicompost at both levels of fertility significanlly increased grain yield and nutrients uptake by both crops in rotation. The highest mean grain yield of 2.91 t ha^{-1} of maize and 3.78 t ha^{-1} of wheat obtained by 10 t ha^{-1} vermicompost application which was 71.7 and 24.8 per cent higher as compared to control plots. Treatment differences among the frequency plots were significant after two year of experiment. Application of vermicompost every year was more beneficial as compared to once in two years. Further, the response to vermcompost application was more pronounced at lower levels of fertility during both years of experimentation. The mean grain yield of maize and wheat decreased about 11.5 and 4.1 per cent under 75% RDF as compared to 100% RDF. Availablity of nutrients in soil were influenced under organic treatment. Organic carbon increased significantlly under vermicompost application. However, available P and K contents were not reached to the level of significance.

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Influence of Phosphorus Solubilizing Fungi and Phosphorus Levels on Growth and Yield of Maize and Soil Properties

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A field experiment was conducted at MARS, UAS, Dharwad during *rabi/summer* season of 2009-10, to study the influence of phosphorus solubilizing fungi (PSF) and phosphorus levels on growth and yield of maize and soil properties. The experiment was laid out in RCBD with fifteen treatments and four replications. These treatments consisted of three levels of phosphorus substitution *viz*., 0, 50 and 100 per cent of the recommended P_2O_5 along with PSF_1, PSF_2, PSF_3 and no PSF inoculation. Seed inoculation with P-solubilizing fungi along with P_2O_5 application increased plant height, number of leaves per plant, dry matter production, grain weight per cob, cob weight, number of grains per cob, number of rows per cob, grain yield and soil nutrient status *i.e.* P_2O_5, K_2O, Fe and Cu and microbial activity (phosphatase activity) at harvest. Stover yield, dehydrogenase activity, available N and available Zn in soil were not significantly differing among various treatments. Enhanced growth and increased yield of maize were achieved when P-solubilizing fungi treated along with 100% RD of P_2O_5 application compared to 0 and 50% RD of P_2O_5. It is concluded that single and dual inoculation along with P-fertilizer was 20-23 per cent better than control to improve grain yield of maize.

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Nutrient Transformation in the Mycorrhizosphere of Isolated AM Species from Different Agroclimatic Zones of Jammu

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Three agro-climatic zones of Jammu region *i.e.* sub-tropical (altitude vary between 300 to 1000 m AMSL), intermediate (altitude vary between 1000 to 1500 m AMSL) and temperate zones (altitude vary between 1500 to 2500 m AMSL) were surveyed for isolation of AM spore indigenous to the soils falling under these zones. Five strains of endomycorrhizae from different agro-climatic zones of Jammu were identified on the basis of their morphological characteristics as per standard methodology. The spores identified were nomenclatured as: AM-1: *Glomus mosseae*, AM-2: *Glomus fasciculatum*, AM-3: *Glomus intraradices*, AM-4: *Gigaspora* sp., AM-5: *Acaulospora* sp. The viability of AM fungal spores has been evaluated in terms of root colonization. A significant difference was evident in the root colonization that ranged from 6 to 67 per cent, 5 to 65 per cent and 4 to 42 per cent in *G. mosseae, Glomus fasciculatum* and *Gigaspora* sp. inoculated soils, respectively.

Spore production varied with respect to species composition and type of soil. Soil samples from Banota, Tikri, Thein, Kotlibhagwan, Chowkichora and Jhajarkotli (sub-tropical zone) of Jammu region displayed spore density of 7 g^{-1} of soil ($\bar{X}$). Whereas, intermediate zone (Kishtwar, Rajouri, Kalakote, Ramnagar, Ramgarh, Kagote, Chenani, Solki, Sailsui, Siot, Kud and Sunderbani) displayed spore density of 9 g^{-1} of soil. In soils falling under temperate zone the distribution of AM spore population was found higher in soils of Batote (13 g^{-1} soil) whereas least distribution of AM spore population was found in Dhomail soil (9 spores g^{-1} soil). As for the predominance of different AM species, spore density of *Glomus fasciculatum* was higher (4 spores g^{-1} soil) followed by *G. intraradices* (3 spores g^{-1} soil) whereas spore population of *Acaulospora* sp. was reported to be minimum with the corresponding value of 1 spores g^{-1} soil. The AM spore count had positively significant correlation (r = 0.712**) with available phosphorus in intermediate zone followed by temperate zone (r = 0.863**).

The isolated AM species were further investigated for their efficacy in releasing mineral nitrogen and phosphorus in mycorhizosphere. In the soils of subtropical zone, maximum release of N was observed in soil inoculated with *Glomus mosseae* with a value of 4.26 mg kg^{-1} soil followed by *Glomus fasciculatum and Gigaspora* sp. with the corresponding mineral N values of 3.50 mg kg^{-1} soil and 2.93 mg kg^{-1} soil, respectively. Under intermediate zone, the amount of average mineral nitrogen (5.01 mg kg^{-1} soil) release was found to be higher in soils inoculated with *Glomus mosseae* while the *Gigaspora* sp. inoculated mycorrhizosphere mineralised nitrogen @ 3.45 mg kg^{-1} soil. The mineral N release was significantly higher in *Glomus mosseae* inoculated soil compared to *Glomus fasciculatum* and *Gigaspora sp.* under temperate conditions.

Phosphorus moblised in mycorrhizospheric soils under subtropical zone by inoculation of *Glomus mosseae* was 6.58 mg kg^{-1} soil followed by *Glomus fasciculatum* with the corresponding P value of 6.22 mg kg^{-1} soil. Likewise, in intermediate zone, soils inoculated with *Glomus fasciculatum* showed highest P availability of 6.63 mg kg^{-1} soil followed by *Glomus mosseae* (6.47 mg kg^{-1} soil) .The least P availability was observed in *Gigaspora* sp. with the corresponding value 6.19 mg kg^{-1} soil. Under temperate conditions, Maximum average P availability was observed in *G. mosseae inoculated* soils having P value of 8.74 mg kg^{-1} soil followed by *Glomus fasciculatum with* 8.44 mg P kg^{-1} soil. The least average P availability has been noticed in *Gigaspora* sp. to the tune of 8.18 mg kg^{-1} soil P.

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Soil Microbial Biomass Dynamics under Continuous Cropping in Long-term Fertilizer Experiment of Coimbatore, Tamil Nadu

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The Indian Council of Agricultural Research (ICAR) in collaboration with State Agricultural Universities (SAU) initiated the All India Co-ordinated Research Project on Long Term Fertilizer Experiments (LTFE) in 1972 at Tamil Nadu Agricultural University (TNAU), Coimbatore. The main objective is to study the effect of continuous application of fertilizer nutrients on soil microbial dynamics under maize - finger millet cropping sequence. Totally this experiment consisted of ten treatments which were replicated four times in randomized block design (RBD).

The soil samples were collected after the harvest of finger millet and maize 92nd (*kharif*) and 93rd (*rabi*) crops and processed for soil analysis. Enumeration of bacteria, fungi and actinomycetes population, and biomass nitrogen and biomass carbon was done in the above soil samples.

The results revealed that the highest root biomass yield was observed in the 100% NPK + FYM (INM) treatment followed by the treatment received 100% NPK+ $ZnSO_4$. The INM treatment significantly recorded the highest bacterial population of 110, 98 x 10^{-6}, fungal population of 29, 27 x 10^{-3} and actinomycetes population of 13, 11 x10^{-4} for finger millet and maize, respectively. Bacterial and fungal population were found to be highest in the treatment received INM followed by 100% NP. Similarly, biomass carbon and nitrogen were also found to be higher in the INM treatment followed by application 150% NPK.

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Effect of Urban Compost and Bio-Solid Waste (Sludge) on Growth of Eucalyptus, Teak and Neem Trees

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A study was conducted during 2009-10 to recycle the Greater Hyderabad Muncipal Corporation (GHMC) urban compost (UC) generated in Autonagar dumping yard, bio-solids (sludge) generated in Sewage Treatment Plant, Amberpet, Hyderabad to find out their effect on growth of eucalyptus, teak and neem trees. The teak and eucalyptus trees located at AICRP on Agro Forestry farm and neem trees located at student farm, Dept. of Forestry, College of Agriculture, Rajendranagar, Hyderabad were used in the study. The design of the experiment was factorial RBD with three replications. The treatments included application of different solid wastes (No solid waste (control), urban compost (UC), biosolid waste (sludge) and urban compost + biosolid waste (1:0.5 ratio) applied in three different levels (18.5 kg UC / 8.0 kg biosolid / 9.25 kg UC + 4 kg sludge, 37 kg UC / 16.0 kg biosolid / 18.5 kg UC + 8 kg sludge, 55.5 kg UC / 24 kg biosolid / 27.75 kg UC + 12 kg sludge waste) per tree. The age of different tree species ranged from four to six years. The level of urban compost and biosolid waste were fixed based on their N composition, so as to supply recommended dose of 100 g N/tree. During first week of November, 2009 the treatments were imposed and data on girth of the trees at base (2" above ground) and girth at breast height (142 cm above ground) and total plant height were collected after one year and three months of the imposition of treatments.

The experimental soil was sandy loam in texture, slightly acidic in reaction, non- saline, low to medium in organic carbon content, low in available N, medium to high in available phosphorus and low in available potassium contents. The urban compost and biosolid waste analysis indicated that, every 100 kg of urban compost can supply 0.54 kg N, 1.19 kg of P, 0.414 kg of K, and 1.112 kg of Ca, 0.367 kg of Mg and 0.18 kg of S. Similarly, every 100 kg of biosolid (sludge) can supply 1.228 kg of N, 1.572 kg of P, 0.368 kg of K, 0.843 kg of Ca, 0.278 kg of Mg and 0.99 kg of S. The urban compost was found to be unsafe with regard to Cr (274 mg kg^{-1}), Cu (785.1 mg kg^{-1}), Fe (26,700 mg kg^{-1}) , Pb (528.5 mg kg^{-1}), Ni (76.6 mg kg^{-1}) and Zn (903.9 mg kg^{-1}). It was safe with regard to As, Co, Hg (all <0.1 mg kg^{-1}), and Mn (541 mg kg^{-1}). Similarly the sludge from Amberpet contained unsafe quantities of heavy metals like Cd (215.9 mg kg^{-1}), Cr (263.7 mg kg^{-1}), Cu (620.5 mg kg^{-1}), Fe (31,200 mg kg^{-1}), Ni (69.3 mg kg^{-1}) and Zn (1705 mg kg^{-1}) and it was in safe limits with regard to As, Co, Hg (all < 0.1 mg kg^{-1}) and Mn (399 mg kg^{-1}).

Different tree species showed differential response to the applied solid waste materials. In case of eucalyptus, significantly higher mean basal girth (39 cm) was recorded with application of urban compost + sludge (1: 0.5) at 27.75 kg UC + 12 kg sludge dose followed by only UC at 18.5 kg level (36.3 cm) and UC + sludge (1: 0.5) at 18.5 kg UC + 8 kg sludge dose (36.1 cm) as compared to no manures application (control) (30.4 cm). The girth at breast height (ranged from 22.4 to 26.7 cm) and plant height (ranged from 9.0 to 10.6 m), which were not significantly influenced by different treatments.

In case of teak trees, the highest mean girth at breast height was recorded with application of UC at 37 kg dose (53.4 cm) followed by UC at 55.5 kg dose (51.2 cm) and UC at 18.5 kg dose (49.5 cm) as compared to the control (31.1 cm). Application of only sludge was found to be inferior as compared to UC or UC + sludge. The basal girth (ranged from 40.8 to 61.0 cm) and plant height (ranged from 8.3 to 9.3 m) was not significantly influenced by different treatments.

In case of neem trees different treatments did not show significant influence on basal girth, girth at breast height and plant height. These parameters ranged from 44.7 to 51.6 cm, 35.9 to 44.9 cm and 6.3 to 7.0 m, respectively. The neem trees under control which did not receive neither sludge nor UC or mixture of UC + sludge relatively showed higher values of growth parameters.

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Impact of Long-term Manure and Fertilizer Application on Bulk Density and Microbial Population of Soil

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The present investigation was carried out to study the impact of various manure and fertilizer treatments continuously uplied for 16th years on the changes in bulk density and microbial population in a long-term manure and fertilizer experiment at Sabour, Bhagalpur. The soil of the experimental site is sandy loam alluvial having EC 0.26 dS m^{-1}, pH 7.6 organic carbon 4.6 g kg^{-1}, total N, P and K were 0.080, 0.050 and 0.244%, respectively whereas available N, P and K were 221, 16.5 and 210.4 kg ha^{-1}, respectively. The experiment was laid out in randomized block design with 19 treatments and three replications. After 16 years of continuous cropping (maize-wheat), the soil samples were collected and analyzed for bulk density. However the composite soil samples were used for estimating microbial population.

Data indicated that the increasing nutrients or graded doses of NPK fertilizer showed lesser bulk density than control. It may be due to the higher organic carbon content in fertilizer treated plots. Similarly, soil under treatment T_{13} (20 t FYM ha^{-1}) and T_{19} (Compost 10 t ha^{-1} + N_{20} P_{20}) showed lower bulk density (1.20 mg m^{-3}) than control (1.41 mg m^{-3}).

It was observed that higher microbial population was recorded in T_{13} (20 t FYM ha^{-1}) plots. In general NPK fertilizer application either with FYM or compost increased microbial population. Application of FYM @ 20 t ha^{-1} alone or in combination with P, showed highest bacterial population in soil. It varied from 1.51 to 2.71 g^{-1} soil. The fungal population varied from 1.40 to 1.97 g^{-1} soil. Continuous use of fertilizer and manure recorded highest fungal population in the treatment T_{13} (1.97 g^{-1}) followed by T_{14} (1.94 g^{-1}) and T_{15} (1.90 g^{-1}), where FYM and P or P+N were applied. A balance dose of fertilizer NPK significantly increased the actinomycetes population over control. The actinomycetes count has been highest (2.35 g^{-1}) in treatment where FYM @ 20 t ha^{-1}.

Azotobacter counts varied from 1.45 to 2.20 g^{-1} soil. The *Azotobacter* counts was higher in FYM treated plots than application of inorganic fertilizer treated plots.

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Release of Potassium from Soil Applied with Graded Levels of Fly Ash with Silicate Solubilizing Bacteria and Farm Yard Manure

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An incubation experiment was conducted to study the release characteristics of potassium from native soil and applied sources *viz*, fly ash (FA), silicate solubilizing bacteria (SSB) and farm yard manure (FYM). The soil for incubation study collected from Eastern block of Agricultural Engineering College and Research Institute which is medium in potassium status. The treatments consist of graded levels of FA *viz.*, 0, 12.5, 25, 37.5 and 50 g kg^{-1} of soil with and without SSB and FYM. Six sets of plastic containers consist of 40 numbers in each set to accommodate 20 treatments with 2 replications under factorial completely randomized design for 15, 30, 45, 60 75 and 90 days duration of incubation. The calculated quantity of FA, SSB and FYM was applied to each container containing 10 g of soil and maintained submergence throughout the incubation period. Neutral *N* NH_4OAc extractable K was estimated flame photometrically at 15 days interval *i.e.* 15, 30, 45, 60 75 and 90 days of incubation.

The results revealed that among the different treatments such as SSB, FYM and SSB + FYM, the application of FYM with SSB recorded the highest NH_4OAc extractable K. The highest NH_4OAc-extractable K of 172.0 kg ha^{-1} was recorded by the addition of SSB + FYM at 30th day of incubation. The application of SSB had comparatively low effect on increasing the NH_4OAc-extractable K over control throughout the incubation period, however, the application of graded levels of fly ash increased it. A consistent release of K was noticed due to addition of FYM. Among the graded levels of fly ash, application of 50.0 g kg^{-1} fly ash to soil recorded the highest mean NH_4OAc-extractable K of 153.4 kg ha^{-1} when compared to 129.3 kg ha^{-1} recorded at control. The interaction of graded levels of fly ash with different treatments have resulted a significant increase over control throughout incubation period. A consistent increase of K release was observed up to 30th day after incubation thereafter slight decrease of K was noticed. From 45th to 90th day of incubation the interaction of graded levels of fly ash with all treatments was not conspicuous in K release.

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Impacts of Transgenic *Bt* Cotton on Yield and Biochemical Parameters in Rhizosphere under varied Soils

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Transgenic *Bt* cotton is genetically modified to have agronomically desirable traits. But there is a concern that *Bt* cotton carry genes that could have undesirable effects on natural and agro-ecosystem functions. Keeping in view the above points in mind, the present study is designed to evaluate yield and biochemical parameters under varied soils with *Bt* and non-*Bt* systems. The experiment was conducted in a net-house on three different soil orders *viz*. Entisols, Inceptisols and Alfisols during wet season (July to December) in 2010. *Bt*-cotton (*cv* NCS-138) and its non-transgenic isoline (*cv* NCS-138) were grown until maturity. Rhizosphere soil and plant samples were collected periodically at 50, 100 and 150 days after sowing. A significant reduction in dehydrogenase activity (9.4%) but an increase (8.5%) in alkaline phosphatase activity was associated with *Bt* cotton over non-*Bt* isoline at three growth stages. Alfisols exhibited higher root infection as compared to Inceptisols and Entisols. Arbuscular mycorrhizal fungi colonised both the *Bt* and non-*Bt* cotton cultivars equally, providing firm evidence that both the *Bt* and non-*Bt* cotton cultivars were equally capable of establishing mycorrhizal symbiosis. Available mineral-N in soil was reduced by 12-13%, whereas Olsen-P was increased by 7.8% because of *Bt* cotton. It was observed that available K value varied from 82.9 to 76.9 kg ha^{-1} in the soil under *Bt* cotton and from 90.3 to 83.5 kg ha^{-1} in the non-*Bt* crops. A significant increase in the available Zn in the soils under *Bt*-cotton over non-*Bt* isoline was also observed. *Bt* cotton showed comparatively more root length (m $plant^{-1}$) than non-*Bt* throughout the different growth stages. Higher shoot and root biomass (weight) was found in *Bt* crop than that of non-*Bt* isoline. Our results suggest that although there are constraints of the *Bt* trait on soil microbial and nutrient cycling in the agro-ecosystem, but there were some positive or no negative effects of *Bt* cotton on the studied indicators.

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Influence of Fipronil on Some Microbiological Parameters and Enzymatic Activity of Soil

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We assessed the influence of fipronil, a pyrazole insecticide on microbial biomass carbon (MBC), basal and substrate induced respiration (BSR and SIR) and on the activities of fluorescien diacetate (FDA), dehydrogenase, β-glucosidase, alkaline phosphatase, and arylsulphatase in a clay loam alluvial soil. Fipronil was incorporated in the soil at field rate (0.675 μg ml^{-1}) and 2-fold (1.350 μg ml^{-1}) and 10-fold higher (6.75 μg ml^{-1}) of field rate along with a control and incubated at 25-30 ^{0}C under 60% water holding capacity for different periods of time (1, 3, 7, 15, 30, 45 and 60 days). Initially fipronil increased the FDA but subsequently decreased. A similar trend was also observed for MBC, BSR and SIR. By contrast, a short lived and transitory detrimental effect was observed on alkaline phosphatase, arylsulfatase, β-glucosidase and dehydrogenase. These findings suggest that fipronil had little inhibitory effect on soil microbial properties and enzymatic activities when applied in recommended rates.

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Recycling of Organic Wastes for the Production of Vermicompost and its Response in Adsorption of Cadmium

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Investigations were made to recycle agricultural wastes for the production of vermicompost using earthworms (*Eisinia foetida*). Six different sources of organic waste including farm yard manure, cow dung vermicompost, vegetable crop residues, dry mango leaves, fresh temple wastes (floral tributes, milk *etc*. offered to Lord Vishwanath, Varanasi), and green grass/weed residues were used for making vermicompost. The study showed that biodigested wastes and green weeds were an ideal combination for vermicompost considering the nutrient content, CEC and compost maturity period. A laboratory study was also conducted to evaluate the effect of vermicompost in sorption of cadmium through standard batch culture technique. The data were fitted to the logarithmic form of the Freundlich equation; log x/m =log k + 1/n log C_e. The values of k range from 1.921 to 5.628, with maximum adsorption found in case of vermicompost derived from grass/weed residues. The adsorption capacities of all the vermicompost samples were high enough to be effectively supplemented for the removal of excess cadmium from any soil. Vermicompost was able to adsorb nearly 80-99% of the cadmium in solution at variable concentrations. The flow rate (1/n value) ranged from 1.673 to 8.192 was affected only slightly for the removal of Cd (II) ions in vermicompost. Adsorption capacity of vermicompost for cadmium was seen to be mostly enhanced by the higher water holding capacity, organic carbon and the total phosphorus content of the vermicompost. Vermicompost was also analyzed to be nutritionally richer than general garden compost. The parameters like cation exchange capacity, water holding capacity, organic carbon and phosphorus content which enhanced the adsorption capacity of vermicompost also tend to improve the physical and fertility status of the soil. High adsorption capacity of vermicompost was demonstrated and an alternative for effluent treatment offered, especially due to its ease in acquisition and low price.

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Dynamics and Stability of Soil Organic Carbon in Different Land Use Systems of Sodic Vertisol and Reclaimed Sodic Soils

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Yield plateau in rice-wheat system along with diminishing factor productivity is a serious problem engulfing the agriculture. Identification of efficient and sustainable land use system has, therefore, assumed greater significance under these circumstances. Soil organic carbon (SOC), one of the largest terrestrial carbon pools, enhances soil quality, reduces soil erosion and degradation, and increases soil productivity. The SOC is also an index of soil fertility and crop productivity. The restoration of SOC pool in lands put to agricultural use represents a potential sink for atmospheric CO_2 thereby, has the potential to offset the effect of anthropogenic carbon emission to a great extent. The management and enhancement of SOC is important for sustainable agriculture. Influence of land-use on SOC build-up and identification of efficient and sustainable land use system for the purpose, therefore, assumed greater significance under present era of climate change. Keeping this in view, seven land use systems established on reclaimed sodic soils of Karnal, Haryana and three land use systems of sodic Vertisol of Bharauch, Gujarat were evaluated to ascertain the changes in SOC. The results showed that SOC decreases more rapidly with depth in reclaimed sodic soil than that of sodic Vertisol. Since pedoturbation is common phenomenon in sodic Vertisol, the SOC in the profile get uniformly distributed. Thus, SOC was found to be more evenly distributed in sodic Vertisol of western part of India than that of reclaimed sodic soil of North-West Indian conditions. Soil organic matter stability under different systems were also estimated for the sodic Vertisol under three different land uses comprising of agriculture, woody perennials and pasture-based systems. Woody perennials and pasture-based systems recorded higher value than agriculture-based systems.

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Influence of Value-added Organic Manures and Mineral Fertilizers on Soil Enzymatic Activity and Grain Quality under Maize-Wheat Rotation

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To evaluate the short-term effect of organic manures and chemical fertilizers on soil health and grain quality, enzyme activities (dehydrogenase and urease) and chemical composition of grain were monitored. A field experiment was carried out in an Inceptisol (Typic Haplustept) under maize-wheat cropping sequence. Eight treatments consisting of three different organic manures (vermicompost, NADEP compost and FYM) and chemical fertilizers in various combinations were used to study the changes in enzyme activities in soil at different growth stages of crops. It is evident that application of organic manures and chemical fertilizers resulted in significant increase in dehydrogenase and urease activity over control throughout the growth period of maize and wheat. The highest dehydrogenase activity was reflected under integrated application of organic manures and chemical fertilizers, while the highest urease activity was noticed in 100% NPK. Integrated application of organic manures and chemical fertilizers was found to maintain significantly higher dehydrogenase and urease activity as compared to soils amended with organic manures alone throughout the growth period of maize and wheat. Significantly higher dehydrogenase and urease activity were observed during the active crop growth stage in case of both maize (seedling and tasseling stage) and wheat (CRI and flowering stage) than maturity stage. Applications of 50% NPK along with organic manures significantly improved grain mineral composition and yield. Grain protein content and test weight of both maize and wheat were found to improve under integrated nutrient management and equal to 100% NPK. It can be concluded from the study that application of value-added manures not only effectively reduced mineral fertilizers dose but increased grain yield, enhanced grain quality with improving soil quality.

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Clay Mineralogy of Soils Formed on Granite-Gneiss Parent Materials in Renigunta Mandal of Chittoor District, Andhra Pradesh

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The mineralogical and chemical characteristic of soils developed from Granite-Gneiss and alluvium parent materials in Chittoor district of Andhra Pradesh were studied. The clay film invariably exhibited the characteristic peaks of illite, kaolinite, quartz and feldspars. Semi-quantitative estimation of clay fraction based on the relative areas under corresponding peaks indicated that the pedons 1, 2, 3, 4, 5, 6 and 7 are dominated by mica followed by kaolinite. Further, pedons 1, 2, and 6 contains 9, 18 and 24 per cent feldspars respectively whereas pedons 5 and 7 contains 9 and 4 per cent quartz respectively. However, use and management of the soils for agriculture production required an understanding of the clay mineralogy.

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Characteristics, Classification and Suitability Evaluation of Soils of Rohtas District, Bihar

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Soils occurring on different landforms of Rohtas district, Bihar are studied for their characterisation, classification and suitability evaluation for various crops. Soils of the district are mostly developed in two distinct landforms, viz. (1) hills of Kaimur plateau and (2) alluvial plain of Son river. The soils in the hill top of Kaimur plateau are moderately shallow, well drained, yellowish red to reddish brown and fine loamy in texture. The soils are classified as fine-loamy, mixed, hyperthermic Typic Haplustepts and moderate to severely eroded with sparse forest vegetation. The soils occurring in escarpment are very shallow, excessively drained, yellowish brown in colour and gravelly sandy loam in texture. Soils are classified as loamy-skeletal, mixed, hyperthermic Lithic Ustorthents and are severely eroded with no vegetation cover. The soils in the foot hill slope are deep, well drained, yellowish red in colour and sandy loam in texture. The soils are classified as coarse-loamy, mixed, hyperthermic Typic Haplustepts and moderately eroded with sparse vegetation.

The soils of gently sloping plain are very deep, well drained, dark yellowish brown to reddish brown in colour and fine loamy in texture. Soils are classified as fine-loamy, mixed, hyperthermic Typic Haplustepts. Soils are slightly eroded and mostly under vegetable cultivation. The soils of nearly level alluvial plain are very deep, imperfectly drained, yellowish brown to dark greyish brown in colour and fine in texture. Soils are classified as fine, mixed, hyperthermic Aeric Endoaquepts. Soils are mostly under paddy cultivation in *kharif* and wheat/mustard cultivation in *rabi* season.

The soils in the hills are strongly to slightly acidic (pH 5.4 to 6.4) and in other landforms, they are moderately acidic to mildly alkaline (pH 5.9 to 7.6). The organic carbon content of the surface soils is low to medium (0.21 to 0.62%) and it decreases gradually with depth (0.26 to 0.12%). The clay content of the soils varies from 12.3 to 38.8%. The CEC of the soils is low to medium (3.6 to 21.5 cmol(p^+)kg^{-1} and base saturation is medium to high (60 to 98 %). The $CaCO_3$ content of the soils ranges 2.3 to 12.2 percent.

The suitability evaluation of the soils is carried out for various crops viz. mustard, pigeon pea, banana, citrus, potato and chilli. The study indicates that the soils of hill top are marginally to unsuitable for all crops due to the limitaions of slope, gravelliness, soil depth, acidity and moisture stress. The soils on escarpment are unsuitable for all crops due to steep slope, gravellines, depth and acidity. The soils occuring on foot hill slopes are moderately suitable for pigeon pea, banana, citrus, potato and chilli for the limitation of slope and soil acidity and marginally suitable for mustard and banana due to slope and light texture. Soils of gently sloping alluvial plain are highly suitable for mustard, pigeon pea, banana, citrus and moderately suitable for potato and chilli due to higher pH. Soils of nearly level alluvial plain are moderately suitable for most of the crops due to improper drainage and textural limitation. In the hills of Kaimur plateau, afforastation with suitable conservation measures should be taken as the soils are not suitable for crop production The culltivation of various crops in other landscapes can be continued with high yield by improved management practices.

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Soil Resource Database for Farm Planning in Lower Indo Gangetic Alluvial Plain

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Soil survey on 1:12,500 scales is one of the effective methods for identifying, characterizing and classifying the problems and potentialities of the soil resources at the farm level. The accuracy and predictability of such kind of survey enhanced by the use of modern techniques of remote sensing and GIS, which spined off the new dimensions in storing and retrieving the data and to arrive at optimal solution / action plans for sustainable development. A case study of such kind of survey was taken in lower part of Indo-Gangetic plain covering Puinam village clusters of Polba-Dadpur block, Hugly district, West Bengal. Cadastral maps were reduced to a uniform scale of 1:12,500 and integrated with satellite Imagery (IRS P6 LISS IV) and used as a base map. Based on image characteristics, the study area divided into upland, lowland and transition land between these two. Six soil series were identified and it was mapped in 10 mapping units to the level of phases of soil series. Soil landform relationship revealed that soils on the upland were deep, well drained sandy loam to loam soils on the surface and silt loam to silty clay loam in the sub surface. Low land contained very deep, imperfectly drained to poorly drained, silty clay loam to silty clay soils on the surface and silty clay to clayey soils in sub surface. Transitional land between upland and low land showed very deep, moderately well drained, clay loam to silty clay loam soils on the surface and silty clay loam to silt loam soils in sub surface. The study indicated that integration of soil map with the cadastral maps of 1:12,500 scales is very effectively deliver the plot wise soil information to the farmers in terms of soil morphology, properties related to soil moisture and fertility which are needed for developing sustainable land use plan.

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Soil Quality Indicators for Different Soil Orders with Rice-Potato-Sesame Cropping Systems and Determination of their Critical Values

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We screened soil quality key indicators and determine their optimum and threshold values for *Inceptisols, Entisols* and *Alfisols* with rice-potato-sesame (R-P-S) cropping systems. Soil samples (66 numbers) were collected at 0-0.20 m depth from fields growing the cropping systems for a long time and analysed for a large number of physical (bulk density, textural analysis and aggregate analysis and structural indices and aggregate associated organic carbon), chemical (soil pH both in water and 0.02 M $CaCl_2$, cation exchange capacity, very labile (VL), labile (L), less labile (LL) and non labile (NL) and total soil organic C, available N, P, K, Ca, Mg, B and DTPA extractable cationic micronutrients) and biological (microbial biomass carbon, C_{mic}; microbial biomass nitrogen, N_{mic}; mineralizable carbon, C_{min}; mineralizable nitrogen, N_{min}; and a few enzymes such as dehydrogenase, fluorescein diacetate hydrolyzing, b-glucosidase, acid and alkaline phosphatase and aryl sulphatase) attributes. The average yield of individual crop for the last five years for each geo-referencing site was also collected from the farmers and equivalent rice yield (ERY) was calculated for each of the sites. Out of the 40 attributes, cation exchange capacity, microbial biomass C and dehydrogenase activity were screened as key indicators of soil quality in *Inceptisols*; whereas organic C, aggregate stability and dehydrogenase activity were for *Entisols*; but organic C, available Zn, aryl sulphatase and â-glucosidase activity were for *Alfisols*. The optimum values of cation exchange capacity selected as key indicator of the soil was 15 cmol (p^+) kg^{-1} for producing 80% of the maximum yield. Such optimum values for microbial biomass C (C_{mic}) was 625.6 µg C g^{-1} for obtaining good yield and maintaining soil health in *Inceptisols*. Again, for good yield and maintaining soil health in *Inceptisols* and *Entisols*, on an average, dehydrogenase activity of the soils should be about 100 and 55 µg TPF g^{-1} soil $24h^{-1}$. The optimum value is almost double than the thresholds values of available Zn in *Alfisols*.

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Assessing Soil Health with Key Indicators for Soils of a 21-year Old Long-term Fertility Experiment with Different Management Practices and Rice-Rice Cropping System

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We assessed health of soils under different management practices using a 21-year old long-term fertility experiment with rice-rice cropping system in *Alfisols*. The management practices were control, 100% recommended dose (RD) of N, 100% RD of NPK, 50% RD of NPK + 25% N as farm yard manure (FYM) + 25% N as green manure (GM), 100% RD of FYM and fallow. Soil health was assessed analysing a large number of physical (soil texture, bulk density, hydraulic conductivity, aggregate stability and structural indices), chemical (soil pH, cation exchange capacity, pools of organic C, available N, P, K, S, Fe, Mn, Zn, Cu and B, exchangable Ca and Mg, total organic C and N) and biological (mineralizable C and N, microbial biomass C and N, dehydrogenase, fluorescein diacetate, *â*-glucosidase, urease, acid and alkaline phosphatase and aryl sulphatase activity, population of fungi, total bacteria, actinomycetes, non-symbiotic N-fixing, phosphate solubilizing and cellulolytic bacteria) attributes of soil following standard protocol. Results showed that among the treatments, soils with sole FYM had higher values of organic C, aggregate stability and aggregate associated C but available N and P were higher with NPK+GM+FYM treatment. There was a preferential enrichment of C was noted in macro-aggregates than in micro-aggregates in all the treatments; and organic inputs accelerated such process of enrichment. The mineralizable C, microbial biomass C, dehydrogenase, acid and alkaline phosphatase, *â*-glucosidase and fluorescein diacetate activity were also highest in soils with sole FYM > NPK+GM+FYM > NPK > N > fallow > control treatments. Microbial population also followed a similar trend. Microbial biomass C, very labile pool of organic C and available B were screened as the key indicators of soil health. The soil health index values for soils with different management practices were as follows: FYM > NPK+FYM+GM > NPK > N > fallow > control.

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Soil Quality Assessment using Soil Organic Carbon, Total Nitrogen and Microbial Properties in Tropical Agro-ecosystems of North-East India

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Assessment of soil quality is an invaluable tool in determining the sustainability and environmental impact of agricultural ecosystems. The study was conducted to assess the quality of the soils under traditional cultivation practices, i.e. shifting cultivation, agriculture practice, forestry plantations of *Pinus kesiya* Royle ex-Gordon, *Alnus nepalensis* D.Don, *Parkia roxburghii* G.Don, *Michelia oblonga* Wall. and *Gmelina arborea* Roxb.) and modified agroforestry system of Agri-horti-silvi-pastoral system using soil organic carbon (SOC), soil total nitrogen (STN) and soil microbial biomass C (SMBC) and N (SMBN) at ICAR Complex for NEH Region, Umiam, Meghalaya, India. Agri-horti-silvi-pastoral system comprises of agricultural crops (*Zea mays.* L., *Glycine max.* L, *Oryza sativa.* L, *Marihot esculenta*. C, *Colocasia esculenta* L, *Brassica juncea*.), horticultural crops (pineapple; *Ananus squennssa* L., citrus; *Citrus sp*.), alder trees species (*Alnus nepalensis*) and fodder grasses (stylo;*Stylosanthes guyanensis,* guinea;*Panicum maxicum*, setaria;*Setaria sphacelata* and local grass;*Imperata cylindrical*.

Soil samples were collected from soil depths of 0-5 cm and 5-10 cm in all the agro ecosystems and analyzed for physical, chemical and biological properties. The experimental soils are mostly silty clay loam in texture. The forestry plantation had significantly ($P < 0.05$) higher SOC and STN in both soil depths than all the other soils due to greater C inputs into the soil by addition of more root and shoot biomass and more litter fall. The shifting cultivated areas had the lowest SMBC value of 184 mg kg^{-1} while soil under *Michelia oblonga* plantation had the significantly ($P < 0.05$) highest value of 628 mg kg^{-1}. Burning for clearing vegetation and poor stocking of forestry plantations may impair the quality of the soil under shifting cultivation. The proportion of SMBC to total soil organic carbon (SOC) was in the range of 0.37 to 4.28% across all the systems. The SMBC as a percentage of SOC were higher in the surface soil, 0-5 cm than 5-10 cm soil depth in all the soils. These results may be due to greater C and N inputs, which might have stimulated in greater soil microbial biomass production, into the surface soil. In all the soils, the SMBC/SMBN ratios were >6.6 suggesting fungal domination in all the agro ecosystems. The forestry plantation soils had higher SMBC and SMBN as a percentage of SOC and STN respectively than the cultivated arable land soils. The study suggests that the forestry followed by agri-horti-silvi-pastoral system seems to be of better option for sustainable crop production with maintenance of soil quality/health under tropical agro-ecosystems of North-east India.

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Assessing Soil Quality in Semiarid Agroecosystem of India

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A soil quality index (SQI) was determined for soils collected from different land use system of Nalgonda and warangal District of Andhra Pradesh. Total 22 physical, chemical and biological properties of soil were analyzed for all the soil samples. The surface map of soil properties was prepared using the spherical semivariogram parameters through ordinary kriging interpolation techniques using Arc-GIS software. To determine the SQI, four main steps were followed: (i) to define the goal(s); (ii) to select a minimum data set (MDS) of indicators that best represent soil function; (iii) to score the MDS indicators based on their performance of soil function; and (iv) to integrate the indicator score into an index of soil quality. The minimum data sets were chosen using two procedures. One is using Prinicipal Component analysis (PCA) and another is based on contribution of soil parameters to soil function through expert comments. The yield information was considered as goal variable and it was collected from the farmers through survey. All crops' yield were converted to paddy equivalent yield by multiplying a factor considering the Indian market price of that crop to that of paddy. Soil samples were grouped as Alfisols, Inceptisols, and Vertitic Inceptisols and Vertisols soil as per its respective soil order and three principal component analyses were carried out separately for three soil orders. The PCs receiving high eigenvalues and comprising variables with high factor loading were assumed to be the variables that best represent the system attributes and chosen for minimum data set (MDS). To reduce redundancy and to rule out spurious groupings among the highly weighted variables within a particular PCA, Pearson's correlation coefficients were used to determine the strength of the relationships among variables. After choosing the MDS indicators each MDS indicator were converted into score between 0-1 by following a linear scoring technique. Another conceptual approach to compute soil quality index based on expert opinion was also used to calculate SQI. Here the minimum data set of indicators were identified that best represent soil function. The indices included only those indicators thought to contribute to the function of interest. Here four soil function indices were used: nutrient cycling, water availability, resistance to degradation and salinity and sodicity for calculating SQI. The choice of soil functions to index was also driven by concern voiced by participating farmers during project work.

A multiple regression analysis showed there was significant dependence between goal variable i.e., yield with four supporting soil functions. Also there was good relationship ($r^2 = 0.596$) between two procedures of calculating SQI i.,e., by using PCA and by using conceptual framework for calculating SQI. Calculated SQIs resulted in the order of these land use systems: castor < Intercrop< Redgram< sorghum< cotton< maize< fallow< rice. Irrigated systems had better soil quality than areas where rainfed agriculture was practiced. Among the different soil order, Vertic Inceptisols and Vertisols had highest SQI followed by Inceptisols and Alfisols A kriged map of SQI (using soil function) for Nalgonda and Warangal was prepared.

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Impact of Nutrient Management on Soil Quality in Long Term Fertilizer Experiments in India

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Unlike air and water we don't have definite soil parameters and their limits to define soil quality. To assess soil quality, soil indicators (soil properties), are usually linked to soil function. These soil indicators are sensitive to management. Long-term fertilizer experiment provides an opportunity to assess soil quality under different nutrient management practices. Improved soil quality often is indicated by increase in infiltration, aeration, aggregate size, soil organic matter and decrease in bulk density. To identify soil indicators minimum data set is defined covering the physical, chemical and biological properties of soil. On the basis of data generated through long-term fertilizer experiment soil indicators were identified. The study reveled that at different location different soil indicators are responsible for soil quality and therefore indicators are site specific. For instance at Ranchi Ca, Mg, pH, hot water soluble boron (HWSB), soil microbial biomass N (SMBN) were identified as soil indicators whereas at Bangalore bulk density (BD) was found to be among the soil indicators. In Vertisols, mean weight diameter (MWD) and hydraulic conductivity in addition to available K, pH were main soil indicators. Whereas, in Vertisols of Coimbatore, soil organic carbon along and available nutrients were found to be masters indicators. Thus, soil indicators are site specific. Once the soil indicators are identified then soil quality can be worked out using the following relationship. Larger the value better is soil. The soil quality index is calculated by using the following equation :

$$SQI = \sum_{i=1} wisi$$

where, *S* is the score for the subscripted variable and wi weighted factor derived from principal component analysis (PCA). Higher is the score better is the soil quality.

SQI is relative numerical figure which indicate the condition of soil at that point of time under a particular management and how it has affected by management practices. More is the SQI better is the soil quality. By using this concept, soil indicators were identified through PCA and using their relative contribution in productivity. SQI was calculated for some of the sites of long term fertilizer experiments.

The data indicated that at Palampur pH, DHA, SHC, MBC and MBN and PAWC were main soil indicators. Data revealed that continuous use of N alone resulted decline in soil quality whereas balanced use of nutrient resulted increase in soil quality. The SQI calculated were found to be more or less same in NPK, NPK+ lime but greater than control which suggest that balanced application of nutrient improved soil quality. However, incorporation of organic manure further improved the soil quality. Yields are also sustained at higher levels In these treatments which suggest that balanced use of nutrient not only sustained the yield but also improved the soil quality. Similar trend was also observed at Bangalore and Coimbatore. However, SQI values were relatively larger at Coimbatore because of higher reference (control). Thus, nutrient management in balanced and integrated manner is best option to enhance soil quality irrespective of soil and cropping system.

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Soil Health and Fruit Quality of Papaya Under Organic and Conventional Farming

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The objective of this study was to understand how the organic practices in papaya production increase the soil and fruit quality over inorganic practices in tropical conditions. The experiment was initiated during June, 2005 at Indian Institute of Horticultural Research (IIHR), Bangalore, experimental farm using variety 'Surya' with following eight treatments *viz.*, T_1- Recommended NPK fertilizers, T_2- 10 kg FYM plant^{-1} y^{-1}, T_3-7 kg urban compost plant^{-1} y^{-1}, T_4- 20 kg sunhemp + 150 g rock phosphate plant^{-1} y^{-1}, T_5- 2 kg neem cake +0.5 kg wood ash plant^{-1} y^{-1}, T_6- 18 kg rural compost plant^{-1} y^{-1}, T_7- 2.5 kg vermicompost + 12.5 kg sunhemp plant^{-1} y^{-1}, T_8- No manure or fertilizer. Before initiation of experiment, soil chemical properties were analysed and it was compared after two years of the experimentation. In addition, soil microbial qualities in the form of soil respiration, mineralizable nitrogen, microbial population, enzyme activities *viz.*, urease, dehydrogenase β-glucosidase, phosphatase, growth parameters, fruit quality and yield were analysed. The results indicated that, the performance of crop growth and fruit yield (55 t ha^{-1}) was higher in inorganic fertilizer applied treatment compared to organic manure applied treatments (26.9 – 38.7 t ha^{-1}). There was no significant variation in average fruit weight, TSS and N and K content between organic treatments and conventional treatment. But, the shelf life of fruit was found to be significantly higher in organic manure amended treatments (6.2-7.9 days) as compared to inorganic fertilizer applied treatment (5.1 days). Among the treatments, application of 7 kg urban compost plant^{-1} or 10 kg FYM plant^{-1} was found to be ideal for increasing the soil qualities in the terms of microbial population, bio-chemical reaction and nutrient status as compared to other treatments.

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Georeferenced Soil Fertility Status for Optimized Fertilizer Use in Yavatmal District of Maharashtra

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The georeferenced soil fertility status of Yavatmal 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 144 villages from sixteen tahsils of Yavatmal district during December, 2010. 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 georeferenced soil samples (858) were collected using Geographical Position System (GPS) in Yavatmal district. The soil pH ranged from 6.47 to 8.79. The electrical conductivity of soil varied from 0.03 to 0.44 dS m^{-1}.

The free $CaCO_3$ content found to vary from 0.75 to 15.0 per cent. It was found higher in Babulgaon tahsil. Organic carbon content in the soil ranged from 1.19 to 9.87 g kg^{-1} which was higher in Zari Jamni tahsil (2.13 - 9.87 g kg^{-1}).

The available nitrogen varied from 52.7 to 295.0 kg ha^{-1} out of which 99 per cent samples were found in low category. The available phosphorus ranged from 2.16 - 61.93 kg ha^{-1} in which 35.4 per cent samples were found in low category. The available potassium ranged between 112.0 to 941.0 kg ha^{-1} where in 77.6 per cent samples were found high while 20 per cent samples were found medium. The available sulphur ranged from 7.50 to 42.29 kg ha^{-1} in which 10.7 per cent samples were deficient and 68.9 per cent samples were found medium.

The available zinc ranged from 0.10 - 4.99 mg kg^{-1} where in 68 per cent samples were deficient and 30 per cent samples were in medium category. The available iron ranged from 1.20 to 54.37 mg kg^{-1} out of which 4.8 per cent samples were deficient while 71.9 per cent were under medium category. 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 1.01, 1.76, 2.75 and 2.09, respectively. The nutrient index of nitrogen was low, phosphors and sulphur were medium whereas the nutrient index of K was found low. The nutrient indices of Zn, Fe, Mn and Cu were found to be 1.31, 2.18, 2.99 and 2.94 respectively. The nutrient index of zinc was found low while that of iron was medium. The nutrient indices of Mn and Cu were recorded high.

It could be inferred that, fertility of soils in Yavatmal district of Maharashtra was low in nitrogen and zinc, medium in phosphorus and iron while high in potassium, copper and manganese.

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Spatial Variation of Fertility Status of Soils of Upper Brahmaputra Valley Zone of Assam

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A study of the fertility status of the soils of Upper Brahmaputra Valley Zone of Assam representing Jorhat, Sivasagar and Golaghat district was made during 2010-11 using GPS and GIS technique. About 10 percent villages were selected from each block of each district and a total of 1339 georeference surface (0-15 cm) soil samples were collected from selected identified farmer's fields. The collected soil samples were analysed for available major nutrients and micronutrients. The available N ranged from 178-439, 178-344 and 184-398 kg ha^{-1} for Jorhat, Sivasagar and Golaghat districts, respectively. Similarly, available P_2O_5 and K_2O varied from 14.8-39.4 and 102.6-244.1 kg ha^{-1}, 10.5-34.2 and 101.3-241.2 kg ha^{-1}, 14.2-36.3 and 138.7-316.0 kg ha^{-1} for Jorhat, Sivasagar and Golaghat districts, respectively. In respect of micronutrients, the DTPA-extractable Fe, Mn, Zn and Cu ranged from 10.6-168.5, 3.52-52.39, 0.26-0.88 and 0.22-10.88 mg kg^{-1}, respectively for Jorhat district, 11.2-129.1 3.52-52.39, 0.25-2.68 and 0.26-12.08 mg kg^{-1}, respectively for Sivasagar district and 23.4-201.9, 8.96-30.68, 0.23-1.25 and 1.09-10.88 mg kg^{-1}, respectively for Golaghat district. Hot water soluble boron (HWSB) varied from 0.29-0.95, 0.29-0.96 and 0.21-0.63 mg kg^{-1} for Jorhat, Sivasagar and Golaghat districts, respectively. Irrespective of all the districts, soils exhibited deficiency in N, P_2O_5 and K_2O content ranging from 6.0 to16.0 per cent for N, 11.0 to 15.0 per cent for P_2O_5 and 14.0 to 17.0 per cent for K_2O.

Based on the critical levels of micronutrients, all soils were adequately supplied with DTPA-extractable Fe, Mn and Cu. However, zinc was found to be mostly deficient nutrient in all these three districts followed by boron. Available zinc was found about 34, 23 and 34% deficient in Jorhat, Sivasagar and Golaghat district, respectively, whereas, in case of boron, it was recorded as 21, 17 and 49% in Jorhat, Sivasagar and Golaghat district, respectively.

Correlation studies indicated that major nutrients showed positive and significant correlation with pH, while significant negative correlation was observed with micronutrients. Highly significant positive correlation was observed between organic carbon and N, P_2O_5 and K_2O (r=0.231**, 0.120*, 0.385** for Jorhat district, r=0.487**, 0.142**, 0.159* for Golaghat district and r=0.150*, 175*, 0.108* for Sivasagar district). Similar significant positive trend was also recorded in between micronutrients and organic carbon. In respect of EC, no significant correlation was found with major and micronutrients.

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Soil Health as Influenced by Nutrient Management Practices in Five Different Cropping Systems in a Vertisol of Northern Transition Zone of Karnataka

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Maintaining and improving soil fertility for sustainable agriculture is becoming more crucial due to increasing complexity of the nutrient problems. To overcome these problems proper nutrient management practices is to be followed. A field experiment was conducted to study the effect of nutrient management practices on soil health and crop response under different cropping systems in a Vertisols of northern transition zone of Karnataka at Main Agricultural Research Station, UAS Dharwad during 2007-08. The objectives of study were to know the effect of these nutrient management practices on soil quality in terms of nitrogen release pattern, enzymes activity and soil fertility. The experiment was laid out in strip plot design with three nutrient management practices as main plots and five predominant cropping systems of the zone as sub-plots with three replication. The initial soil pH was 7.30, EC 0.30 dS m^{-1}, organic carbon was 4.9 g kg^{-1} and available N, P_2O_5, K_2O and S were 240,16,330 and 12 kg ha^{-1}, respectively. Among the nutrient management practices organic plot recorded significantly higher soyabean (2.79 t ha^{-1}), groundnut (3.71 t ha^{-1}) and chilli (1.00 t ha^{-1}) equivalent yields where as integrated plots recorded significantly higher maize (4.33 t ha^{-1}) and potato (4.72 t ha^{-1}) equivalent yields and were found superior over inorganic plots. Both organic and inorganic fractions of nitrogen in soil increased over time under organic followed by integrated nutrient management practices during both *kharif* and *rabi* seasons. Whereas nitrogen fractions under inorganic nutrient management practice increased up to 60 DAS and later declined. The dehydrogenase, phosphatase and urease activity were found to be maximum under integrated followed by organic nutrient management practice and their activity increased up to 30 DAS and then sharply declined. After harvest of *rabi* crops the soil organic carbon in organic plots increased by 32.6%. Similarly in integrated plot it increased by 17.1% whereas in inorganic plot soil organic carbon decreased by 11.0% over the initial value. The available N, P_2O_5, K_2O and S content of soil increased by 19.1, 46.3, 9.6 and 54.0%, respectively, similarly DTPA-extractable Zn, Fe, Mn and Cu increased by 18.6, 30.6, 36.5 and 30.0%, respectively under integrated nutrient management practice over their initial values. The contribution of humic acid to total soluble humic fractions was more than the fulvic acid in organic plot. Legume based cropping systems in the investigation recorded significantly higher nitrogen fractions in soil under organic and more so with INM practices which indicates their buildup in soil. Similarly legume based cropping system at the end of their crop cycle improved the soil fertility status with respect to available N, P_2O_5, K_2O, S and micronutrients content of soil . Soil fertility as well as biological activity of soil declines under intensive and high energy demanding cropping system such as chilli + cotton warranting not only high nutrient use preferably with integration of organics and inorganic but also crop rotation essentially involving legumes for sustained productivity over time.

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Effect of Different Sources of Silicon on Growth of Seedlings in FCV Tobacco Nursery

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More and more reports are coming out on the importance of silicon (Si) as a plant nutrient in many crops, in the recent past. Silicon is known to increase the photosynthetic activity, lodging resistance in crops. It is also known to impart pest and disease resistance. Large area under tobacco in Zone-7 has red sandy soils subjected to heavy leaching of Si. But so far, there is no recommendation for Si use in tobacco. Hence, a study was conducted to evaluate different Si sources for their influence on growth of FCV tobacco seedlings in the nursery. A field experiment was conducted at Zonal Agricultural Research Station, Shimoga for two years during 2009 and 2010. The study involved nine treatments and three replications tried under RBD. The treatments included three sources of Si *viz*., Ca-silicate, rice hull ash and oligomeric silicon tried under different levels and compared with control (no Si). The soil of the experimental site belongs to the textural class of sandy loam with available Si content of 14 mg kg^{-1} and is classified under Typic Haplustalf.

Results of two years of the study indicate that there was a significant improvement in the plant height, leaf area per plant and number of transplantable seedlings m^{-2} of tobacco nursery due to application of Si. Highest number of transplantable seedlings (208 m^2) was recorded with application of RHA @ 1.5 kg m^{-2} followed by oligomeric Si spray @ 6 ml L^{-1} (203 m^{-2}), while control recorded only 146 seedlings per m^2. Spray of oligomeric Si @ 6 ml^{-1} recorded highest leaf area (3.07 dm^2 $plant^{-1}$) followed by calcium silicate @ 1.5 kg m^{-2} (2.86 dm^2 $plant^{-1}$) all which were significantly superior to control (2.04 dm^2 $plant^{-1}$). Economics of the use of different sources of Si indicated highest additional returns of Rs. 855 per 115 m^2 of nursery with the application of rice hull ash to soil @ 1.5 kg m^{-2}. With an ICBR of 1:4.6, this was found to be very useful for tobacco nursery. Foliar spray of oligomeric silicon @ 6 ml L^{-1} with an ICBR of 1:3.9 was found to be next best.

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Efficient Use of Soil Nitrogen in Rainfed Lowland Rice Ecosystem

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In vast areas of rainfed lowlands in eastern India, only one crop of rice is grown in wet season and the fields remain fallow through the dry season due to inadequate water supply. When flooded or saturated soils dry and become aerobic in dry season, NH_4 formed from mineralization of organic N is oxidized to NO_3 which may accumulate in the soil or be used by the plants. Nitrate N accumulated in the soil and unused by plants through the dry season may be lost through leaching and denitrification when the soils are subsequently flooded and puddled for rice cultivation. Such loss from the soil profiles of Khurda district, Orissa has been found to range from 20.7 to 52.3 kg NO_3 N ha^{-1}. Besides depleting soil N fertility, this practice (rice-fallow copping system) contributes to pollution of ground water and atmosphere. Conservation and recycling of NO_3 accumulated in soil profile during dry season are necessary for sustenance of soil N fertility in rainfed rice lands. Growing of drought-tolerant legumes in dry season and incorporation of their biomass into soil when the lands are flooded and puddled for planting wet season rice offers an opportunity for conservation and recycling of soil nitrogen. Besides capturing soil NO_3, the legumes fix atmospheric N_2 and thereby help in sustenance of soil N fertility in rainfed lowlands. Growing of horsegram (*Dolichos biflorus* L.) on residual soil moisture through the dry seasons (from Nov/Dec to Feb/Mar) and incorporation of its residues into soil at the time of land preparation for planting *kharif* rice, reduced fertilizer N requirement by about 30 kg ha^{-1} and increased farm productivity in Khurda district, Orissa. Adoption of dry, direct-seeded rice culture that eliminates soil flooding and puddling for crop establishment provides further opportunity for effective use of residual NO_3 present in soil.

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Impact of Land Use Management System on Carbon Storage, Yield Sustainability and Soil Fertility in Acid Soils of Nagaland

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The prevalent agri-based land use patterns in the hill and mountain ecosystem of north eastern hill (NEH) region of India represents complex, diverse and risk prone (CDR) agricultural production systems. The average annual rainfall is 1825 mm, 90% of which is experienced during June to September. Geologically, the rock sequence of the region is dominated by Disang, Borail, Surma, Tipam and Dihing groups. These groups are characterized by ramifying quartz veins with few serpentinised intrusions, well bedded sandstone with shale inter- relations, alternations of shales and sandstone with conglomerates, ferruginous sandstone of huge thickness of clay layers, and pebble beds with clays and sands. The average altitudes of the districts are – Dimapur 275 m, Kohima 1250 m, Wokha 1350 m and Mokokchung 1375 m above mean sea level. The present study was carried out in diverse land use systems (LUS) to establish relationship between soil fertility and yield sustainability over a wide altitude range in Nagaland as a footstep for developing land use based soil quality indices for future. Soil fertility traits, crop productivity and their inter relationships revealed considerable variations in response to land use management practised and altitude. Irrespective of altitude, the maximum soil pH (4.85) was recorded in lowland paddy LUS while the lowest pH (4.43) was observed in upland terraces. The maximum soil organic carbon (SOC) (31.34 g kg^{-1}) was observed in natural forest LUS, whereas, upland terrace LUS recorded the lowest (11.09 g kg^{-1}). Vegetable based LUS was the most promising human managed system in terms of nutrient cycling potential with higher contents of soil available N, P and K (330, 9.11 and 194 kg ha^{-1}, respectively) coming second only to natural forest LUS where no anthropogenic activity is involved. Vegetable based LUS performed even better than natural forest LUS in terms of available micronutrients (DTPA- Mn, Cu and Zn) barring some erratic results regarding DTPA-Fe. Prominent effects of altitude were also recorded on soil parameters irrespective of LUS. There was a steady increase in soil organic carbon content with altitude from 15.79 kg ha^{-1} in Dimapur (275m above msl) to 22.16 kg ha^{-1} in Mokokchung (1375 m above msl), whereas soil pH declined from 4.85 to 4.45 with increasing altitude within that range. Soil available N along with all the micronutrients studied (DTPA-Fe, Mn, Cu and Zn) registered a constant increase with altitude; whereas, soil available P and K recorded a steady decline. Soil pH was positively correlated with all the major nutrients studied, the strongest one being with soil available P. Strong negative correlation of soil pH with DTPA-Fe and Mn irrespective of LUS and altitude was also prominent. Soil organic carbon (SOC) was positively correlated with available N. The strongest positive correlations of SOC with available N in natural forest (r=0.91; p= 0.01), vegetable based (r = 0.91; p= 0.01) and lowland paddy LUS (r= 0.94; p=0.01) reflects healthy nutrient transformation reactions underway therein.

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Refinement of Soil Test-based Fertilizer Dose for Chickpea (*Cicer arietinum* L.)

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Present investigation was carried out to assess fertility status of important chickpea growing areas of north Karnataka and to tailor soil test based fertilizer doses to achieve sustainable and higher grain yields. Thirty black soil samples were collected from chickpea growing fields in northern Karnataka and were subjected to fertility and chemical analysis. Soils belonged to Vertisols order. The soils were neutral to slightly alkaline in reaction and were non saline. Available nitrogen was the most deficient and all the soils were rated as low for available nitrogen. The soils were either medium or high in available phosphorus. Available potassium status was higher in most of the soils and almost all the soils were rated as sufficient. Among the micronutrients, zinc and iron were the most deficient. Based on the soil test rating of these soils, six experiments were conducted in the farmers' fields with recommended fertilizer dose and modified recommended fertilizer doses adopting different approaches of modification under different soil test rating categories. The experiments were conducted under different rating of available N, P_2O_5 and K_2O status. Soil test crop response fertilizer (STCR) dose with higher doses of applied nitrogen and phosphorus recorded the highest grain and straw yield in all the experiments. Enhanced N fertilizer dose by 25 and 50 per cent under low status of soil nitrogen and enhanced P_2O_5 fertilizer dose by 25 per cent under medium P_2O_5 status of soil available P also recorded higher crop yields compared to fertilizer dose that had been modified following state agricultural department criteria.

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Nitrogen Release Patterns and its Availability to Maize (*Zea mays* L.) in Relation to Soil Fertility Ratings in a Vertisol of Transitional Zone of Northern Karnataka

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To evaluate the release pattern of nitrogen in relation to soil fertility ratings, nutrient uptake and its effect on yield of maize crop a field experiment was carried out on a Vertisol at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2008-09. The experimental site has the pH of 7.67, E.C 0.39 dS m^{-1}, available nitrogen 224 kg ha^{-1}, available phosphorus 33 kg/ha, available potassium 334 kg ha^{-1}, while the ammonical nitrogen, and nitrate nitrogen were 13.8 kg ha^{-1} and 8.0 kg ha^{-1}, respectively. The design adopted was RBD with nine treatments replicated thrice.

Ammonical, nitrate and available nitrogen did not differ significantly among the treatments except in the treatment which received 30 per cent more nitrogen than RDF. Treatment receiving 30% more nitrogen than RDF recorded the highest content of ammonical, nitrate and available nitrogen throughout the crop growth period. It was followed by the treatment which received 20% more nitrogen than RDF. At knee high stage NPK content of the index leaf differed significantly among the treatments. Higher nitrogen with RDK treatments recorded higher N and K content in the index leaf but the opposite trend was observed in P content. Higher nitrogen with less RDK recorded the highest content. Treatment which received 30 per cent more nitrogen than RDF recorded the higher N and K content while treatment which received higher nitrogen and less potassium than RDF recorded the higher P content in the index leaf. At tasselling stage, NPK contents differed significantly among the treatments. Treatment which received 30 per cent more nitrogen than RDF recorded the higher N and K content and the treatment which received higher nitrogen and less potassium than RDF recorded the higher P content. The lowest NPK content was observed in the control. Yield differed significantly and however the highest grain yield of 10.78 t ha^{-1} was observed in the treatment which received 30 per cent more nitrogen than RDF and it was closely followed by the treatment which received higher nitrogen and less potassium than RDF recorded an yield of 10.76 t ha^{-1}. The lowest yield was observed in control (5.84 t ha^{-1}) and FYM treatments (6.06 t ha^{-1}), respectively. The decrease in the potassium content than RDK did not show much effect on the yield. NPK content in the grain and stalk differed significantly and the treatment which received 30 per cent more nitrogen than RDF recorded the higher N and K content. Treatment which received higher nitrogen and less potassium than RDF recorded the higher P in both grain and stalk. The lower N, P and K content was recorded in the control treatment. Nitrogen and P differed significantly among the treatments. The treatment which received 30 per cent more nitrogen than RDF recorded the highest N and P content in the soil after harvest of the crop and however the lowest N and P content was recorded in the control treatment. Potassium content did not differ significantly among the treatments and however the highest content was recorded in the treatment which received 30 per cent more nitrogen than RDF.

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Supplementation of Nutrients through Foliar Application for Boosting the Yield of Alphonso Mango

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A field experiment was conducted for three years to study supplementation of nutrients through foliar application for boosting the yield of Alphonso mango at Regional Fruit Research Station, Vengurle. Forty years old Alphonso mango trees were selected for trial. Nutrient salts/fertilizers easily available in local market were selected which is needed of lateritic soil. Three concentration formulations were prepared to test efficacy. The fertilizer urea, SOP and salts $ZnSO_4$, $CuSO_4$, borax and sodium molybdate are water soluble salts. Source of P as SSP dissolved in water and water soluble P was added in solution by filtering the solution. Filtration of SSP was carried out for non chocking of pump nozzle. As per treatments three sprays were applied to the Alphonso plants every season. First spray was given at bud break stage, second at flowering initiation/ on flowering and third at egg size fruit. The pooled mean result shows that the flowering percentage, no of fruits, yield (kg ha^{-1}) differed significantly. Spraying of T_4 : 0.5% (urea, SOP, SSP each) + 0.25% ($ZnSO_4$, borax, $CuSO_4$ each) + 0.01% (sodium molybdate) first spray at bud break stage, second at full bloom inflorence stage, third at egg size fruit showed statistically significant flowering percentage, fruit set, fruit yield and non scorching of leaves as well as inflorescence. Treatment T_4 pooled mean indicated fruits yield (50.24 kg $tree^{-1}$) and 1: 3.15 C:B ratio. Reduce spongy tissue. Observed lowest spongy tissue at tune of 3% in treatment T_4, however in control treatment it was 12.10%. Increase inflorences and fruit set. –Increased inflorences (65.00%) and fruit set (280/plant) in treatment T_4 and better TSS over other treatments. No changes in soil properties was observed due to treatment, however in the leaf samples, reduction in the nutrients content were observed after harvest of crop than at start of experiment every year. The content of nutrients in the leaves were increased due to foliar application at end of experiment than initial (start of experiment) leaf sampling.

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Identification of Soil Fertility Constraints in North Karnataka by GIS Technique

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The importance of soil fertility to the health and survival of all life cannot be understated. As human population continue to increase, human disturbance of the earth's ecosystem to produce food and fiber will place greater demand on soils to supply essential nutrients. If we do not improve and/or sustain the productive capacity of our soils, we cannot continue to support the food and fiber demand of our growing population. It is therefore important to monitor the nutrients status of soil from time to time with a view to monitor the soil health.

Hence, georeferenced information on the location, extent, quality of spatial data is a must for advisory purposes. Geographic information system (GIS) can be used in producing a soil fertility map of an area, which will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally. This is an important technique for formulating site specific recommendation of nutrients.

Soil fertility status in representative micro watershed/village from four agro-ecological zones of north Karnataka such as northern dry zone (Zone-3), northern transition zone (Zone-8), hill zone (Zone-9) and coastal zone (Zone-10) was studied and mapped nutrients status by GIS technique for identification of soil fertility constraints. Detailed strategies for management of nutrient constraints were elucidated.

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Preliminary Identification of Potassium Needs in Banana using GIS

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The leaf analysis information is made use for making site-specific decision in many crops. Soil analysis information at the same time helps in better understanding of the plant nutrient requirement. The major task is to determine how well the plant analysis data agree with the soil test report so that a common yield-limiting nutrient can be identified and management practices are planned accordingly. Site-specific nutrient management strategies are developed using GIS (Geographic Information System) for developing need based nutrient management strategy in banana. Nutrient contour maps for potassium were prepared for a selected banana orchard using GIS technique at initial stage and at flowering stages to assess the impact of management induced practices on K level in soil and plant. Three management zones for soil available potassium in the range of 25 to 93 ppm, 94 to 162 ppm and 162 to 231 ppm were delineated. The percentage of area under each management zones were identified based on nutrient contour maps prepared at initial and flowering stages The available potassium at initial stage was in the range of 25 to 93 ppm in bulk of the area (62%) within the plot and there was no significant build up in available potassium at flowering stage, although there were isolated pockets having available potassium in the range of 93 to 162 ppm due to management practices. Potassium concentration in plant varied from 1.5 to 4.5 ppm at flowering stage. Potassium concentration in plant was grouped in to three ranges *viz.* <3.84 ppm, 3.84 to 4.87 ppm and >4.87 ppm. Plants grown in 28% of the area had potassium less than 3.84% at the initial stage of sampling and this increased to 82% at flowering stage. The super imposing the soil nutrient contour maps with plant nutrient concentration maps indicated that soil analysis data agreed well with the plant analysis information and relationship between soil and plant analysis results of K was distinctly different from that of immobile nutrients like Zn in banana. The maps prepared showed that there was a large variability with spatial pattern in K status in soil and the nutrient map was found useful in avoiding error due random sampling for better nutrient management in banana.

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Response to Iron Application by Fe-efficient and Inefficient Varieties of Gram (*Cicer arietinum L.*) for Fe Enrichment in Grain

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Biofortification of staple food crops is sustainable strategy to defeat iron malnutrition in the population depend on the plant origin diet. Screening for Fe efficient genotype having ability to enhance Fe content in food grain is basic objective for iron biofortification programme. A field experiment was conducted in *rabi*, 2009 to screen 20 diversified genotypes of gram on soil deficient in available Fe content at Anand. Different treatments of Fe *viz.*, 20 kg Fe ha^{-1} as soil application alone and in combination with 0.5% $FeSO_4$ foliar spray at three different physiological growth stage (flowering, pod development and grain filling stage) were imposed and grain of gram were analyzed for total Fe content after harvest. The genotypes GG-1 and GAG-735 were identified as Fe- efficient while ICCC-4 and GJG-305 were considered as Fe-inefficient genotypes based on both yield and uptake efficiency indices.

During *rabi*-2010 a microplot experiment was conducted to study the effect of external Fe application on Fe enhancement in grain of selected varieties from Fe-efficient and Fe-inefficient groups keeping six different Fe treatments comprising of two Fe levels (0, 20 kg ha^{-1}) and four foliar spray treatments of 0.5% $FeSO_4$ spray at different growth stages (flowering, pod development grain filling and combination of all stages). The results revealed that Fe application enhanced Fe content in grain of gram varieties of Fe -inefficient group (ICCC-4 and GJG-305) maximum by 31 per cent over no-Fe application (34 µg g^{-1}). In general, the Fe contents of grain and different plant parts of gram were more with Fe spray at all the growth stages than soil application of Fe. Further, it was also noticed that Fe concentration of upper and lower leaves of gram varieties of Fe-inefficient group was maintained at higher level than Fe-efficient group; whereas, reverse trend was noticed in stem and root. The results indicated that Fe-enrichment of grain due to Fe supplimentation in Fe-inefficient varieties was maximum upto 41.9 ìg g^{-1} which was higher by 10 per cent over Fe-efficient group of varieties.

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Influence of Bioinoculation and Soil Amelioration on Yield, Nutrient Recovery and Crop Quality of Ragi-Berseem Cropping System in Inceptisols of Bhubaneswar

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A field experiment was conducted in a sandy, acidic (pH 5.40) soil having organic carbon content of 4.81 g kg^{-1} soil, available N-200 kg ha^{-1}, Bray's P-14 kg ha^{-1} and available K of 111 kg ha^{-1} during *kharif* and *rabi* seasons of 2010 in the campus of College of Agriculture, OUAT, Bhubaneswar. The two test crops ragi (cv. Nilanchal) and berseem, grown during *kharif* and *rabi* seasons respectively, had received eight different treatments, namely : (1) no nutrient- control, (2) 100% NPK (based on soil test), (3) 100% NPK + FYM @ 5 t ha^{-1}, (4) 100% NPK + VC @ 2.5 t ha^{-1}, (5) 100% NPK + FYM + BI , (6) 100% NPK + VC + BI , (7) 100% NPK + lime (as PMS @ 0.1 LR to ragi and @ 0.2 LR to berseem) + FYM + BI and (8) 100% NPK + PMS + VC + BI. Each treatment was replicated thrice in statistically laidout field with in RBD design. The 100% NPK dose was 40-20-30 for ragi and 20-20-40 for berseem, supplied through urea, 20-20-0-13 (Navaratna), muriate of potash, respectively. Both the crops were grown up to maturity with all intercultural operation and package of practices. Berseem crop was given four cuttings at 25 days intervals. Lime as paper mill sludge was applied as basal. Bioinoculation of crop was done through the application of *Azotobacter, Azospirillum* and PSB in 1:1:1, applied @ 3 kg each ha^{-1}, inoculated to pre limed (5%) vermicompost in 1:25 ratio, incubated for 7 days at 30 per cent moisture and applied as basal either mixed with FYM or vermicompost.

The grain yield of ragi and fodder (green) yield of berseem in absolute control fields were 5.7 and 72.5 q ha^{-1}, respectively. The yields due to 100% soil test based NPK dose were significantly higher compared to absolute control and were 18.1 and 185.6 q ha^{-1}, respectively indicating fertilizer responsiveness of the crops. Bioinoculation of crops integrated with FYM and fertilizers resulted in increased yield by 19 and 20 per cent, but with vermicompost and fertilizers, the increase was 27 and 25 per cent, respectively. Soil amelioration with PMS, along with BI and fertilizers application to crop, when applied with FYM, resulted in increased grain and fodder yield by 31 and 25 per cent, and when applied with VC increased the yield by 17 and 15 per cent compared to the yields due to integration with bioinoculants, respectively. In addition to the yields, the nutrient recovery and the quality of the crops were influenced significantly by bioinoculation , particularly when integrated with the application of organics and soil amelioration with lime as PMS. From this experiment it was concluded that the crop productivity, applied nutrient use efficiency, recovery and crop quality can be improved considerably by adopting soil test based fertilizers application, integrated with bioinoculation of crops with organic and inorganic soil amelioration.

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Effect of Nutritional Schedule and Variety on Growth, Yield and Quality of Soybean (*Glycine max* L.)

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Soybean (*Glycine max* L. Merr.) is an important crop containing 40-45% protein and 18-22% oil. In Nagaland soybean is grown on slopes, *jhum* lands, terraces and plains but the productivity is low compared to other north eastern states. This experiment was conducted to study the effect of different nutritional levels on growth, yield and quality of newly released soybean varieties at the Experimental Research Farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema during *kharif* season of 2010. The experimental soil was sandy loam in texture, having pH 4.5, organic carbon 12.5 g kg^{-1} and available N, P and K 250.8, 17.9 and 165.3 kg ha^{-1}, respectively. The experiment was laid out in randomized block design with eight nutritional schedules *viz.* N_1-75% recommended dose of fertilizer (RDF) (RDF is 20:80:40:40 kg ha^{-1} N:P:K:S), N_2-75% RDF+FYM@ 5 tha^{-1}, N_3-100% RDF, N_4-100% RDF+FYM@ 5 t ha^{-1}, N_5-125% RDF, N_6-125% RDF +FYM@ 5 tha^{-1}, N_7-FYM 10 tha^{-1}, N_8-Absolute control and two varieties *viz.* JS 97 52 and RKS 18.

Application of different nutritional schedules significantly affected the dry weight at all the stages of crop growth and was recorded maximum with 125% RDF +FYM @ 5t ha^{-1}. However, the effect of varieties on dry weight was found significant only at 60 days after sowing. Similarly, various nutritional schedules brought significant differences in nodule dry weight $plant^{-1}$ with 100% RDF + FYM @ 5 t ha^{-1} recording the maximum nodule dry weight $plant^{-1}$ (0.48 g) which was at par with the rest of the nutritional schedules except FYM @10 t ha^{-1} (0.32 g) and absolute control (0.21 g). Among the varieties JS 97-52 recorded the highest nodule dry weight $plant^{-1}$ (0.42 g). Significantly maximum pods $plant^{-1}$ (61.0) was recorded with 125% RDF + FYM @ 5 t ha^{-1}. JS 97-52 recorded higher pods $plant^{-1}$ than RKS 18.

Significantly maximum seed index 14.7 g was recorded with 100% RDF which was at par with 100% RDF + FYM @ 5t ha^{-1}, 125% RDF and 125% RDF+ FYM @ 5 t ha^{-1} while JS 97-52 recorded maximum seed index (14.3 g) between the varieties. The maximum seed yield 24.10 q ha^{-1} and straw yield 31.11 q ha^{-1} was recorded by the application of 125% RDF + FYM @ 5 t ha^{-1} and was at par with 125% RDF. JS 97-52 produced significantly higher seed and straw yield with 18.45 and 24.95 q ha^{-1}, respectively. Total N, P and K uptake by soybean was maximum with the application of 125% RDF + FYM @ 5 t ha^{-1}. Between the varieties, JS 97-52 recorded higher total N, P and K uptake. The maximum oil (19.66%) and protein content (41.47%) was recorded by the application of 125% RDF + FYM @ 5 t ha^{-1} and was superior over the rest of the treatments. Variety did not have any significant effect on the oil and protein content. The maximum net return Rs 52786 ha^{-1} was recorded with 125% RDF+ FYM @ 5 t ha^{-1} and minimum Rs 17209.50 ha^{-1} with absolute control. JS 97-52 recorded higher net return of Rs 37225.67 ha^{-1} than RKS 18.

From this study it can be concluded that soybean variety JS 97-52 along with application of 125% RDF+ FYM @ 5 t ha^{-1} is beneficial in terms of obtaining high crop productivity, quality and net return of soybean grown in Nagaland.

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Enhacement in the Productivity of Maize (*Zea mays L.*) through Integrated Balanced Nutrient Management in Banswara District

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Banswara is one of the tribal dominated district of Rajasthan.The socio economic condition of the farmers does not permit them to adopt any new technology resulting in poor grain yield. One of the major reasons of low productivity in maize is lack of supply of balance nutrition to the crop even though soil is low to medium in its inherent fertility. To study the effect of integrated balanced nutrient management on the productivity of *rabi* maize on farm trials were conducted for to two consecutive years (2007-08, 2008-09) in *rabi* season in village Jantoda and Khandadera of Banswara, Rajasthan. Three treatments *viz*., Farmers practice (T_1=110:60:0 NPK kg ha^{-1}), Recommended doses of fertilizers (T_2=150:60:0 NPK kg ha^{-1} + 5 t ha^{-1} FYM+Bio-fertilizers) and INM based on soil test value (T_3=150:60:3 NPK kg ha^{-1} + 5 t ha^{-1} vermin-compost+Bio fertilizers) were tested in a randomized block design with four replication, each farmer field was considered as a replication accommodating all the three treatments.

The grain yield of *rabi* was influenced by the treatments in both the years. The average grain yield increased from 24.36 q to 31.57 q ha^{-1} with application of RDF over farmers practice. Further, use of INM on soil test basis increased grain yield to 36.75 q ha^{-1} which were higher than application of RDF alone. The increase in grain yield was of the order of 33.71% over farmers practice. The B:C ratio was also higher (1.32) with INM in comparison to farmers practice (1.01).

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Effect of Nitrogen and Phosphorus Doses With and Without S, B, Zn and Culture on Yield, Quality and Balance Sheet of Nutrient in Mustard Crop

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Mustard is the most important and economical crop and the chief source of vegetable fat in the diet of vegetarian people of northern India. The area under the crop is increasing progressively because of its high economic value, but the yield per unit area per unit time is still low because inadequate use of fertilizer. Nitrogen and P are important and inevitable nutrient and uses of culture are responsible for crop yield and its quality. A field experiment was conducted during *Rabi* season of 2010–11 at the Morena under supplemental irrigated conditions. The experimental soil had sandy loam to clay loam in texture having 0.45% organic carbon, $KMnO_4$ extractable N–185 kg ha^{-1}, Olsen's P_2O_5–19 kg ha^{-1} and 1*N* ammonium acetate extractable K_2O–380 kg ha^{-1}. The treatments were: control, 50% (N + P_2O_5), 75% (N + P_2O_5), 100% (N + P_2O_5), *Azotobacter* + PSB seed treatment, *Azotobacter* + PSB seed treatment + 50% (N + P_2O_5), *Azotobacter* + PSB seed treatment + 75% (N + P_2O_5), *Azotobacter* + PSB seed treatment + 100% (N + P_2O_5), 100% (N + P_2O_5) + S 30 kg ha^{-1}, 100% (N + P_2O_5) + Zn 25 kg ha^{-1}, 100% (N + P_2O_5) + B 10 kg ha^{-1} and 100% (N + P_2O_5) + S 30 kg + Zn 25 kg + B 10 kg ha^{-1} replicated three times in randomized block design. Full dose of N, P_2O_5, S, Zn, B and half dose of N were given as basal dressing at the time of sowing and remaining half dose of N was top dressed in standing crop, 35 days after sowing.

Seed yield, oil content and uptake of nutrients significantly influenced by different treatments. The maximum seed yield (2903 kg ha^{-1}) was obtained with the treatment 100% (N + P_2O_5) + S 30 kg + Zn 25 kg + B 10 kg ha^{-1} followed 100% (N + P_2O_5) + S 30 kg/ha which was significantly superior over all the treatments. The lowest seed yield of 2160 kg ha^{-1} was noticed in control plot. Higher dose of fertility levels increases the available nutrients in soil and uptake by crops as well as protein content in seed. However, higher oil content in seed was noticed under low dose of fertility levels but it was non-significant. Highest balance sheet of nutrients was recorded under 100% (N + P_2O_5) + S 30 kg + Zn 25 kg + B 10 kg ha^{-1}.

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Initial Soil Test Values Based Recommendation of Potassium Fertilizer for Cropping Sequence (Sorghum-Blackgram-Cotton)

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A field experiment was conducted at farmer's field at Thekkupalayam, Coimbatore. Four fertility gradient strips were created within the experimental plot under soil test crop response to develop the suitable model to tailor the fertilizer recommendations for cropping sequence sorghum-blackgram-cotton for predicting the soil test values after the harvest of the crop using the post-harvest soil test value of potassium as dependent variable and initial soil test values, applied nutrients and yield of crops as independent variable.

The NH_4OAc-extractable potassium left after the harvest of the crop was significantly correlated with grain yield (r=0.330**), K-uptake (r=0.201*), the initial soil test value (r = 0.647**) and negatively correlated with fertilizer-K (r = - 0.201).

Multiple regression equation was worked out using three independent variables *viz*. initial soil test value (IS-K), fertilizer-K (FK) and grain yield (YG) with post harvest soil test value (PH) of NH_4OAc – K as a dependent variable. The multiple regression equation obtained was Y = 295.01 - 2.83 YG + 040** IS-K+ 0.25 FK with multiple regression coefficient (R^2) value is 0.424**. The initial soil test value of K contributed significantly to the yield of post harvest soil test value.

Correlation Coefficient (n=96)

Variables	NH_4OAc –K (PH)	HNO_3-K (PH)
Grain yield	0.330**	0.309**
Biological yield	0.432**	0.324**
K - uptake	0.201*	-0.174
Fertilizer-K	-0.201	0.248*
NH_4OAc-K (IS)	0.647**	—-
HNO_3-K (IS)	—-	0.621**

Multiple Regression Equation

Y = 295.01 – 2.83 YG + 0.40** IS-K + 0.25 FK [R^2 = 0.424**]

Where,

Y = Post Harvest Soil Test Value [NH_4OAc –K]
YG = Grain Yield
IS-K = Initial Soil Test Value [NH_4OAc –K]
FK = Added Potassium Fertilizer
R^2 = Multiple Regression Coefficient

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Critical Level of Hot Water Soluble Boron for Predicting Response of Toria (*Brassica compestris*) in Alluvial Soils of Punjab

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Boron plays a pivotal role in cell wall biosynthesis and in regulating membrane permeability, tissue differentiation, carbohydrate and protein metabolism, cell division and cell elongation, pollen germination and pollen tube growth, ensuring adequate seed set in the pods which is important to achieve a high seed yield. Under B deficiency, pollen viability and seed set of toria is greatly reduced and protein formation is also restricted. A lack of B in contrast to other nutrients is the only deficiency which accelerates physiological processes instead of reducing them. Toria responded to boron application in wide range of boron deficient soils. For this twenty bulk soil samples (0-15 cm) representing a wide range in hot water soluble B were collected from Ludhiana district of Punjab. The soils belong to great group Ustochrepts. Each soil sample was air-dried and ground in a wooden mortar to pass through 2 mm sieve. The soils under study were loamy sand to sandy loam in texture, neutral to alkaline in reaction, pH 7.4 to 8.4. Also the soils were low to medium in organic carbon to 0.28 to 0.45% and medium to high in available N (179 - 367 kg ha^{-1}) and P_2O_5 (14 to 22 kg ha^{-1}) as well as low to medium in K (84 to 358 kg ha^{-1}). The hot water soluble B (HWS-B) in untreated 20 soils ranged from 0.10 to 1.71 mg kg^{-1} soil.

A screenhouse investigation was conducted on 20 soils to determine the critical deficiency limit of B in Entisols and Inceptisols for predicting response of toria with cultivar TL 15 to B application. Field investigation was also conducted at research farm area of Department of Soils, PAU, Ludhiana to confirm these results under field conditions. The soils selected for this study were having a wide range of hot water soluble boron (HWS-B), varying from 0.10 - 1.70 mg kg^{-1} soil. Depending upon response of toria to applied B, nine soils out of 20 were classified as B deficient whereas, eleven were grouped into B sufficient range. The results of our study predicted that HWS-B was significantly related with Bray's per cent dry matter yield. Soil application of B @ 0.44 mg kg^{-1} soil significantly increased the dry matter yield of toria over control and with application of B @ 0.22 and 0.88 mg kg^{-1} soil. However, increase in dry matter yield was not significant with increase in concentration of B beyond 0.44 mg kg^{-1}. Both statistical and graphical models of Cate and Nelson technique were employed for analysis of data which indicated that the critical level to be 0.51 mg kg^{-1} soil of HWS-B for prediction of B deficiency in the soils for toria crop. On the other hand the critical deficiency level in toria of 45 days toria plants was 29.2 mg kg^{-1}. The predictability of soil and plant critical limit for B was 94 per cent. These results were also confirmed in the field experiment which reported the equivalent results and similar response of toria crop to applied B @ 1.0 kg ha^{-1}.

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Enhancing Productivity of Off-season Cauliflower through Boron and FYM under Mid-Hill Conditions of Western Himalayas

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Himachal Pradesh has huge potential for growing off-season cauliflower which fetches high premiums in local and super vegetable markets. The imbalanced application of chemical fertilizers in cauliflower is one of the major reasons responsible for low yield resulting in multinutrient deficiencies, yield stagnation and deteriorated soil health. A field experiment on cauliflower variety "NS 60" was conducted during 2007-08 (July) in the farmers' field adjoining to the experimental farm of CSK HPKV Hill Agricultural Research and Extension Centre, Bajaura, Kullu (HP) with the broad aim of assessing the impact of boron and FYM on off-season cauliflower. A total number of 12 treatments comprising to levels of FYM (20 and 30 t ha^{-1}), two boron sources (boron and granubor-II) and three levels of boron (0.5, 1.0 and 1.5 kg ha^{-1}) were replicated thrice in a factorial randomized block design and compared with a control (farmers' practice). The uniform doses of recommended N, P and K fertilizers were applied in all the plots. However, fertilizers were applied as per the existing farmers' practice of the concern area in control. Initially, the experimental soils had pH 7.0; organic carbon 4.2 g kg^{-1}; available N 206 kg ha^{-1}; available P 19.2 kg ha^{-1}; available K 190 kg ha^{-1}; available B 0.62 ppm with silty loam texture. The study revealed that there was a significant individual effect of FYM, boron and its sources on productivity, quality, B use efficiency and economics of cauliflower. The increase in curd compactness, vitamin C and yield with FYM applied @ 30 t FYM ha^{-1} was 5.9, 17.5 and 5.7 per cent over 20 t ha^{-1} FYM, respectively. Among two B fertilizer sources, application of granubor-II increase curd compactness, vitamin C content and yield by 3.2, 5.1 and 3.7 per cent, respectively over borax. The highest curd yield (142.7 q ha^{-1}) was recorded with an application of boron applied @ 1.5 kg ha^{-1}, resulting 8.0 and 5.0 per cent increase, respectively over 0.5 and 1.0 kg ha^{-1} B. The efficiency of applied boron was significantly higher (10.3 per cent) with granubor-II in comparison to borax. Further, the B use efficiency decreased with increasing boron levels from 0.5 to 1.5 kg ha^{-1}. The maximum B:C ratio (2.70) was recorded in treatment receiving granubor-II @ 1.5 kg ha^{-1} + 20 t FYM ha^{-1}. It may be inferred that the vegetable growers of mid hill areas of western Himalayas may apply granubor-II @ 1.5 kg ha^{-1} with 20 t FYM ha^{-1} and recommended doses of N, P and K for getting maximum returns per rupee invested.

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Response of Mustard Varieties to Fertility Levels in Alluvial Soils of Madhya Pradesh

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Rapeseed-mustard oilseed crops are important sources of edible oil in Indian diet. The area under the crop is increasing progressively because of its high economic value, but the yield per unit area per unit time is still low because of use of traditional varieties and inadequate use of fertilizers. The yield and quality of Indian mustard may be increased by the use of high yielding varieties. N, P, K S and Zn are important and inevitable nutrients responsible for crop yield and its quality. A field experiment was conducted during *rabi* season of 2008-09 and 2010-11 at the farmers' field of Ambah *tehsil* of Morena district under supplemental irrigated conditions. The experimental soil had sandy loam to clay loam in texture having 4.2 g kg^{-1} organic carbon, $KMnO_4$ extractable N-195 kg ha^{-1}, Olsen's P_2O_5-22 kg ha^{-1}, 1*N* ammonium acetate extractable K_2O-390 kg ha^{-1}, Morgan S 16 kg ha^{-1} and DTPA extractable Zn 40 mg kg^{-1}. Five promising varieties (Varuna, Kranti, Rohini, JM-2 and JM-1) and 4 levels of N:P:K:S:Zn (60:30:15:22.5:15, 80:40:20:30:20, 100:50:25:27.5:25 and 120:60:30:45:30 kg ha^{-1}) were evaluated in split plot design with three replications. Full dose of P_2O_5, K_2O, S and Zn and half dose of N were given as basal dressing at the time of sowing and remaining half dose of N was top dressed in standing crop, 35 days after sowing.

Seed yield and uptake of N, P, K, S and Zn significantly influenced by different fertility levels and varieties. Mean value of three years data revealed that the variety Rohini produced considerably higher seed yield and oil content over other varieties. Seed yield and N, P, K, S and Zn in soil and plant increased significantly with increasing levels of N:P:K:S:Zn up to 120:60:30:45:30 kg ha^{-1}. Higher oil content was recorded under lower dose of fertility levels. The higher uptake of total N, P, K, S and Zn by Rohini may be attributed to the higher N, P, K, S and Zn content and higher biological yield. Application of N, P_2O_5, K_2O, S and Zn @ 120, 60, 30, 45 and 30 kg ha^{-1}, respectively recorded highest available status and balance sheet of N, P_2O_5, K_2O, S and Zn.

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Long-term Integrated Nutrient Management on Soil Chemical Characteristics and Productivity of Rainfed Groundnut (*Arachis hypogea*) in an Alfisols in Arid Region of Andhra Pradesh

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The soil nutrient dynamics and groundnut pod yields studied in the ongoing long-term integrated nutrient management for groundnut experiment initiated during rainy (*kharif*) season 1985 at Agricultural Research Station, Anantapur, A.P, comprised of 10 treatments including inorganics with and without recyclable farm wastes *viz*. FYM , groundnut shells and zinc replicated three times in RBD with the objective to study the long-term effects of recycling of farm wastes and organic manures on soil properties. The manures and mineral fertilizers given to groundnut (*Arachis hypogea*) every year in treated plot and no fertilizers and manures have been applied since 1993 in depleted plots. Soil samples from all the treatments collected from 0-15 cm depth. Significant increase in organic carbon was recorded in treatments applied with organics alone or organics along with inorganics. The initial available phosphorus content increased with only inorganics applied plots where as available potassium increased over initial value in treatments received with organics or organics in combination with inorganics. In the control, initial available phosphorus (P_2O_5) and available potassium (K_2O) levels of 44 and 155 kg ha^{-1} were reduced to 29 and 88 kg ha^{-1} respectively over 26 years. Mean differential yield was at par in both RFD (980 kg ha^{-1}) and HRFD+FYM @ 4 t ha^{-1} (1000 kg ha^{-1}). However, control (773 kg ha^{-1}) recorded lowest mean pod yield over 26 years. Even without application of fertilizers and manures for the past 18 years (since 1993) in depletion studies, recommended fertilizers dose of 20-40-40 N, P_2O_5, K_2O kg ha^{-1}, HRFD(10-20-20 N, P_2O_5, K_2O kg ha^{-1}) + FYM @ 4 t ha^{-1} and FYM @ 5 t ha^{-1} applied plots are giving sustainable yields over control. So keeping in view of soil inherent nutrient status, the treatment with half recommended dose (10-20-20 N, P_2O_5, K_2O kg ha^{-1}) along with FYM @ 4 t ha^{-1} is giving at par groundnut pod yields compared to full recommended fertilizer dose (20-40-40 N, P_2O_5, K_2O kg ha^{-1}) which not only giving sustainable yields but also enhancing the soil health.

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Effect of Insecticide Residue on Micronutrient Concentration in Brinjal Fruits (*Solanum melongena* L.)

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A microplot field experiment was conducted during *rabi* (2004-2005) to assess the effect of endosulfan on micronutrient concentration (Fe, Mn, Cu and Zn) in brinjal fruit (Var.- Muktakesi) as influenced by fertilization, manuring and liming in Alfisol of Ranchi. Three levels of endosulfan i.e. RD (recommended dose 1 mL L^{-1} water), two times (2RD) and four time (4RD) were applied along with different nutrient combinations (NPK, NPK+FYM, NPK+ lime and NPK + FYM + lime). The results indicated that the concentration of micronutrient in brinjal fruits decreased with increases in insecticide levels. The highest Iron conc. of 83.7 mg kg^{-1} in brinjal was observed with recommended doses. However, concentration decreased significantly to 66.6 and 62.0 mg kg^{-1} with higher doses i.e. 2RD and 4RD, respectively. The manganese concentration in brinjal highest (23.6 mg kg^{-1}) with recommended dose of endosulfan and its decreases (22.0 & 19.3 mg kg^{-1}) with higher concentration (2RD and 4 RD) of endosulfan.

The lowest concentration of Cu and Zn (13.8 & 33.9 mg kg^{-1}), respectively, was observed where treatments receiving 4RD of insecticide. The micronutrient content (Cu and Zn) increased significantly with decrease in doses of insecticide i.e. 14.9, 15.7 mg kg^{-1} and 36.1, 39.4 mg kg^{-1} with 2RD, respectively.

The effect of different doses of endosulfan on brinjal yield (fresh weight), the maximum yield 16.7 t ha^{-1} was obtained with 2RD of endosulfan. However, when endosulfan was applied at 4RD, the yield (14.3 t ha^{-1}) decreased and it was even lower than that of recommended dose (15.6 t ha^{-1}).

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Response of Soybean to N, P and S Fertilization

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Soybean is the most popular oilseed in the country after groundnut. One of the reasons of some stagnation in the crop productivity is depletion of soil fertility in oilseed growing fields as this crop removes a large quality of nutrients from soil while their replenishment through balanced fertilization is negligible. Proper nutrient management of oilseed crop is one of the key factors in harvesting their yield potential. The use of N in conjunction with S is important to enhance both yield and quality of soybean. The soybean cultivation in eastern part of Gujarat is on increase during past decade which covers tribal belt of Gujarat. The field study was carried out at TRTC, Devgadh Baria during 2008-10 on sandy loam soil under RBD experimental design. The soil was neutral in reaction having 3.9 g kg^{-1} organic carbon; and available P and K were in marginal (51 kg ha^{-1}) and sufficient (330 kg ha^{-1}) range, respectively. There were twelve treatments comprising of two levels of nitrogen (30 and 45 kg N ha^{-1}), two levels of phosphorus (30 and 60 kg P_2O_5 ha^{-1}) and three levels of sulphar (0, 20 and 40 kg ha^{-1}).

The results revealed that combined application of 45 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} recorded significantly the highest seed yield (855 kg ha^{-1}); and it was at par with treatment combination of 45 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1} (832 kg ha^{-1}). The uptake of N , P and K by soybean seed, straw as well as total uptake were not influenced significantly due to N application while application of P at 60 kg ha^{-1} and application of S at 40 kg ha^{-1} significantly increased N, P and K uptake by seed and straw over control. The S uptake and Zn uptake were significantly maximum at higher level of N (45 kg ha^{-1}) and P (60 kg ha^{-1}). The organic C content was also improved significantly by N and S application. The treatment combination of 45 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} produced significantly the highest seed yield and net realization among the treatments which was followed by 45 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}. The overall results indicated that S application @ 25 kg ha^{-1} was necessary along with N and P fertilization to get higher yield of soybean.

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Integrated Nutrient Management in Bt Cotton

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Cotton is a very important commercial crop in middle Gujarat. The low productivity of A severe damage by insect pests is one of the major reasons for low productivity of cotton. It has been estimated that nearly 50% of insecticides used in the country are only for the cotton crop. However, the Bt cotton hybrid has changed the production scenario in the country and Gujarat in particular. The Bt cotton is a heavy feeder and needs balanced supplementation of nutrients in soil to sustain yields. Rising costs and associated pollution hazards of chemicals besides low availability of organic manures have made integrated nutrient management most relevant in present day agricultural scenario of Gujarat.

An experiment was conducted during *kharif* seasons of the year 2007-08 to 2009-10 to Study the integrated nutrient management in Bt cotton at Agricultural Research Station, A.A.U., Thasra. The field trial was laid out in factorial randomized complete block design with four levels of organic manures OM1 (without organic manure), OM2 (FYM @ 10 t ha^{-1}), OM3 (Vermicompost @ 2 t ha^{-1}), OM4 (FYM @ 5 t ha^{-1} + Vermicompost @ 1 t ha^{-1} (50:50) + Azatobacter -C) and four levels of nitrogen N1(120 kg N ha^{-1}), N2(180 kg N ha^{-1}), N3(240 kg N ha^{-1}), N4 (300 kg N ha^{-1}). The yield data and economics of various treatments showed that the treatment OM2 (Vermicompost @ 2 t ha^{-1}) gave the highest net return per hectare (CBR of 1: 1.69) followed by treatment OM1 (FYM @ 10 t ha^{-1}) with CBR of 1: 1.63.

In case of nitrogen levels, treatment N4 (300 kg N ha^{-1}) recorded highest net income per hectare with CBR of 1:1.71 followed by treatment N3 (240 kg N ha^{-1}) with CBR 1:1.71.

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Effect of Seed Mn Content on Growth and Mn Utilization by Wheat

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Intensive cultivation of high yielding cultivars with heavy applications of nitrogen, phosphorus and potassium fertilizers leads to the occurrence of micronutrient deficiencies. Manganese (Mn) deficiency has become a perpetual problem in coarse textured alkaline soils of Punjab, where rice-wheat cropping system has been adopted for the last several years. During submergence of soils for rice cultivation, Mn solubility increases due to its reduction, and a large part of Mn leaches down to the lower layers that causes its deficiency in the following wheat crop which is the highly susceptible to Mn deficiency as compared to other cereals. Since the foliar application of Mn salt solution is highly labour intensive and costly, the present investigation was carried out to study the effect of seed Mn content on growth and Mn utilization by wheat.

A pot culture study was conducted to investigate the effect of seed Mn content on wheat growth and manganese utilization in a screen house, Department of Soil Science, PAU Ludhiana. The experiment was conducted with two wheat cultivars PDW 233 (*Triticum durum* L.) and PBW 621 (*Triticum aestivum* L.) under Mn deficient conditions. Seed of these cultivars both low and high in inherent Mn content was collected from an ongoing experiment. The seed was soaked for five hours in 0, 0.2 and 0.4 *M* solutions of $MnSO_4$ before sowing. Plant samples were collected at tillering and booting stage. Higher seed Mn content, either achived artificially or naturaly from the mother plant, played a significant role in improving the plant growth. The mean dry matter yield at tillering increased from 160 mg $plant^{-1}$ in control to 185 and 210 mg $plant^{-1}$, respectively by soaking seed in solutions of 0.2 and 0.4 *M* $MnSO_4$, respectively. The positive effect of high seed Mn content on dry matter accumulation was relatively more visible in PDW 233 than PBW 621. The wheat cultivar PBW 621 produced relatively higher dry matter (282 mg $plant^{-1}$) than PDW 233 (88 mg $plant^{-1}$) A similar trend was also observed at booting stage. Manganese utilization by wheat was also improved significantly with high seed Mn content. The mean shoot concentration in control was 11.1 mg kg^{-1} shoot dry matter which increased to 12.5 and 13.7 mg kg^{-1} by using the seeds soaked in solutions of 0.2 and 0.4 *M* $MnSO_4$, respectively. The Mn concentration of shoot was relatively low in PDW 233 than PBW 621. The relatively less dry matter accumulation and Mn content in PDW 233 reflects its poor Mn stress tolerance power than PBW 621. Higher seed Mn content improved the chlorophyll content and delayed the onset of Mn deficiency symptoms.

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Long-term Effect of Continuous Cropping, Fertilizer, Manure and Lime Application on Crop Yield and Soil Fertility under Soybean-Wheat Cropping System in Jharkhand

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A long-term fertilizer experiment was initiated during 1972-73 at Ranchi, Jharkhand to study the effect of continuous use of manure, fertilizer, weedicide and lime application on yield, sustainability of the system in particular agro ecosystem and changes in soil fertility status under soybean-wheat cropping system. The soil was sandy clay loam and acidic in nature with low organic carbon content and low to medium available nutrient status. Fertilizer doses (N: P_2O_5:K_2O) were 25:60:40 and 80:60:40 for soybean and wheat, respectively. Due to higher buildup of phosphorus the dose of P_2O_5 was changed to 25:30:40 and 80:30:40 for soybean and wheat crop respectively since 2008-09.Ten treatments having different levels of fertilizers, manure, lime and weedicidees, *viz.* 50%, 100%, 150% NPK, NPK+hand weeding, NPK+Lime, 100% NP, 100% N, 100% NPK+FYM, 100% N(S)PK (sulphate source of N and P through ammonium sulphate and p through single super phosphate, respectively) and control were used. Result of the year under report (39th years) revealed that highest grain yield of soybean of 23.48 q ha^{-1} was recorded in the treatment (NPK+FYM), followed by 23.01 q ha^{-1} for the treatment (NPK+Lime). FYM application found to be significantly better than lime application. Higher sustainable yield index (SYI) was also found higher in T_8 (0.62) followed by T_5 (0.60). Optimal dose of fertilizer application (100% NPK) produced grain yield of 18.08 q ha^{-1} which was statistically at par with super optimal dose of NPK (150%NPK). Lowest grain yield of 5.93 q ha^{-1} was observed in the treatment receiving 100% N alone in the form of urea. Maximum reduction in pH of 0.9 units was observed in the treatment 100% N(S) PK, followed by 0.8 unit in 100% N and 150% NPK treatment. Application of lime resulted in increase in soil pH by 0.9 units. Organic carbon content declined from its original value in almost all the treatment but application of FYM along with NPK could maintain the organic carbon content of the soil. Build up of available phosphorus was noticed relative to the level of application. Application of urea and DAP devoid of potassium resulted in significant reduction in grain yield of soybean over the years and deficiency symptom of K was observed in recent years in soybean. At the end of 39 years the soil chemical properties like pH, organic carbon, available N, P, K and S and exchangeable Ca and Mg shows significant differences due to various treatments imposed. The result suggests that application of potassic and phosphatic fertilizers in acid Alfisol is very important for *kharif* and *rabi* crops, respectively for incrasing crop production. Liming or manuring along with recommended dose of inorganic fertilizers is essential in red and lateritic soils of Ranchi for sustaining crop productivity and maintaining soil health.

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Effect of Crop Geometry and Fertilizer Levels on *Bt* and Non *Bt* Cotton Hybrids Grown under Irrigated Condition

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A field experiment was conducted at CCS Haryana Agricultural University Regional Cotton Research Station Sirsa to study the effect of crop geometry and fertilizer levels on *Bt* and Non *Bt* cotton hybrids. The *Bt* cotton (RCH134) along with its Non *Bt* version (RCH 134 Non *Bt*) were grown at two spacing (S_1= 100x45 cm^2) and S_2= 100x60 cm^2) and with three fertilizer levels (F_1= 100% RDF, F_2= 125% RDF and F_3= 150% RDF). The straw dry weight of Non *Bt* hybrid was found more than *Bt* hybrid, however seed weight and total dry weight was higher in *Bt* hybrid as compared to Non *Bt* hybrid. The total dry weight was higher at S_1 spacing (100x45 cm^2) as compared to S_2 spacing (100x60 cm^2). In case of fertilizer levels, the straw weight was higher at F_2 (125% RDF) and F_3 (150% RDF) levels as compared to F_1 (100% RDF) level; however seed weight was statistically on the par with respect to each other. The seed cotton yield was significantly higher in *Bt* hybrid (4.25 t ha^{-1}) as compared to Non *Bt* hybrid (2.08 kg ha^{-1}). Similarly numbers of boll/plant and boll weight were also higher in *Bt* hybrid as compared to Non *Bt* hybrid. The seed cotton yield was higher at S_1 (100x45 cm^2) spacing as compared to S_2 spacing (100x60 cm^2). The effect of fertilizer levels on seed cotton yield was found non significant, which indicates that recommended dose of fertilizers for cotton hybrid was also sufficient for *Bt* cotton hybrid (RCH134). The N P and K uptake was higher in *Bt* hybrid at spacing S_1 (100x45 cm^2) and at fertilizer level F_3 (150% RDF). The water and nutrient use efficiency was also higher in *Bt* hybrid at spacing S_1 (100x45 cm^2) and at fertilizer level F_1 (100% RDF).

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Enrichment of Indian Spinach with Soil Application of Zinc along with Orgnaics

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Zinc (Zn) deficiency in humans is a widespread problem across the globe. Hence, an attempt has been made to enrich Indian spinach (*Beta vulgaris*, var. All green) with soil application of Zn. In a pot culture experiment, effects of four levels of Zn (0, 5, 50 and 100 mg kg^{-1}) and three levels of organics (control, 3% farmyard manure and 3% sludge) were evaluated on the Zn content in shoot of Indian spinach grown on acid and alkaline soils. Results indicated that the crop responded (dry matter yield) positively to the applied level of 5 mg Zn kg^{-1} on alkaline soil, while such response was conspicuously absent in case of acid soil. In case of alkaline soil, significant reduction in dry matter yield occurred only at 100 mg kg^{-1} of applied Zn, whereas such reduction was recorded in acid soil even at 50 mg Zn kg^{-1}. Both FYM and sewage-sludge were found to moderate the toxic effect of applied Zn or dry matter yield. Zinc content in shoot of Indian spinach increased to the tune of 1.49, 4.08, and 5.01 fold due to applied level of Zn at 5, 50 and 100 mg kg^{-1}, respectively over control. With reference to the control Zn content in shoot of the test crop reduced to greater extent due to application of FYM and sludge in acid soil as compared to alkaline soil. It can be concluded from this study, soil application of Zn may prove to be very effective in enriching Indian spinach with Zn. No additional advantage was obtained in case of Zn application along with FYM and sludge as far as enrichment is concerned. However, it appears that the crop could withstand better to the higher level of applied Zn in presence of organics, particularly FYM.

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Nutrient Contents of Organic Manures under Different Management Conditions

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The global consumer are showing inclination towards health cautiousness with their day to day food. Food crops grown organically or grown with less use of chemical fertilsers are proffered over conventionally produced foods by end users. Organic farming needs large quantity of organic manure to supply plant nutrients. But on the contrary the organic carbon content of Indian soils are generally low particularly under tropical conditions. Application of organic manure besides improving fertility of soil also improves soil physical conditions. Besides green manuring farm yard manure is major organic manure used by farmers. Although the trend of using vermicompost has also been seen in Punjab but the major demand of organic manures is met through farm yard manures (FYM). A specific FYM handling technology has been generated and recommended for use by the farmers but most of the farmers are not following the proper handling procedure and hence heavy losses of nutrients through volatilization due to sunshine and leaching through rain water are experienced. The vermiscomposting is very refined technology and moreover due to controlled micro environment the nutrient losses are minimized.

Eight organic manure samples were collected from properly managed FYM heaps (2), improperly managed FYM heaps (2) and vermicomposting unit (4). These samples were analysed on ICAP – AES, with the objective to generate information on nutrient losses due to improper handling of FYM.

The mean data revealed that maximum moisture contents was recorded in vermicompost (22.5%) followed by properly managed FYM (14%) followed by improperly managed FYM (12.5%). Data also revealed minimum contents of all nutrient elements in improperly managed FYM. Among the three sources of organic manures properly managed FYM recorded the edge in potassium, manganese and iron content by 218%, 247% and 266% over improperly managed FYM and 1.6%, 10.1% and 16.9% over vermicompost. The mean value of nutrient composition revealed that although phosphorus, Zinc and sulphar contents were maximum in vermicompost but the value were almost comparable with properly managed FYM. Hence, on the basis of study we can conclude that FYM should be properly managed in order to retain maximum nutrient contents in it.

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Soil Fertility Status of Village Hari Nau in Indo-Genetic Plains of Punjab

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Soil test based application of nutrients is best approach to enhance nutrients use efficiency. Application of fertilizer on soil test basis results in use of nutrient element according to the need of the crop. Application of nutrient on soil test basis besides, increasing fertilizer use efficiency also cut down input expenses. The significance of soil testing and use of costly fertilizer inputs based on sol fertility status was not known to most of the farmers of village Harinau. Hence, a soil fertility survey of the villages was conducted with the objective to generate information about nutrient (N, P and K) supplying power of the soil and nutrient deficiency likely to affect crop grown in such soil . Surface soil sample 0-15 cm were collected from representative cultivated area of the village. These samples were air dried, ground, sieved and analyzed for pH, electrical conductivity (EC), organic carbon, available phosphorus and potassium. The texture of the soil was estimated by feel method.

The texture of the soils in general is loamy sand to loam. The pH of the soil varies from 8.5 to 9.0 with a mean value of 8.77. The analysyis results revealed that 50% soils have pH of 8.7 or below and 50% had 8.8 to 9.3. None of the sample had above 9.3. The soils having pH 8.8 to 9.3 require careful management for obtaining good yields. Addition of organic manure and the inclusion of green manuring in the crop sequence may be helpful in checking the rise in pH of such soils. The electrical conductivity ranged from 0.2 to 1.18 dS m^{-1} with mean value of 0.536 dS m^{-1}. The EC values of less than 0.8 was recorded in 54.6% samples and EC values of more than 0.8 was recorded in 53.4% samples. Organic carbon (OC) of the soils varies from 3.6 to 6.6 g kg^{-1} mean value 5.03 g kg^{-1}. 15.4 and 84.6 % samples had low and medium organic carbon status respectively and none of field had high OC status. Thus, most of the soil of the village Hari Nau inherited medium to low potential for supplying essential nutrient to the crops. The available phosphorus and potassium status of the soils varied from 7.5 to 66.5 kg P ha^{-1} and 26.25 – 600 kg K_2O ha^{-1} with their mean value of 26.4 and 453.1 kg ha^{-1} respectively. About 3.8 percent of the samples recoded available phosphorus in very high category. Phosphorus contents of 57.7%, 7.7% and 30.8% fields fell in high, medium and low category. The available potassium status of these soils however was adequate.

The results of this investigation about soil fertility status of the cultivable area of the village Harinau has shown that crops grown on these soils are likely to suffer from deficiencies of nitrogen and phosphorus in 15.4 and 30.7% fields, respectively. The balanced use of these nutrient is essential for realizing the full yield potential of the crops and to obtain maximum profit from the costly inputs. To increase the yield potential of the soils of the village, the farmers should use FYM and include practice of green manuring in the crop rotations.

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Sustainable Production Management for Yield Maximization of Rice-Wheat Cropping System under Irrigated Condition of Jammu

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A field experiment was conducted under assured irrigated condition on fixed site for four consecutive years at FSR centre Research Farm, SKUAST-J, R.S. Pura, Jammu in randomized block design with five replications. The soil was clay loam having neutral in reaction with medium in soil organic carbon content, available P and K and low in available N. The experiment comprised four treatments viz. T_1: recommended package of practices (33 plants m^{-2}, 120:60:30 kg N : P_2O_5: K_2O ha^{-1}, chemical weed control through Butachlor@1.5 kg ai. ha^{-1} for rice and 20 cm row spacing with 100:50:25 kg N: P_2O_5:K_2O ha^{-1}, chemical weed control through sencor @ 200 g ha^{-1} for wheat; T_2: T_1 + 5 t ha^{-1}, green manuring (green leaves of leucaenia, containing 1.25% N content) for rice and recommended practices for whet; T_3: T_2 + 25% higher plant population/seed rate i.e. 43 hills m^{-2} for rice and 125 kg seed ha^{-1} for wheat, and T_4: T_1 + 25% higher dose of fertilizer to rice and wheat. Rice (cv. Jaya) and wheat (PBW-343) used as a test crop. Entire quantity of P and K and half dose of N was applied at the time of transplanting/ sowing, rest of N was applied at 30 and 60 DAT/DAS in two equal splits.

Highest average grain yield (four years) of rice (6.57 t ha^{-1}) and wheat (4.79 t ha^{-1}) was recorded in treatment (T_3) where recommended dose of fertilizer + green leaf manuring of leucenia @ 5 t ha^{-1} to rice crop with maintained 25% higher plant population then followed by T_4 and T_2 where 25% higher dose of fertilizer from the recommended dose and recommended dose coupled with green leaf manuring of leucenia @ 5 t ha^{-1} was applied. Mean productivity in rice-wheat system was 23.6 and 13.0% higher in T_3 and T_4 over recommended practices treatment (T_1) with sustainability yield index (SYI) of 0.89, 0.85, 0.84 and 0.84 in T_3, T_2, T_4 and T_1, respectively. Similarly, highest productivity efficiency of 44.03 kg ha^{-1} day^{-1}, energy use efficiency of 12.15 and energy productivity of 0.4 were also obtained in the same treatment where 25% higher plant population was maintained compiled with recommended dose of fertilizer + green leaf manuring (T_3). After 4 years of study period, available N, P and K content in the soil was increased over their initial value where 25% higher plant population maintained with green leaf manuring of leucenia, while organic carbon content in soil declined in the recommended package of practices (T_1) and there was a build up of SOC in the treatment where incorporate of green leaf manuring alone or along with higher plant population practice was adopted during study period. Thus, it was concluded that under sub-tropical conditions recommended dose of fertilizers coupled with 25% higher plant population and inclusion of green manuring to rice crop was found to be sufficient to enhance the productivity of rice and wheat.

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Enhancing Nitrogen Use Efficiency and Soil Productivity through Integration of Nutrient Sources in Pearlmillet-Wheat Cropping Systems

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Soil health deterioration is considered one of the serious second generation problems of green revolution, leading to an undesirable fatigue in crop production and productivity growth rates. Recent diagnostic surveys indicate that in the high productivity areas of irrigated ecosystems, like Trans- and Upper Gangetic Plain zones, farmers are resorting to even excessive use of fertilizers, especially N, to maintain the yields at levels attained previously with lower fertilizer application rates. Such indiscriminate use of N fertilizers not only aggravates the extent of soil fertility depletion, but also proves ultimately 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 of groundwater pollution due to excessive leaching of nitrates beyond root zone. Hence, a field experiment was conducted for two consecutive years (2009-2011) on a Typic Haplustept of IARI, New Delhi to study the effect of different N levels under conventional and modified top dressing on N use efficiency and crop productivity in a pearlmillet-wheat cropping system. Soil samples from surface (0-15 cm) layers were collected at maximum flowering of wheat, and analysed for mineral N.

Instead of conventional 3-splits i.e. basal dressing + 2 top dressing, the skipping of basal N for one additional top dressing resulted in substantial increase in grain yield, agronomic efficiency and recovery of N in pearlmillet-wheat system. It was also possible to curtail 30-45 kg N ha^{-1} in each crop by modifying the N scheduling. The depth wise distribution of NH_4-N and NO_3-N was also less in modified splits of N application. Results further revealed that modified N splits increased not only the N use efficiency but also minimized the NO_3-N level in lower depth of soils.

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Diagnosis of Yield Limiting Nutrients in Rice through Diagnosis and Recommendation Integrated System (DRIS) in Andhra Pradesh

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A crop nutrient survey was conducted in Karimnagar district of Andhra Pradesh for developing the DRIS foliar diagnostic norms for N, P, K, S, Zn and Fe and to identify the yield limiting nutrients in rice. The population was divided into low (113 observations) and high yielding groups (37 observations) based on the third quartile method for developing the DRIS foliar diagnostic norms. Index leaf samples were collected from all the selected fields at tillering stage and analyzed for N, P, K, S, Zn and Fe contents. Based on critical nutrient concentration (CNC), N, S, Zn and Fe contents in index leaf samples of rice under study were deficient to an extent of 40, 44, 53 and 10 per cents respectively, and no deficiencies were observed with respect to P and K. The direct correlations between N, P, K, S, Zn and Fe contents in index leaves and rice yields were poor. DRIS norms were established for various nutrient ratios obtained from high yielding population of rice crop and were further used to compute the DRIS indices, which identified the yield limiting nutrients and their requirement in order of priority. The DRIS derived sufficiency ranges for N, P, K, S, Zn and Fe for rice crop in the district were 2.2 to 3.6, 0.30 to 0.38, 2.02 to 2.89, 0.18 to 0.34%; 14.9 to 26.3 and 19.7 to 167.8 mg kg^{-1}, respectively. The number of nutrients diagnosed as yield limiting and extent of deficiencies observed by DRIS are more than those identified by the CNC method. The majority of the nutrients identified as deficient by CNC method also find place among the nutrients diagnosed as limiting by DRIS method. The DRIS indices computed for the rice crop identified not only the yield limiting nutrients, but also prioritized the deficiencies, which varied from field to field. Nutrient diagnosis with DRIS indices was found to be more appropriate in identifying the yield limiting nutrients than critical nutrient concentration method for getting the high yields of rice.

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Soil Fertility and Crop Response as Influenced by Mulching and Potash Spray in *Rabi* Sorghum

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A field study was conducted at College of Agriculture, Bheemarayangudi, UAS, Raichur to know the effect of mulching and foliar sprays of potassium to sorghum crop during *rabi* 2009-10 and 2010-11. The field was laid out in a split plot design with two main plots mainly mulching (M_1) and non-mulching (M_2), seven sub treatments mainly T_1 – RDF, T_2- RDF+10 kg K_2O as soil application, T_3- RDF+ 1% MOP spray at 30 DAS, T_4- RDF+ 1% MOP spray at 60 DAS ,T_5 –RDF+1% MOP spray at 30 and 60 DAS, T_6 – RDF+ cow urine spray at 30 and 60 DAS, and T_7- RDF+ Jeevamruth spray at 30 DAS. The plots were replicated thrice. The crop residues were used as mulch material. The soil samples were collected at initial and after harvest of the crop and analysed following stand procedures. The initial soil pH was 7.92, EC 10.25 (dS m^{-1}), organic carbon (0.43%) available N, P_2O_5 and K_2O was 173, 57.25, 311 kg ha^{-1}, respectively.

The pooled data revealed that the sorghum grain yield differed significantly with mulching and non-mulching. The mulched plot recorded significantly higher grain yield of 1.44 t ha^{-1} and it was superior over non mulched plots (1.30 t ha^{-1}). Among the treatments RDF+ Soil application of 10 kg K_2O ha^{-1} recorded significantly higher grain yield of 1.50 t ha^{-1} followed by treatment receiving RDF+ foliar spray of MOP at 30 and 60 DAS. However it was superior over treatment receiving RDF (1.17 t ha^{-1}) only. Similarly sorghum stalk yield was also significantly high in the mulched plot (3.35 t ha^{-1}). Among the treatments RDF+1% MOP spray at 30 and 60 DAS recorded significantly higher stalk yield of sorghum (3.68 t ha^{-1}) over control (2.88 t ha^{-1}). Available N, P_2O_5 and K_2O status of soil over 2 years was increased by 6.36, 8.55 and 22.50 per cent respectively with mulching. The mulched plots recorded significantly higher available N (184 kg ha^{-1}), P_2O_5 (62.2 kg ha^{-1}) and K_2O (381.0 kg ha^{-1}) of soil when compared to non-mulched plots. Mulching reduces the deterioration of soil by way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation. Thus facilities for more retention of soil moisture and helps in control of temperature fluctuations improves physical, chemical and biological properties of soil, as its adds nutrients to the soil and ultimately enhances the growth and yield of crops. The foliar sprays had significant effect on soil available N, P_2O_5 and K_2O. Treatment receiving RDF+10 kg K_2O ha^{-1} as soil application recorded significantly higher available N (180.0 kg ha^{-1}), P_2O_5 (67.2 kg ha^{-1}) and K_2O (403.0 kg ha^{-1}) and was superior over treatment receiving RDF only. This might be due to supply of K_2O to soil which will help in better response of the crop.

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Efficient Management of Wheat Straw and Zero Tillage for Maintaining of Soil Fertility Status and Environment for Improving Cotton Productivity

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A field study was conducted at PAU, Regional Research Station, Bathinda during 2008-09 to find out the effect of zero tillage to encourage early sowing of cotton to increase sustainable productivity, soil health and saving of water using different methods of sowing and plant geometry in upland cotton. Among the different methods of planting i.e. bed planting having zero tillage in situ of wheat straw found to be the effective technology for early planting with enhanced yield potential. The technique also improved soil health as well and avoided environmental pollution hazards by burning of straw. The treatment increases the significantly higher seed cotton yield i.e. 3.35 t ha^{-1} than the other treatments. Wheat straw contains considerable amount to plant nutrients representing 30-35 % N, 10-15 % P and 70-75% K of total nutrients removal by the crop along with several other secondary and micronutrients. Cotton on an average removes about 194 kg N, 64 kg P and 210 kg K t^{-1} of cotton produce. Hence, in order to get fairly good yields the nutrient must be supplied in the form of organic and inorganic manures. It is well established in the world that N, P and K fertilizers alone are not sufficient to provide balanced plant nutrition for optimum crop yield and quality. For long-term resources and income sustainability it is necessary that the most scares resources-soil and water must be used rationally. Therefore, recycling of wheat straw in the combine-harvested fields can be a good help in sustaining soil health particularly in cotton-wheat cropping sequence.

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Effect of Different Levels of Zinc Fertilization on the Fruit Yield and Quality of Peach *(Prunus Persica Batsh)*

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The experiment was carried out to find out the effect of zinc fertilization on the yield and fruit quality of peach at Punjab Agricultural University, Regional Station Bathinda. The soil of the experimental field was calcareous and alkaline in nature. The content of DTPA extractable Zn was 0.78 mg kg^{-1}. The source of zinc was applied through zinc sulphate @ 200, 400 and 800 g $plant^{-1}$ as soil and 0.50% $ZnSo_4$ (neutralized with calcium hydroxide) as foliar application. Fruit yield and fruit weight was recorded at maturity and TSS and acidity were recorded as per usual methods. For the estimation of zinc in leaves, the samples were collected from the plants and washed with diluted HCL, distilled and finally with double distilled water. The samples were digested in acids mixture for the determination of zinc and analyzed by atomic absorption spectrophotometer. The experimental data shows that fruit yield of peach increased with increasing application of zinc sulphate. The Maximum fruit yield (58.25 kg $plant^{-1}$) and fruit weight (89.00 g) were observed with the application of 800 g Zn SO_4 per plant as soil application whereas minimum yield was obtained without zinc application. Zinc application also improves total soluble solids (TSS), although the acidity of fruits obtained from treated and untreated plants was not differ significant level but the highest acidity was observed in control treatment, whereas lowest was in foliar application of 0.50% Zn SO_4. The highest concentration of zinc (11.55 ppm) in leaves was observed at higher doses of soil zinc application and was in lowest in control treatment.

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Fertilizer N Management to Improve Maize-Wheat System Productivity in Soils of Jharkhand

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Improvement in maize and wheat productivity is the key to mitigate food, fodder and nutritional security in major parts of eastern India. Maize has high potential for diversified agricultural market in terms of food, feed and agro- based industries and provides nutritional security to the marginal farming community in backward, hilly and tribal areas. However, productivity of both the crops is low due to inadequate and inefficient nutrient management. Optimizing the rate and timing of nitrogen application to match crop requirement at key growth stages is critical for improving yield of these crops and will ensure better nutrient use efficiency and higher farm profit.

Maize and wheat were grown in rainy (June-October) and winter (November to March) seasons of 2009 and 2010 at the University farm of Ranchi, Jharkhand ($23^0 19^/$ north and $83^0 17^/$ east) in a acidic red and lateritic soil with low organic carbon and available nitrogen (N), phosphorus (P), potassium (K) and sulphur (S). Twelve treatment combinations, with four levels of N and three combinations of application times, for each of the crops were tested in randomized block design. Uniform doses of P and K, along with limiting secondary and micronutrients, were applied to all the treatments.

Maximum grain yield (4.9 t ha^{-1}) of maize was recorded at 160 kg N ha^{-1} applied in three splits guided by leaf color chart (LCC). Wheat yield was highest (4.8 t ha^{-1}) at application of 150 kg ha^{-1} of N in three splits on the basis of LCC. Post harvest nutrients status of soil after one cycle of maize and wheat showed that higher level of N application in two and three split doses decreased the N, K and S status by 11 to 19% from its initial status. Percent increase (254%) in maize-wheat system yield, as compared to the check treatment, was highest with the application of 240 and 150 kg N ha^{-1} in maize and wheat respectively, applied in three splits based on LCC guidance. Results suggest the need for N application based on periodic assessment the plant N status to minimize losses of fertilizer N, save environment and improve NUE.

Maize-wheat system yield can be doubled in the rain-fed tracts of Jharkhand through optimization of N management, along with balanced application of other limiting nutrients. The rate and timing of N application is critical to improve yields as well as to increase nutrient use efficiency for better farm economics.

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Influence of Long-term Fertilization on Yield, Nutrient Uptake and Economics of Maize–Wheat Cropping System

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The Long Term Fertilizer Experiments initiated in *kharif*, 1997 at the Instructional Farm of the Rajasthan College of Agriculture, Udaipur with maize-wheat cropping system. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in reaction (pH 8.2), medium in available nitrogen (427 kg ha^{-1}) and phosphorus (22.4 kg ha^{-1}) and high in available potassium (671 kg ha^{-1}), sulphur (21.0 mg kg^{-1}) and zinc (3.76 mg kg^{-1}). The twelve treatments, viz. T_1 :100% NPK, T_2 :100% NPK + Zn, T_3 :100% NPK + S + Zn, T_4 : 100% NPK + S, T_5 :100% NPK + seed treatment with *Azotobacter*, T_6 :farmyard manure 10 t ha^{-1} + 100% NPK (-NPK content of farmyard manure), T_7 :100% NPK + farmyard manure 10 t ha^{-1}, T_8 : farmyard manure 20 t ha^{-1}, T_9 : 150% NPK, T_{10} :100% NP, T_{11} :100% N and T_{12} : control were replicated four times in randomized block design. The treatments were laid in *kharif*,1997 after taking exhaustive crops. NPK was applied as 90:30:15 for both crops up to 2002-03 and then increased to 120:60:30 as per soil test recommendation.Urea, di-ammonium phosphate (adjusted for its N content) and murate of potash were used as sources of N, P and K, respectively. The *Azotobacter* for seed inoculation was used@500g ha^{-1} for both crops and FYM (as per treatment i.e.10 and 20 t ha^{-1}), Zinc @ 5 kg ha^{-1} as $ZnSO_4.7H_2O$ and sulphur @ 40 kg ha^{-1} as gypsum were applied only in *kharif* season.

The results revealed that integrated use of recommended dose of fertilizer with FYM @ 10 t ha^{-1} has excelled all the treatments for sustaining crop production and improving soil quality. The highest mean grain yield of maize (4.7 t ha^{-1}) and wheat (4.99 t ha^{-1}) was obtained under 100% recommended NPK+10 t ha^{-1} FYM application as compaired to 1.44 and 3.41 t $ha^{-1}$of maize and 1.70 and 4.33 t ha^{-1} of wheat under control and 100% NPK, respectively. This treatment gives maximum net return of Rs 31,253 and 48,490 ha^{-1} for maize and wheat crop with B:C ratio of 1.79 and 2.37.

The yield response of maize and wheat to nutrients increased gradually over the years.the order of response to the nutrients was N>P>K>Zn>S. N,P and K uptake was maximum with NPK+FYM followed by 150% NPK and lowest in control plot. The average removal of nitogen, phospurus, potash, sulpur and zinc to produce one tone food grain were 25.7, 5.4, 20.9, 4.5 and0.08 kg for maize and 21.7, 3.9, 18.7, 6.5 and 0.05 kg for wheat, respectively. Nitrogen use efficiency considerably improved with balanced NPK which was further enhanced from 34 to 51 and 43 to 59 per cent for maize and wheat crops under NPK+FYM treatment. Similarly, P and K use efficiency increased from 12.6 and 52.3 per cent to 18.38 and 86.30 per cent for maize and 17.0 and 21.4 to 25.2 and 78.8 per cent for wheat by application of FYM in conjunction with NPK.

Considerable build-up of organic and inorganic fractions of nitrogen, *viz.*, hydrolysable-N, amino sugar –N, amino acid-N, NH_4 –N, and NO_3 -N with continuous application of fertilizer, manure and their combinations was observed. Similarlly, appreciable build-up of total P, Ca-P, Al-P, Fe-P, Saloid-P and reduction soluble P and water soluble and exchangeable K in soil was observed.

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Agronomic and Physiological Approaches for Biofortification of Wheat Grain with Zinc

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Biofortification focuses on enhancing the mineral nutritional qualities of crops at source which encompasses processes that increase both mineral levels and their bioavailability in the edible part of staple crops. Among the different approaches of biofortification, agronomic biofortification is one of the cheaper and better options to increase the concentration of Zn in food grain. Keeping this in view, a field study was undertaken to investigate the effect of soil application of Zn (through $ZnSO_4.7H_2O$) besides its scheduled foliar application at different growth stages with the perspective of biofortification of wheat (Var. GW 496) grain with Zn on Typic Ustochrept soils of Anand (Gujarat). The study was conducted with eight treatments in a randomized block design with three replications. The mode of Zn application was through soil (25 kg $ZnSO_4$ ha^{-1} as basal), foliar (four foliar application of 0.5% $ZnSO_4$) and soil+foliar (20 kg $ZnSO_4$ ha^{-1} + two foliar sprays of 0.5% $ZnSO_4$) at different growth stages *viz.* crown root initiation, panicle initiation, milk and dough stage.

The results showed that foliar supplementation of Zn in wheat through 0.5% $ZnSO_4$ was found effective in increasing grain, straw and root yields over their normal practices of soil application *i.e.* 25 kg $ZnSO_4$. It also indicated that two foliar application of Zn through 0.5% $ZnSO_4$ at panicle initiation (PI) and milk along with its soil application @ 20 kg $ZnSO_4$ ha^{-1} resulted in one and half times increase in grain Zn concentration in wheat over control (21.5 mg kg^{-1}). In general, foliar Zn supplementation either at very early or late stage was less efficient in enhancing Zn concentration in grain; and the treatments receiving spray at PI /milk stage recorded higher increase. The physiological interventions through foliar sprays at different growth stages caused favourable changes in accumulation factor, transfer coefficient and mobility index to cause enhancement of Zn in wheat grain. The overall results suggested that the production of high density Zn grain of wheat through agronomic approaches could be a cheaper and better option to alleviate malnutrition in human being.

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Efficacy of Soil and Foliar Application of Iron in Correcting its Deficiency in Aerobically Grown Rice

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As water crisis threatens the sustainability of the irrigated rice ecosystem across the globe, cultivation of aerobic rice is gradually catching the imagination of people and efforts are being made to increase the productivity of this system. Iron (Fe) deficiency is one of the major problems which limit the productivity of aerobically grown rice. Deficiency of this micronutrient is the most difficult and expensive to correct under field conditions. Unlike other micronutrients, precise diagnosis of Fe deficiency is also equally problematic. Enhancing the content of Fe in edible portion of crops for improving human health is a global challenge. Food fortification and supplementation are being widely used in some countries to mitigate the Fe deficiency in humans. However, these approaches appear to be expensive and not easily accessible in developing countries. In view of the limited information available on the above-mentioned aspects, the present investigation was carried out i) to monitor the levels of active (Fe^{2+}) and total Fe content in control and Fe-treated rice plants at different physiological growth stages, ii) to study the relative effectiveness of soil and foliar application of Fe in alleviating Fe deficiency in aerobic rice using different cultivars, and iii) to compare the efficacy of soil and foliar application of Fe in enhancing its content in rice grain. Two field trials on diagnosis and amelioration of iron (Fe) deficiency under aerobically grown rice were conducted using Sugandh 3, IR 64, IR 55419 and IR 55423 as test rice cultivars. Apart from control, Fe management treatments consisted of soil (150 kg $FeSO_4$ ha^{-1}) and foliar application of 3% $FeSO_4$ solution.

Results indicated that active Fe (Fe^{2+}) in rice plants was a far better predictor of Fe-nutrition status compared to total plant Fe and chemically extractable soil Fe. The Fe^{2+} content of 46-50 mg kg^{-1} in plants (on dry weight basis) at 35 days after sowing (DAS) can be used as a guide value to monitor the Fe-nutrition status of direct seeded rice. The corresponding value at 60 DAS ranged from 41 to 46 mg kg^{-1}. The application of Fe had positive impact on both active Fe in plants. The higher grain yield was obtained with two foliar sprays of Fe (3% $FeSO_4$; 30 kg $FeSO_4$ ha^{-1}) at 30 and 45 DAS as compared to soil application of Fe @ 150 kg $FeSO_4$ ha^{-1}. Among the rice cultivars, Sugandh-3, IR55419 and IR 55423 performed better under aerobic condition compared to IR 64. Four foliar sprays of $FeSO_4$ were more effective in enhancing the Fe content in rice grain, followed by two foliar sprays and soil application. Similar trends were also obtained in case of Fe content in rice husk. On an average, grain to husk ratio (on dry weight basis was decreased significantly due to supplementation of Fe from external source. It can be concluded from this study that at least two foliar sprays should be included in the fertilization schedule for enhancing the productivity of aerobically grown rice.

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Impact of Long-Term STCR Based Fertilizer Recommendations on Yield, Soil Fertility Status and Economics under Pearl millet-Wheat Cropping Sequence

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A long-term experiment on soil test crop response correlation (STCR) based fertilizer application was started during *kharif* 2003 on a sandy loam soil (Typic Halustept) at the research farm of Indian Agricultural Research Institute, New Delhi, to study the effect of STCR based fertilizer application for targeted yield of pearl millet-wheat cropping sequence on yield and soil fertility. The experiment was laid out in Randomized Block Design with four treatments *viz.* T_1= FYM @ 20 t ha^{-1} in each crop, T_2= STCR based integrated fertilizer dose with 10 t ha^{-1} FYM, T_3= STCR based fertilizers dose and T_4 = Control under with four replications. Results showed a significant and positive impact of integrated use of FYM (T_2) and FYM alone (T_1) on productivity of cropping sequence and soil fertility build-up. Integrated use of fertilizer with FYM on soil test based produced significant higher grain and straw yield of pearl millet and wheat compared to other treatments. The highest mean (2006-2011) grain and straw yield of pearl millet (29.0 and 66.9 q ha^{-1}) and wheat (53.1 and 71.3 q ha^{-1}) was recorded with STCR based integrated fertilizer dose with 10 t ha^{-1} FYM (T_2) for yield target of 25 and 50 q ha^{-1} respectively. Average increase in grain and straw yield of pearlmillet was 224.6 and 214.4% and of wheat was 193.4 and 190.6% under treatment T_2 over the control (T_4) during the experiment period from 2006-2011. The lowest mean grain and straw of pearl millet (8.9 and 18.1 q ha^{-1}) and wheat (21.3 and 24.5 q ha^{-1}) was observed in control plot (T_4). The average fertility status i.e. available N, P and K of soil after five years of cropping sequence was at par in the treatments where STCR based integrated fertilizer dose with 10 t ha^{-1} FYM (T_2) and FYM @ 20 t ha^{-1} in each crop (T_1) were applied and significantly higher as compared control (T_4) and fertilizer treatments except available phosphorus. Average of five year (2006-2011) pearl millet-wheat cropping sequence gave maximum net return Rs. 101337.00 ha^{-1} and extra profit Rs. 65869.00 ha^{-1} yr^{-1} with STCR based integrated fertilizer (T_2) over control (T_4). Therefore, STCR based integrated fertilizer may be recommended economically viable proposition to be adopted by the farmers in India.

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Nutrient Management in Jute-Rice–Wheat Cropping System – Forty Years Experience

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Intensive cultivation with high yielding varieties increased the grain yield of rice as well as fibre yield of jute and removed huge quantities of nutrients (including micronutrients) from the soil every year. Observations of the long term fertilizer experiment over last four decades are discussed in respect of sustainable crop production and maintenance of soil health. The experiment was laid out with ten treatments in randomized block design with four replications. The optimal levels of N, P and K (100% NPK) were taken as 120, 26 and 50 kg ha^{-1} for rice and wheat and 60, 13 and 50 kg ha^{-1} for jute. In 100% NPK+FYM treatment, farmyard manure @10 t ha^{-1} was applied along with NPK before jute sowing every year. All the treatments showed significantly higher yield compared to control. Highest yield (average of five years) in jute was recorded in 150% NPK followed by 100%NPK+FYM treatment. In sub-optimal dose (50% NPK) and imbalance treatments (100% NP and 100% N) dry fibre yield of jute was significantly lower as compared to optimal and super optimal (150% NPK) dose. Similar results were found in case of rice and wheat also. From the result it was observed that incorporation of FYM along with NPK significantly increased the grain yield as compared to NPK alone. The highest average yield in 150% NPK treatment indicates that the amount of NPK applied in 100% NPK is not sufficient to get the potential yield. So there is a need to relook into the doses of nutrient (NPK). From the yield trend analysis, it can be concluded that recommended optimum dose of fertilizer for jute, rice and wheat were inadequate. To obtain sustainable yield over the years, there is need to increase the amount of NPK in all the crops or FYM is to be included in regular fertilizer schedule to achieve maximum yield.

After 40 years of continuous cropping soil organic carbon and available N, P, K was analyzed for post jute soils. The SOC build-up was highest in 100%NPK+FYM treated plot followed by 150% NPK treated plot. Hence, it can be inferred that the continuous application of inorganic fertilizers (NPK) in a balanced manner along with FYM leads to the enrichment of SOC. Among the treatments, highest soil available N was recorded in 100% NPK+FYM. It was observed that available P content increased significantly in all the treatments over control except in 100% N treatment where no phosphatic fertilizer was applied. Similarly available K content was highest in 100%NPK+FYM treatment followed by 150% NPK treatment. After four decades of experimentation, DTPA extractable Fe, Cu, and Mn decreased as compared to the initial status. Among the micronutrients depletion of Mn was maximum. Optimum fertilization as well as incorporation of FYM in the regular fertilizer schedule increased the soil microbial biomass carbon as well as fluorescein diacetate activity (FDA). Hence, FYM Should be incorporated in regular fertilizer schedule to obtain sustainable crop production and maintain soil health.

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Status of Soil Chemical Properties, Macro, Micro and Secondary Nutrients in District Ludhiana, Punjab

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Five hundreds twenty-eight soil samples were collected from the soils of district Ludhiana on the basis of GPS reading and analyzed to judge the status of soil chemical properties *viz.*, pH, electrical conductivity, organic carbon, macro, micro and secondary nutrients. Majority of soils (99.2%) of Ludhiana district were alkaline in nature and normal in electrical conductivity. Generally 78.6% soils were medium in organic carbon status, however, available soils were invariably deficient in nitrogen indicating that available N is not the good indicator for recommending nitrogenous fertilizers for project soils. The higher build up P was observed in Punjab soils as 77.8% soils were having high P status and 14.4% soils had medium P status. Potassium status of majority of the soils were medium (63.4%) followed by 19.1% low and 17.4% high. More than half percentage of soils (51.3%) have high Zn status followed by 36.2% were in medium range and only 12.5% soils were deficient. The deficiency of Cu was negligible only 1.5% soils were in low category while 83.6% soils were in high and 15% were in medium status. The deficiency of Fe was observed only in 10.2% soils while majority of the soils (84.3%) where having high Fe content. More than half the soils were medium in Mn (54.9%) followed 25% soils have high and 20.1 soils have low Mn status. Half the soils were in medium range in boron followed by 26.3% in low and 22.7% soils in high status. Soil of Ludhiana was high in sulphur status (58.2%) and only 12.9% was deficient. Higher percentage of soils with respect to Mn and B were found in deficient range indicating that these elements will be the limiting factors in crop production in near future in Punjab. Zinc deficiency was prevalent in only 12.5% soils and thus showing decreasing trend over the years which are attributed to regular use of zinc fertilizers by the farmers.

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Response of Soybean (*Glycin max*) to Different Fertility Levels in Alluvial Soils of Madhya Pradesh

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Soybean is important oilseed crops of Madhya Pradesh. It covers largest area of world. Nutrient management is important factors which increased the yield and quality of soybean. In this view a field experiment was conducted during *Kharif* season of 2007-08 to 2009-10 with soybean variety JS 93 – 05 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 1*N* ammonium acetate extractable K_2O-382 kg ha^{-1}. The experiment was laid out in randomized block design with four replications. The treatments consisted of four fertility levels (50, 75, 100 and 125% RDF). The observations were recorded at their critical stages.

The significant improvements in seed as well as straw yields of soybean were observed with every increasing level of nutrient application from 50 to 100% RDF. The mean response due to 100% RDF was 27.86 and 16.29% in seed yield over 50% and 75% RDF, respectively.

The nutrient use increased with decreasing levels of fertilizers from 125% to 50% RDF. The maximum nutrient use was recorded with 50% RDF of N, P, K and Zn (109.7, 27.5, 109.7, and 87.8 kg seed/kg nutrient) and lowest with 125% RDF. The production efficiency was improved with progressive increase in fertilizer application and highest was gained with 100% RDF (17.30 kg ha^{-1} day^{-1}).

The gross returns, net returns, additional returns and benefit cost ratio were affected by various fertilizer treatments. The highest gross returns (Rs. 55123 ha^{-1}), net returns (Rs. 41917 ha^{-1}), additional returns (Rs. 14426 ha^{-1}) and B:C ratio (4.17) were achieved under 100% RDF.

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Soil Fertility Status of 100 Years Old Permanent Manurial Experiment with Sunflower-Maize Cropping Sequence at Coimbatore, Tamil Nadu

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The permanent manurial experiment conducted at Tamil Nadu Agricultural University, Coimbatore is the oldest one in India and second in the series of Permanent Manurial Experiments next to Rothamsted Permanent Manurial Experiments in U.K. This experiment was started in the year 1909 under irrigated condition and from 1937 onwards it is being conducted under rainfed conditions with ten treatments *viz.*, control, N alone, NK, NP, NPK, PK, K alone and P alone besides cattle manure and cattle manure residue. Recently from 2008, new treatments *viz.*, INM, STCR based NPK, farmers practice and No manure no crop, FYM N equivalent basis, poultry manure N equivalent basis and residue mulching were included. The Permanent Manurial Experiment is non-replicated trial.

The main objective of this experiment is to study the effect of continuous application of plant nutrients either singly or in combination with and without organic manure on crop yield, nutrient composition, nutrient removal and soil fertility status.

The results obtained from this experiment revealed that application of single nutrients (N or P or K) alone results in significantly low crop yields. Combination of N and P gave higher yield and was on par with NPK and FYM. Phosphorus becomes the limiting nutrient when it is not applied. This results in considerable reduction in yield to the extent of 50-60 per cent. Available N, P and K status of soils is higher wherever these nutrients are applied continuously. Continuous withholding of P from manuring schedule depleted native soil P to very low level of 1.7 to 2.0 kg ha^{-1} as against 15 kg ha^{-1} in treated plots. Available K was depleted in control, N, NP plot (670 kg ha^{-1}) as compared to NK, NPK and PK (940 kg ha^{-1}) treatments. Combined N, P and K application improved the water holding capacity, pore space and volume expansion of soil. A build-up of soil organic carbon content was noticed in all the treatments except control over years and was found to be higher in the FYM / NPK applied plots. The microbial count and the soil biomass carbon were found to be higher with the application of balanced dose of NPK followed by FYM applied plots.

Overall, the combined application of NPK fertilizers and continuous application of organics sustained the grain yield at a higher level in the long run and sustained the soil health in terms of soil physico-chemical properties and soil fertility as reflected by the organic carbon, and available NPK status.

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Response of Berseem and Maize crops to the Application of Boron in Alluvium Derived Soils of Punjab

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Boron deficiency which was earlier confined to calcareous soils of Bihar and terai region of West Bengal has stated emerging in alluvium derived coarse texture, low in organic matter, alkaline and calcareous soils of Punjab. It is presumed that continuous mining of B due to intensive cropping, high yield crop varieties, reduced recycling of organic manures have depleted the soil nutrient reserve of this element. more so of micronutrient including boron. Enough evidence has become available from various sources, that about 10-15 percent soils are deficient in available boron in Punjab which has obstructed to attain the full yield potential crops and thus expected to respond to its application.

Field experiments were conducted to study effect of boron applied through granubor ($Na_2B_4O_7.5H_2O$; 15% B) on berseem (var BL- 5) and maize crops on soils deficient in available boron.(0.5 mg kg^{-1} soil). The treatment consisted of control, soil application of five levels of B (0.5 0.75, 1.0 and 1.5 and 2.0 kg ha^{-1}). The experiment was laid down in a randomized block design (RBD) with three replications. Both the crops were raised following the package and practices. Green fodder yield of berseem and grain and straw yield of maize was recorded at maturity. Berseem yield increased from 82.9 to 102.6 and 96 to 115.5 q ha^{-1} in the first and second cutting with the application of 0.75 kg B ha^{-1}, 134.8 to 146.3 q ha^{-1} in the third cutting with the application of 1.0 kg B ha^{-1}. This implies that increasing levels of boron application up to 0.75 kg B ha^{-1}increased the green fodder yield significantly in first and second cutting beyond which the improvement was not significant. How ever application of 1kg B ha^{-1} was required to increase the yield significantly in the third cutting. This may be due to more boron requirement for latter cutting because of higher yield in later cutting. Dry matter yield showed the same pattern as that of green fodder yield. Boron content of berseem crop gradually decreased with aging. It was maximum in the first cutting and the lowest in the third cutting, the decrease in B content may be due to dilution factor. The mean B concentration increased from 20.8, 16.7 and 14.9 μg g^{-1} in control treatments to 26.2, 23.3 and 19.2 μg g^{-1} when boron was applied at the 2 kg ha^{-1} in first, second and third cutting respectively. However, significant increase in B content was obtained at the application rate of 0.75 kg B ha^{-1} in the first and second cuttings and at 1.0 kg B ha^{-1} in the third cutting. Uptake of boron showed a peculiar pattern being highest in the third cutting despite having low content of B compared to first and second cuttings probably due to considerably high dry matter yield. No response of boron application to maize crop was observed indicating low requirement of the cereal crop. Divergence in boron acquisition mechanism among crops suggest that there is need to refine the critical limit.

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Effect of Graded Doses of Fertilizer on Chilli under Rice-Chilli Cropping System in an Ustochrepts of Orissa

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A field experiment was conducted to study the effect of graded doses of fertilizer on chilli under rice-chilli cropping system in a laterite soil at Central Research Station, Bhubaneswar. The soils were classified as fine, mixed, hyperthermic, Vertic, Ustochrepts. The experimental site (0.3 ha) was divided into three equal blocks during kharif, 2010 to create fertility gradient strips and rice (cv. Lalat) was transplanted after addition of 25% dose of N, full dose of P and K in last week of July at the rate of $N_0P_0K_0$ in Block-I, $N_{80}P_{40}K_{40}$ (recommended dose) in Block-II and $N_{160}P_{80}K_{80}$ (twice the recommended dose) in Blcok-III. The rest dose of N was given in two splits as top dressing. After the harvest, soil samples were collected along with grain and straw samples for chemical analysis. Then these three blocks were ploughed and each block was sub-divided into 24 sub-plots. Soil samples were collected from each sub-plot for laboratory analysis. There were 21 combinations of NPK fertilizers and 3 controls in each block.

Chilli (cv. *Utkal Abha*) was taken up during rabi season as per the fertilizer treatments. The crop was harvested after maturity and soil samples were collected along with plant samples from each plot for laboratory analysis for determination the uptake of nutrients.

The result indicated that the highest yield of chilli was achieved with application of $N_{150}P_{80}K_{80}$ (kg ha^{-1}) in all the three fertility gradient strips i.e. 23.3, 24.2 and 25.7 q ha^{-1} in Block-I, Block-II and Block-III, respectively. From the data on yield of chilli, total nutrient requirement (NR); percent contribution of soil (Cs) and percent contribution of fertilizer (Cf) for NPK was calculated. From the above data, the fertilizer prescription equations for targeted yield of Chilli were formulated.

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Effect of Copper Ore Tailings on Groundnut and Wheat Yield

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Micronutrients play a vital role in growth and development of plant. Due to intensive cropping system with high yielding varieties and application of major nutrients, incidence of micronutrient deficiencies have been more pronounced. In this direction some of the industrial ore waste and agricultural wastes containing micronutrients can be used as cheaper source of micronutrients. One such mining ore waste is copper ore tailings (COT).

The field experiments were conducted on farmers field under irrigated condition on black soils of Garag village (2002-03) and Yattinagudda village (2003-04) near MARS, UAS, Dharwad to find out the efficiency enhancement of copper ore tailing as a source of micronutrient in groundnut-wheat cropping sequence, using different levels of COT (0.5, 0.75 and 1.0 t ha^{-1}) with organics manures (namely vermicompost (VC), farm yard manure (FYM), biogas slurry (BGS), poultry manure (PMS) and acids). The pooled data of two years at two different locations indicated that application of VC 2.5 t + COT 1.0 t ha^{-1} significantly increased the concentration and uptake of N, P, K, Ca, Mg, S, Cu, Fe, Mn and Zn in of groundnut. The application of VC 2.5 t + COT 1.0 t ha^{-1} as a source of micronutrient increased the uptake of major, secondary and micronutrients which helped for increasing significantly the pod yield (3578 kg ha^{-1}) over COT @ 1 t ha^{-1} (2881 kg ha^{-1}). The increase in pod yield was mainly due to more number of developed pods per plant, highest test weight, more number of filled kernels and higher shelling percentage. The positive response of groundnut crop to COT mixed with organic manures was ascribed to the modification of soil textures and increase in water holding capacity of soil. As a result, the soil was friable and thus helped in achieving better crop stand, peg penetration, pod development and easy harvesting of groundnut.

The residual effect of application of pretreated COT had significant effect on yield parameters (1000-grain weight, number of grains per ear, ear length, ear weight, number of effective tillers per meter row length), grain yield and straw yield of wheat over standard check. The application of VC 2.5 t + COT 1.0 t ha^{-1} recorded highest grain yield followed by VC 2.5 t + COT 0.50 t ha^{-1}, FYM 10 t + COT 0.50 t ha^{-1}, PM 2.0 t + COT 0.75 t ha^{-1} and BGS 5.0 t + COT 1.0 t ha^{-1} treatments and the lowest values were recorded in control. The grain yield may be attributed to higher total dry matter accumulation due to better major, secondary and micronutrients uptake and their translocation to the reproductive parts and improvement in yield attributing characters like number of grains per ear head, grain weight per ear head, 1000-grain weight and number of effective tillers.

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Integrated Nutrient Management in Potato-Summer Pearlmillet Cropping Sequence

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Supplementation of nutrients through only chemical fertilizers has detrimental effect on soil health and thereby productivity of the crops. Therefore, use of organic manure along with chemical fertilizers is necessary to maintain soil health and fertility for sustainable crop productivity. The biogas slurry of biogas plant is a good source of nutrients which is being utilized by the farmers in the middle Gujarat region. The use of enriched biogas slurry obtained from mixing with concentrated organics like castor cake is supposed to contain more quantity of the nutrients which in turn help to reduce chemical fertilizers.

A field experiment was conducted during 2000-01 to 2003-04 at RRS, AAU, Anand on potato (cv. kufri locker) in *rabi* and pearmillet (cv. GHB 316) as succeeding crop in summer to study the effect of biogas slurry application to potato with inorganic fertilizer on growth, yield and nutrients utilization by the crops. The treatments comprised of different combinations of organics (FYM and biogas cow dung slurry alone and enrichment with 20 % castor cake) and nitrogen (200, 150 and 125 kg/ha) were tested in RBD with three replications. The soil of the experimental field was loamy sand, low in OC and N, medium in available P, Fe and Zn and rich in available K having alkaline pH 7.6 with low soluble salts.

The pooled results of four years revealed that number of tuber per plant (5.97), tuber weight (349 g plant^{-1}) and tuber yield (227 q ha^{-1}) were significantly higher with the application of 150 kg N ha^{-1} + 7.5 t/ha enriched cow dung slurry with 20% castor cake than other treatments and the tuber yield was higher by 32 per cent over recommended dose of N (200 kg ha^{-1}). The utilization of sulphar and micronutrients by potato was also higher in this treatment than other combinations. Residual effect of integrated nutrient management practices did not adversely affect on yield of succeeding pearlmillet. The results indicated that the saving of 50 kg N ha^{-1} could be achieved with utilization of castor cake enriched biogas slurry in potato-pearlmillet cropping sequence.

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Formulating Nutrient Management Schedules for Improving Yield and Quality of Broccoli

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Broccoli (*Brassica oleracea* var. italica) is one of the healthiest vegetables grown almost throughout the world. We studied the effects of different source of nutrients on yield, yield attributing characters, contents of value added products and its post-harvest changes in broccoli. The treatments of the experiment included: 2 levels of inorganic (F_1 = 150:75:75:: N:P:K, F_2 = 200:100:100:: N:P:K), 3 types of organic (vermicompost, VC, 12.5 t ha^{-1}, farmyard manure, FYM, 25 t ha^{-1}, mustard oil cake, MOC, 7 t ha^{-1}) and 9 levels of their combinations. Total biomass yield, curd yield and yield attributing parameters *viz.*, plant height, leaves per plant, average curd weight per plant, curd circumference and curd diameter of broccoli were significantly influenced by different levels and sources of nutrients. On an average, curd constituted ~28.8% of the total biomass of broccoli. Among the treatments compared, FYM+ F_2, MOC + F_2, VC+ F_2 and only F_2 had an edge over the others. Boron application through spray @ 0.025% caused little increase in yield. It was observed that the inorganic and organic+inorganic combinations produced higher plant height, more number of leaves per plant, higher leaf length and breadth and also higher curd weight per plant. Biggest curd size with respect to curd circumference and diameter was also associated with organic+inorganic combinations. Inorganic treatment caused higher synthesis of α-carotene (9225.9 IU) in the curd followed by organic+inorganic (9186.8 IU) > organic (8946.8 IU) > control (8648.3). Boron application had little influence on α-carotene content. The maximum (115.5 mg $100g^{-1}$) and minimum (49.2 mg $100g^{-1}$) values of vitamin C were associated with FYM+ F_2 or MOC+ F_2 and control treatments, respectively. Boron application, however, increased vitamin C content in the curd over the no B application. α-carotene content in curds recorded an increase under refrigerated conditions for 3, 7 and 15 days and later on it decreased after 20 days. α-carotene content increased in broccoli when treated with 100 μg g^{-1} solution of 6-benzylaminopurine. Vitamin C content however was found to decrease gradually in post harvest conditions in refrigerated as well as in non-refrigerated conditions. Finally, application of FYM @ 6.25 t ha^{-1} + F_2 along with B @ 0.025% sprayed twice at 25 and 40 days after transplanting was found to be the best treatment not only for yield but also for the quality of broccoli.

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Screening of Popularly Grown Rice Cultivars as to their Iron Harvest Index in Inceptisols of West Bengal

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Screening of rice cultivars as to their high iron content is of major global concern as about two thirds of the world's population is at risk of iron-deficiency induced anemia. We evaluated twenty six popularly grown rice cultivars with wide genetic variability containing 7 local, 13 high yielding varieties (HYV), 3 hybrids and 3 aromatics in randomized block design with three replications as to their native Fe contents as well as Fe-harvest index in intensively rice growing Inceptisols of West Bengal. Although available Fe content in these soils (138.6 ppm) was much higher than its critical value *i.e.* 4.0 mg kg^{-1}, cultivars differ widely in native Fe content in grains as well as in straw. Grain yield of the cultivars was in the order of HYV followed by hybrid > local > aromatic with a mean value of 36.0, 28.6, 24.8 and 23.1 q ha^{-1} respectively, while straw yield followed the trend Hybrid > local > aromatic > HYVs with a mean value of 104.2, 96.7, 93.5 and 71.7 q ha^{-1}, respectively. On average, highest Fe content in grains was found in HYVs followed by local > aromatic > hybrid with mean value of 92.1, 87.6, 80.7 and 69.2 mg kg^{-1} respectively, while Fe content in rice straw followed the trend HYVs > hybrid > aromatic > local with mean value of 108.7, 98.8, 92.7 and 79.8 mg kg^{-1}, respectively. Iron harvest index (HI) of these cultivars was, in general, followed the trend HYVs > local > aromatic > hybrid with mean value of 0.31, 0.23, 0.19 and 0.18 respectively. Variation in Fe harvest index indicating that grains of the former cultivars could accumulate a higher amount of iron than those of the latter types. Higher iron content in grains of high yielding cultivars might be due to high iron chelating phytosiderophore secretion from roots and more efficient utilization of iron from high iron containing soils of this region.

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Improving Yield and Quality of Pointed Gourd (*Trichosanthes dioica* Roxb.) through Nutrient Management

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Pointed Gourd (*Trichosanthes dioica* Roxb.) is a major highly remunerative vegetable crop grown in eastern India. It is one of the best and cheapest sources of vitamin C and micronutrients for human nutrition. It is hypothesized that quality and yield of the crop is affected by nutrient management practices. But there is no nutrient management schedule available for the cultivation of the crop. An attempt has been made in this study to develop it conducting a field experiment with different management practices. The management practice are: 3 levels of inorganic (F_1 = 150:60:60:: N:P:K, F_2 = 180:90:90:: N:P:K and F_3 = 220:110:110:: N:P:K), 2 types of organic [OM_1 = farm yard manure (FYM) @ 20 t ha^{-1}, OM_2 = farm yard manure (FYM) @ 10 t ha^{-1} + vermicompost (VC) @ 4 t ha^{-1}] and 6 levels of their combinations applied in 3 factor factorial completely randomized block design. With all these treatments, B was applied every month after 150 days of planting of stolen as spray at 0 and 0.025% concentration. To optimize the harvesting stage fruits were harvested at 7, 9, 11, 13 and 15 days after fruit-setting/pollination. Total yield, length of fruit, girth and average fruit weight were significantly influenced by different levels and sources of nutrients. The average data of two years showed that fruit production attained peak during May, irrespective of treatments. May month yield constituted ~ 25% of the total production. The higher yield (38.5 t ha^{-1}) was recorded in F_3OM_2 treatment. In organic treatment, foliar spray of B @ 0.025% once in a month was found to cause significant increase in yield (11.1%). Among the major nutrients N (4.24%), P (0.45%) and K (1.86%) content of the fruits were higher at the initial stage but decreased with increasing maturity; while Ca and Mg kept on decreasing. Micronutrient Fe and Mn concentration increased slightly with maturity of fruits but Zn, Cu and B recorded a decrease. Content of dietary fibre varied in fruits significantly it increased with increasing maturity. The highest (45.8%) dietary fibre was recorded with integrated treatments. Organics facilitated the synthesis of vitamin C (16.2 mg 100 g^{-1}) in fruits and such synthesis increased with fruit maturity.

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Screening of Wheat Cultivars as to their Zinc Sequestration Potential in Inceptisols

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Zinc malnutrition is a serious problem in India. Improving Zn concentration in cereals is one of the ways to curb the problem. Knowledge regarding zinc sequestration potential of cereal cultivars is thus useful. We evaluated twenty five wheat cultivars commonly grown by farmers as to their Zn sequestration potential raising them with standard management practices and also with three levels of zinc *i.e.* Zn_0 (control), Zn_1 (soil application of Zn @ 50 kg ha^{-1}) and Zn_2 (soil application of Zn @ 50 kg ha^{-1} + foliar application @ 0.5% $ZnSO_4,7H_2O$). The inherent zinc sequestration potential of the cultivars ranged from 19.4 to 63.2 mg kg^{-1} with the mean of 45.8 mg kg^{-1}; the highest and lowest values were associated with HI 1563 and UP 262 cultivars, respectively. Such Zn sequestration potential of the cultivars increased significantly with the application of Zn both through soil and foliar. On an average, the magnitude of increase varied from 45.8 to 76.1 mg kg^{-1}. Of the tested cultivars, UP 262 responded most; while GAYETRI least. In general, cultivars inherently low in Zn responded more with applied amount. Based on response, the cultivars were grouped into three classes - low (0 to 50%, GAYETRI, HD 2888, KRL 213 *etc*.), medium (50 to 80%, PBW 343, DBW 14, NW 2036 *etc*.) and high (80 and 155%, UP 262, Raj 4229, CG 8001 *etc*.) Zn sequestration potential. Variation in zinc sequestration potential of different wheat cultivars under different zinc treatments might be governed by their genetic makeup, although the role of external environment could not be ruled out.

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Studies on the Influence of Micronutrients Particularly Zinc and Boron on the Yield and Quality of Potato

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Due to follow of intensive cultivation with high yielding varieties of crops using high analysis fertilizers micronutrient deficiency has become widespread all over the country. Now-a-days, micronutrient addition is a common practice not only to sustain the crop production as well as to maintain the crop quality. Since micronutrient control various metabolic processes particularly innumerable enzymatic reactions in plants. With this background a study was made to study the effect of zinc and boron in the yield and quality of potato. For this study a field experiment was conducted at Adisaptagram Block Seed Farm situated in the district Hooghly, West Bengal, where Zn and B were applied through foliar applications. The treatment combinations were: variety-2 (Kufri Chandramukhi and Kufri Jyoti), Zn addition – 2 levels (0 and 0.5 % $ZnSO_4.7H_2O$), boron -2 levels (0 and 0.2 % Borax). Zn and B were applied through three foliar sprays at 10 days interval. Treatments were imposed at three replication in split plot design with varietal main plot and Zn and B in factorial as sub-plot. At the time of harvest of potato, yields were recorded. The plant and tuber samples were taken for the analysis of micronutrients elements as well as some antioxidants *viz*. ascorbic acid, phenol and carotene content and bio-chemical parameters such as sugar, starch and protein were estimated. Results showed that Zn and B spraying caused a yield increase in both the varieties of potato upon Zn application. The yield increase was 11.74 and 14.37% over control in Kufri Chandramukhi and Kufri Jyoti, respectively. Effect of Zn was more than B regarding yield increase in both the varieties of potato. Like yield increase, quality parameters e.g. antioxidant contents of potato *viz*. phenol, carotene, and ascorbic acid and protein and sugar contents were also increased upon Zn and B application. But the effect was more with Zn than B, excepting carotene content where sole application of B was more effective. The relative efficacy of the treatments was as follows: $B_0Zn_1 > B_1Zn_1 > B_1Zn_0 > B_0Zn_0$. Interaction effect of Zn and B was also positive for the aforesaid quality parameters but the case was very conspicuous in case of starch content.Here the relative efficacy of the treatment was as follows: $B_1Zn_1 > B_1Zn_0 > B_0Zn_1 > B_0Zn_0$. So, from the overall results it can be concluded that Zn and B spraying would be very effective not only for increasing the yield of potato but also for the quality of potato.

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Response and Enrichment of Green Gram (*Vigna radiata* L.) Genotypes with Iron Application

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Among different nutrient enrichment (biofortification) techniques, agronomic methods are known to be the most cost effective approach; but there is a doubt whether this agronomic methods are successful to fortify Fe in grains or not. To verify this, effect of Fe application methods on enrichment of Fe in seed and straw of seven genotypes of green gram was investigated in a screen house experiment. Green gram was selected as test crop because it is one of the most widely cultivated pulse crops in the country and occupies an important place in daily food habit of majority. Seven genotypes of green gram (Asha, Basanti, Satya, MH 318, MH 421, MH 565 and Muskan) were used in the experiment. Iron application treatments consisted of 0 and 10 kg Fe ha^{-1}, 0.1% Fe as foliar application, and 10 kg Fe ha^{-1} + 0.1% Fe spray through $FeSO_4,7H_2O$. In the case of foliar application, two sprays of 0.1% Fe, one at pre-flowering and another at pod initiation stage were applied. The seed and straw yield of all the green gram genotypes increased significantly with Fe application over the control. When Fe was applied @ 10 kg Fe ha^{-1} plus foliar spray of 0.1% Fe, it gave the maximum straw yield of 63.2 g pot^{-1} and seed yield of 9.12 g pot^{-1} in green gram genotypes. Among genotypes highest straw and seed yield was recorded in Satya (67.6 g pot^{-1} and 9.85 g pot^{-1} respectively). Combined application of soil (10 kg Fe ha^{-1}) plus foliar (0.1% Fe) gave the highest straw and seed (1.9 fold increment in straw Fe and 1.3 fold in seed Fe over control) concentration of Fe in all the genotypes. The maximum Fe concentration in straw was found in Basanti (298.1 mg kg^{-1}) and in seed of MH 421 (56.3 mg kg^{-1}) genotypes. The Fe uptake by all the genotypes of green gram increased significantly with the application of Fe externally. Highest uptake of Fe in seed was 0.46 mg pot^{-1} and in straw 23.6 mg pot^{-1} obtained with the application of soil (10 kg Fe ha^{-1}) plus foliar (0.1% Fe) spray. Soil plus foliar application of Fe also increased the seed crude protein content to 26.5% compared to 21.9% of control. Soil+foliar application thus outperformed other methods. This might be due to more availability of Fe to plants at all the growth stages. Although, increment of seed Fe concentration was not so satisfactory; but soil plus foliar application method may be practised instead of only soil or foliar application of Fe for better results.

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Effect of Micronutrients Application on *Alternaria* and White Rust of Mustard in Alluvial Soils of Madhya Pradesh

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Mustard is the most important oilseed crop of northern India. The yield per unit area is still low because of various diseases. Application of various micronutrients mitigate the severity of different diseases of rapeseed and mustard which in turn increase the crop yield. Keeping this view, a field experiment was conducted in alluvial soils of Madhya Pradesh during *rabi* season of 2009-10 at research farm ZARS, Morena. The experimental soil was sandy loam in texture having 0.45% organic carbobn, alkaline. $KMnO_4$ extractable N-180 kg ha^{-1}, olsen's P-20 kg ha^{-1} and normal neutral ammonium acetate extractable K-390 kg ha^{-1}. The soils were deficient to Zinc and Sulphur compound the treatments were: T-1: ZnO soil application @ 15 kg ha^{-1} as basal dose, T-2: Borax soil application @ 10 kg/ha as basal dose, T-3: S as per local recommendation as basal dose (30 kg ha^{-1}), T-4: ZnO soil application @ 15 kg ha^{-1} as basal dose + Borax soil application @ 10 kg/ha as basal dose, T-5: ZnO soil application @ 15 kg ha^{-1} as basal dose + S per local recommendation as basal dose, T-6: Borax soil application @ 10 kg ha^{-1} as basal dose + S as per local recommendation as basal dose, T-7: ZnO soil application @15 kg ha^{-1} as basal dose + Borex soil application @10kg/ha as basal dose + S as per local recommendation as basal dose, T-8: Slaked lime (CaOH) 1% (W/V) applied in late afternoon hours as 50 DAS, T-9: Mancozeb 0.2% applied in late afternoon hours at 50 DAS after sowing (Fungicidal check), and T-10: Control (Untreated check)}. The experiment was laid out in randomized block design with three replications. A common dose of N, P and K @ 80, 40 and 20 kg ha^{-1}, respectively where applied to each plot.

The seed yield of mustard was significantly influenced by various treatments. The highest seed yield (1867 kg ha^{-1}) was obtained with the application of Zinc and Borex as soil application @ 15 kg ha^{-1} and 10 kg ha^{-1} respectively along with Sulphur @ 30 kg ha^{-1} as basal dose followed by spray of 1% slaked lime. The maximum 46.0% *Alternaria* blight disease was observed in control plot and minimum 15.0% disease severity was recorded in spray of Mancozeb @ 0.2% at 50 DAS. In case of white-rust the maximum disease severity was observed in control plot and no staghead were observed in spray of Mancozeb @ 0.2% at 50 DAS followed by in application of Borex @ 10 kg ha^{-1} (1.7%) and Zinc @ 15 kg ha^{-1} (2.0%) disease severity was recorded in treatment 5 and 6, respectively.

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Evaluation of Suitability of Chemical Extractants for Assessing Available Zinc in Soils Amended with Organics

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In view of limited information on the suitability of commonly used chemical extractants in assessing the plant availability (leafy vegetable) of Zn in soil amended with farmyard manure and sewage-sludge, the present investigation was undertaken. For this purpose, a pot experiment was conducted to assess the suitability of DTPA, EDTA, Mehlich-3 and $Ca(NO_3)_2$ in predicting plant Zn content in acid and alkaline soils amended with orgnaics using Indian spinach as test crop. Results indicate that on an average, DTPA extractable Zn in post-harvest soil increased by 1.65, 6.90 and 16.4 fold over control due to application of Zn @ 5, 50 and 100 mg Zn kg^{-1}, respectively. More or less, similar increase in extractable Zn with increasing rate of Zn addition was recorded in case of other three extractants. Extraction efficiency of these reagents for Zn was far more in acid soil than that in alkaline soil. Application of FYM reduced the extractable Zn content in soil to greater extent as compared to sludge. On an average, Mehlich-3 (20.9 mg kg^{-1}) extracted highest amount of Zn followed by EDTA (19.9 mg kg^{-1}), DTPA (14.3 mg kg^{-1}) and $Ca(NO_3)_2$ (4.47 mg kg^{-1}). Simple correlation analysis indicated that almost comparable values of correlation co-efficient of plant Zn content was obtained with all the four extractants. From this study, it can be concluded that all these four extractants *viz*. DTPA, EDTA, Mehlich-3 and $Ca(NO_3)_2$ are equally effective in assessing plant availability of Zn in organic-amended soils.

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Effect of Spacing and Integrated Nutrient Management on Green Cob Yield, N and P Content and Uptake of Sweet Corn (*Zea mays saccharata* sturt)

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A field experiment was conducted at the College Agronomy Farm, Department of Agronomy, B. A. College of Agriculture, Anand Agricultural University, Anand during *kharif* season of the years 2006 and 2007 on loamy sand soil with a view to study the effect of spacings and integrated nutrient management on green cob yield, N and P content and uptake of sweet corn (*Zea mays saccharata* sturt). Experiment comprising two levels of spacing (45 cm x 20 cm and 60 cm x 20 cm), two levels of FYM (0 and 10 t FYM ha^{-1}) and five fertility levels (100% RDF, 75% RDF + *Azotobacter*, 75% RDF + *Azotobacter* + PSB, 50% RDF + *Azotobacter* and 50% RDF + *Azotobacter* + PSB) were tried under split plot design with four replications. The narrow spacing of 45 cm x 20 cm produced significantly higher green cob (11988 kg ha^{-1}) and fodder (14692 kg ha^{-1}) yields. However, N content in fodder and N uptake in grain and fodder as well as P uptake by fodder were significantly increased due to wider spacing of 60 cm x 20 cm. Available N and P status of the soil after harvest of the crop was remained unaffected due to spacing treatments

Significantly higher green cob (12179 kg ha^{-1}) and fodder yields (14957 kg ha^{-1}) yields were obtained by applying 10 t FYM ha^{-1}. The N and P content, their uptake by grain and fodder as well as post harvest soil available N and P status of the soil were significantly increased with an application of FYM @ 10 t ha^{-1}. An application of 100% RDF recorded the highest green cob (12145 kg ha^{-1}) and fodder (15210 kg ha^{-1}) yields as well as N and P content and uptake by the grain and fodder. However, all the values were statistically at par with application of 75% RDF + *Azotobacter* with or without PSB. Significantly the highest value of post harvest N and P status of the soil were found under 100% RDF than all the other fertility levels. The FYM × fertility levels interaction effects for N uptake by grain, P content and uptake by the grain and fodder were found significant. Wherein, F_2B_1 (10 t FYM ha^{-1} + 100% RDF) treatment combination recorded higher values for N uptake by grain, P content and uptake by grain and fodder.

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Zinc Bio-fortification in Indigenous, High Yielding and Hybrid Rice Cultivars (*Oryza Sativa*) Grown in Jharkhand

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Rice is one of the most important stable crops and is almost exclusively consumed by human being in whole world. Rice based cropping system is predominant in India and particularly in tribal populated state of Jharkhand. While rice containing low level of micronutrients (specially Zn), it is a mostly important source of energy intake to human being. Like many others crop species, rice genotypes poses great variation in their Zn acquisition and utilization.

The present investigation was aimed to study the acquisition and utilization of Zn by indigenous, high yielding and hybrid rice cultivars grown in acidic soil condition (2.66 mg kg^{-1} DTPA extractable Zn). A field experiment was conducted in experimental area of the university with 25 rice cultivars (7 indigenous, 16 HYV and 3 hybrid) during rainy season 2009 on a sandy clay loam soil with the treatments of three Zn application levels *viz*. RDF, RDF + 100 kg $ZnSO_4.7H_2O$ and RDF + 100 kg $ZnSO_4.7H_2O$ + 3 spray of 0.5% $ZnSO_4.7H_2O$. Mean accumulation of Zn in paddy grain among the 25 selected rice cultivars varied from 23.11 to 36.67 mg kg^{-1}. Highest mean Zn accumulation 33.52 mg kg^{-1} was recorded in indigenous cultivars of rice followed by 29.63 and 27.15 mg kg^{-1} accumulation in HYV and hybrid varieties of rice. Accumulation of Zn in rice without husk was also followed similar trend and in all cultivars of rice (indigenous > HYV > hybrid) mean Zn accumulation was found in decreasing order. Mean accumulation of Zn in rice grain and rice without husk in selected all three categories of rice with the application of Zn (soil and foliar application) was recorded 1 to 5 mg kg^{-1} more accumulation over RDF (without Zn) in acidic soil condition of Jharkhand.

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Effect of Different Cropping Systems on Crop Productivity, Profitability and Soil Properties in Alluvial Tract of Uttar Pradesh

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A field experiment with nine crop sequences was conducted during 2006-07 to 2009-10 at C.S. Azad University of Agriculture and Technology Kanpur, Uttar Pradesh. All these crop sequences were evaluated for their productivity, profitability and improvement in soil properties. Rice (*Oryza sativa* L.) equivalent yield was recorded maximum (392.94 t ha^{-1}) through maize + blackgram-potato-onion crop sequence followed by 319.30 q ha^{-1} through maize-garlic-green gram (G+R) crop sequence. Maximum production efficiency (169.37 kg ha^{-1} day^{-1}) was also recorded with maize +blackgram-potato-onion cropping system while maximum land use efficiency (99.17%) was measured with maize-mustard-onion crop sequence. Economic analysis revealed that the maximum net return of Rs. 2,10,997 ha^{-1} fetched out through maize+ blackgram-potato-onion crop sequence while maximum B:C ratio 2.81 was recorded through hybrid rice-wheat crop sequence. All cropping sequences showed slight improvement in physicochemical properties of soil. Maximum improvement in physicochemical properties of the soil was recorded in green manuring of green gram in summer and inclusion of legumes in cropping sequence. Hence maize + blackgram-potato-onion cropping sequence identified as the most productive and profitable cropping sequence while hybrid rice-wheat cropping sequence was identified as most economical crop sequence of Uttar Pradesh.

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Effect of Biofertilizers and Chemical Fertilizers on Growth and Flower Yield of Desi Red Rose (*Rosa damascena* L.)

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A field experiment was conducted on effect of biofertilizers and chemical fertilizers on growth and flower yield of Deshi Red Rose during 2008 to 2011 at Flower Nursery, Horticulture Research Farm, B. A. College of Agriculture, Anand Agricultural University, Anand. The experiment was laid out in Randomized Block Design (RBD) with seven treatments. All treatments were replicated four times and each treatment having 6 plants. For growth parameters, the treatment 40 + 40 + 25 NPK g plant^{-1} + *Azospirillum* 1 mL plant^{-1} + PSB 1 mL plant^{-1} recorded significantly maximum plant height (68.75 cm), number of branches / plant (30.50) and plant spread N-S (67.72 cm) and E-W (61.33 cm), while maximum stem girth (0.60 cm) was recorded with treatment 30+ 25 + 25 NPK g plant^{-1} + Azospirillum 1 mL plant^{-1}.

For yield parameters, flower diameter (7.21 cm), weight of flower (4.61 g), number of flowers plant^{-1} (447.31), yield of flowers plant^{-1} (2033.80 g) and yield of flowers ha^{-1} (15.07 t) were recorded significantly maximum in treatment 40 + 40 + 25 NPK g plant^{-1} + *Azospirillum* 1 mL plant^{-1} + PSB 1 mL plant^{-1}.

While, shelf life of flower (23.50 hours) recorded in treatment 40 + 40 + 25 NPK g plant^{-1} + *Azospirillum* 1 mL plant^{-1} + PSB 1 mL plant^{-1}.

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Response of Organic and Inorganic Sources of Phosphorus and Method of their Application on Productivity of Groundnut in Rainfed Situation

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Phosphatic fertilizers have resulted in a tremendous increase in the food production and have contributed significantly in green revolution. However, 'P' fixation are the main draw backs of the chemical fertilizers. Phosphate rich organic manure - a value added product produced by composting of different organic wastes with rock phosphate has become a useful, eco-friendly and effective alternate to costly chemical fertilizers. Therefore, the present investigations were undertaken to explore the possibility of utilization of rock phosphate as P-enriched compost, vermicompost and increase the efficiency of P by method of its application (broadcast and placement) in groundnut in rainfed situation. Field experiment was conducted on sandy loam soil in *kharif* season during 2005-06 and 2006-07 at research farm of Banasthali University, Tonk, Rajasthan with three sources of phosphorus, *viz*. diaamonium phosphate, P enriched compost and vermicompost and two methods application such as broadcast and placement in groundnut crop. The experiment was laid out in randomized block design with three replications. The results revealed that the placement of recommended doses of P through P enriched vermicompost increased significantly higher growth parameters, pod (2.43 t ha^{-1}) and stover (3.10 t ha^{-1}) yield of groundnut followed by placement of P enriched compost and broadcasted enriched P vermicompost as compared to other treatments. Similar trend was found in oil and protein content in kernels, uptake of P by kernels and stover, net return and B:C ratio of groundnut in rainfed conditions.

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Effect of Recommended Dose of Fertilizers on Yield of Genotypes of Wheat in Alluvial Soil

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Wheat is an energy rich winter cereal contributes 39.4% to food grain basket of the country grown in 28.4 million ha area with a total production of 80.6 million tones. But the average productivity 2.84 t ha^{-1} of the wheat crop is low as compared to the other countries like France (7.45 t ha^{-1}), China (4.75 t ha^{-1}). The low productivity may be due to adoption of low yielding varieties, non-judicious use of fertilizers and improper management of agronomic practices, over the last 30 years improvement in crop yield could be 40-50% attributed due to use of high yielding of wheat genotypes. A field experiment was carried out at ZARS-KVK Research farm, Morena district of Madhya Pradesh during winter season 2010-11 in alluvial soils. To study the effect of recommended doses of fertilizer on growth parameters and yield of 18 genotypes of wheat. The soils of experimented field was low in available nitrogen (134.5 kg ha^{-1}) medium in available phosphorus (13.82 kg ha^{-1}) and potash (320.50 kg ha^{-1}) with pH 7.5. The experiment was replicated 4 times with R.B.D. with eighteen genotypes viz. Sujata, JW-3211, GW-190, GW-173, GW-273, GW-322, GW-366, HI-1544, HI-1555, HI-8381, HI-8498, HD-2930, HD-2932, PBW-343, DL-803-3, DL- 788-2, RV-4106, MP-4010, The recommended doses of fertilizer (100 kgN : 60 kg P_2O_5 : 40 kg K_2O ha^{-1}) applied all genotypes except Sujata recommended dose of Sujata genotype (60 kg N: 30 kg P_2O_5 : 20 kg K_2O ha^{-1}). Agronomy practices were follow as per package of practices. The crop was sown on 7th Dec., 2010 at row distance 20 cm apart with seed rate 120 kg ha^{-1}. The data on various biometric characters, grain and straw yield were recorded and statistically analyzed. The growth and yield attributes and grain yield of wheat were significantly registered due to different genotypes. The variety Sujata recorded significantly higher plant height (107.5 cm) over other genotypes. Those maximum tiller were noted under genotype DL-803-3 (13.5 nos) the length of spike observed maximum (11.1cm) in genotype HD-2932, the maximum straw yield 12.4 t ha^{-1}, grain yield (5.4 t ha^{-1}) and net return were registered under genotype MP-4010, which is recommended and developed by RVSKVV Gwalior.

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Long-Term Effect of Integrated Nutrient Management in Rice Wheat System on Soil Properties in an Acidic Soil of North Western Himalaya

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The present study is a part of the on going long-term field experiment being conducted at *Padhiarkhar* Research Farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur. Effect of nitrogen substitution in rice through different organics continuously for 18 rice-wheat cropping cycles was studied on some physical and chemical properties of soil. Ten treatments comprising of control, inorganics *viz.*, 50, 75 and 100% NPK; and conjoint use of 50 and 75% NPK with 50 and 25% N substitution either through FYM, Wheat cut straw or green manure *Dhaincha (Sesbania aculeata)* during *kharif* followed by 100 and 75% NPK through inorganics in *rabi*, respectively were imposed. Results based on the soil samples collected at harvest of wheat (*rabi* 2008-09) showed that the application of 50% N through FYM along with 50% NPK through chemical fertilizers to rice followed by 100% NPK to wheat, was found to be better treatment over rest of the treatments in improving the soil physical and chemical properties. The bulk density was lowest (1.32 Mg m^{-3}) while water holding capacity was highest (63.8%) in this treatment. It also recorded highest values of organic carbon (9.0 g kg^{-1}) and CEC (14.1 cmol (p+) kg^{-1}), while the status of available nutrients was 303, 91 and 185 kg ha^{-1} of N, P and K, respectively. Further, the 50% substitution of N through any of the organic sources, proved better over 25% substitution, through their respective sources.

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Evaluation of Integrated Use of Sewage Sludge and FYM with Chemical Fertilizers on Yield and Quality of Carrot–Bhendi Cropping Systems

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Sewage sludge is rich source of major and micronutrients as well as heavy metals, which causes toxicity in plants and pollute the soil. To study the effect of sewage sludge on performance of crops in terms of yield and uptake of nutrients and trace metals and also to find out the safe limits of heavy metals for human consumption in sewage sludge applied crops the present investigations were carried out under field (2008-09) conditions at College Farm, College of Agriculture, Rajendranagar, Hyderabad.

The treatments for bhendi crop in the *kharif* 2008 with four main treatments *viz*., 0, 50, 75 and 100 per cent RDF and five sub treatments *viz*., two levels of each sewage sludge, FYM (10 and 20 t ha^{-1}) and control (without manure) and combination of fertilizer levels along with organic manurial levels, thus, total of 20 treatments, each in triplicate was laid out in a split plot design. The recommended dose of fertilizer applied to bhendi crop was 120 N, 50 P_2O_5 and 50 K_2O ha^{-1}, respectively. In the second season (*rabi*) carrot crop was grown to study the residual effects of organic manures applied to the previous season bhendi crop. Recommended dose of fertilizer (50, 40 and 50 kg N, P_2O_5 and K_2O ha^{-1}, respectively) was added to the carrot crop (CS-II). Another cropping sequence carrot in *rabi* season followed by bhendi in summer season (CS-II) was grown with same treatments at simultaneous fields to study the residual effects of organic manures applied to the previous season carrot crop.

The highest fresh fruit yield (18.05 t ha^{-1}) plant dry matter (1.95 t ha^{-1}) and fruit dry matter (1.54 t ha^{-1}) of bhendi (CS-I) were resulted in treatment with sewage sludge applied @20 t ha^{-1} along with 100 per cent RDF over control. In carrot (CS-II) also showed higher fresh root yield (20.2 t ha^{-1}), leaves dry matter (3.99 t ha^{-1}) and root dry matter (3.57 t ha^{-1}) with sewage sludge applied @20 t ha^{-1} along with 100 per cent RDF.

The mean highest concentration and uptake of all heavy metals in bhendi crop resulted with the application of sewage sludge @20 t ha^{-1} followed by 10 t ha^{-1}. Similar trend was observed under CS-II. Integrated application of manures and fertilizers also showed significant effect on all heavy metal (Pb, Ni, Co, Cr and Cd) concentration in plant and fruit than fertilizers alone. Highest concentration and uptake of all heavy metals were recorded in plant and fruit with the application of sewage sludge applied @20 t ha^{-1} along with 100 per cent RDF.

Application of manures either alone or in combination with fertilizers have significantly influenced on quality parameters of bhendi fruit at harvest when compared to fertilizers application only, but highest ascorbic acid (20.15 mg 100 g^{-1}) and crude protein content (22.6%) were observed in sewage sludge applied @20 t ha^{-1} along with 100 per cent RDF. Whereas highest crude fibre content was observed in 100 per cent RDF (without manures).

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Effect of Cotton Stalk-based Enriched Compost on Soil Properties and Growth and Yield of Sunflower Crop

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Composting method with enrichment techniques were adopted by 7 treatments with three replications using chemical amendments *viz.*, super phosphate and micronutrients and organic additives like cow dung, garden weeds and urea. Composts were analyzed for organic carbon, pH, EC and total nutrients content at the end of composting. The treatment composed of all additives had lower organic carbon and higher content of major and micro nutrients compare to other compost treatments. The effect of enriched cotton stalk compost on growth and yield of sunflower was also assessed in field in a randomized block design with three replications and thirteen treatments, along with 100 and 50 per cent NPK of recommended dose of fertilizers on sunflower during kharif 2010 in black soil of MARS, Raihur The pH, EC, OC, major and micro nutrients were analyzed after the harvest of the crop by following the standard methods. Enriched compost with 100 per cent NPK recorded highest plant height (158.61cm), number of leaves (16.86), head diameter (14.29 cm), seed yield (1326 kg ha^{-1}), oil content (38.6%), dry matter production (3261 kg ha^{-1}) and higher available nutrients *viz*., N (308.43 kg ha^{-1}), P_2O_5 (76.30 kg ha^{-1}), K_2O (522 kg ha^{-1}) and the micronutrients 0.62 mg kg^{-1}, 5.94 mg kg^{-1}, 2.93 mg kg^{-1} and 0.38 mg kg^{-1} of Zn, Fe, Mn and Cu respectively as compared to RDF.

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Assessing Soil Health of Vertisol of AESR 15.1 using Selected Physical, Chemical and Biological Attributes of Soils

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Georeferenced Soil Samples (0-15 cm) were collected in 2008 (before the sowing of winter crops) from the farmers fields of Sehore (n=120) and Vidisha (n=156) district, belonging to AESR 15.1 covering largely Vertisol to assess the soil health using the procedure described by Pierce and Larsen (1993) and Larson and Pierce (1994). In this study, 15 soil attributes comprising of three physical attributes (available moisture, texture and bulk density), two biological attributes (soil organic carbon and microbial biomass carbon) and ten chemical attributes (pH, avail. N, P, K, S, Fe, Mn, Zn, Cu and B) were used, with an appropriate weight for each attribute. The status of each attribute was categorized into four classes namely, Class – I (Very good status), Class – II (Good status), Class – III (Poor status) and Class – IV (Very poor) with a assigned marks of 4, 3, 2 and 1, respectively. The soil quality index (SQI) was calculated by the equation, SQI = " Wi Mi, where, Wi is the weight of the attribute and Mi is the mark of the attribute classes. Thus, summing up of all the 15 attributes, the SQI value for a particular soil of the farmer's field was computed. The theoretical range of the SQI was 100 to 400 *i.e.* minimum value is 100 (poor quality soil) and maximum value of SQI is 400 (best quality). In order to judge the SQI value of any site against the theoretical maximum value of SQI (*i.e.* 400), we used the concept of relative soil quality index (RSQI) which is given by

$$RSQI = \frac{\text{SQI of the given site}}{\text{Maximum theoretical value of SQI}} \times 100$$

The result showed that 70 and 27.5% of the soils of Sehore district was having OC content in medium and low range while 75.6% of the soils are low in OC content in Vidisha district. In both the districts, more than 80% soils are having available P status in medium range and more than 75% soils are medium in available K status. Available S status was high in more than 50% of the samples in both the districts while S deficiency was observed in less than 3% of the soil samples. Around 74.2% and 97.4% soils samples of Sehore and Vidisha district were found deficient in available Zn status, while none of the soil samples was found deficient in available Fe, Mn and Cu content. Around 29.5% of the soils of Vidisha district were found deficient in B content while 8.33% samples were found deficient in B in Sehore district. In Sehore district, 18.3%, 48.3% and 25.8% soils were found to have no deficiency, single nutrient deficient and two nutrient deficient category, but in Vidisha district 38.5%, 36.5% and 18.59% soil samples were found to have deficient in one, two and three elements.

The soils of Sehore and Vidisha districts were classified into three categories based on RSQI values. The soils having RSQI value less than 50% was rated as poor quality soil where the observed relative yield was 51.8%. The soils having RSQI value ranging from 50 – 70% was rated as medium category where the observed yield was 66.6%. The soils having RSQI value > 70% was rated as good category where the observed yield was 75.5%. Thus the results indicated that this approach of rating soil health using 15 soil attributes can be used for evaluation of Vertisol in AESR 15.1.

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Impact of Integrated Nutrient Management on Soil Physical and Chemical Properties and Productivity of Maize-Chickpea Cropping Sequence in Vertisols of Malaprabha Command

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A field experiment was conducted at WMRC, Belvatagi, UAS, Dharwad on Typic Chromustert for four years from 2007-08 to 2010-11. Three levels of moisture regimes 0.8 IW/CPE, 0.6 IW/CPE and 0.4 IW/CPE and five levels of nutrient management systems (F_1 = RDF, F_2 = RDF + BF (*Azospirillum* + PSB), F_3= RDF + BF + GM (sun hemp) , F_4 = 75% RDF + Maize stalk incorporation with cellulolytic culture +BF + GM, F_5 = 50% RDF + Maize stalk incorporation with cellulolytic culture+ BF + GM). All the treatments received 10 t ha^{-1} FYM. Bulk density(Mg m^{-3}), maximum water holding capacity (%), percent stable aggregates (%) and mean weight diameter (mm) were higher in the treatments receiving organics in conjunction with inorganic fertilizers as compared to only inorganic fertilizer (RDF only). The soil bulk density in recommended fertilizer dose treatment decreased from 1.36 to 1.31 Mg m^{-3} with the treatment 50% RDF + maize stalk incorporation with cellulolytic culture+ BF+GM. Maximum water holding capacity of the soils increased with 50% RDF + maize stalk incorporation with cellulolytic culture + BF+ GM (71%) as compared to RDF only (69.1%). The improvement in these soil properties might be attributed to the significant increase in organic carbon (0.46 to 0.66%) content. The per cent stable aggregates were higher in F_5 (58.6%) and lowest in F_1 treatment (46.0%). The mean weight diameter (MWD) of the aggregates ranged from 0.349 to 0.399 mm and highest in F_5 (0.399 mm) treatment and the lowest MWD was in F_1 (0.349 mm) treatment.

Significantly higher organic carbon (%) content of soils was observed in 0.8 IW/CPE irrigation treatment (0.62%) as compared to 0.4 IW/CPE ratio (0.57%). Significantly higher available nitrogen (208.9 kg ha^{-1}) , phosphorus (31.0 kg ha^{-1}) and potassium (815 kg ha^{-1}) content of soils were noticed in F3 treatment RDF+BF+GM as compared to rest of the treatments. For maize- chickpea cropping sequence significantly higher maize equivalent yield (1.41 t ha^{-1}) recorded with 0.8 IW/CPE moisture regimes as compared to 0.6 IW/CPE (1.25 t ha^{-1}) and 0.4 IW/CPE (1.14 t ha^{-1}). Among fertilizer levels, application of RDF+BF+GM recorded significantly higher maize equivalent yield (1.45 t ha^{-1}) as compared to other fertilizer levels. Interaction effects were non significant. The uptake of NPK (grain+stalk) were significantly superior at F3 (N- 215 kg ha^{-1}, P-58.73 kg ha^{-1} and K – 236.9 kg ha^{-1}) followed by F2 (N- 189.2 kg ha^{-1}, P-55.06 kg ha^{-1} and K – 216.1 kg ha^{-1}), F1 (N- 181.2 kg ha^{-1}, P-52.6 kg ha^{-1} and K – 203.9 kg ha^{-1}) , F4 (N-167.1 kg ha^{-1}, P-49.14 kg ha^{-1} and K – 195.0 kg ha^{-1}) and F5 (N- 131.8 kg ha^{-1}, P-41.4 kg ha^{-1} and K – 158.3 kg ha^{-1}).

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Studies on Water and Nutrient Requirement of Bt-Cotton Under Vertisols of Malaprabha Command

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A field experiment was conducted at AICRP (Water Management), Water Management Research Centre, , Belvatagi, University of Agricultural Sciences, Dharwad, Karnataka, during 2009-10 and 2010-11 in the *kharif* season to determine the response of Bt cotton to higher levels of recommended dose of fertilizer (RDF) at different irrigation levels in a split plot design. The experimental site was deep black with clayey texture, available N, P_2O_5 and K_2O of the soil were 207.2, 30.0 and 780 kg ha^{-1} respectively, with a soil pH of 8.34, Electrical conductivity 0.21 dS m^{-1} and organic carbon content of 0.54%. The values of field capacity and bulk density were 40.0 per cent and 1.32 Mg m^{-3} respectively. In the main plots three irrigation levels viz., I_1 = 1.0 IW/CPE, I_2 = 0.8 IW/CPE and I_3 = 0.6 IW/CPE and in sub plots four fertilizer levels *i.e.* F_1 = 100% RDF, F_2 = 125% RDF, F_3 =150% RDF and F_4 = 175% RDF (nitrogen, phosphorus and potassium) were tried.The results of two years indicated that the treatment receiving 175% RDF significantly increased growth parameters *i.e.* plant height, sympodial branches per plant, number of bolls per plant and seed cotton yield and NPK uptake by the cotton plants. Pooled data of two years seed cotton yield indicated that significantly higher seed cotton yield (2.68 t ha^{-1}) was recorded under 175% RDF treatment as compared to rest of the treatments. Among irrigation levels, significantly higher seed cotton yield was recorded at 1.0 IW/CPE ratio (2.54 t ha^{-1}) and was on par with 0.8 IW/CPE ratio (2.51 t ha^{-1}). Interaction effects were non significant. Nutrient management significantly influenced the NP and K nutrient tissue concentration (%) and their uptake (kg ha^{-1}). Nutrient uptake (NPK) at 60 DAS, 90 DAS and at harvest of Bt-cotton significantly increased with increase in fertilizer dose. The total uptake of NPK by Bt cotton at harvest were significantly superior with F_4 (N- 99.58 kg ha^{-1}, P-15.19 kg ha^{-1} and K – 43.66 kg ha^{-1}) followed by F_3 (N- 97.29 kg ha^{-1}, P-14.74 kg ha^{-1} and K – 42.11 kg ha^{-1}), F_2 (N- 91.3 kg ha^{-1}, P-13.58 kg ha^{-1} and K 39.70 kg ha^{-1}) and F_1 (N- 86.1 kg ha^{-1}, P-12.92 kg ha^{-1} and K – 37.48 kg ha^{-1}). Effect of irrigation levels on NPK uptake were non significant.

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Response of Sugarcane (*Saccharum* sp.) var. Co. 265 to Fertilization-based on STCR Approach

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Fertilizer prescription equations were developed for sugarcane (Co. 265) with and without FYM on Inceptisols at Sugarcane Research Station, Padegoan, District Satara. Based on these equations a field experiment was conducted in the assured rainfall region located at College of Agriculture, Kolhapur (MS) on Inceptisols during the year 2010. The object of the experiment was to study the response of sugarcane (Co. 265) to fertilizer prescription equation with and without FYM. The experiment was conducted in RBD with eight treatment and three replications. The treatments comprised of two yield targets of sugarcane 175 and 200 t ha^{-1} with and without FYM and compared with recommended dose of fertilizer 340 N:170 P_2O_5:170 K_2O kg ha^{-1}, fertilizer application as per soil test values and application of FYM @ 20 t ha^{-1}. The fertilizers were applied as per fertilizer prescription equations with FYM: FN= 4.03 × T-1.49 × SN-3.81 FYM, FP_2O_5 = 1.23 × T-2.44 × SP-1.83 FYM, FK_2O = 2.26 × T-0.55 × SK-140 FYM and without FYM: FN = 4.21 × T-1.49 × SN, FP_2O_5 = 1.39 × T-2.75 × SP, FK_2O = 2.39 × T-0.58 × SK

Findings revealed that the preset targets of 175 t ha^{-1} and 200 t ha^{-1} cane yields were achieved with and without application of FYM to the sugarcane crop however, the targets were more precisely achieved when the FYM was applied along with chemical fertilizers. The highest cane yield was recorded by the treatment STCRC target 200 t ha^{-1} + 10 t ha-^{1} FYM (198 t ha^{-1}) and this was significantly superior to the recommended dose (130 t ha^{-1}). The treatment on fertilizer application as per soil test was also showed significantly higher yield (162 t ha^{-1}) than the recommended dose. The nutrient uptake pattern revealed that N, P, K removal by the sugarcane crop corresponded to the higher yields of the sugarcane. The treatment STCR 200 t ha^{-1} + 10 t ha^{-1} FYM recorded highest uptake of nutrients N 262, P 47, K 487 kg ha^{-1} while the lowest uptake was recorded control N 141, P 46, K 225 kg ha^{-1}. The organic carbon content of the soil recorded higher values at higher yield target treatments and in the treatment application of FYM @ 20 t ha^{-1}. The treatment receiving higher quantity of fertilizer recorded higher values of available N, P and K kg ha^{-1} in the soil after harvest of the crop. The quality parameter varied in the narrow band and did not reveal any definite trend as the influence of applied fertilizer to the crop. The treatment STCRC target 200 t ha^{-1} recorded highest B:C ratio of 4.34 and it was significantly superior over all the treatments and followed by STCRC target 200 t ha^{-1} + 10 t ha^{-1} FYM (4.23). The treatment application of fertilizer as per soil test recorded significantly higher B:C ratio (4.03) when compared to recommended dose.

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Influence of Soybean (*Glycine max*) Cultivation on Soil Properties in Virgin Soil

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A field experiment was conducted in the assured rainfall region located at Zonal Agricultural Research Station, Shenda Park, Kolhapur (MS) on Entisol for five years during 2007-2011 to study the effect of soybean cultivation in virgin soils on soil properties. The experiment was conducted in randomized block design comprising of six treatments and four replications. The fertilizer treatments consisted of Recommended dose (RD) of fertilizer 50 N:75 P_2O_5 kg ha^{-1}, the RD of nitrogen applied through organic inputs, 75% RD of nitrogen applied through organic and 25% RD applied through chemical fertilizer, 50% RD of nitrogen applied through organic and 50% RD applied through chemical fertilizer and 25 % RD of nitrogen applied through organic and 75% RD applied through chemical fertilizer.

The findings revealed that the soybean yields were higher in the first year of cultivation and gradually decline in the subsequent years. The pooled data on grain yields on soybean revealed that the treatment consisted recommended dose of fertilizer recorded the highest grain yields (24.1 q ha^{-1}) and followed by the treatment which consist recommended dose applied as 25% through organic+ 75% through chemical (2.26 t ha^{-1}). Application of recommended N through organic recorded the lowest soybean yield (1.74 t ha^{-1}) amongst the different treatment except control. The organic carbon content of soil showed a gradual decrease over period of time. The different treatments did not contribute to a large extent in modifying the organic carbon contents of the soil. The available nitrogen contents in the soil revealed that the values were at par for the different treatments. The available phosphorus contents in the soil was found to be significantly increased in the treatment RDF (22.2 kg ha^{-1}) over control (17.5 kg ha^{-1}) and was at par with all the treatments except RD of nitrogen applied through organic (20.4 kg ha^{-1}) however, there was an increase in the available potassium content of the soil over control (256 kg ha^{-1}). The data on the microbial population of fungi, bacteria and actinomycetes revealed that the population of microbes had increased when the recommended dose of nitrogen was substituted through organic sources. The highest population of micro-organism was recorded by the treatment recommended of nitrogen through organic and it was observed to be significantly superior to the recommended dose of fertilizer. The B:C values revealed that the treatment recommended dose of fertilizer recorded the highest B:C ratio of 1.87 which was significantly superior to the treatment 25% through organic+ 75% through chemical (1.56).

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Response of Finger millet (*Eleusine coracana*) to Fertilization through Fertilizer Briquettes Containing Nitrogen and Phosphorus

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Field experiment was 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* season of 2010 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 like urea and di-ammonium phosphate was studied in comparison to briquette application at the 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 like urea and diammonium phosphate without adding any binder. The finger millet crop was sown in paired rows having alternate spacing of 15-30 cms and fertilized through briquettes placed in the 15 cm alternate bands of the paired rows to accommodate the different fertilizer levels. The recommended dose (RD) of fertilizers applied to the finger millet crop was 60: 30 (kg N, P_2O_5 ha^{-1}). The fertilizer treatments consisted of 100% recommended dose of fertilizer applied through conventional fertilizers and 100, 75 and 50% recommended dose of fertilizers applied to the crop and through briquettes. Nitrogen was applied in two equal splits for the conventional fertilizers while phosphorus was applied as basal. The briquettes containing the entire dose of fertilizers was applied as basal at the time of sowing of finger millet.

The findings of the field experiment revealed that the application of 100% recommended dose of fertilizers to the finger millet crop through fertilizer briquettes significantly increased the grain yields of finger millet (2.83 t ha^{-1}) when compared to the recommended dose of fertilizers applied through the conventional fertilizers (2.44 t ha^{-1}). Application of fertilizer briquettes @ of 75 % RDF to finger millet crop also revealed significantly higher yields of the grain yield (2.63 t ha^{-1}) as compared to the recommended dose (2.44 t ha^{-1}) applied through conventional fertilizers. The treatment 50% RDF through briquettes was at par (2.33 t ha^{-1}) to the treatment RDF through conventional fertilizer (2.44 t ha^{-1}). The straw yields of the crop also revealed the similar trend.

The soil analyses after harvest of the crop revealed that the nitrogen and potassium contents did not differ significantly amongst the different treatments. Application of fertilizer through briquettes recorded significantly superior values of phosphorus when compared to recommended dose applied through conventional fertilizers. The data on plant uptake revealed that application RDF through briquette recorded higher uptake of N, P and K as compared through RDF applied through conventional fertilizer. The B:C ratio revealed that application of RDF through briquette recorded significantly highest B:C (1.64) compared with RDF applied through conventional fertilizer (1.45).

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Response of Soybean Crop (*Glycine max*) to Applied Sulphur

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Field experiment was conducted on sulphur deficient soil located at Zonal Agricultural Research Station, Shenda Park, Farm, Kolhapur on Entisol, Sub-Montane Zone of Maharashtra during the *kharif* season of 2010. The object of the experiment was to study the response of soybean crop to different levels of elemental sulfur. The soil was neutral in reaction (pH 7.0) having OC 0.65%, available N 199 kg ha^{-1}, available P 19.2 kg ha^{-1}, available K 227 kg ha^{-1} and available sulphur 9.2 kg ha^{-1}. The different levels of elemental sulfur applied to soybean were 10, 20, 30 and 40 kg ha^{-1}. The crop was inoculated with *Thiobacillus thiooxidans* to enable oxidation of elemental sulfur. The recommended dose of fertilizers (50 : 75 kg N, P_2O_5 ha^{-1}) were applied as basal at the time of sowing of crop.

The findings revealed that the highest yields of soybean were recorded by the treatment RDF + 40 kg S ha^{-1} (2.77 t ha^{-1}) which was significantly superior over RDF 50:75 (2.40 t ha^{-1}). The treatment RDF + 30 kg S ha^{-1} also recorded significantly higher yields (2.74 t ha^{-1}) when compared to RDF 50:75 (2.4 t ha^{-1}). The treatments RDF + 10 kg S ha^{-1}, RDF + 20 kg S ha^{-1}, RDF + 30 kg S ha^{-1} and RDF + 40 kg S ha^{-1} were at par to each other. The straw yields of soybean as influenced by different treatments followed similar trend as that of grain yields. The soil analysis data after harvest of the crop revealed that the nitrogen, potassium and phosphorus contents did not differ significantly amongst the different treatments however, the values were superior over the control treatment. The available sulfur in the soil revealed significantly higher values in treatment RD + 40 kg S ha^{-1} (14.6 kg ha^{-1}) over the treatments RDF (8.9 kg ha^{-1}), RDF + 10 kg S ha^{-1} (10.5 kg ha^{-1}) and RD + 20 kg S ha^{-1} (12.1 kg ha^{-1}). The data on uptake of nutrients revealed that the treatment RDF + 40 kg S ha^{-1} recorded significantly highest uptake of N, P, K and S over RDF 50:75. The B:C ratio revealed that the treatment RD + 40 kg S ha^{-1} recorded significantly highest B:C (2.08) over RDF (1.87). The treatments RDF + 30 kg S ha^{-1} (2.07) and RDF + 20 kg S ha^{-1} (2.04) recorded at par B:C with RDF + 40 kg S ha^{-1} (2.08).

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Effect of Integrated Nutrient Management on Nutrient Uptake, Fruit Yield and Quality of Tomato (*Lycopersican esculentum* L.)

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Tomato is one of the important vegetable crops grown in India. According to National Horticultural Baord (2010), tomato is cultivated in 0.61 million hectares with a production of 11.97 million tonnes (Mt) and productivyt of 19.3 t ha^{-1}. In Andhra Pradesh it is cultivated in 0.74 lakh hectares with production and productivity of 1.4 Mt and 19 t ha^{-1}, respectively. A field experiment was conducted during *kharif* with 10 treatments in randomized block design and replicated thrice, with a view to study the effect of integrated nutrient management on nutrient uptake, fruit yield and quality of tomato. The initial soil was sandy loam in texture, slightly alkaline (7.9 pH) in reaction, non saline (0.13 dS m^{-1}), low in organic carbon (4.6 g kg^{-1}) and available nitrogen (230.7 kg N ha^{-1}), medium in available phosphorus (25.4 kg P_2O_5 ha^{-1}) and potassium (284.5 kg K_2O ha^{-1}).

The highest total N uptake (106.35 kg ha^{-1}) was recorded from the treatment receiving 100% RDNF through inorganic fertilizer. Whereas P uptake (17.40 kg ha^{-1}) and K uptake (61.82 kg ha^{-1}) were highest in treatments receiving RDNF through 75% inorganic fertilizer + 25% VC. The fruit yield (8.49 t ha^{-1}) of tomato was also highest in treatment receiving RDNF through 75% inorganic fertilizer + 25% VC and was on par with treatments receiving RDNF through 75% inorganic fertilize + 25% PM and also 100% inorganic fertilizer. With regard to quality parameters, the ascorbic acid content varied from 23.83 to 30.83 with a mean value of 28.27 mg $100g^{-1}$ of fruit. The lycopene content varied from 2.09 to 4.05 with a mean value of 3.63 mg $100g^{-1}$ of fruit. The highest values of ascorbic acid (30.83 mg $100g^{-1}$) and lycopene (4.05 mg $100g^{-1}$) were recorded from treatment receiving 50% vermicompost + 50% poultry manure.

Based on the results obtained, it can be concluded that the combined use of 75% RDNF through inorganic fertilizers + 25% RDNF through vermicompost or poultry manure is ideal for obtaining higher tomato fruit yield when grown on light textured soils.

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Soil Fertility Constraints and Yield of Maize in Vertisols of Malaprabha Command of North Karnataka

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The soils of Malaprabha Command area in north Karnataka are mainly deep black clay soils (Vertisols) covering 95% of the command. Hybrid maize – Bengal gram is the main cropping pattern in the command. The yield levels of maize were satisfactory during the initial few years. Now, the farmers are not getting the expected yields in maize. The average yield of maize is hardly 3.5-4.5 t ha^{-1} as compared to 6.0-7.0 t ha^{-1} during the initial period. As maize being exhaustive crop, the reduction in soil fertility might be one of the reasons for yield reduction. Therefore, the study was initiated to study the fertility status of soils of maize growing areas of the command.

Representative fifty soil samples were collected randomly from the maize growing area covering Malaprabha Command and these samples were analysed for fertility status with respect to N, P and K and micronutrients namely Fe, Zn, Cu and Mn. The yield data was collected from the farmers field. The data on maize yield revealed that it ranged from 3.5 to 5.8 t ha^{-1} with a mean value of 4.7 t ha^{-1} as compared to the expected yield of 6.0-7.0 t ha^{-1} used to get at the beginning in vertisols of Malaprabha Command. The available nitrogen content in soil varied from 168 to 336 kg ha^{-1} with a mean value of 248 kg ha^{-1}. Out of 50 samples analysed, nearly 47% samples are low and 53% samples are medium in available nitrogen. Available phosphorous in different soils is low to medium and ranged from 23.6 to 57.5 kg ha^{-1} with a mean value of 36.7 kg ha^{-1}. These soils on high in available potassium and it ranged from 490 to 720 kg ha^{-1} with a mean value of 636 kg ha^{-1}. Soil nutrient index calculated for each nutrient indicated that these soils are medium in nitrogen and phosphorous and but high in potassium status. The status on DTPA extractable micronutrients indicated that zinc content varied from 0.34 to 0.90 ppm with a mean value of 0.55 ppm. Nearly 62% samples are deficit in zinc status and 38% samples are normal. Similarly, the iron content ranged from 2.01 to 6.68 ppm with a mean value of 3.95 ppm. Out of samples analysed about 58% samples are deficit and 42% samples are normal in iron status. Hence, majority soils are deficit in zinc and iron status. On the other hand, DTPA attractable Cu and Mn are high in these soils with mean value of 0.88 and 9.64 ppm, respectively.

Based on the study it could be concluded that the low productivity in maize might be due to low fertility status particularly in nitrogen, phosphorous, zinc and iron. Monocropping, non-practice of INM and excess irrigation would be other reasons for low productivity of these soils. Hence, there is need to go for balanced fertilization and scientific water management practices for improving the yield of maize in these soils.

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Effect of Sources and Levels of Potassium on Growth, Yield and Quality of Red Chillies

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In a field experiment conducted to study the influence of muriate of potash (MOP) and sulphur of potash (SOP) at different levels on growth, yield and quality attributes of chilli transplanted on Typic Chromustert under Dharwad climatic conditions revealed that plant height was not affected significantly by the application of potassium through different sources and levels. The treatment that received 150% RDK through SOP in two split doses (½ basal + ½ at 45 DAT) has shown highest total dry matter production at harvest (109.22 g plant^{-1}). The yield parameters like number of fruits per plant per picking, 100 fruit weight as well as dry fruit yield were highest (36.74 plant^{-1}, 131.74 g and 1.07 t ha^{-1}, respectively) in the treatment that received 150% RDK through SOP in two split doses.

Increased levels of potassium had shown significant effect in increasing the ascorbic acid content in green chillies, but the two sources of potassium did not influence the ascorbic acid content significantly. Higher ascorbic acid content (175.16 mg per 100 g) was recorded with application of 150% RDK through SOP in two split doses and was on par with the treatment that received 150% RDK through MOP. Significant and positive influence of both levels and sources of potassium was observed on the total extractable colour value of red chillies. Highest colour value (225.28 ASTA units) was observed in the treatment that received 150% RDK through SOP in two split doses. Whereas, higher oleoresin content and lower per cent discoloured fruits (16.97% and 4.50%) were observed in the treatment that received 200% RDK as SOP in two split doses, but was on par with 150% RDK as SOP in split application.

Length and breadth of fruits were not much influenced by levels and sources of potassium. In general, per cent pericarp component was higher than seed component irrespective of sources and levels of potassium. The treatments that received sulphate of potash recorded higher per cent seed content with highest value (54.28%) being in split application of 150% RDK through SOP equally as basal dose and at 45 DAT. The levels and sources of potassium had significant effect on the concentration of N, K and S in chilli plants but P content was non significant.

The uptake of N, P, K and S was significantly influenced by levels and sources of potassium. The highest uptake of nutrients (67.93, 13.71, 106.77 and 15.30 kg ha^{-1} N, P, K and S, respectively) was recorded at final picking stage of chilli in the treatment that received 150 per cent RDK as SOP in two split doses. Non-significant difference was observed among the treatments with respect to available nitrogen and phosphorus status as well as DTPA-extractable micronutrients contents in soil at final harvest of chilli. Whereas, the highest available K content in soil was observed at 200% RDK as MOP (423.31 and) and SOP (417.26 kg ha^{-1}) respectively. Highest available S content (32.12 kg ha^{-1}) was noticed in the treatment that received 200% RDK as SOP. Economic analysis indicated that, application of 150% RDK in two split doses either through SOP or MOP has resulted in higher B: C ratio (2.10).

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Effect of Foliar Application of Urea and Potassium Nitrate on Yield, Quality and Nutrient Content of Cashew nut (*Anacrdium occidentale* L.)

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A field trial was carried out at Rukhi Block of Water Management Scheme, Central Experiment Station, Wakawali during November 2009 to May 2010 with the objectives to find out the effect of foliar application of urea and potassium nitrate on yield, quality and nutrient content in leaves and kernels of Cashewnut var. Vengurla-4. The experiment was laid out in randomized block design with three replications comprising seven treatments *viz.* 1, 2 and 3% foliar sprays of urea and potassium nitrate (KNO_3) each and soil application of N, P and K @1.0:0.25:0.25 kg tree^{-1} as a control. Total forty two uniform cashew trees were selected consisting two per treatment. For effective control of tea mosquito and thrips infesting cashew flowering, the different insecticidal sprays (Endosulphan, rogar and carbaryl) were taken and scheduled at new flushing, flowering and seed setting stage. Recommended dose of fertilizer @1.0:0.25:0.25 kg tree^{-1} was applied as a common dose for all the treatments in the moth of August. The foliar sprays of urea and KNO_3 were taken at panical initiation, flowering and nut setting stage. Similarly the plant samples were collected at new vegetative stage, flowering stage, seed setting stage and after harvest for analysis of nutrient content. The study revealed that the application of foliar spray of 3 per cent urea recorded significantly highest nut yield of 5.987 kg tree^{-1} (i.e. 1221.35 kg ha^{-1}) and shelling percentage (28.98). The highest and significant oil content (43.03%), protein content (23.31%), number of nuts kg^{-1} (138.67) and average nut weight (7.16 g) were found in foliar application of 2 per cent KNO_3. The foliar application of 1, 2 and 3% urea and KNO_3 significantly influenced on major, secondary nutrients and Mn content in leaves at different stages. The nutrient content in cashew kernel was significantly influenced by foliar application of urea and KNO_3 except micronutrients.

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Soil Fertility Assessment of Castor Growing Areas of Nalgonda District of Andhra Pradesh using RS and GIS

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A study was conducted in Castor growing areas of Nalgonda district of Andhra Pradesh to establish relationship between soil fertility parameters with satellite based Normalized Difference Vegetation Index (NDVI) of the crop and to derive fertilizer management options for achieving optimum yields. In the study area of Nalgonda, different locations were chosen based on the crop intensity. Basic data on crop record, initial soil fertility, geographical location, fertilizers applied *etc.*, were recorded. Subsequently the sites were visited at different intervals during crop growth period and collected soil and plant samples. Simultaneously spectral reflectance data of the crop with hand held radiometer was also recorded. Cloud free satellite data (IRS P6, LISS III) was obtained for August and November, 2005. The digital data after making geometric corrections was processed by using ERDAS Imagine 8.7 package. NDVI values were extracted for different locations from where ground truth observations pertaining soil and crop were collected. The results revealed that the soils were low in available N, low to medium in available P and K. The leaf analysis for N, P, K content at different stages revealed that N ranged from 2.5 to 4.42%. Correlations were worked-out between NDVI values, leaf N content, yield and soil N. Results revealed that NDVI values extracted from satellite data ranged from 0.056 to 0.296 in August 2005 and from 0.211 to 0.584 in November 2005. Leaf N% was high at vegetative phase and gradually decreased with the advancement of crop stage. The crop yield ranged from as low as 3.8 q ha^{-1} to as high as 10.8 q ha^{-1} over different locations of study area. Vegetation Index (NDVI) derived from satellite data over study area (20 locations) was correlated with castor yield at harvest and leaf N% at different crop growth stages. Soil available N was also estimated periodically. Positive and significant linear correlation existed between leaf N at vegetative phase vs castor yield and satellite data (November) derived NDVI. Similarly, significant correlation existed between satellite data (August) derived NDVI and yield of castor.

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Different NPK Recommendations-based on Soil Test and their Influence on Productivity of Rice

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Chemical fertilizer has been one of the major inputs in achieving higher production levels in intensive cropping systems. But, the present NPK recommendations may not be relevant as there is appreciable decline in the soil organic matter level and the fertility of soils due intensive cultivation with HYV's over decades. Hence, there is an urgent need to revalidate the package of practices recommendations with respect to NPK for selected crops based on soil nutrient status under different agro-climatic zones. In the light of this, a study on the response of paddy to different levels of NPK applied on the basis of soil status and crop demand was taken up.

The study was carried out in Shimoga, Bhadravathi and Channagiri taluks of southern transition zone of Karnataka (zone-7). The trials were conducted at three locations *viz*., Harige, Vaderapura and Kathalagere, in Shimoga, Bhadravathi and Channagiri taluks during Summer-2010. The trial comprised of four replications and six treatments. The treatments involved different levels of NPK use based on soil test crop response (STCR) equation, modifications based on soil NPK status and STL method compared with recommended package of practices. The initial staus of NPK and other nutrients in soil at various locations was studied based on which the NPK doses were arrived at. The available status of NPK in soil ranged from low to medium in three locations.

Results indicated a significant increase in grain yield of rice due to application of NPK based on soil test-crop response (STCR) as compared to recommended package of practices. At Kathalagere the yield increase was from 5.39 t ha^{-1} at recommended package of practices to 6.22 t ha^{-1} with STCR based NPK application. However highest grain yield of 6.72 t ha^{-1} was obtained with farmers' practice. The farmers' practice involved application of more than double dose of recommended NPK *i.e.* 245:150:137 as against the recommended NPK level 125:62:62 NPK kg ha^{-1}. The farmers' practice may not be sustainable in long run from soil health point of view and the productivity level recorded was statistically on par with that obtained with STCR dose, although variation in grain yield of rice was not statistically significant in other two locations. The pooled data over the locations indicated a significantly higher productivity of 6.49 t ha^{-1} with NPK based on STCR compared to 5.76 t ha^{-1} with recommended package of practices. Variation in straw yield due to different levels of NPK was not significant in two locations and at Kathalagere *i.e.* the 3rd location, higher level of 8.46 t ha^{-1} of straw yield was recorded in the farmers' practice.

To conclude, it can be stated that there is a ample scope to increase productivity of rice by judicious use of NPK based on soil test and the crop nutrient demand as compared to the presently recommended NPK level as per package of practices.

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Relationship between Physicochemical Properties of Soil and Nutritional Quality of Finger millet grown in Konkan Region of Maharashtra

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To study the relationship between the physicochemical properties of soil and nutritional quality of finger millet, surface soil (0-15 cm) before sowing (initial) and after harvest of the crop and the grain samples were collected from farmers' fields cultivating white and red finger millet genotypes, with and without fertilizer application in Konkan region of Maharashtra state. The soil and grain samples were analysed according to the standard procedures.

In general, soil was sandy clay loam in texture, moderately acidic in reaction, with high organic carbon content and low electrical conductivity. The availability of N was medium , P was low, K status was high. DTPA extractable micronutrients (Fe, Mn, Zn and Cu) were found to be adequate. The physico-chemical properties of soil represented the typical of lateritic soils of Konkan region. There was depletion in available macro and micronutrient status after harvest of the crop as compared to initial status. Fertilizer application showed significant positive effect on available nutrient status of N, P, Fe, Mn and Zn. When nutritional qualities of the two genotypes were compared, white finger millet showed significantly higher content of protein, crude fibre, Fe, Mn and Zn, whereas carbohydrate, energy, Ca and P contents were significantly higher in red finger millet. Further, fertilizer application showed significant positive correlation with protein, energy and P. The physicochemical properties of soil showed significant effect on the nutritional quality of finger millet. Yield was significantly affected by pH, Fe, Mn and Cu content of the soil. A significant positive correlation between sand, P, Fe, Zn and Cu in the soil and energy content of the millet was observed. Silt, K and Mn had significant positive correlation with protein. Silt also showed significant effect on the nutrients like Fe, Mn and Zn. Further, significant positive correlation was found to exist between Mn and Ca with EC and OC, respectively. Thus, the study reveals a significant relationship between soil properties and nutritional quality of finger millet.

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Effect of Micronutrients on Available Ca and Mg in Soil and Content and Uptake of Ca and Mg by Groundnut (*Arachis hypogaea* L.) as Influenced by Zinc and Boron

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Unbalanced and inadequate fertilizer accompanied by restricted use of organic manures and micronutrients resulted in large scale mining of the plant essential nutrients in the cultivated soils. This has become a limiting factor for high productivity of oil seeds crop in the country. Therefore, it is imperative to apply those micronutrients that are deficient in soils for high productivity of oil seeds crops. Among the essential nutrients calcium, magnesium, zinc and boron are play a key role in legumes and oil seeds crop productivity. Hence, a study was under taken to know the "effect of zinc and boron application on soil available Ca and Mg and its content and uptake of Ca and Mg by groundnut". In the view of the above a very little information is available on this topic. Hence, the present investigation is planned by using groundnut as the test crop.

The field experiment was conducted at Zonal Agricultural Research Station (ZARS) Navile, Shimoga, University of Agricultural Sciences, Bangalore. The experiment was laid out in RCBD design with eight treatments three level of $ZnSO_4$ (5, 10 and 20 kg ha^{-1}) and borax @ 5 kg ha^{-1} and was replicated in to three. As per the recommendation, FYM @12 t ha^{-1} was applied uniformly to all plots well in advance. Recommended NPK (25 kg N, 50 kg P_2O_5 and 50 kg K_2O) are applied in the form of urea, single super phosphate and murite of potash to the experimental site at the time of sowing.

Application of borax @ 5 kg ha^{-1} did not increased the calcium content of both haulm and kernels of groundnut, but, application of zinc sulphate at three levels (5, 10 and 20 kg ha^{-1}) with or without borax significantly increased the calcium content of both haulm and kernels of groundnut over the control (0.62% in haulm and 0.71% kernal). Further, a non significant increase in the calcium content of both haulm and kernels was observed when zinc sulphate applied along with borax. However, a maximum calcium content in haulm (0.69%) and kernels (0.80%) of groundnut was recorded in the treatment, which received zinc sulphate @ 20 kg ha^{-1} along with borax and NPK fertilizers. Magnesium content of both haulm (0.31%) and kernels (0.51%) of groundnut did not influenced by the imposed treatment.

Among the secondary nutrients uptake by groundnut, magnesium uptake was not affected by the imposed treatments but maximum (20.87 kg ha^{-1}) was observed where zinc sulphate @ 20 kg ha^{-1} along with borax and NPK fertilizers. Whereas, calcium uptake significantly increased due to the application of borax and zinc sulphate either separately or in combination. This is probably because of increase in the haulm and kernel yields of groundnut but maximum 38.34 kg ha^{-1} was recorded in the treatment zinc sulphate @ 20 kg ha^{-1} along with borax and NPK fertilizers.

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Studies on Revalidation of NPK Recommendations in Rainfed Maize-based on Soil Nutrient Status

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Sustainable agriculture is possible only when soil is managed scientifically to maintain its productivity and health. However, intensive cultivation with HYV's with imbalanced use of fertilizers over decades has resulted in unscientific nutrient mining, deterioration of soil health and decline or stagnation in productivity of many crops. Farmers are getting responses to higher and higher levels of fertilizer application, although long-term soil health is a concern in such practices. Sometimes full potential of the crop is not realised as the nutrient input does not match the soil status and crop demand. So the situation warrants a more scientific NPK fertilizer use based on the soil status. In the light of this, a study on the response of maize to different levels of NPK applied on the basis of soil nutrient status and crop demand was taken up.

The study was carried out in Shimoga, Bhadravathi and Honnali taluks of southern transition zone of Karnataka (zone-7). The trials were conducted at six locations *viz.*, Nidige, Sogane, Sydara Kallahalli, Attibylu, Nimbegondi and Yaraganalu in Shimoga, Bhadravathi and Honnali taluks during *kharif*-2010. The experiment comprised of four replications and six treatments. The treatments involved different levels of NPK use based on soil test-crop response (STCR) equation, modifications based on soil NPK status and STL method compared with recommended package of practices. The initial status of NPK and other nutrients in soil at various locations was studied based on which the NPK doses in different treatments were arrived at. The available N status in soil was low in all the locations where as P_2O_5 was found to be as high as 148.70 kg ha^{-1} in some soils. The available K_2O status was medium.

Results indicated that there was a significant increase in grain yield of maize at three locations out of six locations due to application of NPK as per STCR as compared to recommended package of practices. In two of the locations higher grain yield level was obtained when recommended NPK was modified by +25 per cent based on soil NPK status. Over all, pooled analysis of data indicated a higher productivity level 8.08 t ha^{-1} by application of NPK as per STCR as compared to only 6.95 t ha^{-1} recorded with recommended package of practices. The next best productivity level of 7.72 t ha^{-1} was obtained when NPK was modified by +25 per cent based on soil NPK status. The variation in stover yield of maize due to various treatments was more or less similar to that in respect of grain yield. NPK application based on STCR recorded higher level of stover yield in three locations out of six locations. Fertilizer modification by +25 per cent based on soil NPK status, resulted in stover yield level next to the level obtained with STCR but significantly higher than the recommended package of practice. Over all, pooled analysis indicated a productivity level of 7.15 t ha^{-1} of stover yield which was significantly higher than the package of practices 6.41 t ha^{-1}. Thus it is clear from results that there is a very good scope to increase the productivty of maize by modifing the presently recommended NPK level of maize based on STCR equation. Judious use of fertilizers based on soil test also help in maintaining the soil sustainble in the long run in contrast to indiscriminate use of higher level of fertilizers.

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Effect of Planting Material and Mode of Fertilizer Application on Growth and Yield of Banana under Western Ghat Zone of Maharashtra

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Banana is an important fruit crop and mostly grown in plane zone area on Vertisol (deep black soil) of Maharashtra. A field experiment was conducted at Zonal Agricultural Research Station, Western Ghat Zone, Igatpuri on entisol (shallow laterite soil) during the year 2008 to 2010 to assess the effect of planting material and mode of fertilizer application on growth and yield of banana. The experiment was carried out in a factorial randomised block design with three types of planting material and four modes of fertilizer application. Banana variety used was Grand Nain. Three types of planting material *viz.*, tissue culture plants, suckers of tissue culture plants and suckers of normal plants were used. The recommended dose of fertilizer (200:40:200 NPK g plant^{-1}) was given through NPK briquettes and through conventional fertilizer. Irrigation was given to the crop with drip irrigation to all the treatments. The results revealed that planting material of tissue culture plants give significantly higher banana yield (96.34 t ha^{-1}) as compared to suckers of tissue culture plants (88.38 t ha^{-1}) followed by suckers of normal plants (87.99 t ha^{-1}). Mode of fertilizer application affects significantly the yield of banana. The treatment application of recommended dose of fertilizer through NPK briquettes gives significantly higher yield (102.22 t ha^{-1}) of banana as compared to other treatments.

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Effect of Different Level of Silicon on Growth, Nutrient Uptake and Yield of Upland Paddy in an Inceptisol

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A field experiment was laid out in an Inceptisol low in available silicon to study the effect of different level of silicon on growth ,nutrient uptake and yield of upland paddy at College of Agriculture Farm, Kolhapur. Silcon was applied through calcium silicate, one month before sowing of paddy. The growth (plant height, no.of tillers per hill and dry matter accumulation), nutrient uptake, and yield of paddy increased significantly with the application silicon. The significantly highest grain The uptake of silicon increased significantly with the application of calcium silicate (5.54 t ha^{-1}) and straw (5.92 t ha^{-1}) yield was recorded with treatment T_4 (750 kg Si ha^{-1}), however it was at par with T_3 (500 kg Si ha^{-1}). The uptake of silicon increased significantly with the application of calcium silicate and the highest uptake of silica (217 kg ha^{-1}) was recorded with 750 kg ha^{-1} application of calcium silicate (T_4). Application of Si significantly reduced the incidence of stem borer and grass hopper. The available silicon status of soil after harvest was increased significantly due to different doses of silicon. The study indicated the beneficial effect of calcium silicate @ 500 kg ha^{-1} in increasing the uptake of silicon and other nutrients and yield of paddy and reducing the incidence of stem borer and grass hopper.

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Effect of Organic and Inorganic Sources of Nutrients on Chemical Properties and Available Nutrients Status of Vertisol

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A field investigation was carried out on the effect of organic and inorganic sources of nutrients either individually or in combination on the chemical properties, available nutrients' status and dehydrogenase enzyme activity of Typic Haplustert during 2007-08 and 2009-10 in fixed site at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The experiment was laid out in randomized block design with nine treatments replicated thrice. Treatments included were RPP (RDF+FYM), RDF, 100 and 75 per cent recommended N through FYM, through organic and inorganic sources each at 50% level). In addition, liquid organic manures namely beejamruth, jeevamruth and panchagavya alone and in combination with above said treatments except RPP and RDF were applied. The soil was clay in texture, alkaline in reaction (pH 8.2) and low in organic carbon content (4.7 g kg^{-1}) and status of available N, P_2O_5 and K_2O and SO_4^- S were 205.6, 26.4, 212.8 and 30.5 kg ha^{-1}, respectively.

The results revealed that the application of different treatments did not influence the pH and total soluble salts content of soil. The organic carbon content in soil increased from 4.7 to 5.56 g kg^{-1} and 5.53 g kg^{-1} in the treatment receiving chemical fertilizers along with FYM and 100 per cent organic manure, respectively. Significant difference existed among the different treatments with respect to available nutrients. The treatment with recommended dose of fertilizers and FYM recorded higher available nitrogen and phosphorus contents in soil (238.6 and 38.2 kg ha^{-1}, respectively) and it was on par with the treatment receiving RDF only and the treatment with 100 per cent organics. Incorporation of FYM (25 t ha^{-1}) with 100 per cent RDF recorded significantly higher available potassium content of 294.4 kg ha^{-1} over two years than other treatments. The available sulphur content in soil was also higher in the treatment supplemented with FYM along with recommended dose of fertilizers (55.16 kg ha^{-1}) and lower value was recorded in the treatment supplied with only liquid organic manures (37.88 kg ha^{-1}).

The addition of FYM along with RDF resulted in relative increase in the DTPA extractable micronutrients content of soil from the initial values. Before the start of the experiment, the DTPA extractable Cu, Fe, Mn and Zn in soil were 1.09, 4.8, 5.4 and 0.48 mg kg^{-1} and increased to 1.41, 5.71, 6.48 and 0.63 mg kg^{-1}, respectively after two years. However, the difference was statistically non significant between the treatments receiving RDF+FYM, RDF, 100 per cent organics and treatment with organic and inorganic sources of nutrients each at 50% level. Further, the dehydrogenase enzyme activity in soil was significantly higher in the treatment receiving FYM in conjunction with RDF (45.20 µg TPF g^{-1} soil d^{-1}) as compared to the treatment with RDF alone (35.16 µg TPF g^{-1} soil d^{-1}). Supplementation of liquid organic manures numerically increased the available nutrients status of soil.

Hence, incorporation of the organic sources of nutrients in conjunction with inorganic fertilizers helps in maintaining the fertility of the soil.

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Modification of the Recommended Fertilizer Dose to Wheat Based on Soil Fertility Rating

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Thirty composite surface (0-15 cm) soil samples were collected from the predominantly wheat growing areas in the Dharwad, Belgaum, Bagalkot and Bijapur districts of North Karnataka. The soil samples were subjected to fertility analysis (macro, secondary and micronutrients) in addition to chemical properties to assess the fertility status of the land. Wheat growing soils are predominantly calcareous deep black and are generally classified as Typic Chromusterts. The soil pH was alkaline and ranged between 8.15 and 9.12 indicating slight to moderate alkalinity. The average pH value was 8.48. This suggested that the soils are calcareous and wheat productivity is restricted due to likely deficiency of Fe and Zn due to alkaline pH. The soils were non saline and 1:2.5 soil water suspension electrical conductivity ranged from 1.24 to 1.75 dS m^{-1}. Wheat being slightly salt tolerant, prevailing soil electrical conductivity was not a limiting factor. Organic carbon content of the soil revealed that soils were low to medium. The values ranged from 2.1 to 10.8 g kg^{-1}. Similarly, available nitrogen content of these soils was also very low to low. The average available nitrogen in soils was 155 kg ha^{-1}. Nitrogen was the most deficient among major nutrient elements in wheat growing fields. Available phosphorus remained medium to high (available P_2O_5 was 44-68 kg ha^{-1}) and available potassium was high in most of the soils. Among micronutrients, Fe and Zn remained the most deficient. Available Zn and Fe ranged from 0.12 to 0.33 mg kg^{-1} and from 1.76 to 4.96 mg kg^{-1}, respectively. Based on these analytical results, eight field experiments were conducted in the farmers' fields under low, medium and high (LMH) and low, high and high (LHH) combination category of the available N, P_2O_5 and K_2O. The results revealed that soil test crop response based nutrient recommendation dose recorded highest crop grain and straw yields (3.18 and 3.14 t ha^{-1} grain yield and 5.17 and 5.10 t ha^{-1} straw yield under LMH and LHH category, respectively). However, this treatment remained on par with the fertilizer dose that was modified by + 50 per cent under LHH category (2.95 t ha^{-1}). The least crop yield was harvested under recommended dose of the fertilizer application under both LMH and LHH category.

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Evaluation of Rice Genotypes for High Zinc and Iron Accumulation in Rice Endosperm

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Rice is an extensively grown important staple food crop, accounting 43% of the total food grain of the country. Biofortification with micronutrient dense cultivars of rice is one of the important options available to fight against malnutrition of micronutrients such as iron (Fe) and zinc (Zn), reported to be widely deficient and predominant in rice eating population. In order to identify promising and stable rice germplasm for high Fe and Zn content in the endosperm and assess the influence of environment on the accumulation of micronutrients in the grain by exploiting the genetic variation in rice germplasm for use in the breeding program appears to be promising. Therefore an experiment was conducted to study the uptake of zinc and iron in some of the genotypes during the *kharif* 2008, 2009 and 2010 at Zonal Agricultural Research Station (ZARS), V. C. Farm, Mandya. Nine rice genotypes were transplanted The paddy genotypes used were IR-36, MTU3626, Aghonibora, NDR6279, TKM9, Profulla, Vasumathi, Thanu and Gouri. Among the genotypes studied IR36 recorded maximum yield 6.09 t ha^{-1} (pooled) followed by Thanu (5.68 t ha^{-1}) and lowest yield recorded in Gouri (1.71 t ha^{-1}). Uptake of Fe was maximum in MTU3626 (126 g ha^{-1}) and lowest in Gouri (36 g ha^{-1}). Zn uptake was maximum in IR36 (105 g ha^{-1}) followed by Profulla (104.66 g ha^{-1}) and was lowest in MTU3626 (28 g ha^{-1}). The genotype profulla recorded Maximum accumulation of iron and zinc in ground rice (29 and 28.66 mg kg^{-1}) as well as in brown rice (31 and 66.66 mg kg^{-1}) respectively.

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Effect of Integrated Nutrient Management on Groundnut-Wheat Cropping Sequence

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The field experiment was conducted during *kharif* and *rabi* season of 2008-09 at Agricultural Research Station, K. Digraj, Dist-Sangli to study the effect of integrated nutrient management on groundnut-wheat cropping sequence. The experiment was laid down in randomized block design with nine treatments and three replications in *kharif* season and on the same plot, the factorial randomized block design in *rabi* season with two factor *i.e.* 75 and 100% general recommended dose of fertilizer (GRDF). The treatments for *kharif* groundnut were GRDF (25: 50 N: P kg ha^{-1} + 5 t ha^{-1} FYM), 25% recommended dose of nitrogen (RDN) –FYM + 75% RDN chemical + *Rhizobium*. + phosphate solubilising culture (PSB) + vesicular arbuscular mycorrhiza (VAM), 25% RDN – vermicompost (VMC) + 75% RDN chemical + *Rhizobium* + PSB + VAM, 25% RDN –wheat straw + 75% RDN chemical + *Rhizobium* + PSB + VAM, 25% RDN –wheat straw + 75% RDN chemical + 100% P-rock Phosphate + *Rhizobium* + PSB + VAM, 25% RDN –green leaf manuring + 75% RDN chemical + 100% P-rock phosphate + *Rhizobium* + PSB + VAM, PSB + *Rhizobium* + VAM + jeevamrut , PSB + *Rhizobium* + VAM + Rock phosphate and control. After harvesting *kharif* groundnut, the same plots were given the fertilizer i.e.75 and 100% GRDF to *rabi* wheat. The application of GRDF (25: 50 kg ha^{-1} + 5 t ha^{-1} FYM) to *kharif* groundnut and 100% GRDF (120: 60: 60 N: P: K kg ha^{-1} + 5 t/ha^{-1} FYM) to wheat crop recorded highest grain yield and straw yields of wheat. The highest available N and available K were recorded in the treatment application of GRDF (25 : 50 kg ha^{-1} + 5 t ha^{-1} FYM) to *kharif* groundnut, whereas the highest available phosphorus (9.73 kg ha^{-1}) was noticed in treatment of 25% RDN through VMC + 75% RDN through chemical + *Rhizobium* + PSB+ VAM for *kharif* groundnut. The highest available N, P and K were noticed in treatment 100% GRDF (120: 60: 60 kg ha^{-1} + 5 t ha^{-1} FYM) fro *rabi* wheat. The maximum total uptake of N, P and K were recorded in treatment application of GRDF of both these crops.

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Identification of Soil Fertility Constraints in North Karnataka by GIS Technique

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The importance of soil fertility to the health and survival of all life cannot be understated. As human population continue to increase, human disturbance of the earth's ecosystem to produce food and fiber will place greater demand on soils to supply essential nutrients. If we do not improve and/or sustain the productive capacity of our soils, we cannot continue to support the food and fiber demand of our growing population. It is therefore important to monitor the nutrients status of soil from time to time with a view to monitor the soil health.

Hence, geo-referenced information on the location, extent, quality of spatial data is a must for advisory purposes. Geographic information system (GIS) can be used in producing a soil fertility map of an area, which will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally. This is an important technique for formulating site specific recommendation of nutrients.

Soil fertility status in representative micro watershed/village from four agro-ecological zones of north Karnataka such as northern dry zone (Zone-3), northern transition zone (Zone-8), Hill zone (Zone-9) and coastal zone (Zone-10) was studied and mapped nutrients status by GIS technique for identification of soil fertility constraints.

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Impact Assessment of Brackish-water Shrimp Farming on Soil Salinity and Allied Consequences

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Brackish-water (EC 20 – 25 dS m^{-1}) serves as a suitable medium for rearing *bagda* (*P. monodon*) a preferred shrimp species in coastal area. Owing to huge benefit of shrimp aquaculture the practice has also stepped into paddy growing area, converted farm-land to shrimp pond wherever brackish-water is accessible and thereby slowly building up salt stress as reported from several places. Slow transformation of cultivated area to salt affected pasture at the surroundings of shrimp culture was reported from Andhra Pradesh and in coastal Orissa as well. Information on the magnitude of salt stress increase and its extent of persistence in soil is insufficient.

In coastal area, soil salinity fluctuates with seasons depending on the length of rainfall received and the magnitude of evaporation took place at a particular time-period. Influence of brackish-water shrimp farming to induce soil salinity is therefore difficult to ascertain in the area. Soil texture however plays a crucial role to determine the salt stress in particular soil type. An effort was thus initiated to determine the impact of soil textural components for salinity retention and release and its consequent threat in brackish-water shrimp farming area.

On the basis of stocking density of shrimp, Astarang (40000 – 60000 ha^{-1}) and Erasama (60000 – 1000000 ha^{-1}) were chosen for the study area. Soil salinity (EC_2, dS m^{-1}) at Astarang varied from 0.1 – 1.0 during post and 0.3 – 3.4 at pre monsoon period with sandy to clay soil texture. At Erasama, soil salinity ranged between 0.3 to 5.8 in post and 0.3 – 9.8 dS m^{-1} in pre-monsoon periods while texture varied from sandy loam to clay with a prevalence of sandy clay loam in general

Soil core was collected from the surface (0 – 0.2 m), leached with natural saline water of EC 6 – 7 dS m^{-1} followed by no-saline good water till to attain a constant EC value in the leachate. Soil with '(silt + clay) / sand' (x) ratio within 0.44 to 0.83 revealed a significant increase of salinity in the form of $0.81e^{2.61x}$, $R^2 = 0.84$ while it increased as $-0.51x^2 + 3.86x - 0.3$, $R^2 = 0.86$ if the ratio varied between 1.04 to 3.66. A severe loss of hydraulic conductivity at a pace of 45 to 100% was also obtained without reflecting any uniform trend either with clay content or '(silt + clay) / sand' ratio. This can be accounted for Na enrichment to the tune of 6.27 to 62.74 % over their respective initial values with percent loss of Ca (14.29 to 42.42) and Mg (17.5 to 62.29) in the soil exchange complex. Soil with low ESP (6.09 – 8.03) appeared to be more vulnerable towards Na saturation than high ESP values. However growing of salt tolerant paddy varieties in between two shrimp crops has been found useful to reduce the salinity retention of a sandy clay loam soil in both the places. To avoid salinity build up and Na saturation in soil the package and practices for growing of salt tolerant paddy and brackish water shrimp can be standardized in paddy cultivated interfaced with shrimp farm in coastal area.

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Soil Physical Environment under Different Tillage and Crop Residue Management Systems

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An experiment was conducted to study the effect of tillage and wheat crop residue management on soil physical properties during soybean growth. The treatment consisted of conventional tillage (CT), conventional tillage+wheat straw incorporation (CT+WS), zero tillage (ZT) and zero tillage+wheat straw spread as mulch (ZT+WS).

The important soil physical parameters studied, at the harvest of soybean, were field saturated hydraulic conductivity (K_{fs}), bulk density (B.D.), soil water contents at field capacity, wilting point, 10 per cent aeration porosity and at 2MPa soil strength. Saturated hydraulic conductivity was measured by Guelph permeameter, this method involved drilling a small, vertical, cylindrical well and determining the steady water discharge when a constant depth of ponding was maintained in the well. Bulk density was measured by core method. Undisturbed soil samples were collected for determination of soil water content at field capacity and wilting point by pressure plate method. Soil water content at 10 percent aeration porosity was determined by subtracting 10 from saturation percentage. Soil water content at 2 MPa soil strength was determined from the regression equation relating penetration resistance to soil water content and bulk density. Upper limit of least limiting water range (LLWR) should be either soil water content at field capacity or at 10 percent aeration porosity, whichever is lower. Lower limit should be either soil water content at wilting point or soil water content at 2 MPa soil strength whichever is higher. For sandy loam soil of experimental farm, upper limit of LLWR was soil water content at field capacity as it was lower than soil water content at 10 per cent aeration porosity. Lower limit of LLWR was soil water content at 2MPa soil strength as it was higher than soil water content at wilting point.

At harvest, K_{fs} at 10 cm were in the following order *i.e.,* conventional tillage+wheat straw incorporation (CT+WS) > conventional tillage (CT) > zero tillage+wheat straw spread as mulch (ZT+WS) > zero tillage (ZT), whereas order was reversed for bulk density. The above trend confirmed the earlier findings that soil compaction was maximum under zero tillage without residue, whereas wheat straw incorporation through conventional tilling keeps the soil bulk density within optimum range. LLWR (value of which if more than 10% is an indicator of good soil structural condition) remained widest in CT+WS (14.2%) and lowest in ZT (5.2%). Results indicated that soil structural condition of all treatments except CT+WS became poor at harvest.

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Farmer's Participatory Action Research on Balanced Use of Nutrients in Transgenic Cotton in Raichur District, Karnataka

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Cotton is a major commercial crop grown in almost all the agroclimatic zones of Karnataka. Cotton is also an important commercial crop of TBP (Tunga Bhadra Project) command area where the soils are medium deep black. In order to implement location specific technologies and to educate farmers on balanced use of nutrients based on soil test, farmer's participatory Front Line Demonstrations were conducted along with farmers practice as check. Most of them apply only fertilizers which is unbalanced and untimely for crop production. This is one of the main reasons why the farmers are getting low seed cotton yield and high incidences of reddening. The soil test data of farmer's field were found low in Nitrogen and high in potassium demanding higher nitrogen and lowering potassium dosages which could save lot of fertilizer in the region. Keeping these in view, front line demonstrations were conducted for four years *viz.*, Sunakeshwarhal in 2007-08, Budinal in 2008-09, Jalibenchi in 2009-10 and Hokrani village in 2010-11 encompassing 137 farmers, have consistently shown the good crop stand and yield of seed cotton yield was distinctly higher i.e. 3.25, 3.28, 2.25 and 2.80 t ha^{-1} in balanced nutrients applied plots and 2.60, 2.73, 2.00 and 2.24 t ha^{-1} in farmer's practice plot, with an increase in yield of 24.3, 20.0, 12.50 and 25.0%, respectively. The yield levels in 2009-10 were low because of 60 to 65 days dry spell fallowed by flood. In spite of that farmers were able to harvest some yield in cotton and pigeon pea in that year as they are long duration crops. In all years there was a low incidence of reddening and early boll formation and boll opening. Farmers have realised the importance of balanced application of nutrients in crop production and started practicing it. This has helped the farmers to obtain higher yield and improve their economic condition.

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Split Application of Lime on Soil Properties

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A field experiment was conducted in central farm of OUAT, Bhubaneswar, during *kharif* 2010. The Soil of the experimental site belongs to *Typic Haplustalfs* with pH-4.6 and exchangeable acidity, Al, H and Ca of 0.55, 0.36, 0.19 and 1.26 cmol(p^+)kg^{-1}, respectively. It was conducted in split-plot design with 3 replications .Main plot treatments consisted of application of 100% PMS (M_1), 100% PMS with FYM @ 5 t ha^{-1} as basal (M_2) and FYM @ 5 t ha^{-1} with 50% PMS as basal and rest 50% after 21 days (M_3) after sowing of groundnut .The subplot treatments consisted doses of lime such as 0,0.1,0.2 and 0.3 LR as determined by modified woodruff buffer method .The values of soil pH, exchangeable acidity, Al, H and Ca were determined in weekly intervals. The soil pH was increased by 0.15 to 1.65 , 0.2 to 1.9 and 0.1 to 2.3 units over initial value in M_1, M_2 and M_3 treatments, respectively. As the dose of lime was increased ,the pH of the soil was increased .The soil pH remained 5.5 or above for a period of more than 49 days, 91 days and 84 days in M_1, M_2 and M_3 methods of lime applications, respectively, when lime was applied @ 0.2LR or above .The soil pH in case of split application (M_3) of lime was found to be more than other methods at corresponding doses .The result further revealed that as the dose of lime application increased, the exchange acidity, exchangeable Al and exchangeable H content of the soil were decreased .The exchange acidity reduced by 0.07 to 0.13, 0.02 to 0.44 and 0.01 to 0.02 cmol(p^+) kg^{-1} in cases of M_1, M_2, and M_3 methods, respectively. Further exchangeable Al reduced from 0.36 cmol (p+) kg^{-1} to zero when lime was applied as basal or split with FYM (M_2, M_3). Unlike basal application of PMS without FYM (M_1) the exchangeable Al maintained at zero level for 49 days in M_1 method, 91 days in M_2 method and 84 days in M_3 method. Similarity the exchangeable H was reduce from 0.19 to a minimum value of 0.07, 0.02 and 0.01 cmol(p^+)kg^{-1} in M_1, M_2 and M_3 methods, respectively. On the other hand, the exchangeable Ca was increased to as high as 2.95, 3.1 and 2.7 cmol(p^+)kg^{-1} in cases of M_1, M_2 and M_3 methods, respectively. The retention of exchangeable Ca was longer in case of spit application of lime as compared to other methods .Thus, the split application of PMS was found to be efficient in amending the acid soils as compared to its basal application.

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Performance of Different Cotton Genotypes under Irrigation with Saline Water

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A field experiment was conducted in the microplots at the Department of Soil Science CCS, Haryana Agricultural University Hisar. Saline water of different EC *i.e.*, 2.5, 5.0 and 7.5 dS m^{-1} was applied for irrigation starting from 30 days after sowing as and when required by the crop along with canal water as control (zero EC). Seven different cotton cultivars *i.e.* H-1236,H-1098-I (American cvs.), HD-123 (Desi cv.), KD-441 BG-II, RCH-134 BG-I, KD-9810 BG-II and Ajit-333-BG-II (Bt. cvs.) were sown in the month of May and harvested in the month of October. The first irrigation with good quality canal water was given for the purpose of field preparation for sowing of cotton crop. The seed cotton yield of all the cultivars decreased with increasing salinity of irrigation water. Desi cotton HD-123 was found highly sensitive to salinity and Bt. cotton hybrid KD-9810-BG-II followed by American cotton variety H-1098-I were found least sensitive to salinity. An irrigation water of EC of 7.5 dS m^{-1} led to an overall yield reduction of about 60 percent, However, At salinity level of 2.5 dS m^{-1}, the overall yield reduction was found 21 percent but Ajit 333-BG-II showed non significant yield reduction at this level. The Bt cotton hybrid KD-9810-BG-II performed better and highest seed cotton yield was obtained in this cultivar. The number of bolls per plant did not show any consistent pattern with increasing salinity levels. Similarly, the ELWL (excise leaf water loss) an indication of transpiration rate did not show any relation with salinity except for HD-123 and H-1236. Rate of photosynthesis consistently decreased with increasing salinity levels in all the cultivars except in Ajit 333-BG-II where as HD-123 showed just the reverse trend. Although Chlorophyll status did not show consistent trend under salinity but higher stomatal conductance was recorded under saline conditions in all the cultivars.

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Quality of Underground Irrigation Water of Mahendragarh Block of Mahendragarh District in Haryana State

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The study is based on 87 ground water samples collected randomly at a distance of 2 to 3 km with the spatial points through GPS in Mahendragarh block of Mahendragarh district in Haryana State. The samples were analysed for their cationic and anionic composition by following the procedures outlined in USDA Handbook No. 60 (Richards, 1954). The study revealed that 85.06% of the samples showed EC values less than 4 dS m^{-1} and the maximum value of EC was found as 9.65 dS m^{-1} in village Khudana. Residual sodium carbonate (RSC) and Sodium adsorption ration (SAR) varied from nil to 14.72 and 0.54 to 17.32, respectively. According to AICRP classification, the maximum samples were found in good quality (25.3%) category followed by marginally alkali (19.5%). The per cent samples in saline classes were 12.6, 10.4 and 12.6% in marginally saline, saline and high SAR saline classes, respectively. High alkali category recorded 13.8% samples and the lowest percentage of samples (5.8%) was observed in alkali class. The concentration of Na^{+}, Ca^{+2} and Mg^{+2} --ions generally increased with increase in EC of the water samples. Chlorides and HCO_3^{-} were found in appreciable quantities whereas CO_3^{-2} were in traces. Contour map of EC, SAR and RSC of Groundwater used for irrigation in Mahendragarh block were plotted to study spatial variability of these parameters. EC contour map reveals that quality of water is better in southern and western parts of the block in comparison to eastern, northern and central parts.

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Effect of Saline Water Irrigations on the Yield and Physiological Parameters of Cotton (*Gossypium hirsutum*) Genotypes

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The tolerance of cotton varieties (H-1117, H-1300, H-1236, H-1098-1, H-1226, HD-123 and HD-432) and different saline water irrigation treatments (canal water, EC_{iw} 2.5, EC_{iw} 7.5 dS m^{-1}) was evaluated in Pucca micro-plots of 2 m x 2 m in size. The plots were constructed above ground and filled with the sandy laom surface soil (0-15 cm). The soil was allowed to stabilize before sowing the crop. Increasing salinity generally led to a gradual decrease in cotton production. At EC_{iw} of 7.5 dS m^{-1}, yield reduced by 58.5 % as compared to control treatment. The mean yield of H-1236 was significantly higher than other genotypes followed by H-1117. The genotype HD-123 was the lowest yielder. Various physiological parameters (ELWL%, transpiration rate, photosynthesis rate, chlorophyll status) and nutrient uptake were also studied. Both ELWL% and transpiration were generally reduced with increasing levels of salinity. Rate of photosynthesis was reduced with the increasing salinity except that a level of 2.5 dS m^{-1} had even led to an increase in the rates in H-1117 and H-1098-1 genotypes and no change in H-1300. Nitrogen content of the leaves of cotton plants increased at lower levels of salinity but decreased at the highest level 7.5 dS m^{-1}. Phosphorus and K content of the leaves generally decreased with increasing levels of salinity whereas Na content generally increased with the increasing levels of the salinity. Mean EC (1:2) in the soil profile upto 45 cm varied from 0.58 to 1.86 dS m^{-1} from control to 7.5 dS m^{-1} plots at the time of sowing.

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Survey of Nitrates in Ground Water of Krishna Zone, Andhra Pradesh

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Nitrate occurrence in ground water is one area that has received attention in India. Available evidence from elsewhere does indicate the possibility of fertilizers leaching and subsequent contamination of underlying ground water. The applied nitrogen is subjected to so many losses, of which leaching is most common and adding to ground water and causing nitrate water pollution. The use of this water for drinking causes methemoglobineima to human beings. Over the last five years, as per the FAI statistics, Guntur, and Krishna districts are consuming more chemical fertilizers after west Godavari. Farmers are in discriminatively using nitrogenous chemical fertilizers for crops like cotton, tobacco, chillies, turmeric, sugarcane, rice *etc*. Survey of under ground water and collection of ground water samples from highly fertilized areas of Krishna, Guntur and Prakasam districts was undertaken in Krishna Zone of Andhra Pradesh during 2010-11.

Three hundred ground water samples were collected from highly fertilized areas of Krishna Zone Covering Krishna, Guntur and Prakasam districts growing commercial crops. The NO_3 content ranged from 0.75 -33.32 ppm in Krishna district, 1.0 to 22.3 ppm in Guntur district and 0.25 to 12.5 ppm in Prakasam district. pH ranged from 6.9 to 9.7 and EC ranged from 0.5 to 3.69 dS m^{-1}. Bicarbonates ranged from 1.2 to 11.3 meq l^{-1}, Chlorides ranged from 1.2 to 16.4 meq L^{-1} while Sulphates ranged from 0.2 to 6.63 meq L^{-1} indicating Chlorides are dominant among anions. Among Cations, Sodium was dominant with a range of 1.92 to 17.69 meq L^{-1} followed by Ca (0.80 to 17.2 meq L^{-1}) Mg (0.40-12.0 meq L^{-1}) and K (0.01-0.17 meq L^{-1}). Sodium Adsorption Ratio (SAR) ranged from 0.50-67.11 meq L^{-} and residual sodium carbonates (RSC) ranged from nil to 16.00 meq L^{-1}.

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Performance of Soybean under Partially Reclaimed Sodic Vertisols

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The reclamation and utilization of sodic lands are of prime importance in view of the ever increasing population pressure for demand of food grains. Gypsum is most efficient amendment for reclamation of soidic soils. But the availability of mined gypsum is questionable in future. Spent wash contained appreciable amount of calcium, sulphur and other essential nutrients along with organic carbon. It is acidic in nature which may help in faster amelioration of sodic soils. The present study was undertaken to test the performance of soybean under partially reclaimed sodic Vertisols. A field experiment was conducted in RBD with three replications during *kharif* 2011-12 at RVSKVV Salinity Research Farm, Barwaha, district Khargone, M.P. with soybean (JS-9305). The treatments consisted control, FYM @ 5 t ha^{-1}, vermicompost @ 5 t ha^{-1}, gypsum @75% GR, gypsum @75% GR + FYM @ 5 t ha^{-1}, gypsum @75% GR+ vermicompost @ 5 t ha, spent wash 2.5 cm, spent wash 5.0 cm and spent wash 10.0 cm. The soil of the experiment was sodic Vertisols having pH 8.5, EC 1.4 dS m^{-1} and ESP 40. The treatments were applied during preceeding three years under paddy-wheat cropping sequence. After three year, the soybean crop was raised in the same plots. The results showed that the application of spent wash @ 5.0 cm produced significantly higher seed (2.14 kg ha^{-1}) and straw (2.45 kg ha^{-1}) yield of soybean over control. The increase in seed and straw yield was 50.2 and 50.8 % over application of gypsum @ 75% GR respectively. ESP of the soil after harvest of soybean was 18.6 under spent wash (5.0 cm ha^{-1}) treated plots.

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Evaluating Response of Halophytes and Other Salt Tolerant Plant Species to Saline Water Use in Vertisols

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Bio-saline agriculture is one of the biological approaches to utilize saline soils and saline waters for agriculture. It is vital to use saline wastelands to produce food, fibre, fodder *etc*. to meet the demands of increasing populace. The introduction of halophytes or salt tolerant plants, therefore may provide a sensible alternative for many developing countries. The selection of halophytic species of economic uses, with appropriate management, could result in the rehabilitation and re-vegetation of salt affected land and the use of marginal quality waters. Extensive survey was conducted in the coastal and inland salt affected lands of Gujarat. Six coastal and 3 inland salt affected districts of Gujarat were traversed and dominance of different halophyte and salt tolerant plant species was identified. Different dominant halophyte/salt tolerant species identified includes *Acacia catechu, Salvadora persica, Casuriana equisetifolia, Zizyphus nummularia, Tamarix ericoides, Suaeda maritima*, *Suaeda nudiflora, Aleuropus lagopoides*, *Avicennia* spp. and *Calatropis procera*.

The germplasm or seeds of the three dominant halophytes and salt tolerant plant species *viz*. *Salvadora persica*, *Acacia catechu* and *Casuriana equisetifolia* were collected and pot experiments were conducted to evaluate their response to the saline water of EC 2.5, 5.0 and 7.5 dS m^{-1} in Vertisol alone and in combination with vermicompost (VC) and AM. Eight kilograms of soil (Vertisol) was filled in the pots and one plant in each pot was maintained. The pots were irrigated with 600 ml water of different salinity as per treatment at weekly intervals with total of 8 irrigations. The growth parameters *viz*. height, biomass and root length were recorded. It was observed that at 60 days after sowing, VAM and VC application helped in augmenting the plant growth under saline water irrigation at all the salinity levels of 2.5, 5.0 and 7.5 dS m^{-1}. However, imposing salinity of 7.5 dS m^{-1} resulted in reduced plant height by 12.4 per cent as compared to control. Similarly, imposing salinity in *Acacia catechu* resulted in lower plant height to the tune of 5.7 cm and 11.2 cm with salinity levels of 5.0 and 7.5 dS m^{-1} as compared to 2.5 dS m^{-1}. Application of VAM+VC helps in mitigating the effect of salinity as evident from the increased plant height by 5.0, 13.8 and 11.5 per cent, respectively at 2.5, 5.0 and 7.5 dS m^{-1} salinity levels.

Significant increase in growth of *Salvadora persica* with applied AM at all the three salinity levels was observed. The per cent increase was to the extent of 4.4, 6.3 and 7.7 per cent at salinity levels of 2.5, 5.0 and 7.5 dS m^{-1}. Average root zone salinity was reduced from 5.8 dS m^{-1} and 3.6 dS m^{-1} to 4.7 and 2.4 dS m^{-1} when VAM was applied to the soil receiving irrigation waters of 5.0 and 7.5 dS m^{-1}. There was reduced growth of the plant species when salinity was imposed in the absence of VAM. As compared to 2.5 dS m^{-1} salinity, 33.2% and 27.4% lower plant height was observed at 7.5 dS m^{-1} and 5.0 dS m^{-1} in case of *Casuriana equisetifolia*.

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Effect of High Electrical Conductivity, High SAR Water on the ESP of the Soil Profile and Performance of Okra

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The effect of high ECiw and high SAR waters on the ESP of soil profiles and yield of okra were studied in micro plots conducted on a sandy loam soil at the research farm of CCS HAU, Hisar. Okra was grown with three qualities of irrigation water (ECiw = 0.6 dS m^{-1} and SARiw = 0.4 $mmol^{1/2} L^{-1/2}$; ECiw = 5.1 dS m^{-1} and SARiw= 11.6 $mmol^{1/2} L^{-1/2}$ and ECiw = 9.0 dS m^{-1} and SARiw= 17.8 $mmol^{1/2} L^{-1/2}$). In all there were eight irrigation five of 5 cm and three of 1.25 cm. Soils samples were collected before and after each irrigation and these samples were analysed for EC1:2, soluble sodium and calcium plus magnesium and exchangeable sodium. It was observed that the EC1:2 and ESP of the soil profile decreased with depth irrespective of quality of irrigation water. Whereas EC1:2 and ESP of the soil profile increased with increase in ECiw and SARiw of the irrigation water. There was a significant decrease in the yield of okra with increase in ECiw and SARiw of the irrigation water. The ESP of the soil profiles were simulated using Pal *et al.* (1990) model. The trend and magnitude of observed and simulated ESP of the soil profile showed a close agreement.

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Conjunctive Use of Canal Water and Marginally Saline Groundwater for Wheat Cultivation under Calcareous Soil of Bundi District

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A field experiment was conducted at Krishi Vigyan Kendra, Bundi (Rajasthan) to find out the effect of conjunctive use of canal water and marginally saline groundwater and zinc sulphate application on wheat crop under calcareous soil condition. The experiment comprised of 20 treatment combinations having five treatments of water (*i.e.* I_1 = All irrigation with canal water, I_2 = All irrigation with groundwater, I_3 = One irrigation with canal water followed by one irrigation with groundwater in cyclic mode, I_4 = Two irrigation with canal water followed by one irrigation with groundwater in cyclic mode and I_5 = One irrigation with canal water followed by two irrigation with groundwater in cyclic mode) and four levels of zinc (*i.e.* control, 15, 25 and 35 kg zinc sulphate ha^{-1}). The results indicated that the increasing number of irrigations of poor quality groundwater increased the EC of soil from 0.73 (I_1) to 1.33 dS m^{-1} (I_2) and decreased the pH from 8.15 (I_1) to 7.88 (I_2) and organic carbon of soil from 3.76 to 2.77 g kg^{-1} soil at harvest of the crop. Whereas increase in EC of soil and improvement in organic carbon content found non-significant with addition of zinc to the soil. The growth and yield attributes (plant height, number of total tillers, effective tillers, test weight), and yield of wheat (grain and straw) decreased significantly with increasing number of irrigations with saline groundwater in both the years. But the growth, yield attributes and yield of wheat achieved at the same level (statistically at par) with I_2 level of conjunction of water sources i.e. two irrigations with canal water followed by one irrigation with marginally saline groundwater in cyclic mode. The perceptible improvement in growth, yield attributes and yield of wheat recorded with the application of 25 kg zinc sulphate ha^{-1}. Hence, we can save one-third (33%) good quality (canal water) without significant reduction in economic produce.

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Effect of Different Saline Water on Growth and Yield of Mustard (*Brassica Juncea*) Varieties

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Pollution affects water quality both in river and ground water. Exploitation of ground water for domestic and irrigation use has further aggravated its problem of salinity and sodicity. Therefore, studies on crop production with multiple water quality are of immense significance. Keeping this in view a field experiment was conducted during *rabi* seasons 2008-09 and 2009-10 at research farm of Water Technology Centre, IARI, New Delhi, to study yield and growth parameters of six mustard varieties *viz*. JD- 6, Kranti, Pusa Agarhani, Pusa Bold, Pusa Vijay and Varuna irrigated with 0.4, 6.0 and 12.0 dS m^{-1} saline waters. Sowing was done on third week of October 2008 and 2009 in micro plots (2m × 2m) in a RBD design. Ionic composition of saline was adjusted by adding the salt of NaCl, $CaCl_2$, $MgSO_4$ as per their proportion in naturally occurring saline water in this area. Over all three irrigation with above quality of water were given as and when required. Growth parameters such as height, number of branches and no. of pods were recorded periodically in all the varieties for two years. Based on the results it was evident that seed germination was reduced by 4 to 8 per cent and delayed by 2 and 4 days in pre-irrigated plots with 6.0 and 12.0 dS m^{-1} EC water , respectively. The increasing levels of salinity in irrigation water had depressing effects on growth characteristics particularly height of plant. Pusa Bold was tallest variety followed by Kranti and Pusa Vijay. There was negligible variation in no of branches and no of pods decreased with increasing salinity. From salt tolerance behavior point of view, the varieties were rated in decreasing order as :

Varuna > Kranti> Pusa Bold> Pusa Vijay> JD- 6 > Pusa Agrahani

In general highest salinity (EC) of 12.0 dS m^{-1} decreased the grain yield of all the varieties by about 7 to 14 per cent .

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Sodicity Tolerance in *Bixa orellana*

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Bixa orellana is a shrub plant known for producing natural edible colours from their seeds. Presently about 500 metric ton dry seeds are produced in India, which is a very little contribution (3.45%) in the global market demand in a year. An attempt was made to grow *Bixa orellana* on sodic lands at Banthra, Lucknow. Since sodic soils are categorized as 'A', 'B' and 'C' classes depending on increasing sodicity levels, therefore the experiment was carried out in a RBD setup with four replications on the said three types of sodic soil *i.e.* slightly sodic 'A', medium sodic 'B' and highly sodic 'C'. Seedlings of 16 plants were planted in each plot at 2x2 m^2 in 2008. Soil sampling, plant growth and seed yield were recorded after two years, as per treatments. Soil samples up to 30 cm depth were collected from 3 places of each category of soil. All the soil samples were analyzed for physicochemical properties following the standard methods.

Plant growth and yields were affected by soil sodicity stress. The pH, EC, ESP, total $CaCO_3$ (%) and bulk density of soil samples were lowest at highest plant growth and vice versa. The higher growth of plants was recorded at 'A' category of soil where organic carbon, available N., P., K. and porosity were found better than that of 'B' and 'C' categories where medium and low growth observed. The plant height, stem girth, canopy diameter, number of branch/ plant, fresh and dry weight of leaves, number of pods per branch, quantity of seeds / pod and test weight of 100 seeds (all the growth and yield parameters) were recorded in increasing order from C < B < A categories of soil. Seed production per plant was estimated in the order of 3609 >1282> 57 g $plant^{-1}$ at three categories of sodic soil ('A', 'B' and 'C'), respectively. It appears that economic yields can be achieved around pH 9, after that plant growth and yield reduced significantly at 'C' level of soil.

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Effect of Organic and Inorganic Soil Amendments on Mustard Crop under Saline-Sodic Soil Environment

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Most of the soils of Rajsamand district are saline-sodic in nature and sandy loam to clay loam in texture. Farmers are not using any reclamation measures so far to reduce the salinity/ alkalinity effects of salinity/sodicity on crop growth and yield. A field experiment was conducted during 2009-10 at Krishi Vigyan Kendra, Rajsamand to study the effect of gypsum, FYM and green manure on reduction of soil sodicity and its residual effect on subsequent mustard crop. The experiment was laid out in randomized block design with 3 replications. There were 7 treatments *viz.,* (T1) 100% GR based on soil testing; (T2) *Dhaincha* green manuring in *kharif;* (T3) 100% GR based on soil testing + *Dhaincha* green manuring in *kharif* ; (T4) Cluster bean green manuring in *kharif;* (T5) FYM 10 t ha-^{1} ; (T6) T1 + T5 ; (T7) T1 + T2 +T5. Gypsum was applied in the field on the basis of assessment of gypsum requirement (8.46 t ha-$^{1)}$ of the soil sample collected from experimental field. Soil samples were collected before experiment and after experiment and analyzed the pH, EC, gypsum requirement, ESP, N, P and K. Results indicated that pH and EC of after experiment soil samples were slightly reduced but not statistically significant. Gypsum requirement of soil was significantly affected by the treatments. Application of gypsum, FYM and *Dhaincha* green manuring significantly improve the soil health and enhanced the yield attributes and yield of mustard. The maximum yield (18.75 q ha^{-1}) was obtained in treatment of 100% GR based on soil testing + *Dhaincha* green manuring in *kharif* + FYM 10 t ha^{-1} followed by 100% GR based on soil testing + FYM 10 t ha-^{1} (15.40 q ha-$^{1)}$.

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Effect of Green Manuring in Rainfed Wheat on Soil Moisture in Foothill Region of Jammu

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The yield of rainfed wheat in the foothill region of Jammu is much lower not only due to poor soil fertility status but also on account of less moisture availability during rabi season. The soils of the region are poor in organic carbon and coarse in texture having low water holding capacity. The rainfall in the region is sufficient but erratic in distribution in space and time. Also, 80 per cent of the rains occur during kharif season. In-situ soil moisture is one of the greatest constraints for poor rabi crop in the region. Green manuring with legumes is an important organic source for plant nutrients that is known to improve soil physical structure, moisture retention and fertility status. The efficiency of the nutrient can however be enhanced if it is applied in conjunction with green manure. No systematic study has been undertaken to evaluate the effect of green manuring in conjunction with chemical fertilizers on wheat based crop sequences, soil moisture conservation and physical and chemical properties of soil.

The field experiment was conducted in foothill region of Jammu where sunhemp crop was grown and incorporated after 50 days for maize production. For comparison, summer fallow was taken as control. The plots were green manuring, maize and fallow were cultivated for wheat during rabi season. It was observed that sunhemp as green maure added 2867 kg ha^{-1} of organic matter in the soil. Green maured plots recorded significantly higher water retention before sowing of wheat at all the soil depths *viz.* 0-10, 10-20 and 20-30 cm under 0, 10, 33 and 1500 kPa suction as compared to fallow and maize cultivated plots. Soil moisture was consistently maintained at higher level at critical stages of wheat growth *viz.* crown root initation, tillering and reproductive stages in green manure-wheat system as compared to conventional fallow-wheat and maize-wheat systems. It was noted that moisture content under green manure-wheat system was more pronounced in upper 30 cm soil layer and least average moisture content upto 50 cm depth was recorded in the maize-wheat system throughout the cropping period.

Commission 3.5: Soil Degradation Control, Remediation, and Reclamation

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Irrigation Induced Saline-Sodic Soils in Katepurna Command Area in Akola District of Maharashtra

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The present investigation was carried out in the Anvi village of Katepurna command area in Akola District of Maharashtra to study the effect of continuous irrigation on the soil properties and to assess the degree of soil degradation. The sampling was carried out from the grids at 2.5 cm X 2.5 cm on the 1:10,000 scale map to collect the soil samples from 0 to 20 cm depth and six representative pedons were studied. The soil degradation along with its degree and kind has been assessed by detailed laboratory analysis and effect of long term irrigation on the soils has been ascertained.

It was revealed that the soils are developing salinity and/or sodicity due to continuous irrigation from last 35 years. Among the soil properties the pH (8.0 to 9.5), ECe (0.26 to 5.76 dS m^{-1}) and ESP (5.1 to 12.2 per cent) of the soils are increasing specifically in sub soil horizons. The exchangeable Ca/Mg ratio varied from 1.4 to 2.8 in different soil horizons which showed in general decrease in the soil profile. The downward decrease in the Ca/Mg ratio in the pedon was observed with concomitant increase in the exchangeable sodium along with depth. In saturation paste extract the pHs varied from 7.6 to 9.2. While among the cations sodium dominated over calcium, magnesium and potassium. Chlorides dominated among anions followed by bicarbonates and sulphates. The sodium adsorption ratio ranged from 2.3 to 14.5 which showed in general increase within the depth.

The organic carbon content of the soil was in general low which ranged from 2.9 to 6.4 g kg^{-1} in the surface horizons. The soils were highly calcareous (7.4 to 15.8 per cent) with more calcium carbonate in the sub soil horizons. The soils with high sodium on exchange complex in association of high clay content of smectitic nature showed problems and caused restriction in drainage. Field observations in the form of conditions of poor drainage at ESP above 10 support this fact indicating the necessity of lowering the ESP in black swell-shrink soils for categorizing them as sodic. The kind and degree of degradation assessment based on the modified criteria indicated that the soils are none to very slightly saline-sodic (SS1), slightly saline-sodic (SS2), slightly sodic (S2) and moderately sodic (S3) indicating considerable soil degradation which was not revealed by the USSL criteria.

The negative correlation between ESP and cotton yield (r = - 0.46), soybean yield (r = - 0.57), pigeon pea yield (r = - 0.80), chick pea yield (r = - 0.84) and wheat yield (r = - 0.35) have been recorded which reveals the extent and dominance of ESP in controlling the yield. ESP is thus an important stress causing soil parameter not reflected by the use of same criteria for all the soils. This further justifies the refinement made in defining the lower limit of ESP. The existing criteria of 15 ESP of USSL for categorizing sodic soils is not suited for categorization of these swell shrink soils and the problems in these soils are not properly diagnosed. The study indicates that the soils in Katepurna command area are on the way of degradation due to salinity/sodicity and there is decline in the productivity of crops which can be improved by diagnosing the problems in these soils by appropriate and locally suitable criteria followed by adopting only need based management measures.

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Effect of Bio-methanated Spentwash on Properties and Available Nutrients Status of Soil

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Spentwash is a waste by-product of sugar industry. Safe disposal of bio-methanated spentwash is the major problem for most of the sugar industries because of high amount of organic load and total solids. It also contains a good amount of potassium with nitrogen, calcium and magnesium. Apart from these, it contains chlorides along with high BOD and COD. Therefore, studies are in progress since 2007-08 to find out the agricultural utility of spentwash as a source of nutrients to crops. The bio-methanated spentwash of Godavari sugar mills, Sameerwadi was slightly alkaline in reaction (pH 7.90), high in total soluble salts (EC 32.0 dS m^{-1}), COD (23,600 mg L^{-1}) and BOD (7128 mg L^{-1}) contents, with higher amounts of bicarbonates and chlorides. On other hand, it was rich in potassium (average value of 0.61%) followed by nitrogen, sulphur and phosphorus. It also contains small amounts of micronutrients. Results indicated that the application of bio-methanated spentwash did not alter the soil reaction. Since the spentwash contains higher amount of total soluble salts, application of spentwash resulted in build-up of soluble salts soon after application of spentwash. The EC ranged from 0.05 to 0.78 dS m^{-1} and 0.15 to 1.78 dS m^{-1} in soils before and after application of bio-methanated spentwash, respectively.

Bio-methanated spentwash application also resulted in significant improvement in the content of organic carbon and on an average it increased from 4.9 to 5.8 g kg^{-1}. Addition of organic matter through effluent and better crop growth with concomitant higher root biomass generation could be the probable reasons for improvement in organic carbon content. The results indicated that the application of bio-methanated spentwash had drastic increase in available K and slight build-up of available N when compared to the other nutrients. However, status of available P and S did not alter considerably with the application of bio-methanated spentwash.

The exchangeable sodium content increased significantly in soils upon application of bio-methanated spentwash. The increase in sodium content of soils resulted in increase in exchangeable sodium percentage (ESP) from 2.7 to 5.6 cmol(p^+)kg^{-1}. Further, the data clearly indicated that the ESP values attained after application of spentwash in the soils of the farmers' fields were in permissible limits (< 15%).

The exchangeable calcium plus magnesium content in soils varied from 18.0 to 50.0 cmol(p^+)kg^{-1} and 18.0 to 51.0 cmol(p^+)kg^{-1} in soil before and after application of bio-methanated spentwash, respectively. However, the exchangeable calcium and magnesium contents of soils did not alter to a large extent by application of bio-methanated spentwash. Application of spentwash to the soil clearly indicated that there was little build-up in the DTPA extractable copper, zinc manganese and iron contents in soil. The studies clearly indicated that the spentwash may be used as a source of plant nutrients only once in four years as it is high in total soluble salts and high BOD and COD.

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Use of Processed Industrial Biowaste as Manure in Wheat

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Utilization of processed industrial biowaste (BW) as manure in agriculture depends on the type of industry and raw materials utilized. The BW from biotech industry contains essential elements in appreciable quantity besides some heavy metals. Keeping this in view, a field experiment on wheat was conducted during *rabi* 2009-10 and 2010-11 on sandy loam soil having medium fertility status to study the effect of processed biomass on growth and yield of wheat besides changes in soil fertility status as well as contamination level for heavy metals. In all, there were ten treatments comprising of different combinations of NPK (100, 75, 50% of RD) and organics (FYM and BW, each at 2.5, 5.0 and 10.0 t ha^{-1}) under RBD experimental design on sandy loam soil.

The results revealed that maximum grain (2.68 kg ha^{-1}) and straw (4.74 kg ha^{-1}) yield of wheat were recorded due to NPK (100% RD) application in conjunction with FYM at 2.5 t ha^{-1} + BW 7.5 t ha^{-1} which was significantly higher by 21.8 and 19.8 per cent over control (100% RD). The results indicated that NPK application along with FYM/ BW application is necessary for higher wheat yield. However, sole application of BW has not been found advantageous at higher rate *i.e.* 10 t ha^{-1} in combination with full dose of NPK. The results also revealed that the higher application of BW at 10 t ha^{-1} reduced chemical fertilizer load by 25-50% without affecting yield of wheat.

The increase in contents of heavy metals in grain and straw of wheat due to BW application at lower rate (*i.e.* up to 7.5 t ha^{-1}) was not alarming; while the level of heavy metals contamination in grain and straw was comparatively higher at 10 t ha^{-1}. Therefore, the application of processed BW up to 7.5 t ha^{-1} in conjunction with FYM to make total quantity of organics at 10 t ha^{-1} in addition to NPK (100% RD) to wheat has been found more advantageous in increasing wheat yield without affecting soil health.

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Assessing Accumulation and Mobility of Heavy Metals in Different Crops Grown on Metals Contaminated Soils of *peri* Urban Area in Gujarat

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The indiscriminate disposal of industrial effluents on agricultural lands is becoming a major source of heavy metals contamination in irrigated soil and ultimately ground water. The crops grown on such soil provide way for heavy metals to enter into food chain of human and animals. However, the absorption and translocation of heavy metals varies with crops and varieties. Keeping this in view, the experiment was carried out to study the assessment of different plant species of local importance for their heavy metals accumulation/removal capacity/efficiency and suitability for phytoremediation by computing accumulation factor. The contaminated sandy loam soil collected in bulk from Lali- Vatva industrial area was utilized in the micro-plots (1.5 x 1.0 x 0.5 m^3) under factorial completely randomized design. Three levels of irrigation water *viz.*, 100% mixed industrial effluent (I_1), 1:1 diluted effluent (I_2) and tube well water (I_3) were kept to study their effect on growth and yield of different crops [Sunflower (*Helianthus annus*), Cotton (*Gossypium hirsutum*), Tobacco (*Nicotina tabacum*) and Castor (*Ricinus communis*)]. The results revealed that the biomass yield of castor was maximum followed by cotton while minimum yield was recorded in tobacco. However, the maximum value of accumulation factor was cited with tobacco and the minimum was noted with castor for all the elements except Ni. Although, the removal of heavy metals in absolute quantity was maximum with castor followed by cotton.

The mobility index was calculated in order to know the translocation behaviour of heavy metals from soil to various plant parts *i.e.* roots, stem, leaf, seed and oil in different crops. The results indicated that the sunflower showed maximum mobility index values for all the heavy metals from soil to roots which indicated absorbance of heavy metals from soil to root was faster in sunflower than other crops. The minimum absorbance of Cr, Co and Pb from soil to root was noticed in castor, Ni in tobacco and Cd in cotton.

The mobility index values for seed oil was higher in cotton for Cr, Ni and Co in castor and Pb in sunflower. The minimum translocation of Cr and Pb was noticed in castor seed oil, Cd and Co in sunflower and Ni in cotton seed oil. The sunflower oil showed least risk of heavy metals except Pb.

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Assessment of Metal Contamination in Soils of *Peri*-urban Areas Receiving Irrigation through Sewage and Industrial Effluents

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Long-term use of sewage, sludge and industrial effluents in agriculture often results in the build-up of the elevated levels of trace toxic metals in soils. Crops raised on the metal-contaminated soils accumulate metals in quantities excessive enough to cause clinical problems both to animals and human beings consuming these metal rich plants. The present investigation was undertaken i) to assess the build-up of heavy metals in soils of *peri*-urban agricultural lands in and around Delhi, ii) to compute the hazard quotient (HQ) for intake of metals by human through consumption of vegetables grown on these soils, and iii) to predict the metal uptake by vegetable crops grown on these soils. For this purpose, 82 composite surface (0-15 cm) soil samples were collected from sewage irrigated agricultural lands of Keshopur, western Delhi. These agricultural lands have been receiving sewage irrigation for last three decades. Composite surface soil samples were also collected from adjacent tube well water-irrigated lands as a reference. Similarly 103 and 5 composite surface soil samples were collected from sewage and tube well-irrigated agricultural lands of Modanpur Khadar. These agricultural lands have been irrigated with sewage effluents emanating from Okhla sewage treatment plant for last five decades. In addition, 16 surface soil samples were also collected from from the fields adjoining Atlas Cycle Factory, Sonepat, Haryana. These fields had been receiving industrial effluents for fifteen years. In all, 74 samples of edible portion of various vegetable crops were also collected from these sewage and industrial effluent-irrigated fields.

Results indicated that DTPA-extractable Zn, Cu, Fe, Ni and Pb contents in soil were increased by 290, 52, 108, 138 and 92%, respectively in sewage irrigated soils of Keshopur as compared to tube well-irrigated soils. However, there is a declining trend in available Mn as a result of sewage irrigation. In Modanpur Khadar, there were substantial build up of DTPA-extractable Zn, Cu and Fe to the extent of 81, 384 and 1088%, respectively in sewage irrigated soils over tube well water-irrigated ones. Whereas, Mn contents in soils was declined by 26%. In industrial effluent-irrigated soils of Sonepat, enormous build up of Zn, Cu and Ni were recorded. For Keshopur and Madapur Khadar, HQ for dietary intake of Zn, Cu, Fe, Mn and Ni by humans through Indian Spinach (*Spinacea oleracia* L.), gobhi sarson (*Brassica napus*), poi (*Basella alba*), radish leaf and root (*Raphanus sativus* L.), sponge gourd fruit *(Luffa aegyptiaca,* colocasia leaf (*Colocasia esculenta* L.), and bottle gourd leaves and fruit (*Lagnaria leucantha*) were within the safe limit for consumption. However, vegetables, particularly bottle gourd grown on industrial effluent irrigated soils of Sonepat were not suitable for human consumption as far as their Fe and Ni content are concerned. Although values of prediction coefficient (R^2) for solubility-free ion activity model for predicting Zn, Cu, Fe, Mn and Ni uptake by Indian spinach were statistically significant, this integrated model could explain variation in Zn and Ni uptake to the extent of 59 and 74%, respectively. It appears from this study that this model can be used for routine risk assessment of metal-contaminated soils.

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Extent of Spread of Heavy Metal Contamination in Municipal Dump Environs in Tirupati, Andhra Pradesh

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Studies on the extent of spread of heavy metal contamination in municipal dump environs in Tirupati, Andhra Pradesh" were conducted with the objective of assessing the effect of municipal dump environs on soil properties, ground water qualities, nutrient status of index leaf, and uptake by whole plant and crop yield losses at different distances from the municipal dump environs. The ground water from bore wells at different lateral distances and soil samples at 0, 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 m distance from the municipal dump environs were collected and analyzed for different properties in the year 2006. The crop yield losses in the farmer's fields around municipal dump environs were also recorded.

The composition of municipal waste in terms of pH, EC, N, P, K, Ca, Mg, Na, micronutrients (Fe, Mn, Zn and Cu) and heavy metals (Cd, Cr, Ni and Pb) was relatively more as compared to that of ground water adjoining municipal dump environs. The salt concentration, cationic and anionic composition, micronutrients and heavy metals of ground water increased by the municipal dump environs. The maximum EC recorded was 2.57 dS m^{-1}. The adverse effects of municipal dump environs on quality of ground water in the immediate vicinity (in terms of EC, cations, anions, micronutrients and heavy metals) were more as compared to farther distances. The soluble salt content of ground water adjoining the municipal dump environs was above the permissible levels upto 113 m.

The soil properties like EC, OC, N, P, K, Ca, Mg, S, CO_3^{--}, HCO_3^-, Cl^-, micronutrients *viz.*, Fe, Mn, Zn and Cu and heavy metals *viz.*, Cd, Cr, Ni and Pb were significantly more in the immediate vicinity of the municipal dump environs. Due to municipal dump environs, the concentration of N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Cd, Cr, Ni and Pb in the index leaf and uptake by rice collected during study periods were slightly higher in the immediate vicinity of the municipal dump environs as compared to the farther distances. The adverse effects of municipal dump environs on rice were continued up to 200 m.

There is a need to take up legislation regarding the disposal of municipal wastes, so as to maintain sufficient distance from agricultural fields, drinking / irrigation water sources and human habitations.

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Nutrient and Heavy Metal Content of Crops Grown on Soils of Musi River Bed Area in *Peri*-Urban Agriculture of Hyderabad

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Peri-urban agriculture has a vital and increasing role to play for local and national economies in India. However, there is little awareness of the increasing environmental threats associated with food production in *peri*-urban areas. Pollutants in *peri*-urban areas, which can affect the safety of crops grown here, can have a dramatic and widespread impact on urban inhabitants. One of the threats to food quality and safety in these areas are heavy metals in industrial effluents including sewage water. Dietary intake of heavy metals is a substantial risk to human and animal health. In addition, heavy metal contamination can affect plant health and nutritional value of crops. Urbanization and industrialization has increased the food contamination and it is not regularly monitored or controlled. Industry is often a main source of severe water pollution apart from sewage and municipal wastes. The present studies were conducted for evaluation of nutrient and heavy metal uptake by different crops grown in Musi river bed area of Hyderabad. In Musi river bed area, plant samples were collected at harvesting stage from different crops grown on these polluted agricultural soils, where soil samples were also collected. Each plant sample was collected in three replicas along with the roots. The standard methods were adopted for the estimation of different elements in plant samples (AOAC, 1980). The results indicated that, due to continuous usage of sewage and industrial effluents affected waste waters for irrigation of field crops in Musi river bed area the concentrations of N, P and K in plants were found within the range. While, the concentrations of micronutrients and heavy metals were found within the permissible limits in edible parts of the plants except Pb, which was found to be exceeding the permissible limits. The concentration of major nutrients, micronutrients and heavy metals were found to be accumulating least in edible parts of most of the plants of Musi river bed area while highest accumulation was found in their roots. The accumulation pattern of heavy metals in edible parts of all the plants collected from different locations of Musi river bed area was found in decreasing order of magnitude as: Fe > Zn > Mn > Cu > Pb > Ni > Co > Cr > Cd.

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Quasi Equilibrium of Soil Carbon Stock in Saline Vertisols under Different Land Use Systems

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Knowledge about the variation in soil organic carbon (SOC) due to changes in land use is required to restore soil quality and sustain productivity. The soil system attain a quasi-equilibrium stage after accumulation of organic matter in soil and its loss over a period of time and it depends upon the prevailing land use system. After each land use system, the soil system acquires a new quasi-equilibrium level of SOC over a period of time depending on the vegetation cover and management practices. Three land use systems viz, agriculture, pasture and forestry were selected to know the quasi-equilibrium value of SOC and total carbon stock under these systems.

The study area is representative of saline Vertisol near Samni village of Bharuch district, Gujarat. The land is presently managed by CSSRI, RRS, Bharuch as an experimental farm that was an abundant area with different kind of vegetations like *Prosopis juliflora, Acacia arabica, Prosopis cinareria, Azadirecta indica* and some native grasses. During 2002, 50% of the farm area was cleared for cultivation of agricultural crops like cotton, castor, pigeon pea, sorghum, mung and wheat. A detailed soil survey was carried out for entire farm following the standard method. A total of 20 soil profiles were exposed and studied for their morphological properties and soil were analyzed for different physical and chemical properties using standard methods. Quasi equilibrium value (QEV) was calculated using SOC% of the soil over different depths (0-15, 0-30, 0-50 and 0-100 cm) under different land uses. QEV = S(C x d)/D, where C value refers to the SOC% under different land use systems, d is the depth of soil horizon (cm) and D is the depth for which this is to be calculated (*i.e.* 15, 30, 50, 100 cm *etc*.). Soil organic carbon stock, soil inorganic carbon stock and total carbon stock were calculated

The QEV of SOC under the different system shows that the agriculture system at 15 cm depth had the lowest value of 0.57% as compared to the forest (0.85%) and pasture land use system (0.95%). The QEV of SOC under the pasture system is highest as compared to forest and agriculture system. At this depth the carbon decreases to 0.57% after 8 to 10 years of agricultural practices indicating the decrease of 40%. This indicates that the pasture had the capacity to sequester more SOC than the forest and agriculture system. The study indicated that the QEV of SOC in saline shrink swell soils decreased when they were used for agriculture crops production. The data on the carbon stock indicate that the agriculture system had the lowest SOC stock at all the depth as compared to pasture and forest system. The results indicated that to attain the QEV of SOC under agriculture system comparable with pasture and forest system, the fertility status of these swell-shrink soils has to be maintained by adding the external input like FYM, green manuring *etc*.

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Long-term Effect of Treated Distillery Spentwash on Soil Properties and Crop Yield

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Spentwash, the process waste water generated in molasses based distilleries is a good source of organic carbon and plant nutrients, especially potassium. Its utilization in agriculture is permitted by Pollution Control Board after bringing down the pollutants within the permissible limits for land application by subjecting it to primary (biomethanation) and secondary (aeration) treatment by the industry. A long-term study on the effect of land application of treated spentwash from M/s SLN Distillery, Garag, Dharwad district has been initiated in the University farm during 2005 with maize and wheat as test crops during *kharif* and *rabi* seasons, respectively. The spentwash was applied on the basis of nitrogen requirement of crop in two splits. The first application of 60 per cent of calculated quantity was applied a fortnight before sowing and the remaining 40 per cent before flowering. Soil samples were collected after harvest of crop and analysed for pH, EC, SOC, available N and K_2O by following standard laboratory methods. Yield of the crop was also recorded. The results of *rabi*, 2010 season revealed that there was no adverse effect of applied spentwash either on soil properties or on the crop yield even after six years of its application. The highest wheat yield was recorded in the treatment receiving one and half times recommended N through spentwash, which was on par with N applied through fertilizer at the same rate. A steady increase in yield was observed in the spentwash applied treatments. A build-up in SOC and available K_2O content in soil over the years in spentwash applied treatments was observed. The SOC and available K_2O contents increased from 0.70 to 1.26% and from 789 kg ha^{-1} to 1288 kg ha^{-1} in 2005 and 2010, respectively in the treatment which received one and half times recommended N through spentwash.

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Phytoextraction of Chromium from Contaminated Soil by *Zea mays* as Influenced by Chelating Agents

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Chemically enhanced phytoextraction has been proposed as an effective approach for removing heavy metals from contaminated soil through the use of high biomass plants. For this, a pot experiment was conducted to evaluate the effect of amendments on phytoextraction of chromium (Cr) using chelating agents namely, CDTA, citric acid, DTPA, NTA (at 10 mmol kg^{-1} soil) and FYM (3%) with *Zea mays* grown with the sewage sludge unamended and amended (at 3%) soil. Application of chelating agents influenced dry matter yield and uptake of Cr by roots and shoots differentially depending upon the nature of the chelating agents. Dry matter yield of roots and shoots of *Zea mays* increased due to application of CDTA and FYM whereas reverse trend was observed in NTA, citric acid CDTA, and DTPA treated soils. Addition of sewage sludge at 3% on dry weight basis was found beneficial in improving the plant growth. Chelating agents enhanced the Cr uptake by both roots and shoots and significantly higher values of Cr uptake by roots and shoots were observed from sewage sludge amended as compared to unamended soil. Application of CDTA was found more effective in enhancing the Cr uptake by roots and shoots of *Zea mays* than any other chelating agents at both the growth stages. The chelating agents are found useful in enhancing phytoextractability of Cr by *Zea mays*. Hence, marginally Cr contaminated soil may be remediated by adding chelating agents.

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Spatial Variability of Fluorine in North-west India

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Data on water soluble fluorine (F) content of 470 soil samples (collected at a grid of 10×10 km) of different agro-climatic zones of the Haryana state, were statistically analyzed for their spatial variability. The frequency distribution of the data was found to be normal. The mean values of the water soluble F were 4.42, 4.60, 4.23, 2.47 and 2.12 mg kg^{-1} for the hot and arid, hot and dry, hot and semi-dry, hot and sub-humid and hot and humid zones of the state, respectively with a mean value of 4.19 mg kg^{-1} for the entire state. This distribution of the F levels was mainly attributed to the soil pH as a linear correlation between the two parameters was statistically significant. The highest variation of F was observed in the hot and semi-dry zone (coefficient of variation, CV = 54.6 %). In other zones the variation was low to medium (CV = 24.1 to 38.4%). Finally, a relationship between standard error and number of observation has been worked out so as to use it to estimate the number of samples to be collected in future F monitoring in the soils of the study area for a given precision and probability level.

The semivariogram of F showed definite sill of 4.2 $(ppm)^2$ up to a separation distance of 225 km and expressed by Gaussian Model. The nugget variance was 72.1% of the sample variance. The models was used to prepare the isarithmic maps of F. The isarithmic map obtained by observed and block kriged values showed that block kriging is the better estimation method of interpolation from the management point of view as compared to point kriged maps. Such isarithmic maps can be of great help in making appropriate management decisions, as they show the spatial display of F over the entire area of the state. Cross validation technique indicate that the kriging interpolation was unbiased and showed low variance. The number of samples required to obtained the mean within ± 10% of the true mean at different confidence levels, were much less by kriging as compared to classical technique. The estimated sample size by block kriging was 3-14 times smaller than that by point kriging and classical estimation, respectively.

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Carbon Addition and Storage under Integrated Nutrient Management in Soybean-Wheat Cropping Sequence in A Vertisol

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Sustenance of soil organic carbon (SOC) in soil is of utmost importance for soil health and sustainable agriculture. Vertisols of central India contains appreciable amount of clay. Under such circumstances, the soil carbon storage potential of these soils is high, which offers an opportunity to sequester carbon into the soil by devising suitable agronomic measures. Therefore, we attempted to quantify the C input and storage in soils under different IPNS modules in the predominating soybean-wheat cropping system in central India and to establish a relationship between annual C addition and storage. There were 12 IPNS modules with three replications arranged in randomized block design for soybean cultivar (JS 335) and wheat (cultivar WH-147) cropping system. The soil carbon storage with turnover rates of biomass under different IPNS modules in a Vertisol under the predominant soybean-wheat cropping system of central India revealed improvements in carbon sequestration through balanced and integrated nutrient management. The highest C addition and storage was recorded under 16 and 8 t ha^{-1} FYM addition to soybean and wheat, respectively. Carbon addition and storage relationship revealed that to maintain the initial SOC 554 kg C ha^{-1} is required. The vertisol of central India have high C storage potential and the soybean-wheat cropping sequence hold promise to maintain its SOC even in the event of no fertilizer and no manure addition.

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Evaluating Organic, Inorganic and Integrated Nutrient Management Practices for Cultivation of Cauliflower: A Comprehensive Analysis

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We made a comparative assessment for cultivation of cauliflower (*Brassica oleracea* L. var. botrytis) considering yield, economics, quality of produce with respect to human and animal nutrition, nutrient use efficiency, input-output energy balance, quality of growth medium (soil) and also soil organic carbon (SOC) balance for choosing the best management practices. Fifteen nutrient management practices *viz*., control, inorganic NPK, three types of organics *viz.*, farmyard manure (FYM), greenmanure (GM) and vermicompost (VC) and their different selected combinations were compared for three years (2007-10). Results showed that organics produced at par with the control and yielded around 164 and 170% less than inorganic and integrated sources of nutrients respectively. Integrated application of organic and inorganic was not only excelled in yield but also had higher B:C ratio and improved crop and soil quality. Among the organics, FYM outperformed over others by producing maximum biomass yield, obtaining higher marginal net return, maintaining higher SOC stock and SQI value; while VC produced the best quality heads for human, but GM for animals. Finally, integrated application of organic and inorganic was found to be the best nutrient management practices for getting optimum yield and quality of cauliflower with higher economic return and leaving good health of soil on harvest.

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Soil Health and Fruit Quality of Papaya under Organic and Conventional Farming

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The objective of this study was to understand how the organic practices in papaya production increase the soil and fruit quality over inorganic practices in tropical conditions. The experiment was initiated during June, 2005 at Indian Institute of Horticultural Research (IIHR), Bangalore, experimental farm using variety 'Surya' with following eight treatments *viz.*, T_1- Recommended NPK fertilizers, T_2- 10 kg FYM pl^{-1} y^{-1}, T_3-7 kg urban compost pl^{-1} y^{-1}, T_4- 20 kg sunhemp+150 g rock phosphate pl^{-1} y^{-1}, T_5- 2 kg neem cake +0.5 kg wood ash pl^{-1} y^{-1}, T_6- 18 kg rural compost pl^{-1} y^{-1}, T_7- 2.5 kg vermicompost + 12.5 kg sunhemp pl^{-1} y^{-1}, T_8- No manure or fertilizer. Before initiation of experiment, soil chemical properties were analysed and it was compared after two years of the experimentation. In addition, soil microbial qualities in the form of soil respiration, mineralizable nitrogen, microbial population, enzyme activities *viz.*, urease, dehydrogenase β-glucosidase, phosphatase, growth parameters, fruit quality and yield were analysed. The results indicated that, the performance of crop growth and fruit yield (55 t ha^{-1}) was higher in inorganic fertilizer applied treatment compared to organic manure applied treatments (26.9 – 38.7 t ha^{-1}). There was no significant variation in average fruit weight, TSS and N and K content between organic treatments and conventional treatment. But, the shelf life of fruit was found to be significantly higher in organic manure amended treatments (6.2-7.9 days) as compared to inorganic fertilizer applied treatment (5.1 days). Among the treatments, application of 7 kg urban compost $plant^{-1}$ or 10 kg FYM $plant^{-1}$ was found to be ideal for increasing the soil qualities in terms of microbial population, biochemical reaction and nutrient status as compared to other treatments.

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Effect of Sewage Sludge Incorporation on Yield and Soil Properties in a Cowpea-Wheat Sequence

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Use of sewage sludge in agriculture as a source of plant nutrients has gained momentum in recent years. Land application of sewage sludge has much beneficial effect not only in improving soil properties but also from the point of view of environmental implications. Field experiments with cowpea-wheat cropping sequence were conducted at the research farm of IARI, New Delhi during *khaif* and *rabi* seasons for two years (2009-2011). Sewage sludge (@ 2.5, 5, and 10 t ha^{-1}) alone and with 50% NPK was applied to both the crops. Untreated control and plots receiving recommended dose of NPK were kept for comparison. Significant increase in cowpea and wheat yield was observed due to sewage sludge treatments than control. The highest yield of cowpea in both the years was obtained in sewage sludge @ 10 t ha^{-1} + 50% NPK which was statistically at par with recommended dose of NPK. In case of wheat, the highest grain yield was obtained in treatment which received 100% NPK and found statistically at par with sewage sludge @ 10 t ha^{-1} + 50% NPK in both the years. The application of 50% of the recommended dose of NPK yielded at par with sewage sludge @ 2.5 t ha^{-1} + 50% NPK which shows that lower dose of sewage sludge alone or in combination with NPK was not able to increase the grain yield of wheat. The soil pH did not differ significantly among the treatments except in sewage sludge alone @ 10 t ha^{-1} which recorded significantly lower values. Application of sewage sludge along with 50% NPK improved available nitrogen significantly. The available P was significantly higher in all treatment over control but available K in control was at par with treatments which received 50% NPK alone and along with sewage sludge @ 2.5 t ha^{-1}. Application of sewage sludge along with 50% NPK not only increased the yield but also improved soil available nutrients thereby saved 50% NPK fertilizers.

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Effect of Bentonite on Transfer of Cadmium and Nickel from Typic Haplustept to Spinach

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Heavy metal content in the leafy vegetables being aroused as a major concern in the 21st century due to rapid industrialization. Inclusion of leafy vegetables in our diet is one of the major root through which these toxic heavy metals enter to the human system and cause many diseases. So, strategies have to be adopted to reduce the transport of these toxic elements from soil to the edible portion of the crops. Therefore a pot culture experiment was undertaken to investigate the effect of bentonite doses on transport of cadmium and nickel from Typic Haplustept to spinach.

Soils collected form IARI farm (Typic Haplustept) in the pots (to hold 4-kg) were fortified with $NiCl_3$ and $CdCl_2$ at the maximum allowable limit (Ni-100 ppm, Cd- 8 ppm) and double the maximum allowable limit (Ni-200 ppm, Cd- 16 ppm). The soils were amended with bentonites (@ 0, 10, 20, 40 and 80 g pot^{-1}). Spinach was used as test crop during 2010-11 season. Recommended doses of nutrients and cultural practices were adopted as per the package of practices. Three cuttings of spinach were done at 45, 75 and 105 days after sowing (DAS), dried, digested in di-acid mixture (3:1 nitric acid and Perchloric acid) and analyzed for Ni and Cd content. At lower dose the total amount of cadmium (in plant) per pot was found to be decreased as the clay dose increases from control (0 g pot^{-1}) to 80 g pot^{-1} in all the three cuttings and maximum uptake (8.5-22.5 µg) was observed in second cutting compared to rest of the cuttings. Similar trend was also observed at higher dose except, the maximum uptake was observed in 3rd cutting. Cadmium concentration in plant was found to be decreased from 6.2 to 0 and 8.5 to 0.83 mg kg^{-1} in 1st cutting, 11.4 to 3.5 and 21.8 to 5.7 mg kg^{-1} in 2nd cutting and 9.8 to 0.7 and 24.6 to 7.3 mg kg^{-1} in 3rd cutting at higher and lower metal dose, respectively. The trend was similar in case of nickel also. As the clay dose increases from 0 to 80 g pot^{-1}, the total nickel content (in plant) per pot decreased from 52.0 to 8.6, 67.5 to 11.2 and 29.1to 8.4 µg in 1st, 2nd and 3rd cuttings, respectively. The nickel concentration in plant was found to be decreased from 407 to 5.4 mg kg^{-1} in 1st cutting, 30.0 to 6.4 mg kg^{-1} in 2nd cutting and 12.4 to 5.1 mg kg^{-1} in 3rd cutting, respectively. The result shows that the bentonite @ 40 g pot^{-1} can be used as potential amendment to reduce the transport of heavy metals (Cd and Ni) from Typic Haplustept to the spinach crop. Further, this has to be tested for the other toxic elements also so that the bentonite can be recommended as an amendment to reduce the heavy metal transport from soils to crops since it is commercially available at affordable rate.