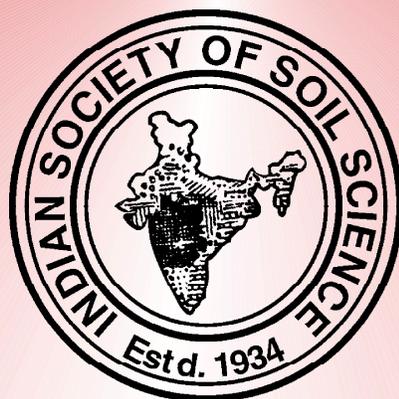


NATIONAL SEMINAR

ON

DEVELOPMENTS IN SOIL SCIENCE – 2014

ABSTRACTS



**79th Annual Convention
Indian Society of Soil Science
24-27 November 2014**

79th ANNUAL CONVENTION

November 24-27, 2014

held at the

**Prof. Jayshankar Telangana State Agricultural University
Hyderabad**

Abstracts

Indian Society of Soil Science

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Commission 1.1: Soil Morphology



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Soil and Land Resource Inventory of Agro-Bio-Diversity Park of ANGRAU, Hyderabad

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In the present study twenty representative pedons were selected based on topography from various physiographic units identified in Agro-bio diversity park (ABDP) of Acharya N.G. Ranga Agricultural University, Hyderabad. On the basis of geomorphic units, soils were selected from Upland, midland and low lands. All the pedons were studied for their morphological characteristics and horizon wise samples were analyzed for soil properties and available nutrient status. Based on morphology and analytic data profiles were characterized. The results showed that variation in soil properties strongly influenced the landform and topography. The analysis of soils indicate that the upland soils are shallow, midland and low land soils are medium to deep, but along the slope the depth of soil increased. The pH is neutral to moderately alkaline and EC is non saline in nature and low to high in organic carbon content. The soils are low to medium in available N and P low to high in available K the base saturation deficient and sufficient in available S fertile to infertile, available micro nutrients are sufficient range and decreasing trend with depth. All soils were classified up to family level the detailed soil survey (1:2500) and trophographical and planimetric data, two sites were identified for the construction of check dams with an ultimate objective of conservation and management of soil and rain water during monsoon at 0.5 control intervals was prepared.

Commission 1.2: Soil Geography



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An Android Application for Real Time Soil Survey Field Data Collection, Transfer and Monitoring

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Field measurements in the soil survey still depend upon the pencil and paper sheets for data collection. Although robust, this method is labor and time-intensive and susceptible to recording and georeferencing errors during transcription. Recent advances in mobile computing and wireless communications allow the scientist to process and transmit data while still in the field, thereby minimizing human errors and time delays. We describe an integrated system developed to acquire, store, display and transmit georeferenced soil-site characteristics data including geo-tagged profile and site photographs during field campaigns that is intended to streamline the soil survey process. The system encompasses advanced mobile, wireless and Internet computing technologies that together facilitate the sharing of field data between the study site and remote locations in real-time.

The field data collection system involves a rugged IP68 certified smart phone - SXtreo™ WP60 and an android application developed for the data entry, photograph collection, storage and transfer. Maximum fields in the soil-site characteristics proforma have been kept in drop down menu to minimize the human error. The device having 5 mega pixel camera and inbuilt GPS removes the need of separate GPS and camera in the surveyors' kit. The 32 GB storage capacity of the device can store the entries in absence of internet signal which may be sent to the server when it gets signals. Separate web based systems have also been developed for individual user and for admin at different level for monitoring and report generation. Provisions for entry of laboratory data of soil physical and chemical properties have also been made to have an integrated database. Thus the developed system provides systematic data collection and real-time transfer to central server, less manual error, accurate GPS location with altitude and Date and Time from Satellite, geo-tagged photographs, three level data security, instant generation of report, live monitoring of work progress from anywhere and centralized data repository. The collection and transmission of soil survey field data is executed without the loss of precision that typifies manual data transfer.



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Reassessment of Micronutrient Status in Medium Black Soils of Bharuch District in South Gujarat

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During green revolution, adoption of high yielding varieties, increased use of high analysis fertilizers and intensive cropping resulted in increased removal of micronutrient and decreased rate of supply from the soil to the crop. In view of the extensive deficiency of micronutrient noticed in soils and crops, surveys were carried out in the state. During the first phase of delineation work about 30,000 surface soil samples were analyzed for micronutrient contents and revealed wide spread deficiency of Zn and Fe which was to the extent of 25 and 9 per cent, respectively. Therefore, it is necessary to monitor periodically changes in depletion or build-up of micronutrient status over the years. Thus, the reassessments of micronutrient have been completed for the Bharuch district of south Gujarat region and thematic maps for various micronutrient viz., Fe, Mn, Zn and Cu have been prepared using GIS. Under reassessment programme, total 224 soil samples were collected during 1990-95 from different villages of Bharuch district and analyzed for micronutrient contents. The deficiency of Fe, Mn and Zn was to the tune of 16.3, 8.4 and 33.4 per cent.

Based on the analysis of soil samples (total 390) collected from villages of Bharuch district during 2011-12 revealed that on the average the Fe content varies from 2.10 to 44.7 mg kg⁻¹ with an overall mean of 10.8 mg kg⁻¹ indicating medium fertility status. The per cent samples in low category for Fe and Zn were 7.4 and 28 as against the earlier value of 16.3 and 33.4, respectively. Similarly, the deficiency of Mn was also observed to be reduced from 8.4 to 2.6 per cent in the region. On the basis of NI value, the soils of Bharuch district are adequate in Cu status. The overall fertility rating for micronutrient in the soils of Bharuch district revealed medium in Fe, Zn and B status and high in Mn and Cu soil status. Therefore, there is a need to create the awareness among the farmers for use of Fe, Zn and B micronutrient containing fertilizers in the medium black soils of Bharuch district.



Soil Nutrient Status in Salt Affected Soils of Anantapur District in Andhra Pradesh

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The presence of salts in irrigation water and the evaporation potential in the irrigated areas usually lead to the salinization and alkalization of soils, particularly in arid and semi-arid zones. The monitoring of both soil and water qualities in irrigated areas is necessary to measure the sustainability of the production system. The use of GPS in surveys of salt-affected soils has improved the quality of comparable studies like improvement in soil properties in the post reclamation phase, precise detection of hot spots of salinity emergence, expansion, identification and establishment of salt-affected soils.

Anantapur district lies between 13'-40' and 15'-15' northern latitude and 76'-50' and 78'-30' eastern longitude. The soils in Anantapur district are predominantly red. The normal rainfall of the district is 553 mm. Due to continuous droughts the ground water levels have gone down precariously and the areas under bore wells/wells have shown a declining trend. Hardly 13% of gross sown area is covered by irrigation support. Soil erosion and poor ground water discharge are the major problems in Ananthapur.

Survey and collection of salt affected soils in Ananthapur district was completed based on satellite imageries obtained during 2010. A total of 22 soil samples were collected along with GPS readings at three depths *viz.*, 0-15, 15-30 and 30-60 cm and analysed chemically for various soil properties. The total geographical area of the district is 19.13 lakh ha, out of which 0.34 lakh ha is under salt affected in nature. The soils were neutral to strongly alkaline (7.00 to 9.40) in reaction. Electrical conductivity (0.40 to 14.1 dS m⁻¹) values are normal to saline in nature. Soil available nutrient status showed that low to high in organic carbon (16 to 108 mg kg⁻¹), available phosphorous (19.26 to 62.27 kg ha⁻¹) and available K (120 to 779 kg ha⁻¹) and medium to low in available N (126 to 472 kg ha⁻¹).



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Delineation and Mapping of Soil available Sulphur and Micronutrients Status in Salem District of Tamil Nadu using GPS and GIS Techniques

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A study was carried out in Salem district, Tamil Nadu to assess the available sulphur (S) and micronutrients status and soil properties to create a data bank and to prepare thematic maps to suggest suitable management strategies for sustained agricultural production. Salem district covers an area of 5,20,134 ha and divided into 9 taluks, 20 blocks and 385 panchayat villages with black, red loam, laterite, red sandy and sandy coastal alluvium soil types. Totally 1691 geo-referenced surface soil samples covering all the panchayat villages in the blocks were collected with GPS data from each sampling site. The soil samples were analyzed for $\text{CaCl}_2\text{-S}$, DTPA extractable micronutrients (Zn, Fe, Cu, Mn) and hot water soluble boron (HWS-B). The analytical results were used for calculating per cent deficiency of sulphur and micronutrients, nutrient index values and fertility ratings. Thematic maps were generated to show the extent of micronutrients deficiency or sufficiency based on block mean, nutrient index values and spatial variability. The availability of S and micronutrients in the soils of Salem was generally sufficient in status except Zn and B which are marginal in status. The Zn deficiency was noticed in all the blocks which demand suitable management strategies for Zn nutrition of crops. Next to Zn, B deficiency was evidenced in all the blocks except Attur, Gangavalli, Mecheri, Omalur and Valapady. Totally 32.3 per cent of the samples were found to be B deficient. Soil reaction, organic carbon content and free CaCO_3 content are the major factors that govern the nutrient availability in the soils of many blocks. Manganese in the soils showed very high fertility rating with a NI value of more than 2.85 while S, Fe and Cu showed high fertility rating with NI values of 2.38, 2.60 and 2.51, respectively. The fertility rating class for Zn is marginal (1.75) whereas B (2.01) is adequate. Not much variation could be observed in the soil properties of irrigated and rainfed system of cultivation, however a marked reduction in the nutrient availability was observed under rainfed system than the soils of irrigated system except B. The cropping systems followed in the tract did not show wide variation in S and micronutrients availability. The spatial variability and multi-micronutrient availability in the soils was studied through thematic maps developed using data set on nutrient availability and NI values. The soils of entire district were sufficient in Fe, Mn, Cu and S availability, while the Zn and B availability differed widely with blocks. Very low status of Zn was found in Konganapuram block and low Zn status was noticed in the soils of Attur, Gangavalli, Mecheri, Omalur, Taramangalam, Veerapandi, Idappadi, Macdonalds Choultry and Sangagiri blocks while the remaining blocks fell under adequate, marginal and high fertility status except Yercaud block which showed very high fertility rating. Next to Zn, B deficiency was predominantly observed. The HWS-B fertility class was very high in Attur, Gangavalli and Valapady blocks, high in Kolathur, Mecheri, Kadaiyampatti, Omalur and Salem blocks, adequate in Talaivasal block, marginal in Panamarathupatti, Idappadi, Macdonalds Choultry and Yercaud blocks. The remaining blocks were found to be low in fertility rating for B. Individual deficiency of Fe, Mn, Zn, Cu and B were observed as single nutrient deficiency with a mean of 0.82, 0.24, 25.8, 3.0 and 11.5 per cent, respectively. All the blocks except Yercaud had more than five per cent of the samples as deficient in Zn. The highest and the lowest per cent of Zn deficiency was noticed in Attur and Yercaud blocks, respectively. Out of the collected samples 4.82, 11.38, 4.62, 1.30, 0.13, 0.59, 0.04, 0.04 and 0.11 per cent of the samples were found to be deficient in ZnCu, ZnB, CuB, FeZn, FeB, MnZn, FeMn, MnB and FeCu in the double micronutrient deficient category and totally 23.03 per cent of the samples were noticed under this category. A combination of ZnCuB (2.94%), FeZnCu (0.08%), FeMnB (0.04%), MnZnB (0.61%) and FeZnB (0.24%) were the triple micronutrient deficiency observed in the soils of Salem district. Out of the collected samples 3.91 per cent were reported under triple micronutrient deficiency. Ayodhiyapattinam block showed three types of triple micronutrient deficiency except FeZnCu. Out of the collected samples, 0.44 per cent showed quadruple micronutrient deficiency. The combination of FeZnCuB (0.13%), MnZnCuB (0.09%), FeMnZnCu (0.16%) and FeMnZnB (0.06%) were the quadruple micronutrient deficiency noticed in Salem district.



Evaluation of Fertilizer Potential of Seaweed Saps on Maize

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Field experiment was conducted to study the fertilizer potential of seaweed saps (*Kappaphycus alvarezii* and *Gracilaria sp*) on maize at TNAU Farm, Coimbatore. The experimental soil was clay loam in texture alkaline in reaction (pH 8.3) and free from salinity (EC: 0.66 dS m⁻¹). The organic carbon content was low (0.36%). The soil available N was low (239 kg ha⁻¹) while the available P (24.6 kg ha⁻¹) and available K (859 kg ha⁻¹) were high. The experiment was laid out with eleven treatments viz., RDF control, RDF + water spray, 2.5, 5.0, 10.0 and 15.0 per cent each of the two seaweed saps, 50% RDF + 7.50 per cent K sap in a RBD with three replications. The sowing of maize hybrid NK-6240 was done at a spacing of 60 x 25 cm. The recommended fertilizer doses were 200:75:75 kg N, P₂O₅ and K₂O ha⁻¹. The entire doses of P and K in the form of SSP and MOP were applied as basal before sowing. The N in the form of urea was applied in three split doses viz., 25 per cent as basal, 50 per cent at knee high stage and remaining 25 per cent at tasseling stage. As per the treatment schedule, the seaweed saps spray was done thrice at 45th, 60th and 75th days after sowing. The crop was harvested at maturity and yield was recorded. The grain and stover samples were collected and analyzed for total N, P and K and their uptake were computed. The post harvest soil samples were analyzed for available N, P, K to assess soil fertility.

Maize responded positively to the foliar feeding of seaweed saps and 100% NPK + seaweed K sap @ 15% recorded the highest grain yield of 7242 kg ha⁻¹ followed by 100% NPK +15% G sap sprays with 7020 kg ha⁻¹ and these two treatments were on par with 100% NPK +10% K sap (6917 kg ha⁻¹). The above three treatments were significantly superior over other concentrations of seaweed saps, 50% RDF + 7.50% K sap (4877 kg ha⁻¹) as well as 100% RDF (6338 kg ha⁻¹). The yield increase in the treatments being 14.2, 10.7 and 9.14 per cent respectively over control. The stover yield also showed the superiority of 100% NPK + 15% K sap with 8737 kg ha⁻¹ followed by 100% NPK + 15% G sap spray with 8515 kg ha⁻¹. The yield increase in these two treatments was 11.5 and 8.71 per cent over control (7833 kg ha⁻¹). Post harvest soil analysis revealed that the available N was lower (221.0 kg ha⁻¹) in 50% RDF + 7.50% K sap spray followed by RDF + 2.5% K sap with value of 228.0 kg ha⁻¹. The N availability in the remaining treatments ranged from 236.0 to 250 kg ha⁻¹. The available P ranged from 23.8 to 26.7 kg ha⁻¹ among K sap sprays and from 24.7 to 26.4 kg ha⁻¹ among G sap sprays as compared to 24.0 and 23.8 kg ha⁻¹ in control and water spray. The lowest available P of 22.8 kg ha⁻¹ was registered in 50% RDF + 7.50% K sap. Regarding available K, RDF + 15% K sap and RDF + 15% G sap recorded a higher value of 861 kg ha⁻¹ and the variations were not significant.

The total N uptake showed that the focus treatments of 100% RDF + 15% (208.8 kg ha⁻¹) and RDF + 10% (194.0 kg ha⁻¹) among K saps and 100% RDF + 15% and RDF + 10% among G sap (200.2 and 190.8 kg ha⁻¹) registered higher values and were on par but superior over 2.5 per cent concentration of K and G saps. The treatment 50% RDF+7.50% K sap recorded the lowest total N uptake (141.2 kg ha⁻¹) which was inferior to RDF control (181.4 kg ha⁻¹) and water spray (187.1 kg ha⁻¹). The total P uptake indicated that the focus treatment of RDF + 15% K sap accounted for higher value of 65.9 kg ha⁻¹ followed by RDF + 15% G sap (64.5 kg ha⁻¹) and were on par with other concentrations but were superior over water spray and control. The lowest total P uptake (41.7 kg ha⁻¹) was observed in 50% RDF+ 7.5% K sap. The total K uptake also revealed the superiority of RDF + 15% K sap (132.4 kg ha⁻¹) and RDF + 15% G sap (132.6 kg ha⁻¹) water spray and RDF control. The lowest total K uptake (98.6 kg ha⁻¹) was observed in 50% RDF+ 7.5% K sap.



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Micronutrient Status and Their Spatial Variability in Banana Growing Tracts of Thoothukudi District, Tamil Nadu

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A study was undertaken in banana growing tracts of Thoothukudi district of Tamil Nadu with a view to assess the micronutrient status at block level. Among the 12 blocks of Thoothukudi district, 5 blocks (Karungulam, Alwartinunagari, Thoothukudi, Tiruchendur and Srivaikuntam) have been identified as banana growing tracts. The present study was conducted with three specific objectives of assessment of available micronutrient status, to correlate the micronutrients with physico-chemical characteristics and calculating the nutrient index and fertility rating for micronutrient and preparation of thematic maps showing the micronutrient status at block level. Totally 714 geo-referenced soil samples covering the entire five blocks of banana growing tracts of Thoothukudi district were collected randomly at three different depths of 0-15 cm, 15-30 cm and 30-45 cm by adopting the standard procedures of soil sample collection. The GPS data were collected from each sampling sites distributed over the entire banana growing tracts by using Garmin GPS 76CS model. The GPS data were used for calculation of percentage deficiency on micronutrients, assessment of nutrient index (NI) and fertility rating and preparation of thematic maps at block wise in the district. Locations of soil sampling sites were marked on base map of 1: 50,000 scales prepared from State Revenue Maps and digitized using Arc-info GIS.

The present study revealed that the soils were neutral to slightly alkaline (7.08-8.49) in soil reaction, low in salinity (0.08-0.45) at 0-15 cm depth and they increased at 15-30 and 30-45 cm depth of soil. The organic carbon content varied from low to high (0.26-0.87%) at 0-15 cm depth of soil. It decreased low to medium (0.04-0.65%) at 15-30 cm and low (0.01-0.34%) at 30-45 cm depth of soil. The DTPA extractable micronutrients were generally sufficient in status excluding Zn and Cu. The DTPA-Zn was low of 38.7, 77.9 and 96.3 per cent at 0-15, 15-30 and 30-45 cm depth of soil. The deficiency of DTPA-Zn was the predominant constraint in the banana growing tract soils of Tiruchendur and Thoothukudi blocks demands suitable management strategies for Zn nutrition of banana crops. Regarding fertility rating, the DTPA-Zn recorded marginal, whereas available DTPA-Cu comes under high category. The very high fertility rating was recorded in DTPA-Fe and Mn.

The correlation studies revealed that the DTPA extractable micronutrients were highly significant and positively correlated with organic carbon. The DTPA-Zn was significant and negatively correlated with available phosphorus while DTPA-Cu, Fe and Mn were significant and positively correlated with available nitrogen. The delineation study clearly indicated that the DTPA-Zn was found to be deficient in 38.7, 77.9 and 96.3 per cent of soils at 0-15, 15-30 and 30-45 cm depth of soils, respectively. The overall view on micronutrient status suggests that soils are severely deficient in DTPA extractable Zn and its deficiency increases as the depth increases. The DTPA-Cu, Fe and Mn are sufficient in general and required to be applied in specific situations. The edaphic factors such as organic carbon and free lime status are widely believed to circumventing the availability of micronutrients which needs to be addressed to develop strategies for alleviation of micronutrient deficiencies in banana growing tracts of Thoothukudi district of Tamil Nadu.

Commission 1.3: Soil Genesis



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Characterization and Distribution of Soil Acidity, Salinity and Nutrient Status in Part of Sunderbans Eco-systems

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The Agriculture is the mainstay of livelihood for sundarbans people, area lying between 20°2' to 22°6' North latitude and 88°25' to 89°00' East longitude. About 68% of the total cultivable land is low lying, mostly mono-cropped (*Aman* paddy). Major land form is coastal alluvial plain with nearly level to very gently sloping topography. The climate of the region is sub tropical humid where annual rainfall getting from 1700 to 1800 mm. Soil resource mapping at 1:12,500 scales was carried out by using IRS LISS IV P6 satellite data and cadastral map. Six soil series were identified and horizon-wise soil sample was collected for each soil series and analyzed by using standard procedure. Soils are very deep to deep (>150 cm), silty loam (sil) to clay (c) texture. Soil matrix colour of the profiles varied at top as dark gray to gray and subsurface horizon is characterized with mottles, yellowish brown to olive yellow in colour are mostly common medium prominent (c2p).

Soil reaction (pH_w) and electrical conductivity (Ece) varied from 3.4 to 6.3 and 4.5 to 20.2 dS m^{-1} , respectively, which as qualifying acid saline soils. Organic carbon content varied from 3.44 to 0.23% respectively. Exchange acidity of soils varied from 0.1 to 3.95 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ when exchangeable Al^{3+} was found to be dominant. Cation exchange capacity was observed in all the pedons in range of 12 to 18 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$. Exchangeable Ca^{2+} is the dominant among the cations in the exchange complex followed by exchangeable Na^+ , Mg^{2+} , and K^+ . Base saturation varies from 46 to 68% except the lower horizon of pedon 1. Available N, P, and K ranged from 39 to 502, trace to 44 and 88 to 572 kg ha^{-1} , respectively and available Sulphur (turbidity method), and are trace to 706. Among the nutrients N was moderate, but P was deficient in all the profile is could be fixation form with Al. K and S were sufficient in most the profiles. Available cationic micronutrients viz. Fe, Mn, Cu, and Zn (DTPA extractable) ranged from, 18.9 to 336, 2.17 to 57.69, 1.35 to 14.54 and 0.27 to 4.73 ppm, respectively. Among the micro nutrients Fe and Mn were found in toxicity level. Cu is moderate and Zn deficient. Soil acidity is more critical in rainy season and salinity in summer. Soils are severely acidic in lower part of the profile but salt content decreases with the depth, which might be due to capillary rise of salt during summer seasons. So, surface layers are having severe salinity problem in during summer. In Some soil series lower part of the profile contains high organic carbon it could be due to mixing degraded wooden materials. The acidity of the soils is gradually increased with the depth however Exchangeable Al^{3+} is contributing more acidity in subsurface layer than surface. Exchangeable cations are trace because of heavy rainfall, although calcium is found slight higher in among the cations. The result reveals that, area have severe problem on soil salinity and soil acidity, it causing low agricultural productivity, which should be addressed through soil and nutrient management for better crop production.



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Studies on Genesis, Characterization and Classification of Soils in Semi-arid Region of Chennur Mandal in Kadapa District, Andhra Pradesh

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Eight typical pedons representing major land forms in semi-arid ecosystem of Chennur mandal viz., plains and uplands developed from limestone and weathered-gneiss parent material under varying land use were studied for their morphological characteristics, physical and physicochemical properties, soil genesis and nutrient status. Soils were shallow to very deep, slightly alkaline to alkaline (pH 7.43 to 8.52) in reaction, non-saline and had iso-hyperthermic temperature and usitc soil moisture regimes. Texture, organic carbon, CEC and base saturation were ranged from sandy clay loam to clay in surface and sub-surface, 0.16 to 0.88 per cent, 25.65 to 53.92 $\text{cmol}(\text{p}^+)\text{kg}^{-1}$ and 50.12 to 95.99 per cent, respectively. Soils were low to medium in available nitrogen, medium to high in available phosphorus, low to high in available potassium and high in available sulphur. Deficient in DTPA-extractable Fe and sufficient in DTPA-extractable Zn (except in pedon 4 and sub-surface horizons of pedon 3), Cu and Mn. Pedons 1, 2 and 6 were grouped under Entisols due to absence of sub-surface diagnostic horizon and classified as Lithic Ustorthents, Typic Ustorthents and Typic Ustifluvents whereas pedons 3, 4, 5, 7 and 8 were placed under Inceptisols due to presence of cambic (Bw) sub-surface diagnostic horizon and classified as Typic Haplustepts and Vertic Haplustepts. All the soils of the study area fall under agricultural land with land capability classes ranging from II to IV. Further, the lands have limitations of slope (s) and erosion (e). On the basis of major soil constraints, suitable land use plan for Chennur mandal was suggested for their sustainable management.



Studies on Genesis, Characterization and Classification of Soils in Central and Eastern Parts of Prakasam District in Andhra Pradesh

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Seven typical pedons from Lakkavaram, Thalamalla, Surareddypalem, Kothavaripalem, Uppalapadu, Kandulur and Marlapudi villages representing the major land forms in the central and eastern parts of Prakasam district of Andhra Pradesh *viz.*, plains and uplands developed from granite-gneiss, sandstone and alluvium parent material under varying land use were studied for their morphological characteristics, physical and physico-chemical properties, soil genesis and nutrient status. Soils were shallow to very deep, slightly acidic to slightly alkaline (pH 6.02 to 8.45) in reaction, non-saline and had iso-hyperthermic temperature and ustic soil moisture regimes. Texture, organic carbon, CEC and base saturation in the profiles ranged from sand to clay, 0.12 to 0.68 per cent, 3.48 to 48.74 cmol (p⁺) kg⁻¹ and 73.44 to 91.52 per cent, respectively. Soils were low in available nitrogen, medium in available phosphorus, low to high in available potassium and high in available sulphur. However, the soils were deficient in DTPA-extractable Zn and sufficient in DTPA-extractable Fe (except in pedon 6, surface horizon of pedon 4 and sub-surface horizons of pedon 2), Cu and Mn. Pedons 2 and 6 were grouped under Entisols due to absence of sub-surface diagnostic horizon and were classified as Typic Ustipsamments and Typic Ustorthents, respectively whereas pedons 1, 4, 5 and 7 were placed under Inceptisols due to presence of cambic (Bw) sub-surface diagnostic horizon and classified as Typic Haplustepts (pedons 1, 4 and 5) and Lithic Haplustepts (pedon 7). Due to the presence of vertic features like slickensides, pressurefaces, cracks and presence of more than 30 % clay in all the horizons, the pedon 3 was grouped under Vertisols and classified as Typic Haplusterts. Recommendations were made based on the soil fertility for better crop production without deteriorating the soil health.

Commission 2.1: Soil Physics



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Soil Physico-Chemical Properties of *Sakharapa* Watershed in Konkan Region of Maharashtra

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As population of developing countries is increasing day by day there is a need to meet increasing demand of food and agriculture production. Therefore, we need to develop new ideas and technologies in agriculture. The crop production is directly influenced by soil fertility and soil physico-chemical properties. Therefore, investigation at Sakharapa watershed was undertaken to know the soil fertility status and to evaluate soil physico-chemical properties of lateritic soil.

To evaluate soil physico-chemical properties, the topographic and soil survey were taken and total watershed was grouped in various land use patterns *viz.* grass land, crop land and terrace land with areas 8.71 ha, 9.21 ha and 9.41 ha, respectively. Physical and chemical properties showed different trends for each land from 0 to 45 cm depth and discussed briefly as follows.

Soil texture ranged from loamy sand to sandy in texture over crop and terrace land. Whereas, grass land showed only sandy texture. The sand content was increased with depth from 0 to 45 cm. Silt and clay did not show major deflection. Particle density showed increased trend with increasing depth and evaluated high value in grass land. Bulk density decreased from surface layer to lower layer, with marked fluctuation in crop land. Porosity varied inversely with depth for all land use types. Maximum water holding capacity of soil (MWHC) ranged from low to medium class over entire watershed. At the terrace field infiltration rate was higher than crop land.

Soil was acidic to slightly acidic over entire watershed and acidity slightly increased as the depth increased. Electrical conductivity (EC) directly varied with soil depth. Terraceland showed linear increment of EC with soil depth. Crop production directly linked with nutrient content of the soil. Available N of soil rated moderately high to high throughout the depth for various land, and showed marked fluctuation in grass land from 0 to 45 cm soil depth. Available P varied inversely with depth and it was rated from high to very high for various land use. Available P did not show marked fluctuation with depth, but slightly decreased as depth increased and ranged from low to medium class. Organic carbon rapidly decreased with depth at surface layer and ranged from medium high class.



Moisture Retention Characteristics of Rubber Growing Soils in Meghalaya

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Meghalaya is the third largest state as per the area under rubber cultivation in the northeast. Meghalaya state comprising three main hills viz. Khasi hills (east Khasi Hills and Ribhoi districts), Gao hills (east, west and south hills districts) and Jentia (or Jaintia) hills. It has seven districts (now eleven) with head quarters at Shillong, Nongstrong, Nongpoh, William Nagar, Tura, Baghamara and Sonapur, respectively. Out of 7 (Now eleven) districts, rubber cultivation is mostly confined to east (now north), west and south Garo hills, Ribhoi and Jentia hills, covering more than 11,875 ha. (Rubber Board, 2014). Six (6) profile samples were collected (0-30 cm, 30-60 cm, 60-90 cm and 90-120+cm) for studying soil texture, structure, bulk density, particle density and porosity etc. Profiles were excavated and samples were collected from each pedogenetic horizon. Composite samples were also collected from rubber plantations with leguminous ground cover as well as ground cover with other Vegetation. A study on the moisture retention characteristics of rubber growing soils of Meghalaya in the region was carried out. The soils belong to the orders Inceptisol, Ultisol and Entisol. Profile soil samples representing the major rubber growing districts of Meghalaya were collected and analyzed for the moisture retention capacity. The moisture retention capacity of the soils varied in all the districts of rubber growing areas. The moisture retention in the surface layers at 0.033 MPa ranged from 21-25% in the profile from North Garo Hill district of Meghalaya. Nevertheless, the available water storage capacity (AWSC) did not show any variation as a result of the concomitant increase in the moisture retained at - 1.5 MPa. The moisture retention at the two tension was influenced by the clay, sesquioxides, silt and organic matter. The moisture retained at - 1.5 MPa was more than 0.4 times clay, suggesting that clay is either not well dispersed or some water is held by the gels. Silt has been found to play an active role in conjunction with clay in the moisture retention at -1.5 MPa, suggesting colloiddally active nature of silt in sub tropical soils. The study on the moisture retention points that the soils in general have high retention potential and this is of high practical significance in a rainfed crop like rubber.



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Effect of Application of Polyacrylamide and Cellulose based Polymer on Moisture Retention and Productivity of Maize in a Sandy Loam Soil

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A field experiment was conducted at Hayatnagar research farm during Kharif 2013 to investigate the effect of application of different rates of Polyacrylamide (PAM) and cellulose based polymer on maize (Var DHM117). Maize crop was sown on 10 June 2013. PAM was applied to maize at 25 and 50 kg/ha and cellulose based polymer was applied at 2.5, 5, 10, and 20 kg/ha rates. The effect of application of different rates of PAM and Cellulose based polymer on maize growth and yield was compared with that of control and conservation furrow (no polymer application) treatments. A uniform level of 90 kg N, 45 kg P₂O₅, and 45 kg K₂O/ha was applied to all treatments. During maize season, there was 1st dry spell during 26 June to 10 July 2013. Due to dry spell, wilting symptoms were observed in maize grown without application of polymer (control) on 2 July 2013. Whereas, in plots treated with PAM (25 kg/ha), maize started wilting from 7 July 2013 onwards. These results clearly showed that the application of polymers at higher rates delayed the wilting of maize by 5-6 days during initial dry spell at early growth stage of maize (photo 1 and 2). Application of PAM at 25 – 50 kg/ha and Cellulose based polymer at 20 kg/ha maintained higher moisture retention in soil at different crop growth stages compared with control treatment. Application of PAM at 25 kg/ha produced 16% higher maize yield compared with control. Whereas, Cellulose based polymer addition at 20 kg/ha produced 15% higher maize yield compared with control. Conservation furrow produced 19% higher maize yield compared with control (normal cultivation without polymer treatment).



Changes in Soil Properties upon Beverage Industry Effluent Irrigation to Grow Barley and Sunflower

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Field experiments were conducted in the premises of Pepsico Pvt. Ltd., near Bengaluru during 2012 and 2013 to study the effect of beverage industry effluent on soil properties after growing barley and sunflower in a sequence without disturbing the plots, with ten treatments replicated thrice using RCBD design. The quantity of gypsum was calculated on equivalent basis of the sodium content (10.3 m.eq L^{-1}) of beverage industry effluent. In both experiments, 50% of the calculated quantity of gypsum was applied. The beverage industry effluent was neutral in reaction (7.55), medium in electrical conductivity (1.59 dS m^{-1}), BOD (42.2 mg L^{-1}) and COD (143 mg L^{-1}) but low in plant nutrient contents. After harvest of barley crop, physical properties such as BD and WHC of soil did not vary significantly due to irrigation with beverage industry effluent. However, there was an increase in the values of BD and WHC. Soil chemical properties like pH (8.20), EC (0.88 dS m^{-1}) and exchangeable Na ($1.02 \text{ c.mol (p+) kg}^{-1}$) were higher in the treatment receiving beverage industry effluent + RDF without gypsum. Significantly higher Ca and Mg (12.7 and $4.6 \text{ c mol (p+) kg}^{-1}$, respectively) and S (6.3 mg kg^{-1}) was recorded in the treatment receiving irrigation with beverage industry effluent + RDF + gypsum. Even after the harvest of sunflower crop, continuous irrigation with beverage industry effluent did not alter the physical properties. Chemical properties like pH (8.30), EC (1.03 dS m^{-1}) and exchangeable Na ($1.17 \text{ c.mol (p+) kg}^{-1}$) content of soil were higher in the treatment receiving beverage industry effluent + RDF without gypsum. Significantly higher Ca and Mg (17.0 and $5.6 \text{ c mol (p+) kg}^{-1}$, respectively), S (11.9 mg kg^{-1}) was recorded in the treatment receiving irrigation with beverage industry effluent + RDF + gypsum. There was no significant effect of beverage industry effluent irrigation on DTPA extractable micronutrients, urease and dehydrogenase activity of soil after harvest of both crops.



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Effects of Irrigation, Crop Residue Mulching and Nitrogen Management on Soil Structure

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Improvement in soil structure is a prerequisite for maintaining soil physical health/quality and for sustaining the agricultural productivity at higher level. Field experiments were conducted in a sandy loam soil at the research farm of the Indian Agricultural Research Institute, New Delhi during the *khari* season of 2012 and 2013 with the objectives: (i) To study the short term impact of irrigation, crop residue mulch and nitrogen management in maize on soil structural indices and (ii) To study the impact of these management practices on soil physical quality indices like Least Limiting Water Range (LLWR) and S index. Maize (cv HQPM 1) was grown in a split-split plot design with two levels of irrigation (irrigated and rainfed), two levels of mulch (No mulch and wheat residue mulch @ 10 t/ha) and three levels of nitrogen (0, 75 and 150 kg N/ha). It was observed that there was improvement in soil structure under crop residue mulching as evident from higher values of mean weight diameter (MWD) and % water stable aggregates (%WSA) by 6.7 and 7.8%, respectively, than no mulch treatment. Application of crop residue mulch significantly reduced BD by 1.3, 1.8 and 1.8% at 0-5, 5-15 and 15-30 cm soil depths, respectively, compared to the no mulch treatment. Soil penetration resistance (PR) was reduced by 5% up to 14 cm soil depth due to crop residue mulching, compared to the no mulch treatment. The soil water transmission parameters such as saturated hydraulic conductivity, initial infiltration rate, steady state infiltration rate and cumulative infiltration also increased due to crop residue mulching. Crop residue mulching increased the initial infiltration rate by 28.7% compared to the no mulch treatment. Nitrogen application registered significantly lower BD at 0-5 cm soil depth than control. Application of 150 kg N/ha significantly increased MWD by 20% compared to control at maize harvest. Application of nitrogen @ 75 and 150 kg N/ha significantly increased the %WSA by 5.1 and 9%, respectively, compared to control after maize harvest. The initial infiltration rate increased by 29.7 % due to application of 150 kg N/ha than the control treatment. Application of irrigation registered significantly higher MWD by 21.4 % after maize harvest compared to the rainfed treatment. Soil physical quality parameters such as S index and LLWR increased due to irrigation, crop residue mulching and nitrogen application. Application of irrigation, mulch and nitrogen @ 150 kg/ha significantly increased the 'S' index by 3.5, 9.9 and 4.3%, respectively, than the respective control treatments (rainfed, no mulch and no nitrogen treatments). Crop residue mulching significantly increased LLWR by 48.3, 11.4 and 31.6% over no mulch treatment at 0-15 cm soil depth at 67 DAS, 95 DAS and harvest, respectively. Therefore, it may be concluded that growing maize crop with need based irrigation, nitrogen application @ 150 kg N/ha and crop residue mulching @ 10t/ha resulted in better soil structural properties and soil physical quality in sandy loam soil of Delhi region.



Yield, Grain Protein Content and Input Use Efficiency by Wheat (*Triticum aestivum* L.) as Influenced by Irrigation and Nitrogen Levels in a Semi-arid Environment

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Field experiments were conducted in Indian Agricultural Research Institute, New Delhi, India to study the interactive effect of irrigation and nitrogen fertilizer on yield, grain protein content and input use efficiency of wheat, the second most important cereal crop of India. The design of the experiment was split plot with irrigation (I0: rainfed, I2: two irrigations (Crown root initiation (CRI) and flowering stages), I3: three irrigations (CRI, tillering and flowering stages), I5: five irrigations (CRI, tillering, jointing, flowering and grain filling stage) as main plot treatment and nitrogen (N0: 0 kg N/ha, N30: 30 kg N/ha, N60: 60 kg N/ha and N120: 120 kg N/ha) as sub plot treatment. The evapo-transpiration production function accounted for 78-89% variation in wheat grain yield. The yield response factor of >1 in the present experiment indicated that wheat crop is highly sensitive to water stress. Pooled over the years, I5 treatment registered 4, 33 and 192 % higher grain yield compared with I3, I2 and I0 treatments, respectively. Similarly, pooled over the years, N120 treatment registered 19, 42 and 93 % higher wheat grain yield compared with the N60, N30 and N0 nitrogen treatments, respectively. The grain protein content increased significantly with increase in N levels. Pooled over the years, I0 irrigation treatment registered 23, 25 and 16 % lower water use efficiency (WUE) compared with the I2, I3 and I5 treatments, respectively. Similarly, N120 nitrogen treatments registered 15, 32 and 71 % higher WUE compared with N60, N30 and N0 nitrogen treatments, respectively. Pooled over the years, I5 irrigation treatment registered 3, 32 and 200 % higher partial factor productivity of nitrogen (PFPN) compared with I3, I2 and I0 irrigation treatments, respectively. However, the PFPN decreased significantly ($p < 0.05$) with increase in nitrogen levels from 30 kg N/ha to 120 kg N/ha for both the years of study. Hence, it can be concluded that wheat (cv. HD 2932) may be grown with five irrigations at CRI, tillering, jointing, flowering and grain filling stages and 120 kg N/ha for better yield, grain protein content and water use efficiency in the semi-arid environment of Delhi.



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Effect of Crop Residue Mulching, Irrigation and Nitrogen Management on Soil Hydrothermal Regime, Soil Organic Carbon Pools, Productivity and Input Use Efficiency of Wheat

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Organic mulching can serve as a useful technology in improving the water use efficiency by minimizing losses of water through evaporation, modification of soil hydrothermal regime and improving soil health. There is a need to optimize the irrigation schedule for different crops under varied mulching and nutrient management practices to achieve higher input use efficiency. A field experiment was conducted on a Typic Haplustep at the Indian Agricultural Research Institute, New Delhi during *rabi* seasons of 2011-12, 2012-13 and 2013-14 in a split-split plot design with two levels of irrigation (2 irrigations and 4 irrigations at critical growth stages), under two levels of mulching (with or without maize stover mulch @ 5t/ha) and three nitrogen doses (0, 60 and 120 kg N/ha) to study the effect of irrigation, mulching and nitrogen interactions on soil hydrothermal regime, soil organic carbon pools, yield and water and nitrogen use efficiency of wheat (cv PBW 502) in a maize-wheat system.

It was observed that there was significant increase in the soil moisture storage due to application of crop residue mulch. Application of 120 kg N/ha registered significantly lower soil moisture storage in the profile than that with control due to higher evapo-transpiration demand in the former treatment. Application of maize stover mulch in wheat registered lower soil temperature than the no mulch treatment in the surface soil. However the difference in soil temperature in 5 and 10 cm soil depth due to mulching was not significant. The surface soil temperature in cropped field was less than the bare soil irrespective of mulching. However, in the lower soil layers the difference in the soil temperature between bare field and the cropped field was not prominent. There was improvement in the soil organic carbon pools at 0-30 cm soil depth due to crop residue mulching, irrigation and N application. The increase in the soil organic carbon pools due to mulching is mainly contributed by the very labile pool of soil organic carbon. This resulted in increase in the carbon management index due to mulching and N application. The grain yield of wheat increased significantly by 18.4% due to application of 4 irrigations compared to 2 irrigations at critical growth stages. The grain yield of wheat increased significantly due to N application but there was no significant difference in the grain yield of wheat due to 60 and 120 kg N/ha. Though there was increase in the grain yield of wheat by 4.4% due to mulching, the effect was not statistically significant. The water use efficiency (WUE) was not influenced by the irrigation level but increased due to N application. Application of crop residue mulch increased the WUE of wheat only one out of three years of study whereas in the other two years the effect of mulching was not statistically significant. The Agronomic N use efficiency was not influenced significantly by irrigation and mulch treatment but decreased significantly at higher N level.

Thus from this study it may be concluded that wheat may be grown with four irrigation at critical growth stages and 60 kg N/ha with maize stover mulch @ 5t/ha to attain better hydrothermal regime, soil organic carbon pools and achieve higher water and nitrogen use efficiency without any significant reduction in crop yield in Inceptisols of Delhi region.



Soil and Nutrient Losses through Runoff as Influenced by Crop Covers in Vertisols of Central India

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A field experiment was conducted to evaluate the crop covers for their impact on runoff, soil and nutrient losses and crop productivity in Vertisols of Central India at Indian Institute of Soil Science, Bhopal. Seven treatments consisted of three sole crop covers *viz.*, soybean, maize and pigeon pea and three intercrop covers *viz.*, soybean + maize (1:1), soybean + pigeon pea (2:1) and maize + pigeon pea (1:1) along with one cultivated fallow (control) were tested. Based on three years experiment data, result revealed that the highest runoff (226 mm) and soil loss (3.38 t ha⁻¹) was recorded under cultivated fallow compared with both sole and intercrops. Among the crop cover treatments, the runoff and soil loss were significantly higher under sole pigeon pea (194 mm 2.64 t ha⁻¹), respectively followed by sole maize (178 mm and 2.38 t ha⁻¹), maize + pigeon pea (155 mm and 1.99 t ha⁻¹), soybean + maize (149 mm and 1.91 t ha⁻¹), soybean + pigeon pea (145 mm and 1.69 t ha⁻¹) intercrops and lowest was under soybean sole crop (149 mm and 1.88 t ha⁻¹). The losses of SOC and total NPK were lower in sole soybean and its intercrops compared with sole crops of maize and pigeon pea. But the highest losses of soil organic carbon (23.1 kg ha⁻¹) and total NPK (6.8, 0.80, 28.2 kg ha⁻¹) were the under cultivated fallow over sole and intercrops. The system productivity in term of soybean equivalent yield (SEY) was significantly higher under maize + pigeon pea (1:1) than rest of the crop cover treatments. Therefore, the combinations of maize + pigeon pea (1:1) is the best options in reducing runoff, soil and nutrient losses and sustaining crop productivity of system in Vertisols of Central India.



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Effects of Tillage and Residue Management on Soil Aggregate Dynamics in a Rice-Wheat Cropping System of Reclaimed Alkali Soil

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For water saving and enhancing water-use efficiency, conservation agriculture plays a vital role. Conservation tillage coupled with residue management in rice-wheat cropping system has the potential for increasing soil organic matter and enhancing soil fertility for the improvement of soil health. The present piece of research work was carried out in a long term field experiment on evaluation of resource conservation technologies in a rice-wheat cropping system. Hence, in which an attempt was made to evaluate the impact of different tillage practices combined with residue management on soil aggregate dynamics and structural changes with special emphasis on soil organic carbon distribution within different size fractions. The objective to evaluate the influence of resource conservation technology on soil aggregate dynamics and to study the relative distribution of organic carbon into different sized soil aggregates. Among the different form of carbon, total carbon and total organic carbon were significantly higher in zero tillage with and without crop residue treatments; whereas, zero tillage with wheat residue and permanent raised beds treatments exhibited significantly higher value of oxidizable organic carbon. Soil receiving conservation tillage management practices (reduced tillage and zero tillage) had significantly higher amount of total aggregate associated carbon within all aggregate size class under 0-15 cm depth, but under 15-30 cm depth, conventional practice with and without crop residue treatments resulted 12.2% increment in total soil aggregated carbon compared to zero tillage with and without crop residue treatments. On an average, (silt+clay) sized particle contained 11.08% carbon out of the total aggregate associated carbon. Thus conservation agriculture is a sustainable approach for a long term preservation of soil quality, health and protecting environment against degradation. From the study, it is concluded that alternative cultivation methods (zero/reduced tillage, residue retention/ incorporation) could improve the soil physical health for long-term sustainable production system and are useful methods to increase the amount of organic carbon in soil and may reduces its emission into the atmosphere. Thus, conservation agriculture is a sustainable approach for a long term preservation of soil quality, health and protecting environment against degradation.



Crop and Water Productivity of *mungbean-raya* Cropping System under Variable Irrigation Water Supplies in a Light Textured Soil

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A field experiment was conducted at Research Farm of the Punjab Agricultural University Regional Station, Bathinda for five years on permanent plots on a light textured soil during 2008-2013 to study the effect of variable irrigation regimes on yield and water productivity in a *mungbean-raya* cropping system. The treatments consist of three levels of irrigation viz. optimum (I₁), sub optimum (I₂) and sub sub optimum (I₃), corresponding to 3, 2 and 1 irrigations each to both *mungbean* and *raya* crops. The chemical characteristics of the soil at the start of experiment were: pH 8.4, electrical conductivity 0.143 dSm⁻¹, organic carbon 3.5 g kg⁻¹ soil, available P 12.4 kg/ha and available K 394 kg/ha. The results revealed that the grain yield of *raya* increased significantly in *mungbean-raya* cropping sequence under varying irrigation regimes. The optimum level of irrigation gave significantly higher *raya* yield than sub optimum (SO) and sub-sub optimum (SSO) irrigation supply. However, *mungbean* yield was not affected by different irrigation regimes. Water expense efficiency (WEE) was found to be the highest in optimum and sub-sub optimum level of irrigation in *raya* and *mungbean*, respectively. The *mungbean-raya* cropping system improved the organic carbon status of soil. The water expense for *mungbean-raya* cropping system was 87.4, 76.7 and 64.4 cm under O, SO and SSO treatments, respectively. The water productivity (Rs/cm of water used) of the *mungbean-raya* system was 882, 849 and 888 under optimum, sub-optimum and sub-sub-optimum levels of irrigations, respectively.



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Impact of Conservation Agriculture on Physical Properties of Soil in Maize (*Zea mays*)-Pigeonpea (*Cajanus cajan*) Crop Rotation in Semiarid Rainfed Alfisols

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This study was conducted to evaluate the effect of conservation agricultural practices comprising of No tillage (direct sowing of the crop without tillage and retention of previous crop (maize) residues at 60 cm stem height in the field), conventional tillage (one pass of cultivator during summer and again one pass of cultivator followed by one pass of disc harrow at the time of sowing and no crop residue retention) and reduced tillage (operation was same as in conventional tillage, except that no summer poughing was done but previous crop residue was retained at 60 cm stem height) on physical properties (soil penetration resistance, bulk density and soil moisture) in maize-pigeonpea crop rotation. The experiment was conducted at CRIDA, Hyderabad in red Alfisols of semi arid tropics. The crop was sown with CRIDA zero till seed drill. The observation was taken periodically during entire growing season of pigeonpea crop.

Among soil physical properties, penetration resistance of soil varied directly with bulk density and inversely with soil moisture content. A higher soil moisture (0-15 cm) and lower bulk density (0-15 cm) was observed in conventional and reduced tillage compared with the no tillage during the early pigeonpea growth period (upto 75-85 DAS). But as the crop stage advanced, bulk density increased in reduced and conventional tillage due to compaction caused owing to settlement of soil particles due to rainfall compared to the no tillage. During the early crop growth stage (75-85 DAS), higher soil moisture was observed in conventional and reduced tillage compared with the no tillage. However, as the crop stages advanced, higher soil moisture was observed in No tillage compared with the conventional and reduced tillage.



Adaptation Measures to Inter- and Intra- Seasonal Temperature Variability in Wheat

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In the present study, field experiments and simulations were carried out to understand (i) impact of inter- and intra- seasonal temperature variability on wheat yield in present and future, (ii) interactions of year and management intervention (three dates of planting, two varieties and two irrigation regimes) (iii) adaptation measure with least seasonal temperature variability for sustaining wheat yield. Field experiments for six seasons (2008-09 to 2013-2014) reveal that, averaged across management interventions, inter-seasonal variability of 3.4% in Tmax and 4.6% in Tmin; and intra-seasonal of 10.3% in Tmax and 27.5% in Tmin causes 8.7% variability in wheat yield. In mid-century (2021-2050), simulation with DSSATv4.5 Cropping System Model point out that variability of 5.5% in Tmax. 3.8% in Tmin would cause 11.2% variability in yield. Wheat yield decreases with increase in number of days having Tmax $\geq 27^{\circ}\text{C}$, Tmin $\geq 11^{\circ}\text{C}$ and $\leq 3^{\circ}\text{C}$ during whole crop period; and Tmax $\geq 34^{\circ}\text{C}$ during grain formation and development stage. A strong interaction of year and management interventions implies that the impact of inter- and intra- seasonal variation on wheat yield can be minimized by staggering date of sowing with appropriate cultivar and irrigation schedule. Growing of longer duration varieties in last week of October with adequate irrigation (stage based - crown root initiation, tillering, jointing, flowering and grain formation), longer and medium duration in 1st week of November with adequate or deficit irrigation (based on IW /PAN-E ratio of 0.9) is the practical adaptive measure to minimize impact of temperature variability on wheat yield. Staggering of date of sowing (Oct 20 to Nov 20) at present and delaying it by 15 days in mid century emerged as the best adaptation measure in central Indian Punjab.



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Influence of Different Volumes of Drip Discharge and Irrigation Regimes on Yield and Water Use Efficiency of Sunflower

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A field experiment was conducted for two years during rabi 2011-12 and 2012-13 at the College Farm, College of Agriculture, Acharya N G Ranga Agricultural University, Hyderabad, Andhra Pradesh, India. The treatments were: two irrigation levels (100 and 75 per cent ETc) and four flow rates (2.0, 1.6, 1.0 and 0.6 LPH). Results showed that the seed yield was significantly influenced by irrigation regimes and linear increase in seed yield also observed with decreasing volume of discharge. The water use efficiency (WUE) increased with decreasing discharge rate and with decreasing water application. Drip irrigation scheduled at 100 percent ETc with the discharge of 0.6 LPH recorded highest seed yield, whereas the treatment which received irrigation at 75% ETc with the discharge of 0.6 LPH recorded highest WUE during both years.



Evaluation of Generic Pedotransfer Functions (Soil Water) for Shrink-Swell Soils of Jalgaon District, Maharashtra

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Soil water content at field capacity (FC) and wilting point (WP) are used for irrigation scheduling, assessing crop suitability and crop growth modeling. The estimation of water content at FC and WP in laboratory is difficult and time consuming. As such an inexpensive and rapid alternative method is necessary for estimating these functions. There are many PTF based estimation methods available in the literature but identification of appropriate location-specific PTF is utmost important for accuracy in estimation. In the present study, an attempt has been made, to compare different popular PTFs like those developed by Baumer, Brakensiek/Rawls, EPIC, Manriques, Rawls, Campbell and Vereecken, available in SOIL PAR 2.00 software, for predicting soil moisture contents at FC and WP of cotton growing shrink-swell soils of Jalgaon district, Maharashtra. For this study, multiple linear regression equations were also developed for the same samples and compared with the generic PTFs at FC and WP. A comprehensive data set containing detailed measurements of 10 soil pedons (32 horizons) distributed in major representative landforms of the area were used. The soils are classified as Typic Haplusterts, dark to dark brown in colours, sand, silt and clay content varied from 10.6 to 49.9, 17.2 to 35.5 and 26.9 to 70.0 %, respectively. They are slightly neutral to alkaline in reaction, calcareous and OC ranged from 0.13 to 0.57 % and bulk density varied from 1.25 to 1.47 Mg m⁻³.

The soil water contents at different matric potentials were measured in the laboratory and compared with model evaluated data. It was observed that the Vereecken model was fitted better ($R^2 = 0.62$ and 0.41 respectively, for FC and WP) compared with Baumer ($R^2 = 0.481$ & 0.25), Brakensiek ($R^2 = 0.36$ & 0.17), EPIC ($R^2 = 0.36$ & 0.14), Manrique ($R^2 = 0.48$ & 0.17), Rawls ($R^2 = 0.31$ & 0.21) and Campbell ($R^2 = .45$ & 0.22). The multiple regression analysis were also carried out for soil water content at FC and WP using the model $Y = a + b_1*c + b_2*si + b_3*s + b_4*o + b_5*d \dots\dots$, and found improved regression coefficient ($R^2 = 0.79$ and 0.85 for FC and WP respectively), indicating their better performance than evaluated generic PTFs for swell-shrink soils of Jalgaon district.



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Detection of Nutrient Deficiencies in Rice through Hyperspectral Remote Sensing Technique

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Rice is an important cereal crop grown in a large area and deficiency of one or more nutrient element would reduce the crop growth and yield. Monitoring crop nutrient status at critical crop growth stages may help to save the crop from yield loss. Visual diagnosis of nutrient deficiency is a common method of monitoring the crop growth and this may not be feasible and viable for larger areas. Many studies have documented that nutrient status of field crops can be assessed through leaf or canopy spectral reflectance data. In the present study an attempt was made to detect the NPK deficiencies in rice through remote sensing technique. Rice was grown in a sand medium in glasshouse and the treatments were imposed through Hoagland's nutrient solution at varying NPK levels *viz.*, 0, 50, 75 and 100 per cent of requirement and replicated thrice in a completely randomized block design. Nutrient solutions were applied at weekly interval and canopy spectral reflectance was measured at different dates. Plant sampling coinciding with spectral reflectance measurement was done and analysed for chlorophyll a, b and total NPK contents. The results indicated that varying levels of nitrogen significantly influenced the leaf chlorophyll a and b concentration at all stages of observation. The chlorophyll a content for N0 treatment ranged from 0.79 to 2.03 mg/g and for 100 % N it was 1.44 to 2.48 mg/g of fresh leaf and similar trend was observed with chlorophyll b also. Varying NPK levels significantly influenced the content of respective nutrients at different growth stages. The spectral indices *viz.*, Normalized Difference Vegetation Index (NDVI) (an indicator of canopy greenness and leaf area) calculated for different stages indicated that nitrogen nutrition significantly influenced the NDVI values whereas, P and K treatments did not influence the NDVI significantly. The red edge position (REP), the peak wavelength slope in between red and near infrared region derived from first derivative of spectral curve recorded low value for N0 treatment (710 to 712 nm). The REP for N 50 was 722 to 725 and for 100 % N it was 724 to 725, indicating the stress in the N0 and N50 treatments. The NDVI correlated well with chlorophyll a (0.64 to 0.87), b (0.52 to 0.82) and nitrogen (0.87 to 0.88) at different crop stages, indicating the crop stress due to nitrogen deficiency could very well be detected by spectral measurement. Thus, the present investigation reveals that nitrogen stress could be detected through remote sensing measurements and no conclusion could be derived for P and K treatments.



Effect of Intensively Mechanized Farming on Soil Physical Health

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Farmers of Tamil Nadu have started to intensify mechanization due to intense labour scarcity. The use of high powered (heavy) tractors has become prevalent. Hence, effects of mechanization on the soil physical health need to be studied in the perspective of the soils of Tamil Nadu. In the light of the above, field experiments were conducted at Tamil Nadu Sugarcane Research Station, Cuddalore under sugarcane cropping system, and at TNAU, Coimbatore under cotton – maize cropping system, and at National Pulses Research Centre, Vamban under groundnut – green gram cropping system and at Tamil Nadu Rice Research Institute, Aduthurai under rice - rice cropping system during 2011–14 to compare the effect of farm mechanization with farmers practice.

There was a mechanization induced soil compaction development in the clay loam soils both under cotton – maize cropping system (TNAU, Coimbatore) and sugarcane cropping system (SRS, Cuddalore) and in the sandy loam soil under groundnut – green gram cropping system (NPRC, Vamban) and in clay soil under rice – rice cropping system (TRRI, Aduthurai) compared to conventional system. This was evidenced from poor soil physical condition induced by mechanization viz., increased bulk density and decreased porosity, hydraulic conductivity and infiltration rate of post harvest soils of cotton – maize cropping system as well as sugarcane cropping system. Consequently reduction in the crop yields was also observed. The effect was well pronounced at lower depth (15-45 cm) than the surface soil (0- 15 cm). However there was no yield reduction in sandy loam soil under pulse – ground nut and clay soil under rice – rice cropping systems. Thus, long term effects of mechanization on soil physical health need to be studied.



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Evaluation of Soil Quality under Different Moisture Regimes in NSLBC (LBC) Command and Adjacent Upland Areas of Nalgonda District of Andhra Pradesh

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This study was conducted with an objective of selecting the appropriate moisture regimes and to identify the key indicators of soil quality for different moisture regimes in NSLBC (LBC) of Nalgonda district of Andhra Pradesh. Soils are degrading due to several physical, chemical and biological constraints. Appropriate soil moisture regimes may help to check further soil degradation. This study was conducted in 2011 with six different soil moisture regimes of command and adjacent upland areas: command area-head reach, middle reach, tailend and upland area – having assured irrigation, protective irrigation and rainfed. Sixty soil samples were collected from six different moisture regimes ten each from each moisture regime and were analyzed for physical, chemical and biological parameters. A standard methodology using principal component analysis (PCA) and linear scoring technique (LST) was adopted to identify the key indicators and for computation of soil quality indices. Among six moisture regimes, the soil quality index (SQI) ranged from 0.848 - 0.945. The highest SQI was obtained in assured irrigation (0.945) followed by tail end (0.927) = protective irrigation (0.927), rainfed (0.897), head reach (0.889) while the lowest was under middle reach (0.848). The key indicators, which contributed considerably towards SQI, were bulk density, water holding capacity, organic carbon, dehydrogenase activity, available N, available Mn, ESP, available P, available K, pH and exchangeable Mg.

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Conservation Agriculture: Impacts on Carbon Retention Potential in Soils of the Western Indo-Gangetic Plains

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Retention of carbon (C) in arable soils has been considered as a potential mechanism to mitigate the elevated levels of atmospheric greenhouse gases and to sustain crop productivity. The short-term impact of different conservation agriculture (CA) practices on biomass productivity and C retention potential of soils in the 0.30 cm layer under a sub-tropical rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) cropping system and cotton (*Gossypium hirsutum* L.) /maize (*Zea mays* L.)-wheat based cropping system have rarely been evaluated. Hence, we appraised the impacts of different CA practices on the aboveground biomass productivity (ABP), soil organic C (SOC) retention and labile and recalcitrant C pools in the western Indo-Gangetic Plains. Cotton and wheat crops were grown during the first three years (2008-2011) and in the last year, maize (*Zea mays*), wheat and green gram (*Vigna radiate* L.) were cultivated. Total estimated C input in the rice-wheat system (-12.2 Mg C ha⁻¹ in three years) to the upper 30 cm soil layer under MBR+DSR-ZTW+RR-ZTMB plots was 14, 170 and 178 per cent higher than DSR+BM-ZTM+RR, DSR=ZTW and TPR-CTW plots, respectively. All plots under CA had significantly higher gain (over initial value) in total SOC than the gains in TPR-CTW and TPR-ZTW and TPR-CTW plots in the 0.30 cm layer. The increase in total SOC contents under all CA plots was mainly confined in the topsoil (0-5 cm soil layer). On an equivalent depth basis (that is normally followed internationally so far), about 7.6% ($R^2 = 0.85$; $P < 0.05$, $n = 6$) of the added C was retained in the 0.30 cm soil layer under all CA practices. However, on an equivalent mass basis, about 12.1% ($R^2 = 0.88$; $P < 0.05$, $n = 6$) of the estimated added C was retained in that layer. Under the cotton/maize-wheat system, plots under zero tillage with bed planting (CT-B) (-5.5 Mg ha⁻¹) in the 0-5 cm soil layer. Plots under ZT-B and ZT-F contained higher total SOC stocks in the 0-5 and 5-15 cm soil layers than CT-B plots. About 9.3% of the gross C input contributed towards the increase in SOC content under the residue treated plots. However, -7.6 and 10.2% of the gross C input contributed towards the increase in SOC content under CT and ZT, respectively. In inference, CA, especially the MIBR_DSR-ZTW+RR-ZTMB management practice, has a good potential to retain C and sustain productivity of the rice-wheat cropping system and both ZT and partial or full residue retention is recommended for higher soil C retention and sustained crop productivity under a cotton/maize-wheat system in this region.



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Leaching Behaviour of Metribuzin and Pretilachlor in Red and Black Soils

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Leaching studies of herbicides in soil columns are simple and reliable methods to assess their environmental fate and contamination potential. Pretilachlor and metribuzin are popular herbicides used in transplanted rice and vegetables crops (tomato, carrot, potato), respectively. A laboratory experiment was conducted for two years (2012 and 2013) in red black soils to study leaching behavior of pretilachlor and metribuzin with soil columns (PVC tubes of 120 cm diameter and 65 cm length). Soils were collected horizon wise and were filled into the column and pre-conditioned pretilachlor and metribuzin were applied to the column surface at recommended (X dose-500 g ha⁻¹, respectively) and double doses (2X) equated to surface area of the column and water was added to the column surface. After 7 days, soil samples were collected from each 5 cm blocks and analyzed for herbicide residues. Herbicide residues were determined using GC-ECD. Pretilachlor recovery varied from 89.2 to 96.4% in soil with LOQ of 0.25 mg kg⁻¹. Recovery of metribuzin in the soil varied from 92.4 to 94.8% with LOQ of 0.015 mg kg⁻¹. In red soils, pretilachlor leached up to 10-15 cm in both X and 2X doses. Depth wise distribution showed that, 46.2% and 50.6% of the total herbicide was detected in the top 0-5 cm layer in X and 2X dose. In 5-10 cm layer, 32.6% and in 10-15 cm layer 14.1% of residues were detected. In 2X dose, herbicide detection was 50.6% in 0-5 cm layer, 36.5% in 5-10 cm layer and 12.9% in 10-15 cm layers. In black soils, pretilachlor leached up to 10 cm and 15 cm depth in X and 2X doses, respectively. In X-dose, 72.5% was detected in the top 0-5 cm layer and 27.4 in the 5-10 cm layer. At 2X dose, 73.3%, 19.9% and 6.7% the herbicide detected in the top 0-5 cm, 5-10 and 10-15 cm soil layers, respectively. In red soils, metribuzin could be detected upto 15-20 cm and 20-25 layer in X and 2X doses, respectively. Highest concentration of the herbicide could be detected in 05-10 cm layer in both doses (38.2% 32.5% in X and 2X doses, respectively). In black soils, highest concentration of the leached herbicide could be detected in the 05-10 cm layer in both X and 2X doses (39.0% and 37.5%). Leaching of metribuzin was restricted up to 15-20 cm layer in both doses in black soils. Higher concentration of the pretilachlor in the top 5 cm layer and metribuzin in 5-10 cm layer indicated higher leaching potential of metribuzin. Higher herbicide retention in top layer in black soil compared to the red soil could be due to higher total clay and higher active clays in the black soils (smectitic) compared to red soils.



Effect of Integrated Nutrient Management on Dynamics of Phosphorus in Medium Black Calcareous Soil under AICRP-LTFE

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The long term experiment was started in the year 1999 at the Instructional Farm, Junagadh Agricultural University, Junagadh to know the effect of continuous application of fertilizer (N, P and K) and manure in a crop rotation of groundnut-wheat. The twelve treatments comprising: T₁ – 50% NPK recommended doses to groundnut-wheat sequence, T₂ - 100% NPK of recommended doses in groundnut-wheat sequence, T₃ – 150% NPK of recommended doses in groundnut-wheat sequence, T₄ - T₂ + 50 kg ZnSO₄ ha⁻¹ once in three years to groundnut only T₅ – NPK as per soil test, T₆ – 100% NP of recommended doses in groundnut-wheat sequence, T₇ - 100% N of recommended doses in groundnut-wheat sequence, T₈ – 50% NPK recommended doses + FYM @ 10 t ha⁻¹ to groundnut and 100% NPK to wheat, T₉ – FYM @ 25 t ha⁻¹ to groundnut only, T₁₀ – 50% of T₂ + *Rhizobium* + PSM to groundnut 100% NPK to wheat, T₁₁ – 100% NPK of recommended doses in groundnut-wheat sequence (P as SSP) and T₁₂ - Control, in randomized block design with four replication. After 12 (twelve) rotations, soil samples were collected and analyzed for different fractions of major and micronutrients. Here, dynamics of only phosphorus is described. Different forms of phosphorus were determined using standard method. Before starting of experiment (*khari*-1999) soils were analyzed for all the parameters. The results revealed that available phosphorus status of LTFE soils decreased after a span of 12 years under all treatments except the treatments that received FYM (T₈ and T₉) in which availability of phosphorus was improved. Whereas, total, inorganic, reductant, saloid and organic P improved while, occluded-P, Fe-P, Ca- & Al-P decreased after a span of 12 years, Highest (1925 ppm) and lowest (1322 ppm) values of total phosphorus were recorded under T₈ (50% NPK-RDF + FYM @ 10 t ha⁻¹ to ground nut & 100% N-RD to wheat and T₇ (100% N-RD in ground nut – wheat sequence), respectively after 12th years. The phosphorus fractions viz. total-P (except-T₇), inorganic-P (except-T₁₂), saloid-P, reductant-P and organic-P (except-T₇) showed negative trend for depletion, whereas, positive depletion was recorded in Ca-P and Fe- P after a span of 12 years. Maximum proportion of phosphorus was found as a reductant-P. In case of available phosphorus, the highest (12%) and lowest (7%) proportion were recorded in T₃ and T₇, respectively. The stepwise regression of available P with its forms explained the variation in form upto 97 per cent. The occluded-P influenced maximum on available P followed by saloid-P, Ca-P, reluctant-P, Fe-P and total P. Available P was highly significantly corrected with inorganic phosphorus (r=0.624**), saloid bound-P (r=0.838**) and reluctant soluble-P (r=-0.806**). All fractions of P exhibited highly significant negative relationship with soil pH and positive relationship with soil EC.



Adsorption-Desorption of Phosphorus in Soil Receiving Long-term Fertilizer, Manure and Crop Residue

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A long-term fertilizer experiment under rice-wheat crop rotation is in progress on *Typic Haplustept* soil at research farm, Department of Soil Science, Punjab Agricultural University, Ludhiana, since 1999. The site is located in the Indo-Gangetic alluvial tract at 30°56' N 75°52'E and at an altitude of 274 m above mean sea level. The effects of fertilizer, manure and crop residue was studied through nine treatments comprising of T₁:100% N, T₂:100% NP, T₃:100% NPK, T₄:100% NPK (P to wheat only), T₅:150% NPK, T₆:100% NPK+farmyard manure, T₇:100% NPK+green manure (*Sesbania aculeate*), T₈:100%NPK+straw incorporation and T₉: control. The surface (0-15 cm) soil samples were collected after the harvesting of wheat during 2012-2013. Soil samples were analyzed for adsorption-desorption behaviour. The adsorption of P varied between 21.7 to 187.4, 19.7 to 140.6, 18.9 to 130.6, 20.9 to 158.2, 17.8 to 122.1, 15.1 to 94.2, 16.2 to 106.0, 17.1 to 112.9, 22.8 to 201.3 mg P kg⁻¹ soil with an application of graded levels of P (25 to 800 mg P kg⁻¹ soil) for the T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ treatment, respectively. The adsorption of P increased with an increase in the amount of added P, however, the percent of P adsorption decreased gradually with increasing levels of added P. The maximum value of Langmuir adsorption maxima ($b=222.2$ mg P kg⁻¹) and bonding energy constant ($k=1.68$ L mg⁻¹) was reported in control whereas, the minimum value of 'b' (108.7 mg P kg⁻¹) and 'k' (1.00 L mg⁻¹) was observed in 100% NPK+ FYM treatment. The desorption of P varied between 0.19 to 8.31, 0.41 to 19.97, 0.62 to 21.90, 0.36 to 16.46, 0.73 to 26.88, 0.91 to 39.78, 0.82 to 33.29, 0.79 to 29.25 and 0.16 to 7.25 mg P kg⁻¹ soil with an application of graded levels of P (25 to 800 mg P kg⁻¹ soil) for the T₁, T₂, T₃, T₄, T₅, T₆, T₇, T₈ and T₉ treatment, respectively. The desorption of P increased with the increase in amount of fertilizer P added. The value of Freundlich constant 'a' was maximum in control (4.01 mg P kg⁻¹) and decreased with fertilizer applications. The value of 'a' and 'n' was minimum under balanced integrated fertilization applications. Desorption of added P improved under the long-term application of balanced fertilizer and integrated use of organic manure and fertilizers.



Influence of Long-term Nutrient Management Practices in Sorghum-Sunflower Cropping System on Enzyme Activity and Sorghum Performance in an Alfisol

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Impact of long term continuous nutrient management practices in sorghum-sunflower cropping system on the enzyme activity and sorghum performance in an Alfisol was studied by monitoring the long term fertilizer experiment in progress at the research farm of Directorate of Oilseeds Research, Hyderabad in its 15th cropping cycle. The soil is sandy loam in texture. At the initiation of the experiment (in 1999) the soil was slightly alkaline in reaction and non saline. It was medium in OC, available N and P and high in available K. Treatments (12) consist of different combinations of nutrients and integrated nutrient management *viz.*, Control (0-0-0), 100% N (60-0-0), 100% NP (60-30-0), 100% NPK (60-30-30), 50% NPK (30-15-15), 150% NPK (90-45-45), 100% NPK+FYM (INM with 5 t FYM ha⁻¹), NPK+CR (INM with sunflower crop residues), NPK+S (gypsum in *rabi*), NPK+B (borax in *rabi* in alternate years), NPK+Zn (ZnO in *rabi*), NPK (S+B+Zn) in randomized block design with 3 replications. Integrated nutrient management practice by applying FYM or crop residues along with optimum NPK fertilizers (*i.e.*, NPK+FYM and NPK+CR) increased the sorghum grain yield over application of only fertilizers (100% NPK). Sorghum yield increased with increasing NPK levels only up to 100% NPK but super optimal dose of fertilizers (150% NPK) did not increase the yield over optimum dose (100% NPK). Application of only nitrogen (100% N) resulted in reduced yields due to the imbalanced nutrient application. Additional application of phosphorus (100% NP) increased the yield over 100% N, while there was no significant yield increase with application of potassium, sulphur, boron or zinc. Application of phosphorus, potassium and zinc significantly increased their uptake by the crop but application of nitrogen or sulphur did not increase their uptake. The enzyme (urease, dehydrogenase and phosphatase) activity increased with the age of the crop till flowering stage and decreased at maturity. The highest enzyme activity was recorded with INM treatments at all the stages. The INM increased the activity significantly over that in 100% NPK. The super optimal dose of fertilizer treatment (150% NPK) recorded lower activity of enzymes than INM treatments. Optimum balanced application of nutrients (100% NPK) resulted in higher enzyme activity than imbalanced fertilization (N, NP treatments). Application of FYM along with fertilizer NPK *i.e.*, integrated nutrient management using FYM (100% NPK+FYM @ 5 t ha⁻¹) proved to be the best for higher yields and better soil health for sorghum followed by INM with sunflower crop residues (100% NPK+CR). They improved the available nutrients and enzyme activity in the soil and resulted in higher nutrient uptake and crop yields over application of only fertilizers (100% NPK).



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Effect of Nanoclay Polymer Composites (NCPCs) Loaded with Urea and Nitrification Inhibitors on Nitrification in Soil

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In common fertilizer usage the efficiency of added nitrogen is very often lower than 50 %, which is mainly attributed to losses of N by various pathways. Loss of N from applied N fertilizer has several possible negative agricultural and environmental consequences. The combination of super absorbent polymer along with clay and slow or controlled release fertilizer in a single formulation may be an effective management practice to improve nutrient supply and water preservation through one pack. In present investigation two studies were undertaken *viz.*, synthesis of NCPCs loaded with urea and nitrification inhibitors and their characterization and their evaluation for nitrification inhibition activity. The NCPCs were synthesized by partially neutralized acrylic acid and bentonite as principal raw materials subsequently loaded with urea and nitrification inhibitors to act as a slow release carrier of urea and characterized. The characterization results showed that the bentonite layers were exfoliated and basically dispersed in the composite after the polymerization. Release of N from nutrient loaded NCPC was studied using distilled water in a laboratory soil column leaching study to work out the effectiveness of nutrient loaded NCPCs over conventional fertilizer. The release rate in water was highest during the first 7 days, and then reaches a plateau. In soil incubation study of 120 days, per cent nitrification inhibition was highest in Schiff base containing NCPCs. The results obtained regarding the movement of NH_4^+ - N and NO_3^- -N in the soil column showed that most of the NH_4^+ ions from NCPCs are retained in 0-5 cm of the soils but NO_3^- ions moved out of it. The leachates marked no NH_4^+ and NO_3^- ions in NCPCs. So, this study could provide a convenient method for designing and preparing superabsorbent NCPCs with suitable release nitrogen rates to meet the requirements of the plant, and thus produce economic and environmental benefits.



Evaluation of Soil Quality Index (SQI) for Different Crops and Soil types in Semi-Arid Regions of South India

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Soil quality indicates health of soil for sustaining crop productivity through its impact on soil physical, chemical and biological properties. Maintenance of soil quality is an important strategy in improving soil status and also enhancing crop performance. Evaluation of soil quality index (SQI) for different crops, cropping systems and soil types supports betterment of these production systems. Soils in the semi-arid regions are often coarse textured, sandy with low soil fertility status and are vulnerable to water and wind erosion. Understanding quality status of these soils is of utmost importance to come out with useful practices. Hence, a study was carried out during 2008-10 to assess the soil quality under different crops and soil types of Nalgonda and Warangal Districts of Telangana (AESR 7.2). Major crops grown in these areas include paddy, castor, cotton, maize and redgram. Alfisol, Inceptisol and Vertisols are major soil types of this region. Soil quality evaluation through various datasets revealed that soils under paddy cultivation resulted in higher SQI value (0.517) followed by maize (0.484), cotton (0.480), redgram (0.472) and castor (0.422). Among the soil types studied, SQI was superior for black soils (Vertisols) *i.e.*, 0.546 indicating good condition of soil, than other two soil types *viz.*, Inceptisol (0.486) and Alfisol (0.473). These results emphasize the need for evaluation of soil quality under different crops and cropping systems for qualitative and quantitative output. Hence, this study has shown impact of crops and soil types on soil quality as depicted by SQI values, which enabled further to frame out strategies for sustainable land management of the region.



Response of Coriander with Variable Soil pH in Typic Haplustalfs and Typic Heplustepts

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Some of the crops traditionally adopted by the farmers in a certain area and later on those areas are recognized as bowl or hot spots for that particular crop. Still there is a scope to achieve more yield of coriander in non-traditional areas than the yield in traditional area. Therefore, present study was conducted under controlled conditions to evaluate the coriander under various soil pH levels (6.0, 6.5, 7.0, 7.5, 8.0 and 8.5 ± 0.35). Data revealed that plant height was at par up to pH 7.0 and reduced thereafter. Plant height reduced about 42% at pH 8.5 as compared to neutral pH. Number of primary branches were more with neutral pH than the lower and higher pH, whereas secondary branches were only lower at pH 8.0 and 8.5 and rest of the pH remained at par. Number of umbel/plant, number of umbelets/plant and number of seed per umbel were at par with neutral to acid side and reduced above the neutral pH. Straw accumulation increased with increase in pH up to neutral level and reduced thereafter. Seed produced by the Ajmer coriander-1 was 5-6 time lower with the alkaline pH than the neutral to slight acidic pH. Harvest index was at par with acid to neutral pH and was lowest at pH 7.0. N and P content in seed and straw decreased with increase in pH. However, potassium content in seed increased with each successive levels of pH, while it was at par in straw up to pH 7.0 and increased thereafter. Iron content in seed and straw increased with increasing levels of pH. However, zinc content in seed increased with increase in pH and reduced in straw with higher pH. Copper and Manganese content in seed and straw decreased with increasing soil pH. The uptake of N and K also increased up to pH 7.0 and reduction took place beyond pH 7.5. However, P uptake was remained at par up to pH 7.0 and reduction observed after pH 7.5. The total removal of iron and zinc increased up to pH 7.0 and decreased thereafter. Moreover, manganese and copper accumulation decreased with increasing in soil pH. Chlorophyll content a, b and total decreased with increase in soil pH. Beyond the pH 9.0, plant could not complete the life cycle and showed chlorosis. Therefore, soil pH is one of the important factors to harvest potential yield of coriander. It can also be inferred that variety ACr-1 is most suitable in slight acid to neutral pH soils than neutral to alkaline soil pH.



Long-term Effect of Organic and Inorganic Fertilizers on Biological Properties and Carbon Sequestration in a Flooded Soil under Rice-Rice Cropping System

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Monitoring the qualitative and quantitative changes of soil organic carbon is very much essential to keep the soil viable and productive for long-term sustainability. The long-term field experiment which has been continuing for the past 22 years at Andhra Pradesh Rice Research Institute, Maruteru, West Godavari District, Andhra Pradesh was used for the study. The treatments consisted of unfertilized (control), inorganic N (90 kg ha⁻¹), inorganic fertilizer NPK @ 90-60-60 kg ha⁻¹, FYM (@ 10 Mg ha⁻¹), inorganic fertilizer NPK @ 90-60-60 kg ha⁻¹ + FYM @ 5 Mg ha⁻¹. The different pools of carbon *viz.*, readily mineralizable carbon (RMC), acid hydrolysable carbon (AHC), water soluble carbon (WSC), permanganate oxidizable carbon (POC) were determined as per the standard procedures. The soil acid phosphatase and dehydrogenase activities during *khari*f season from the rhizosphere soils were estimated as per the procedures. The results revealed that the MBC, RMC, AHC, WSC and POC recorded significantly higher values and were in the order of FYM + inorganic fertilizer NPK > inorganic fertilizer NPK > FYM > N > control. The activities of acid phosphatase and dehydrogenase was found to be significantly higher in inorganic NPK + FYM compared to others. A two fold increase of acid phosphatase and a four-fold of dehydrogenase were recorded at panicle initiation stage of the crop growth. Fourier transform infrared spectroscopy analysis of humic acid revealed that organic fertilized soil fractions were more of aromatic groups with greater diversity than did the inorganic fertilized soil fractions. The enzyme activities were significantly correlated with MBC and TOC contents of soils and interrelationship also existed between the activities of different enzymes. This study emphasizes the importance of organic manure and underscores the recommended dose of inorganic fertilizer to maintain the carbon levels and soil biological properties in flooded rice soil.



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Factors Affecting Potential Carbon Mineralization (PCM) in Soil

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Potentially organic C mineralization (PCM) indicates the total metabolic activity of heterotrophic microbes releasing labile organic carbon as CO₂. The investigation was carried out using the samples collected from different land use systems (agriculture, fallow and forest) from three different agro-ecological regions of the country (Palampur, Jabalpur, and Ranchi). All together 14 soil samples having different soil and climatic conditions were used for determining potential carbon mineralization by conducting long-term incubation studies (247 days). The amount of C evolved in the form of C-CO₂ during different time intervals of incubation study was used for computation of PCM in soil. The cumulative C-CO₂ evolved during different time intervals were fitted with non-linear regression (least square) using statistical software. PCM and decay constant was computed for different soil types and land use systems. PCM ranged from 61.9-146.1 mg C-CO₂ evolved 100g⁻¹ soil whereas decay constant of PCM ranged from 0.013 -0.041 day⁻¹. Subsequently, 12 variables including soil and climatic conditions were subjected to Principal Component Analysis technique for determining the factors responsible for PCM in soil. It was observed that silt, clay and C: N ratio are the main factors affecting potential carbon mineralization in Indian soil.



Availability of Boron in Soils as Assessed by Different Extractants

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A relatively small range between deficiency and toxic limits of boron (B) necessitates precise evaluation of the availability of extractable boron before applying B in deficient soils. The present investigation, is therefore, aimed at a greenhouse pot experiment intended for evaluation of different extractants, both single and multi-nutrient, for assessing availability of B in 20 soils varied in physicochemical properties using soybean as test crop. For this purpose, twenty soil samples (0-15 cm) with wide variation in physicochemical characteristics were selected for greenhouse experiment. These samples were collected from cultivators' fields from different places of the country. A greenhouse pot experiment was conducted with these soils to assess the response of soybean to applied B (1.0 mg kg^{-1}). Selected soils were extracted for B using different extractants *i.e.* hot water (HWB), hot CaCl_2 (HCCB), modified Morgan's reagent (MB), ammonium acetate (AAB), Mehlich-3 (M3B), DTPA-sorbitol (DTPA-SB), and ammonium bicarbonate-DTPA (AB-DTPA). Boron content in the extracts was determined using spectrophotometer and ICP-MS.

Results indicated that drymatter yield of soybean enhanced by 1.0 to 62% across the soils with application of 1.0 mg B kg^{-1} over control. Plant B content and uptake under treated plots showed the positive response of B application in soils and the magnitude of per cent response varied from 14 to 61% and 21 to 80%, respectively. Hot 0.01 M CaCl_2 extractant (HCCB) was more consistent in predicting available B in soil as compared to hot water soluble B method. Among multi-nutrient extractants Mehlich-3 was superior to other multi-nutrient extractants for assessing available B in soil, and also positively correlated with Bray's per cent yield, plant B content and B uptake. The extractants were found to be in the following descending order in respect of efficiency of B extraction: HCCB > M3B > HWB > AAB > MB > AB-DTPA-B = DTPA-SB. Significant correlation was also found between amounts of B extracted by different extractants and different soil characteristics. As far as B determination technique is concerned, between spectrophotometer and ICP-MS determination, ICP-MS always estimated higher B in extract by 1.43 times over colorimetry and can be useful for extracts containing low B content. Critical limit of deficiency of extractable B was worked out for different extractants as 0.52 for HWB, 0.70 for HCCB, 0.25 for MB, 0.42 for AAB, 0.56 for M3B, 0.27 for DTPA-SB and 0.26 mg kg^{-1} for AB-DTPA-B. The critical limit of deficiency in plant (on dry weight basis) was also worked out as 28 mg kg^{-1} using soybean as a test crop.



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Long-term Effect of Different Nutrient Management Practices on Soil Organic Carbon and its Fractions under a Jute-Rice-Wheat Cropping System in Eastern Region of India

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Soil organic carbon (SOC) is of critical importance to maintain soil fertility and to sustain the productivity of agroecosystems. Effect of different nutrient management practices on total organic carbon, SOC fractions such as water soluble carbon, microbial biomass C (MBC), KMnO_4 oxidized organic C ($\text{KMnO}_4\text{-C}$), oxidisable organic C and its four different fractions (very labile, labile, less labile, and non-labile carbon) were examined in a long term jute-rice-wheat cropping system in lower Indo-Gangetic plains of India. The carbon pool index (CPI), lability index (LI) and carbon management index (CMI) were also determined which have been widely used as a sensitive indicator of SOC variation rate in response to soil management changes. The nutrient management treatments included 50% NPK, 100% NPK, 150% NPK, 100% NP, 100% N, 100% NPK+FYM, and control. Application of NPK either through inorganic fertilisers or through combination of inorganic fertilizer and organics such as FYM improved the TOC, MBC, $\text{KMnO}_4\text{-C}$, oxidisable organic C and its fractions. CMI was more significantly enhanced by NPK+FYM. Significant correlations among SOC and its fractions were observed in the soil which indicates the existence of dynamic equilibrium among them. Our findings demonstrate that the measured C fractions and CMI can act as indicators for assessing SOC changes.



Phosphorus Fractions in Sediment and Water Samples of Upper Lake, Bhopal

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Phosphorus is one of the key elements necessary for growth of all forms of life and therefore for food production. While good agronomic management requires use of P to optimize crop growth, excessive application of P may degrade water quality. The investigation from the UNEP (United Nation Environmental Protection) indicates that about 30%-40% of the lakes and reservoirs have been affected more or less by water eutrophication all over the world. Till the middle of the last century, the water from the Upper Lake, Bhopal did not require any treatment before supply for drinking purposes. However, an increased anthropogenic activity around these lakes resulted in deterioration of water quality of the lakes. Keeping this in view, a research investigation was carried out to study the non point sources of phosphorus loading to the Upper Lake, Bhopal.

Geo-referenced Sediment and Water samples from 11 sampling points at pre-monsoon stage were collected from Upper Lake, Bhopal. The pre-monsoon sediment and water samples were analyzed for different fractions of P using the standard procedure. The results showed that the total P in the sediment of pre-monsoon stage samples ranges from 0.03% to 0.07% with a mean value of 0.04%. The mean sediment inorganic phosphorus (SIP) and the sediment organic phosphorus (SOP) was 68.01% and 31.98% of total phosphorus (TP), respectively. Among the inorganic P fractions in the sediment, Ca bound P was maximum and found to be in the range of 86.32 to 96.97% of total sediment inorganic P followed by Fe bound P (2.10 to 11.51%) and loosely sorbed P (LSP) (0.39% to 5.66%). The total P value in the water samples ranged from 0.28 to 0.47mg L⁻¹ with a mean value of 0.39 mg L⁻¹. The total dissolved P, Total reactive P and dissolved reactive P ranges from 0.08 to 0.17 mg L⁻¹, 0.05 to 0.09 mg L⁻¹ and 0.008 to 0.04 mg L⁻¹ with a mean value of 0.13, 0.08 and 0.03 mg L⁻¹, respectively. The mean total dissolved P (TDP), total reactive P (TRP), dissolved reactive P (DRP), dissolved organic P (DOP) and particulate P (PP) was 31.05%, 20.31%, 10.39%, 18.73% and 68.94% of TP, respectively.



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Evaluation of Liming Potential of Some Indian Rock Phosphate

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Four Indian rock phosphates from different sources (Udaipur, Mussoorie, Jhabua and Purulia) were evaluated for their liming potential. The liming potential was evaluated through theoretical calculations, quantified with laboratory titration and incubation with soil. There are three types of anions (PO_4^{3-} , CO_3^{2-} and F^-) present in the carbonate apatite structure of rock phosphate which causes an increase in pH after dissolution from apatite. As the pKa value for HF was so low that F^- had hardly any effect on increasing pH. But pKa value for 2 protons on H_2PO_4^- and H_2CO_3 are high enough to increase pH by releasing PO_4^{3-} and CO_3^{2-} in to the solution if the pH range is between 4 and 6. Here, CO_3^{2-} contributes more effect on liming potential of P rocks because of its high molecular quantity as compared to PO_4^{3-} . Spacing of 'a' axis of the rock phosphate ranging from 9.352 to 9.373 Å in carbonate apatite structure and the theoretical % calcium carbonate equivalence (CCE) varies from 60.13-61.97%. Calculation revealed that %CCE contribution from CO_3^{2-} is much greater than PO_4^{3-} due to the higher amount of moles of CO_3^{2-} in apatite as compared to PO_4^{3-} . Very little difference was observed in total %CCE contributed from both CO_3^{2-} and PO_4^{3-} . Laboratory study on quantification of %CCE (AOAC method 955.01) of Indian rock phosphates were found to vary between 43.7 and 51.3%, which were less than the theoretical value. The less value obtained in AOAC method was assumed to be due to the formation of CaHPO_4 or $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ precipitates which would restrict the neutralization of 2 protons per mole PO_4^{3-} released from carbonate apatite. To overcome this problem, soil incubation experiment was conducted to quantify more accurate %CCE value in soil environment using acid of pH 4.5. Four Indian rock phosphates along with agricultural liming material (LM) were added to 100 g of acid soil @ 0.1, 0.5, 1, 5, 10 g kg⁻¹ soil, incubated for 90 days at field moisture capacity and analyzed for the change in pH and available P. The %CCE of each rock phosphate application was determined by using LM as standard. Soil pH was found increase while extractable Al decreased with the increasing doses of LM and RPs. Available P increased with application rate of RPs in incubation study while %CCE showed qualitative agreement with theoretical calculation. As compared to other RPs, Udaipur rock phosphate exhibit more liming potential and can be used as an amendment in acid soils. Further study on comparing actual %CCE through some model across the variety of soil would be helpful for better understanding.



Studies on Forms and Distribution of Phosphorus under Different Land Use Systems of a Micro-watershed in Northern Transition Zone of Karnataka

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An investigation was undertaken during 2013-14 in northern transition zone of Karnataka to study the forms and distribution of phosphorus and their contribution to available pool under different land use systems of Shinganhalli-Bogur micro-watershed. Three land use systems [agriculture (paddy land and non paddy land), forest and horticulture] were selected for the study. From each land use system, fifteen surface (0-20 cm) soil samples were collected randomly and exact geographical location of the sample site was recorded using a GPS device. Phosphorus fractions were determined by modified method of Chang and Jackson (1957) as outlined by Peterson and Corey (1966). The experimental data obtained was subjected to statistical analysis and testing of significance was done by SPSS 16.0 version. The average percentage of inorganic P fractions in surface soils followed the order; Reductant Soluble-P > Fe-P > Al-P > Ca-P > Occluded-P > Saloid-P (paddy land), Ca-P > Reductant Soluble-P > Al-P > Occluded-P > Fe-P > Saloid-P (non-paddy land), Reductant Soluble-P > Al-P > Fe-P > Ca-P > Occluded-P > Saloid-P (horticulture land), and Reductant Soluble-P > Al-P > Occluded-P > Fe-P > Ca-P > Saloid-P (forest land). The per cent contribution of saloid-P to the total P in surface samples varied from 0.27 per cent (forest land use) to 0.82 per cent (non-paddy land use). The higher Fe-P content in surface soils of paddy land, horticulture and forest land use might be attributed to the presence of more organic carbon which provides organic acids leading to solubilization of iron to ferrous form along with phosphates resulting in precipitation of ferrous phosphate. The contribution of Reductant Soluble-P to total P was observed to be the highest under forest land use system. However, the ratio of Occluded-P to total P in different soil under different land use system varied within a narrow limit of 4.20 to 9.25 per cent. The high Ca-P content of surface soils under non-paddy land use could be attributed to high CaCO₃- content. Under paddy land use system, Al-P alone accounted for 40 per cent of the variation. In case of non-paddy land use system, Al-P and Fe-P were the dominant contributors to the available P₂O₅. The study revealed that even though the Ca-P content was higher in the non-paddy land use system, but when it comes to contribution to the available P₂O₅, Al-P was the dominant fraction. Under horticulture and forest land use system, Fe-P contributed greatly to the available P₂O₅.



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Development of P Saturation Indices for Vertisol, Inceptisol and Alfisol of India

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Phosphorus deficiency in soil is corrected by application of fertilizer P, which undergoes fixation by oxides, hydroxides and oxy hydroxides of Fe and Al and clay minerals in acidic soil, which makes it less available or effectively unavailable to plants. But under intensively cultivated area of India continuous addition of fertilizer and manure in excess of crop requirement has resulted in increased phosphorus content in the surface soil, contributing to accelerate P losses from soil system as reported in some studies. Phosphorus loss from agricultural soils via surface and sub surface pathways depends upon the soil type, rate of P application, source of P, amount and intensity of rainfall, soil P status, etc. It is therefore necessary to develop a more appropriate technique to know the actual potential of soil contributing to the non point source of P pollution. Degree of phosphorus saturation (DPS) has been widely used and accepted method of determining P saturation capacity of the soil in many countries and has been used as an index of P movement in soil. A study was undertaken to determine DPS for major soil orders of India viz., Vertisol (Bhopal), Inceptisol (Barrackpore) and Alfisol (Raipur) using different extractants.

The P sorption maxima (P_{smax}) as determined by Langmuir equation followed the order Vertisol (475.1 mg kg⁻¹) > Alfisol (315.2 mg kg⁻¹) > Inceptisol (183.3 mg kg⁻¹). Soils were incubated with 0, 10, 25, 50, 75, 100 and 200 per cent P_{smax}. The incubated soils were analysed for labile P content with different extractants namely Olsen, Bray 1, Mehlich 3 and ammonium oxalate. In Vertisol DPS was calculated with DPS_{OI}, DPS_{A.O.} and DPS_{M3} ranged 0.5 to 64.9, 0.3 to 16.4 and 0.2 to 68.2 per cent respectively for P1 to P7 treatments. Similarly in Inceptisol, DPS_{OI}, DPS_{A.O.} and DPS_{M3} ranged from 2.8 to 77.7, 0.6 to 19.2 and 1.8 to 103.7 per cent for P1 to P7 treatments. In Alfisol DPS_{By 1}, DPS_{M3} and DPS_{A.O.} ranged from 0.9 to 23.8, 0.3 to 24.2 and 0.04 to 48.6 per cent for P1 to P7 treatments. The results indicated that DPS based on Olsen can be used for neutral to alkaline soils of Vertisol and Inceptisol and DPS based on Bray1 for Alfisol and Mehlich 3 and ammonium oxalate can be used for determining DPS in all the three soils.



Estimation of Carbon and Nitrogen Mineralization in Soil Amended with Legume Residues

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As commercial fertilizers are becoming more costly, legume residues can serve as an alternative in increasing soil available nutrients for increased crop productivity. But in order to optimize the use of legume residues there is need to estimate their mineralization rate after being incorporated in the soil. Keeping in view the above, a screen house and laboratory experiment was conducted to study carbon and nitrogen mineralization pattern in soil amended with different legume residues. Four levels of N viz. 40, 80, 120, 160 mg N Kg⁻¹ soils were applied through urea and legume residues. In laboratory, carbon and nitrogen mineralization from legume residues was studied at 7, 14, 28, 42 and 56 days incubation period. Carbon mineralization expressed as percent of added carbon mineralized increased at a faster rate up to 28 days of incubation and attained a slower rate at 42 and 56 days in all the treatments. Amongst the legume residues, the percent of carbon mineralized in different treatments followed the decreasing trend as: pigeonpea>green gram>black gram>clusterbean>soybean>cowpea. The amount of nitrogen mineralized increased with incubation period. Highest mineralization was reported during early periods and decreased thereafter. After 56 days of incubation the magnitude of N mineralized (% of added N) was in order: pigeonpea>greengram>blackgram>soybean>cowpea.



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Modeling Soil Phosphorus Critical Concentrations for Maize and Wheat Crops in Northwest India

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Phosphorus (P) is one of the most important nutrients to improve crop yield. Majority of the soils of northwestern India are able to fix large amount of fertilizer P added. Therefore, recovery efficiency of added P in these soils ranges from 10 to 40%. In an attempt to achieve higher yield, farmers have resorted to use higher than the recommended levels of P fertilizer in Punjab. Intensive and excessive use of P fertilizers has resulted in the accumulation of P in many soils in Punjab, especially in last 10 years. The increased accumulation of P especially in coarse textured agricultural soils, enhances the P movement below plant roots and increase the risk of P transport to water bodies with serious implications for water quality and freshwater eutrophication. Therefore, the demand for more efficient P management in high P testing soils is increasing. The objective of the present study was to work out the critical soil test phosphorus concentrations for efficient management of P in maize and wheat crops in soils with high P build-up.

Three years data was assessed from an ongoing field experiment on maize-wheat cropping system since 2011 by planting maize followed by wheat on three artificially created soil test P gradients, namely, 'medium', 'high', and 'very high'. The five basal P fertilizer levels (0, 30, 60, 90, 120 kg P₂O₅ ha⁻¹) were randomized on each P fertility strip for both maize and wheat. Critical soil P concentrations were calculated by developing a relationship between soil test phosphorus (STP) concentration and relative grain yield using different statistical models *viz.* Linear, quadratic, exponential and graphical approach of Cate and Nelson. The critical limit of STP calculated by exponential model was the highest (20.8 mg P kg⁻¹) followed by quadratic (20.5 mg P kg⁻¹) and linear models (20.3 mg P kg⁻¹) for maize at 95% of the relative yield. In wheat, quadratic model yielded the highest critical concentration of 25.5 mg P kg⁻¹ followed by 21.3 mg P kg⁻¹ for linear and exponential each. The critical limits of STP were found to be 17.0 and 16.8 mg P kg⁻¹ for maize and wheat respectively by graphical Cate Nelson approach. Among the different models, graphical Cate Nelson model was found to be the best fitted model to assess critical P concentrations for maize and wheat crops in coarse textured soils. The critical concentrations predicted by this model virtually synchronize with the results obtained from different P status soils on 18 short-term one year experiments. Thus, it can be concluded that for determining critical P concentrations for maize and wheat crops in northwest India Cate Nelson approach can be used.



Biochemical Composition and Decomposition Behavior of Shoots and Roots of Sorghum and Green Gram

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The large amount of plant C allocated belowground and the relatively greater biochemical recalcitrance of root C than shoot C makes roots possibly the major contributors to soil organic carbon. Studies were conducted to quantify root and shoot biomass of two varieties each of sorghum (SPV 462 and CSH 14) and green gram (ML 267 and WGG 37) grown under rainfed conditions, to determine the biochemical composition of shoots and roots and to investigate their decomposition behavior in soil. Crops were grown in the field and shoot and root samples were collected at maximum growth stage. Roots were quantitatively extracted by washing exposed soil monoliths of appropriate size.

Varieties of both the crops produced several times higher shoot biomass than root biomass, but the quantities of root biomass were considerable. Shoot:root ratios of green gram varieties were lower than sorghum varieties. Biochemical analysis showed that in both the crops, roots had more cell wall contents while shoots had more cell contents. Further, roots had considerably higher lignin content than shoots, especially in green gram. While roots of sorghum had lower N content than shoots, while it was reverse in case of green gram. Roots and shoots of sorghum had considerably higher C:N ratios compared to green gram. Lignin:N ratio was several times higher in sorghum over green gram. Roots of both crops had higher lignin:N ratios than shoots. Laboratory incubation studies of C mineralization from the plant materials showed that roots of both crops decomposed more slowly than their corresponding shoots, the difference being much more pronounced in greengram. In case of WGG 37 variety of green gram, at the end of 100 days of incubation, 35.6% of added C was mineralized from shoots whereas from roots only 24.9% was mineralized. Differences in C mineralization between varieties of each of the crops were relatively small.



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Effect of Tillage and Crop Residue Management Practices on Stability of Clay-Humus Complex in Rice-Mustard Cropping Sequence

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The effect of tillage and crop residue management practices on the stability of clay-humus complex has not been well investigated, particularly in tropical and sub-tropical soils. Keeping it in view, an attempt was made to study the effect of zero tillage and puddling and application of different crop residue on the stability clay-humus complexes in an ongoing project on rice-mustard cropping sequence started during *kharif*-2009 at IARI, New Delhi. The experiment was laid out in randomized block design in which eight combinations of tillage and crop residue management practices were, Transplanted Rice - Zero Tillage Mustard (TPR - ZTM), Moong Bean Residue + Zero Tillage Directed Seeded Rice - Rice Residue + Zero Tillage Mustard - Wheat Residue + Summer Moong Bean (MBR+ZTDSR-RR+ZTM-WR+SMB), Moong Bean Residue + Zero Tillage Directed Seeded Rice - Zero Tillage Mustard - Zero Tillage Summer Moongbean (MBR+ZTDSR-ZTM-ZTSMB), Wheat Residue + Zero Tillage Directed Seeded Rice + Brown Manuring - Rice Residue + Zero Tillage Mustard (WR+ZTDSR+BM-RR+ZTM), Transplanted Rice - Conventional Tillage Mustard (TPR-CTM), Wheat Residue + Zero Tillage Directed Seeded Rice - Rice Residue + Zero Tillage Mustard (WR+ZTDSR-RR+ZTM), Zero Tillage Directed Seeded Rice + Brown Manuring - Zero Tillage Mustard (ZTDSR+BM-ZTM), Zero Tillage Directed Seeded Rice - Zero Tillage Mustard (ZTDSR-ZTM). The plot-wise composite surface (0 – 0.15 m) soil samples were collected before sowing of *rabi* 2013-14 mustard and were sequentially extracted for their soil organic matter content with a mixture of 0.1M sodium pyrophosphate and 0.1M sodium hydroxide (pH 13) by shaking for 2 h and followed by centrifugation at different time intervals till there was no further extraction of soil organic matter. Organic carbon content in the extracts was estimated by 0.4N chromic acid and in soil by Walkely and Black (1934) method. Organic matter content released at different time interval was fitted in the first order kinetics and stability of clay humus complex was measured as the inverse of exponential content. Clay humus stability constant varied under different tillage and residue management practices. The brown manuring had no effect on the stability constant as the treatments without (ZTDSR-ZTM) and with (ZTDSR + BM – ZTM) brown manuring have the similar stability constant. The highest stability was observed under treatments MBR+ZTDSR-RR+ZTM-WR+SMB and WR+ZTDSR+BM-RR+ZTM in which there were application of rice and wheat residues (wide C:N ratio). The application of rice and wheat residue in treatment WR+ZTDSR – RR + ZTM increased stability constant over treatments TPR-ZTM and TPR - CTM where rice and wheat residue has not been applied. The lowest stability was observed under treatment MBR+ZTDSR-ZTM-ZTSMB in which there was application of moong bean residue (narrow C:N ratio). The higher stability of clay humus complex was observed when rice and wheat residues were applied in combination with either with moong residue or brown manuring.



Carbon Sequestration Potential of Different Orchards in Eastern Plateau and Hill Region

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The different age of two and four year old orchards of litchi, mango and guava were subjected to destructive (two year old orchard) and non-destructive (four year old orchard) sampling to find out the soil and biomass carbon stock. Soil samples were collected at depths of 0-15, 15-30, 30-45, 45-60 cm from the different aged orchard. The soil samples were separated into different size fractions of 2000-200 μ , 200-53 μ and < 53 μ and organic carbon content was determined. The organic carbon content under the two year old tree canopy in the surface soils by all the size fractions (2000-200 μ , 200-53 μ and < 53 μ) was recorded highest in guava orchard (0.58 %) followed by litchi (0.55%) and mango (0.5%). The highest SOC in different size fractions in surface soil was 0.39 % (2000-200 μ size), 0.13 % (200-53 μ size) and 0.06 % (< 53 μ) in guava orchard. In two year old orchard, the highest organic carbon stock of 10.77 t ha⁻¹ was recorded in the surface soils of guava orchard followed by litchi orchard (10.16 t ha⁻¹). The highest biomass-C in two year old orchard was 158 g C plant⁻¹ in mango, followed by litchi (147.8 g C plant⁻¹) and guava (78.3g C plant⁻¹) plant. Among the different parts of plant, stem part recorded highest carbon in all the orchard. The highest biomass carbon stock in two year old orchard was 63.23 kg ha⁻¹ in mango followed by litchi (59.13 kg ha⁻¹).

The soil organic carbon content under the four year old tree canopy in the surface soils by all the size fractions (2000-200 μ , 200-53 μ and < 53 μ) was recorded highest in mango (0.70%) followed by litchi (0.63%) and guava orchard (0.59 %). The highest organic carbon in different size fractions in surface soil was 0.48% (2000-200 μ size), 0.17 % (200-53 μ size) and 0.052 % (< 53 μ) in mango orchard. The organic carbon gradually decreased with increasing depth of soil. The organic carbon stock in soils of mango orchard was recorded highest of 12.58 t ha⁻¹ followed by litchi (11.38 t ha⁻¹) and guava (10.78 t ha⁻¹) in the surface soils. The biomass carbon in four year old orchard was 1.3 kg C plant⁻¹ in mango followed by litchi (0.52 kg C plant⁻¹) and guava (0.38 kg C plant⁻¹). The highest biomass carbon stock in four year old orchard was 528 kg ha⁻¹ in mango followed by litchi (208 kg ha⁻¹).



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Effect of Organic Manure on Humic Fractions and Microbial Biomass Carbon in Alluvial Tea Soils of North Eastern India

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Soil microbial biomass carbon (MBC) is a very important biological indicator of soil health and is the most sensitive index for assessing short-term changes in soil fertility and quality. Increased use of high analysis chemical fertilizers is detrimental to soil health particularly in a mono-crop system like tea. Therefore to study the effect of high value organic manures, studies were initiated in a glass house of Tocklai Tea Research Institute, Jorhat, Assam. Earthen pots of 10 kg capacity were used for the experiment. The soil was used from a nearby experimental garden of the Institute. The treatments included; cattle manure (CM), vermicompost (VC), decomposed tea waste (TW) and decomposed neem cake (NC) and their impact was studied on build up of humic fractions of soil organic matter, microbial biomass carbon and biomass accumulation of young tea plants. The manures were used alone or in combination (1:1) at a rate of 1, 2, 4 and 8 t ha⁻¹ mixed with the soil in pots and planted with tea clone (TV23). After two years of experimentation, plants were gently uprooted and bulk soil was separated by shaking. The remaining soil adhering to the root was considered to be rhizosphere soil and removed by vigorous shaking and brushing and stored in refrigerator for further analysis of humic fractions and MBC. The treatment VC alone or in combination with TW, and NC showed significantly higher build up of humic carbon (0.515 to 0.545%), humic acid carbon (0.118 to 0.124%), fulvic acid carbon (0.397 to 0.421%) and microbial biomass carbon (492 mg kg⁻¹ to 512 mg kg⁻¹) over control (0.395%, 0.112%, 0.283% and 342 mg kg⁻¹), respectively. Though there was a gradual increase in these parameters with the increase of doses of organic manures up to 8 t ha⁻¹, the rate 4 t ha⁻¹ was found to be optimum with respect to plant biomass. The treatment VC + NC produced the highest biomass.



Nitrogen Fractionation in Relation to Physico-chemical Properties of Soil from Ambajogai Tehsil of Beed District in Maharashtra

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The present investigation was carried out during the year 2011-12 to study the nitrogen fraction in relation to physicochemical properties of soil from Ambajogai *tehsil* of Beed district in Maharashtra. For this purpose, one hundred and twenty five representative soil samples were collected from different villages of Ambajogai *tehsil*. These samples were analysed for physicochemical properties and status of N, P, K, S, exchangeable Ca, Mg and nitrogen fractions in soil. The soils under study were neutral to alkaline in reaction, safe in limit of electrical conductivity and moderately calcareous to calcareous in nature. These soils were low to high in content of organic carbon. The soil samples were low in available P and high in available K. The exchangeable Ca, Mg and available S were in sufficient quantity. Total N, available N and organic and inorganic fractions of N were in low quantity. The pH and CaCO₃ showed negative and significant correlation with all the fractions of nitrogen whereas organic carbon showed positive and significant correlation with different fractions of nitrogen. However, EC of soil did not show any relation with nitrogen fractions.



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Quantity-Intensity Parameters of Potassium in Rice Growing Soils of Kurnool District, Andhra Pradesh

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Generally potassium fertilizer scheduling is done on the basis of available K in soil measured by 1N NH₄OAc (pH 7.0). Though, it has been reported by number of workers that 1N NH₄OAc (pH 7.0) is a better extractant for assessing available K status of soils but the results obtained under AICRP on cropping systems indicated that the responses to applied K have been observed in soils analyzing high in available K. Moreover, the physicochemical approaches put forth by Beckett (1964) and the parameters used for this technique were found to be more accurate in assessing available K status of soils.

Surface soils in bulk were collected from eighty locations covering eleven mandals of rice growing soils of Kurnool district and based upon potassium status thirty samples were selected for conducting the present study. The texture of the studied soils belongs to moderately coarse to fine texture with a mean pH value of 7.83 and EC ranging from 0.06 to 1.71 dS m⁻¹. The CEC ranged from 14.43 to 31.65 cmol(p⁺)kg⁻¹. The organic carbon content was in the range of 0.32 to 0.87%. The soils were low to medium in available N with the range being 188 to 327 kg ha⁻¹, medium to high in available P which is in the range of 67 to 226 kg P₂O₅ ha⁻¹ and medium to high in available K with a range of 158 to 2343 kg K₂O ha⁻¹.

Results of investigation indicated that the AR^K (ML⁻¹)^{1/2} × 10⁻³ and ± K (cmol(p⁺)kg⁻¹) values increased with increasing concentrations of added K. The mean AR^K for six K levels (0, 0.4, 0.8, 1.5, 2.0, 2.5 mM KCl L⁻¹) ranged between 0.85 to 6.53 mM KCl L⁻¹ and for ±K values ranged between -0.17 mM KCl L⁻¹ to 1.21 mM KCl L⁻¹. The concentration of Quantity factor *i.e.*, labile K (K_L), ranges from 0.10 to 2.50 cmol(p⁺)kg⁻¹ with a mean value of 0.46 cmol(p⁺)kg⁻¹. The AR_c^K, intensity factor showed the range of 0.30 to 5.50 (ML⁻¹)^{1/2} × 10⁻³ with a mean of 1.42 (ML⁻¹)^{1/2} × 10⁻³.

The PBC^K values were in the range of 0.125 to 0.833 cmol (p⁺) kg⁻¹/(ML⁻¹)^{1/2} × 10⁻³ with an average value of 0.37 cmol(p⁺)kg⁻¹/(ML⁻¹)^{1/2} × 10⁻³. Higher AR_c^K values were found in red soils than black and mixed red where as the buffering capacity was in the order of Black soil > Mixed red soil > Red soil. Since K supplying power of soils belonging to Kurnool district, as indicated by PBC^K values, was found to be low, the soils of the district requires judicious and frequent application of potassic fertilizers for better crop production.



Studies on Rhizosphere Hybridization and Nutrient Dynamics in Sweet Orange

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The present investigation was carried out during 2013-14 at department of Soil Science and Agricultural Chemistry, VNMKV, Parbhani. The rhizosphere soil samples were collected from three different tree such as *Ficus religiosa* (Pimpal), *Ficus benghalensis* (banyan tree / Wad) and *Ficus racemosa* (Umber tree). The soil samples were collected from 15-20 cm depth of root zone and used for pot culture experiment. The seedlings of sweet orange were planted in pots filled with rhizosphere soils collected from 3 *Ficus* species. Pot culture experiment was carried out with 9 treatments and 3 replications. The Treatments were T₁ (Control no microorganism), T₂ (bare soil), T₃ (Soil under *Ficus religiosa* tree), T₄ (Soil under *Ficus benghalensis* tree), T₅ (Soil under *Ficus racemosa* tree), T₆ (*Ficus religiosa* + soil), T₇ (*Ficus benghalensis* + soil), T₈ (*Ficus racemosa* + soil), T₉ (Soil under farmer sweet orange field). Result indicated the positive effect of microbial consortium on sweet orange seedlings growth parameters such as number of leaves, height of seedling, stem diameter, leaf area, microbial population and nutrient uptake increases over control treatment. The treatment T₅ and T₈ were statistically at par, which was followed by T₄, T₃, T₆, T₇, T₉. The available N, P, K in treatment T₅, which was followed by T₃, T₄, T₈, T₆, T₇ and T₉ is compare with control treatment. The micronutrient were also higher in treatment T₅, T₈, T₃, T₄, T₆, T₇ and T₉ over control, Microbial population such as bacteria, fungi and actinomycetes was very high in all treatment except control treatment. As plant roots grow through soil they release water soluble compounds such as amino acids, sugars and organic acids that supply food for the microorganisms. Microbiological activity in the rhizosphere is much greater than in soil away from plant roots. In return, the microorganisms provide nutrients for the plants. All this activity makes the rhizosphere the most dynamic environment in the soil. These results demonstrated that the microbial consortium reduced the sweet orange dieback disease in citrus orchards.



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Comparison of AB-DTPA and DTPA-CaCl₂-TEA Methods for Extractability of Available Zn, Cu, Fe and Mn in Different Soils of Andhra Pradesh

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Multinutrient extractant for estimation of many nutrients at a time is quicker and time saving over the different extraction methods employed for individual elements. An investigation was carried out for comparison and evaluation of multinutrient extractant AB-DTPA with DTPA-CaCl₂-TEA for available micronutrients in different soils of A.P. Twenty five soil samples each, belonging to Inceptisols, Alfisols and Entisols collected from different districts of A.P were used in this study. These soils were extracted for available zinc, copper, iron and manganese using AB-DTPA and DTPA-CaCl₂-TEA extractants.

The extent of extraction of available Zn, Cu, Fe and Mn contents by AB-DTPA and DTPA-CaCl₂-TEA varied in Alfisols, Entisols and Inceptisols. The extraction of mean available Zn was higher with DTPA-CaCl₂-TEA method in all the three soil groups in the range of 35 to 46 per cent. Highest variation of mean zinc extractability of 46 per cent was observed in Entisols with DTPA over AB-DTPA. In case of Cu, AB-DTPA extracted higher amounts over that of DTPA-CaCl₂-TEA method by 39, 22 and 10 per cent in Inceptisols, Alfisols and Entisols, respectively. Available Fe content extracted by DTPA-CaCl₂-TEA was 20 per cent higher than that of AB-DTPA in Inceptisols and lesser in Alfisols and Entisols by 13 and 18 per cent, respectively than that of AB-DTPA. The mean Mn content extraction was higher by 10 and 15 per cent in Inceptisols and Entisols by DTPA-CaCl₂-TEA and it was less by 23 per cent in Alfisols to that of AB-DTPA.

When all seventy five soils belonging to three soil orders were grouped for comparison, it was found that the AB-DTPA extracted 33 per cent lesser Zn, 25% higher Cu, 9 % higher Mn and similar Fe compared to that of DTPA-CaCl₂-TEA. The correlation coefficients between the extracted nutrient contents by both the extractants were found to be highly significant except for Mn.



Potassium Fractions in Inceptisols Continuously Fertilized with Minerals Fertilizers under Maize-Wheat Cropping System

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A field experiment was conducted during *khariif* 2012 under Long-Term Fertilizer Project initiated in *khariif* 1997 at Rajasthan College of Agriculture, Udaipur to study the effect of different mineral fertilizers on potassium fraction after fifteen years of continuous cropping of maize-wheat in an Inceptisol. The soil of experimental field is medium in available nitrogen (360 kg ha⁻¹), phosphorus (22.4 kg ha⁻¹) and high in potassium (671 kg ha⁻¹). The soils are sandy clay loam in texture and classified as Haplustepts at great group level. There were 12 treatments replicated four times in a randomized block design. The treatments consisted of T₁- N₀P₀K₀ (Control), T₂- 100% N, T₃-100% NP, T₄ (100% NPK based on soil test value), T₅ (100% NPK + Zn), T₆ (100% NPK + S), T₇ (100% NPK + Zn + S), T₈ (150% NPK), T₉ (100% NPK + Seed treatment with *Azotobacter*), T₁₀ (FYM 10 t ha⁻¹ + 100% NPK (-NPK of FYM), T₁₁ (FYM 10 t ha⁻¹ + 100% NPK), and T₁₂ (FYM 20 t ha⁻¹). The results indicated that the continuous application of chemical fertilizers improved all the potassium fractions in soil over control. Integrated use of balanced dose of chemical fertilizers with FYM sustained higher yields of maize in comparison to inorganic fertilizers alone. Accordingly, potassium uptake was also higher when FYM was applied with 100% NPK. Significant positive relationship amongst the different forms of soil potassium in 0-0.15 m depth indicated the existence of equilibrium among them. At lower depths, however, non – exchangeable K was not significantly correlated with HCL – K. All the potassium fractions exhibited significant positive relationship with yield and potassium uptake by maize except the non – exchangeable K.



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Soil N, P and K Fractions in Response to Nutrient Management Strategies under Mature Cashew Plantation

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A field experiment was conducted for four consecutive years (2009-13) on a lateritic soil at Directorate of Cashew Research, Puttur, Karnataka to investigate changes in nitrogen (N), phosphorus (P) and potassium (K) fractions in response to nutrient management strategies under mature cashew plantation variety 'Bhaskara' (Nine years old during first year of study). Treatments were established following a split-plot design with method of biofertilizer application) *viz.*, M1:No inoculation; M2:Biofertilizer consortia (*Azospirillum*, *Acetobacter*, PSB and AMF 50 g (each tree⁻¹) inoculation around tree basin to a radius of 45 cm; M3:Biofertilizer consortia inoculation in the rectangular trenches taken in the middle of four trees and M4:Combination of M2+M3 as the main plot and fertilizer levels *viz.*, T1:No fertilizer application, T2: 50% recommended NPK through drip+FYM, T3:75% recommended NPK through drip+FYM, T4: 100% recommended NPK through drip+FYM (135 g N, 39 g P₂O₅, 34 g K₂O and FYM 5.6 kg tree⁻¹ annum⁻¹) and T5: Soil test based fertiliser recommendation (Major nutrients through inorganic fertilizers) through drip as the sub-plot treatments.

The soil samples collected at the end of the experiment i.e. four years after imposing the treatments were fractionated into various N, P and K fractions. Total N content in different treatments varied from 1828 to 2350 kg ha⁻¹. Higher content of N was associated in total hydrolysable N (1406-1807 kg ha⁻¹) followed by amino acid N (466-682 kg ha⁻¹), hydrolysable ammonia N (365-671 kg ha⁻¹), hydrolyzable unknown N (394-522 kg ha⁻¹), acid insoluble N (381-390 kg ha⁻¹), alkaline permanganate hydrolysable N (254-356 kg ha⁻¹), amino sugar N (52-124 kg ha⁻¹), *exch.* NH₄-N (24.8-37.3 kg ha⁻¹) and NO₃-N (11.4-17.4 kg ha⁻¹). The highest content of plant available pool of organic fractions were noted in inoculation of biofertilizer consortia to the tree basin at a radius of 45 cm+100% of recommended dose of nutrients (M2T4) treatment and the increase was by 9.8 per cent over control. There was a depletion of 5.7 per cent organic fractions in control over the initial soil. Total P content of the soil in different treatments varied from 608-661 kg ha⁻¹. The distribution of P in different fractions followed the order: Residual P (206-219 kg ha⁻¹) > HCl-P (180-185 kg ha⁻¹) > NaOH-Po (67.5-75.6 kg ha⁻¹) > NaOH-Pi (46.2-62.9 kg ha⁻¹) > NaHCO₃-Po (19.3-22.4 kg ha⁻¹) > NaHCO₃-Pi (21.1-27.9 kg ha⁻¹). Similar to N fractions, the treatment M2T4 resulted in maximum increase in easily and moderately available plant available pools and indicated 33 per cent increase in NaHCO₃-Pi, 14 per cent in NaHCO₃-Po, 11 per cent in NaOH-Pi and 40 per cent in NaOH-Po forms. A decrease of 9 per cent in NaHCO₃-Pi, 4.2 per cent in NaHCO₃-Po, 3.6 per cent in NaOH-Pi and 14.1 per cent in NaOH-Po forms were recorded in control. The highest content of K was associated in Non-Exch. K (442-614 kg ha⁻¹) followed by Exch. K (138-186 kg ha⁻¹) and water soluble K (11-14.5 kg ha⁻¹). A slight improvement in Non-Exch. K (1.5% increase) was noted in the treatment M2T4 and a 6 per cent decrease in Non-Exch. K was recorded in control over initial soil value. The results of the present study suggest that inoculation of biofertilizer consortia to the tree basin at a radius of 45 cm + 100% of recommended dose of nutrients enhance plant available N, P and K pools in soil.



Release Pattern of Available Phosphorus and Sulphur in Different Soils Type at Constant Moisture Regime

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The nutrient release characteristics of the soils depend upon various factors such as pH, texture, organic carbon, sesquioxide and calcium carbonate. Application of inorganic S sources have an immense impact on release pattern of P and S in soil. The objective of the present investigation is to study the release pattern of P and S through added S levels in alluvial and black indo-gangetic soils of Varanasi and red Vindhyan soil of Mirzapur of eastern Uttar Pradesh. Bulk surface samples (0-15 cm) were collected from alluvial and black soils of Varanasi and red soil of Vindhyan region of Mirzapur, varying in texture, soil reaction, water holding capacity, organic carbon and nutrient retention capacity. A laboratory incubation experiment was carried out to study the release pattern of phosphorus and sulphur in these three type of soils in a constant moisture regime at the Institute of Agricultural Sciences, BHU, Varanaasi during 2013-14. The experiment was laid out in a factorial completely randomized design with three replications. Treatments consisted of six levels of sulphur (0, 10, 20, 30, 40 and 50 mg kg⁻¹) and three type of soils. Soil samples (2-mm sieved 25 g each) were mixed thoroughly with required quantities of sulphur through K₂SO₄ salt solution as per details of the treatment. Constant moisture regime (field capacity) was maintained by adding distilled water. The flasks were sealed tightly and incubated at room temperature for 0, 7, 15, 30, 60 and 90 days. At the end of each interval, soil available P was determined by Olsen method in black and alluvial soils and by Bray P₁ method in red soils. The sulphate sulphur was extracted by 0.15% CaCl₂ solution and was estimated by turbidimetric procedure. Important physicochemical properties of the soils were analyzed by following standard procedures. The result revealed that phosphorus availability increased up to 60 days and then declined. On the other, availability of sulphur increased up to 30 days, then progressively narrowed down. The rate of release of P and S was rapid in initial few weeks and after that gradually declined at later stage. The increase in the level of sulphur showed positive effect on release of available P and S. The higher release of available P and S was recorded in alluvial soil followed by black soil and red soil. The results further indicated that alluvial and black soils of Varanasi have greater potential to release P and S as compared to red soil of Mirzapur.



Soil Organic Carbon and Nitrogen Pools as Influenced by Cutting Cycles of Poplar (*Populus deltoides*) Plantations in Alluvial Soils of Punjab

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The content of soil carbon, nitrogen and their pools is expected to vary with the land use system and the age of tree plantations. In this study the temporal effects of poplar based agroforestry system on dynamics of total organic carbon, oxidisable soil organic C, very labile, labile, less labile, recalcitrant C pools and hot water soluble carbon as well as some nitrogen pools (total N, $\text{NH}_4^+\text{-N}$ and $\text{NO}_3^-\text{-N}$) were investigated in alluvial soils of Punjab. Surface and subsurface soil samples were collected from farmers' fields of two villages, Khehra Bet and Nurpur in district Ludhiana (Punjab) to examine the effects of cutting cycles of poplar (*Populus deltoides* Bartt.) plantations and paddy-wheat sequence and analyzed for various soil organic carbon and nitrogen pools. Sites were selected where different cutting cycles/rotations of poplar (varying from 1 to 4) have been harvested and the plantations were in the final year of their current cycle or first year of the next cutting cycle. Five sites of each cutting cycle were selected. The selected poplar sites have similar soil texture of the surface layer (0-15 cm). Each cutting cycle comprised of 6 years of continuous poplar stand. Thus, 1st, 2nd, 3rd and 4th cutting cycle represented about 6, 12, 18 and 24 years of continuous poplar stands, respectively. Along with these poplar rotations, five sites having permanent rice-wheat cropping system were also selected for the comparison of soil characteristics.

Soil organic carbon (SOC), total organic carbon (TOC) and total carbon (TC) content and their stock increased significantly from first to fourth cutting cycle of poplar up to 30 cm depth. The highest total carbon content (1.37%) among poplar plantations was observed under four cutting cycles of poplar. Maximum content of SOC, TOC and TC was however, observed under paddy-wheat sequence. There was a linear increase in SOC from 9.94 in first cutting cycle to 13.81, 15.69 and 20.29 t ha⁻¹ in two, three and four cutting cycles, respectively in the surface layer. Similar trend of linear increase with increase in number of cutting cycles of poplar was observed for TOC stocks. Different C fractions viz. hot water soluble carbon, very labile, less labile and recalcitrant carbon were higher under four cutting cycles than one cutting cycle. Among different fractions less labile carbon was predominant in all the three soil depths (0-15, 15-30 and 30-45 cm). The stable fractions were the highest under paddy-wheat sequence and four cutting cycles of poplar. The N pools viz. $\text{NH}_4^+\text{-N}$, $\text{NO}_3^-\text{-N}$, KMnO_4 extractable N and total N were also higher in the four cutting cycles of poplar than the other cutting cycles. The comparison of SOC, N content and their pools observed under paddy-wheat sequence revealed that the values were either higher or statistically similar to those found under four cutting cycles of poplar suggesting that long term adoption of agroforestry is required for buildup of stable pools of soil organic carbon.



Effect of Phosphate on Sorption and Desorption of Added Arsenate in Soils

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The occurrence of arsenic in natural environments depends both on geogenic as well as on anthropogenic activities. The contamination of ground water by arsenic has become a critical water quality problem both for irrigation and drinking in many parts of world including India. In the arid south-western zone of Punjab comprising Sangrur, Mansa, Faridkot, Muktsar, Bathinda and Ferozpur districts arsenic has been found to be in the range of 4-688 $\mu\text{g L}^{-1}$ (maximum WHO permissible limit 10 $\mu\text{g L}^{-1}$). The availability, mobility and toxicity of arsenate in soil is controlled by sorption-desorption process. The competition between arsenate and phosphate in soils is an important phenomenon determining the mobility and bioavailability of arsenate. In this study, we examined the effect of phosphate concentration on sorption-desorption of native and added arsenate by aerobic incubation of soil. Combinations of arsenate and phosphate ion concentration were used for sorption studies, so as to make the soil equivalent of 0, 25 and 50 mg arsenate kg^{-1} and 0, 50 and 100 mg phosphate kg^{-1} soil. Soils so treated were maintained at 75% of field capacity and kept in an incubator for 30 days at 25 °C. Samples were drawn at 1, 15 and 30 days after incubation for desorption studies. Desorption patterns of arsenate and phosphate were derived from arsenate and phosphate desorbed after each of six desorption periods carried out by sequential equilibration of the soil with arsenic free 0.01 M KNO_3 . Results revealed that the patterns of release of native as well as added arsenate and phosphate were almost similar, indicating their similar sorption-desorption behaviour in soils. Desorption and sequential extractions results indicated that significant amounts of added arsenate and phosphate were irreversibly retained by soil. The amounts of desorption of native and added arsenate increased with the increase in phosphate concentration, indicating competition for similar sites by both anions. The amounts of native and added phosphate decreased with increase in contact period upto 30 days, indicating sorption of arsenate into more recalcitrant sites. The amount of native and added phosphate desorbed also increased with increasing arsenate concentration. The decrease occurred only upto 15 days incubation period but in the 30 days incubation treatment there was a significant increase in the phosphate concentration, indicating more competitive behaviour of arsenate as compared to phosphate for sorption sites in soils.



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Evaluation of Extractants to Quantify Dissolved Organic C (DOC) and Dissolved organic N (DON) in Dissimilar Soils

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The concentration of C and N measured in soils is significantly influenced by the extractant used. Due to difficulties of removing the soil solution, soil organic matter is often extracted with water or various salt solutions and referred to as soluble organic matter. Many studies have presented results of extractable dissolved organic C (DOC) and dissolved organic N (DON) using a diverse range of extractants. However, the amounts of soluble organic matter extracted differed widely among the extractants used in different studies. Thus, lack of uniformity among different studies to follow similar protocol for extraction of dissolved organic matter (DOM) makes it difficult to compare the DOM values in different studies. Further, soil types may also respond very differently to various extractants. Majority of studies investigating extractable DOC and DON have occurred in forested or rangeland systems, but fewer studies have examined DOC and DON in agricultural soils with different texture. Therefore, an incubation experiment was conducted to quantify DOM extractants (water, 0.5 M K₂SO₄ and 2M KCl) in three texturally divergent soils (loamy sand, sandy clay loam and sandy clay) collected from A horizons (0-30 cm). The experimental soils were amended with mature wheat residue (2% w/w, ground, sieved to 0.25-2 mm), thoroughly mixed into the soils. Following which, 20 g of each soil (loamy sand, sandy clay loam and sandy clay) with residue was added to polyvinyl cores (PVC) with a radius of 1.85 cm and height of 5 cm and a nylon mesh base and packed to the bulk density of the soil in the field. The PVC cores were incubated for two weeks at constant temperature (25 °C) and then extracted using three extractants (water, 0.5M K₂SO₄ and 2M KCl) with four replicates. For each extractant, 5 g of incubated soil was put into 50 mL polypropylene centrifuge tubes and 25 mL of extracting solution was added (1:5 w/v ratio). The samples were shaken in an end-over-end shaker for 1 hour followed by centrifugation at 4000 rpm for 10 min and then vacuum filtered through a 0.45 µm Durapore PVDF membrane filter. The concentration of DOC and DON in the suspensions was measured as non-purgeable organic C and N in a Formacs TOC/TN analyser after acidification of the sample and purging of the inorganic C using gas. Irrespective of the texture of the soils, the concentrations of DOC and DON extracted with 0.5M K₂SO₄ were more than twice than those extracted with water while those extracted with 2M KCl were even higher than extracted with K₂SO₄, which clearly suggested that water extracts give more realistic values than salt solutions. DOC was strongly related to DON in the water extract independent of soil type. The relationship between DOC and DON declined when salt extractants were used. Recovery of DOC and DON was higher in loamy sand and sandy clay loam soil compared to sandy clay with all the extractants. The results indicate that the retrieval of DOC and DON appears to be highly dependent upon the extractant used. Therefore, similar extractant should be used in all studies to enable comparison to be made between differently textured agricultural soils.



Evaluation of Ammonium Bicarbonate–DTPA as a Multinutrient Extractant for Assessing Plant Available Nutrients in Soil

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Multinutrient extractant is a single extractant for the determination of both macro and micronutrients which will save time and cost of soil analysis and facilitates efficient use of multinutrient analysers like AAS and ICP. In this study, suitability of ammonium bicarbonate - diethylene triamine penta acetic acid (AB–DTPA) for simultaneous assessment of available P, K, S, Fe, Mn, Zn and Cu in soils was evaluated. Soltanpour and Schwab (1977) developed the AB-DTPA extractant for simultaneous extraction of NO₃, P, K, Zn, Fe, Cu and Mn from alkaline soil. This extractant is a combination of 1.0 M NH₄HCO₃ + 0.005 M DTPA buffered at PH 7.6. Fifty geo-referenced soil samples having wide pH range were collected from Coimbatore and Niligris districts of Tamil Nadu. Out of the 50 soil samples collected, 15 were acidic, 9 were neutral and 26 were alkaline. AB-DTPA was used for analysis of P, K, S, Fe, Mn, Zn and Cu. Accurately 20 g soil + 40 mL AB-DTPA extractant shaken for 15 minutes, filtered and analysed in AAS for Fe, Mn, Zn and Cu. Phosphorus and S in the extract was estimated colorimetrically and K by flame emission spectroscopy. For comparison with AB–DTPA, the analysis was also performed with established standard methods (P-Olsen and Bray method–based on pH of the soil, K-neutral normal ammonium acetate method, S-CaCl₂ extractable S, Fe, Mn, Zn and Cu-DTPA method). Correlation and regression analysis was carried out to obtain the relationship between amounts extracted by AB-DTPA method with that of standard method. The results revealed that AB-DTPA extractant is more suitable for the determination of available P content of neutral ($r = 0.940^{**}$) and alkaline soils ($r = 0.603^{**}$) than acid soils ($r = 0.449^{**}$). Regarding the determination of available S content of soils, AB-DTPA is suitable only for alkaline soils ($r = 0.867^{**}$) and not suitable for neutral ($r = 0.013^{NS}$) and acid soils ($r = -0.049^{NS}$). AB DTPA can be used for soils in all the pH ranges for the determination of available K ($r=0.855^{**}$ for acid, 0.818^{**} for neutral, 0.891^{**} for alkaline and 0.857^{**} for all the soils put together), Fe ($r=0.887^{**}$ for acid, 0.927^{**} for neutral, 0.773^{**} for alkaline and 0.982^{**} for all the soils put together), Mn ($r=0.782^{**}$ for acid, 0.786^{**} for neutral, 0.808^{**} for alkaline and 0.830^{**} for all the soils put together), Zn ($r=0.947^{**}$ for acid, 0.992^{**} for neutral, 0.956^{**} for alkaline and 0.950^{**} for all the soils put together) and Cu content ($r=0.944^{**}$ for acid, 0.879^{**} for neutral, 0.756^{**} for alkaline and 0.916^{**} for all the soils put together). The results indicated that there is scope for use of AB-DTPA for the simultaneous extraction of available P, K, S, Fe, Mn, Zn and Cu in alkaline soils. However, to use this method for fertilizer recommendation, more research is needed to establish critical levels, preferably under field conditions.



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Potassium Fixation in Vegetable Growing Soils of Ranga Reddy and Mahaboobnagar Districts

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In the present investigation potassium fixing capacities of 32 vegetable growing soils of Rangareddy and Mahaboobnagar districts were studied. Rangareddy soils were slightly acidic to moderately alkaline (pH 6.1 to 8.3) in reaction, non saline (EC 0.054 to 0.353 dS m⁻¹) in nature, available potassium (182.8 to 1198.7 kg ha⁻¹), organic carbon (0.4 to 1.2%), CEC (4.23 to 34.84 cmol(p⁺)kg⁻¹), clay % (2.76 to 16.16) and clay + silt % (3.17 to 17.45). Mahaboobnagar soils were moderately acidic to moderately alkaline (pH 5.4 to 8.3) in reaction, non saline (EC 0.02 to 0.25 dS m⁻¹) in nature, available potassium (71.2 to 1022.8 kg ha⁻¹), organic carbon (0.2 to 1.2%), CEC (3.92 to 27.47 cmol(p⁺)kg⁻¹), clay % (5.56 to 21.56) and clay + silt % (9.56 to 35.56). Potassium fixation in soils *i.e.* transformation of available K forms into unavailable forms, has a direct effect on K availability and on the degree of fertilizer K uptake by plants. The potassium fixing capacities of soils were determined by wet fixation method with a range of applied K through KCl (0, 5, 10, 20, 30, 40, 50, 60 and 100 µg g⁻¹). The potassium fixing capacity was computed from the amounts of K added and extracted at different levels. Potassium fixing capacity of soils varied from 0.0128 to 0.076 cmol(p⁺)kg⁻¹. Most of the soils of Rangareddy and Mahaboobnagar districts have the fixing capacity of 0.0256 cmol(p⁺)kg⁻¹. In general these soils were low in potassium fixing capacity. Silt and clay fractions of soils are largely responsible for potassium fixation. Significant positive correlation between K-fixation capacity and clay % (r = 0.42), clay + silt% (r = 0.56), OC (r = 0.35), EC (r = 0.41) and CEC (r = 0.54) were existed. Soils differ in tendencies to fix applied K in forms unavailable to plants and each soil has its fixing capacity for K, which must be satisfied before a change in soil solution occurs. Hence, it is imperative to know the fixation characteristics of soils with a view to making rational recommendations about K fertilizers.



Transformation and Availability of Copper to Wheat in a Typic Haplustept as Influenced by Phosphorus Application

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A pot experiment was conducted to study the transformation and availability of copper to wheat as influenced by P application in a Typic Haplustept. Six levels of P (0, 25, 50, 100, 200 and 400 mg P kg⁻¹ soil) as monocalcium phosphate monohydrate and four levels of Cu (0, 5, 10 and 20 mg Cu kg⁻¹ soil) as Cu-EDTA were applied in all possible combinations with three replications to a sandy loam soil. The soil was having pH 6.5, EC 0.29 dS m⁻¹, OC 0.38%, available P 12.6 and DTPA-Cu and Fe 1.05 and 51.6 mg kg⁻¹ soil. Wheat crop (cv HD 2967) was raised till maturity during *rabi* 2013-14 by following the recommended package of practices. Soil samples were collected at maturity and analysed for pH, Available P, DTPA-Cu, Fe, Mn and Zn and different chemical pools of Cu. Grain samples were also collected and analyzed. Mean DTPA-Cu, Fe, Zn decreased significantly from 3.65, 58.6 and 2.29 mg kg⁻¹ soil in control to 3.31, 50.2 and 2.12 mg kg⁻¹ soil, respectively with the highest level of applied P. Whereas DTPA-Mn increased significantly from 4.26 mg kg⁻¹ soil in control to 5.07 mg kg⁻¹ soil with application of 200 mg P kg⁻¹ soil. Per cent recovery of native as well as applied Cu @ 20 mg kg⁻¹ soil in different fractions revealed that application of phosphorus moved Cu from exchangeable, amorphous and crystalline oxides bound Cu to organically bound and residual mineral fractions thus indicating a decrease in the availability of Cu in soil with P application. A maximum grain yield of 26.55 g pot⁻¹ was observed with a combined application of 400 mg P and 5 mg Cu kg⁻¹ soil as compared to 15.23 g pot⁻¹ in control. Path coefficient analysis of grain yield revealed that crystalline oxides Cu, organically bound Cu and residual Cu controlled a direct variation of 76.2, 1.4 and 11.6% in grain yield, respectively. An indirect variation of 59.1, 42.1 and 10.0 per cent by DTPA-Cu, 63.4, 42.5 and 9.1 per cent by exchangeable Cu, 62.7, 40.4 and 9.3 per cent by specifically adsorbed Cu, 50.8, 60.6 and 9.8 per cent by manganese oxides bound Cu, 62.2, 40.5 and 9.3 per cent by amorphous oxides bound Cu was controlled through crystalline oxides, organically bound and residual Cu fractions, respectively. Like grain yield, the oxides bound and residual copper played an important role in controlling grain copper concentration also. A direct variation of 18.3, 15.8 and 20.7 per cent in grain copper concentration was controlled by amorphous oxides, crystalline oxides and residual Cu fractions, respectively indicating the importance of these pools of Cu for Cu nutrition of wheat in the soil under investigation.



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Effect of pH on Adsorption and Desorption behaviour of Cadmium in Soils

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Adsorption and desorption behaviour of added cadmium (125, 500 and 1000 $\mu\text{g Cd g}^{-1}$ soil) in two Punjab soils was studied by artificially adjusting their original pH to 7.5 and 6.5. From 125 μg initially added Cd g^{-1} soil, the amount of Cd adsorbed decreased from 112.3 to 100 $\mu\text{g g}^{-1}$ and 93.5 to 77.5 $\mu\text{g g}^{-1}$, by decreasing soil pH from 8.5 to 6.5 and 8.85 to 6.5 in Isri and Jassi pauwali soils, respectively. Similarly, at highest level of initially applied Cd (1000 $\mu\text{g Cd g}^{-1}$), the amount of cadmium adsorbed decreased from 754.6 to 375.0 $\mu\text{g g}^{-1}$ and 397.9- 260.0 $\mu\text{g g}^{-1}$ with the decrease in pH of the two soils, respectively.

Cadmium adsorption isotherms were slightly curvilinear in both soils. However, isotherms became relatively flat at lower pH than at higher pH levels indicating that soils tend to reach adsorption maxima earlier at lower pH than at higher pH levels. Cadmium adsorption data, at adjusted pH levels, were found to fit well in Langmuir equation with high R^2 values (0.937-0.994). Cadmium adsorption data also fitted well in Freundlich equation at these pH levels with R^2 values ranging from 0.966–0.999. Slopes of Freundlich plots were also higher at higher pH levels in all cases. The Freundlich constant 'n' generally increased with increase the in pH level. Thus, with the decrease in pH, adsorption capacity and rate of adsorption decreased in the soils.

Decrease in soil pH also resulted in a substantial increase in the Cd desorption (% of initially adsorbed) at all levels of added Cd in both soils. In Isri soil, decreasing soil pH from 8.5-6.5, desorbed Cd increased from 19.5-44.5%, 23.8-47.0% and 34.5-50.8% at 125, 500 and 1000 μg initially added Cd g^{-1} soil, respectively. Decreasing pH of Jassipauwali soil from 8.85–6.5 and at similar levels added Cd, desorbed Cd increased from 29.8–49.6%, 35.7–53.0%, and 36.4–57.7%, respectively.

In both the soils, at lower levels of Cd addition (125 & 500 $\mu\text{g g}^{-1}$), the cumulative desorbed Cd was higher at low pH than at higher soil pH. However, at 1000 $\mu\text{g g}^{-1}$ level of Cd addition, reverse was true. An examination of cadmium adsorption–desorption isotherms in all the cases indicated that at all the pH levels (6.5, 7.5 and near 8.5), most of the adsorbed Cd was not desorbed back into soil solution and the hysteresis between Cd adsorption and desorption isotherms became greater with increasing pH.



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Dynamics of Sulphur and their Relationship with Soil Properties in Soils of Gwalior, Morena and Bhind District of Northern M.P. under Mustard Cultivation

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One hundred fifty surface (0-15cm) soil samples collected from 10 villages each of Gwalior, Morena and Bhind districts of Gird zone were analyzed for important physico- chemical properties and forms of sulphur. Soils were sandy clay loam to clay loam, pH and EC were in normal range. Range of organic carbon and total N was 0.112-0.810 % and 0.032- 0.165 % with an average value of 0.408 and 0.079%, respectively. Water soluble, available, organic and total sulphur ranged from 1.02-7.44, 4.36-19.58, 84.25-201.35 and 188.21-465.26 mg kg⁻¹ with an average of 3.76, 15.31 135.42 and 317.91 mg kg⁻¹, respectively. About 25% samples were deficient and 75% in medium range. Maximum deficiency was observed in Gwalior district. Different forms under study showed a highly significant and positive correlation with organic carbon, clay and total N. Regression equation revealed that organic carbon had greater impact on different forms of sulphur followed by soil texture.



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Relationship of Forms of Potassium with its Uptake by Potato Crop in Alfisols of Andhra Pradesh

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A field experiment was conducted on a sandy loam soil during *rabi* season of 2009-10 with a view to study the effect of levels of nitrogen (0, 60, 120 and 180 kg N ha⁻¹) and potassium (0, 60, 120 and 180 kg K₂O ha⁻¹) on potassium forms and uptake of potassium by potato haulm and tuber. Application of different levels of nitrogen, potassium and their interactions significantly increased the K uptake by potato at all the stages of crop growth viz., stolonisation, tuberisation and at harvest. The values of K uptake by potato haulm revealed that there was an increase in K uptake upto 60 DAS and decreased at harvest. Potassium uptake by potato tuber increased with the age of the crop and highest uptake was attained at harvest.

The soil samples collected at stolonisation, tuberisation and at harvest stages of potato were analyzed for different forms of K. The contents of different forms of potassium (water soluble K, exchangeable K, 1N HNO₃ K and non exchangeable K) was significantly influenced by levels of nitrogen, potassium and their interactions. The simple correlation study indicated that uptake of potassium by potato haulm and tubers at stolonisation did not bear relationship with all the potassium forms except water soluble K. However, exchangeable K and 1N HNO₃ K played a significant role in meeting K needs at tuberisation stage and at harvest. The non-exchangeable K content found to be significant at harvest stage. The potassium dynamic equilibrium following potassium fertilization shifted towards non-exchangeable K with the advancement of the crop growth.



Study of Different Inorganic Fractions of Phosphorus in Alfisols and Inceptisols Soils of Rajasthan

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Field and pot study was carried out to assess the different inorganic phosphorus fractions in rhizosphere and non-rhizosphere of wheat, maize, sorghum and mustard plants under Alfisols and Inceptisols. A significant ($p=0.05$) difference in adsorbed P, Fe-P and occluded Fe-P, Ca-P, Al-P and occluded Al-P by different plant species were observed between the soils under different plant species. Different inorganic phosphorus fractions were significantly ($p=0.05$) higher in Inceptisols than Alfisols except Fe-P and occluded Fe-P which were higher in Alfisols both under pot as well as field studies. Further, the adsorbed P, Fe-P and occluded Fe-P decreased with plant growth whereas Ca-P, Al-P and occluded Al-P increased with plant growth under all the plant species. These changes in soil inorganic P fractions were considerably higher in Alfisols than Inceptisols except Fe-P and occluded Fe-P fractions. Generally the transformation in different Pi fractions under all the plant species was slightly higher in rhizosphere than non-rhizosphere soils. The effect of different plant species on Pi fractions were generally higher for cereals (maize, sorghum and wheat) than oilseeds (mustard), which were significantly altered up to 30-45 DAS of crop growth.



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Nutrient Release Pattern of Tank Silt

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To assess the nutrient release pattern of tank silt an incubation experiment was conducted at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal with thirteen treatments. In which, the soil was incubated with tank silt and organic manures *viz.*, press mud, sewage sludge, water hyacinth compost, FYM and spent wash and tank silt blended with organic manures. Tank silt and organic manure were added to soil at 2 t ha⁻¹ each, when tank silt was blended with organic manures they were applied to soil at 1 t ha⁻¹ each. The incubation experiment was carried out for 120 days, the soil samples were drawn at 0, 30, 60, 90 and 120 days of incubation and analysed for pH, EC, organic carbon, KMnO₄-N, Olsen-P and NH₄OAC-K. The experimental soil (*Fluventic Haplustept*) as sandy loam in texture, non saline and neutral. The CEC of soil was 20.70 cmol(p⁺)kg⁻¹, the organic carbon content was medium, the KMnO₄-N, Olsen-P and NH₄OAC-K status were low, high and medium respectively. The tank silt used in the experiment was clayey in texture (64.7% clay) with bulk density of 1.08 Mg m⁻³ and pore space of 48.94%. The CEC of tank silt was 47.15 cmol(p⁺)kg⁻¹. The result of incubation experiment revealed that with the advancement of incubation period the pH and organic carbon declined sharply, whereas, the EC and soil available nutrients increased with duration of incubation. The simple linear regression had shown that the pH decreased at a rate ranging from 0.0047 units day⁻¹ (soil alone) to 0.0079 units day⁻¹ (soil + tank silt + FYM). The organic carbon content decreased from 8.0 mg kg⁻¹ day⁻¹ in soil amended with tank silt plus spent wash. The rate of release of KMnO₄-N, Olsen-P and NH₄OAC-K ranged from 0.014 to 0.651, 0.028 to 0.102 and 0.214 to 2.033 mg kg⁻¹ day⁻¹, respectively.

Commission 2.3: Soil Biology



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Potentiality of Bio-Fertilizer and Organic Resources for Sustaining Sesame Yield under Rainfed Condition

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A field experiment was conducted at Dry Farming Research Station, Junagadh Agricultural University, Vallabhipur (Dist: Bhavnagar, Gujarat) during *khariif* seasons of 2003-2011 to ascertain the effect of various combinations of bio-fertilizers, gypsum, castor cake, compost alone or with inorganic fertilizer (total 12 treatment combinations) on yield of sesame and post-harvest soil fertility. The results revealed that sesame seed yield was significantly affected due to different nutritional treatment in pooled results. Application of 50% RDF (12.5:12.5 kg NP kg ha⁻¹) along with castor cake @ 500 kg ha⁻¹ and bio-fertilizer produced significantly higher seed yield of sesame (795 kg ha⁻¹), which was higher by 13.7 per cent as compared to recommended dose of fertilizer (25.25 kg NP ha⁻¹). Organic carbon available phosphorus, potassium and sulphur in the soil were significantly different under different treatments and varied from 0.41 to 0.58%, 20.28 to 35.23 kg ha⁻¹, 402 to 504 kg ha⁻¹ and 12.84 to 17.13 mg kg⁻¹, respectively. In case of micronutrients, availability of Fe and Zn were significantly different under different treatments. Maximum values of all the nutrient elements were recorded with application of gypsum @ 250 kg ha⁻¹ + compost 5 t ha⁻¹ + castor cake 500 kg ha⁻¹ + bio-fertilizer). Maximum gross (Rs.39750 ha⁻¹) and net (Rs.25791 ha⁻¹) income were obtained when sesame crop was fertilized with 50% RDF along with castor cake @ 500 kg ha⁻¹ and bio-fertilizer. However, application of 50% RDF along with gypsum @ 250 kg ha⁻¹ gave higher B.C. ratio (2.36) in comparison to rest of the treatment. It is concluded from this study that the application of 50% RDF (12.5:12.5 kg NP kg ha⁻¹) along with castor cake @ 500 kg ha⁻¹ and 30 mg kg⁻¹ seed (each of Azotobacter and PSM) recorded higher seed yield of sesame as well as gross and net returns, also sustained the soil fertility under rainfed condition.



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Effect of Different Levels of Phosphorus on Quantity of Sugarcane as Influenced by Cane Trash and Mycorrhizae

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The field experiment was conducted at RARS, Anakapalle on the effect of different levels of phosphorus on yield and quality of sugarcane in presence and absence of cane trash and mycorrhizae. The experiment was laid out in split plot design with four main levels and four sub levels. The main levels consists of control (M_1), mycorrhizae alone (M_2), cane trash and mycorrhizae (M_3) and cane trash alone (M_4). The four sub levels consists of 0, 50, 100 and 150 kg P_2O_5 ha⁻¹. Root colonization and percent root infection was significantly influenced by inorganic P application at all the stages in all the crops (plant and ratoon crops). Cane trash and mycorrhizae with the inorganic P at 50 kg P_2O_5 ha⁻¹ increased the root colonization significantly at all stages of growth in all the three crops. The bacterial population and actinomycetes declined with increase in phosphorus levels. The maximum bacterial count, actinomycetes and fungal population was observed in plant and ratoon crops with 50 kg P_2O_5 ha⁻¹ at formative, grand growth and at maturity stages.



Soil Dehydrogenase and Urease Activity as Influenced by Organic Manures in 4-year Old Organic Farming Plot

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A field experiment was conducted on a sandy loam soil taking groundnut as a test crop to evaluate the organic manures *viz.* Farmyard manure and vermicompost prepared from mushroom spent substrate in influencing dehydrogenase and urease activity in comparison with the control (absolute control). Soil has been maintained under organic farming (without fertilizers, herbicides and pesticides) for 4 years. The assay was made at flowering stage of the crop. The FYM was applied @ 6 t ha⁻¹ and vermicompost prepared from mushroom spent substrate was applied @ 2 t ha⁻¹, which is equivalent to recommended dose of 30 hg N ha⁻¹. Among the different organic manures, urease activity was higher with FYM (41 mg of NH₄⁺ released g⁻¹ soil h⁻¹) and vermicompost prepared from mushroom spent (37 of NH₄⁺ released g⁻¹ soil h⁻¹) indicating continuous availability of nitrogen in organic manures treatments. Urease activity was significantly higher at flowering stage of groundnut (30 DAS). Absolute control (26 mg of NH₄⁺ released g⁻¹ soil h⁻¹) showed significantly lower urease activity and in turn lower nitrogen availability and growth of groundnut crop. It was observed that plant height (12 cm plant⁻¹), leaf area (185.5 cm² plant⁻¹) and dry matter production (25 g plant⁻¹) was significantly higher in organic manure treatments at 30 DAS compared to absolute control. The dehydrogenase activity at 30 DAS was significantly higher with vermicompost prepared from mushroom spent substrate, (78 kg of TPF produced g⁻¹ soil d⁻¹) and was followed by FYM (69 kg of TPF produced g⁻¹ soil d⁻¹). Dehydrogenase activity is related to microbial activity and in turn organic matter of the soil. The absolute control plot showed lower levels of dehydrogenase activity (978 kg of TPF produced g⁻¹ soil d⁻¹) compared to application of organic manures.



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Changes in Chemical Properties during Vermicomposting of Organic Residue as Influence by Earthworm Activity

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The investigation was undertaken to explore the suitability and potential use of earthworm (*Eudrilus eugineae*) for management of mango litter waste with animal waste, home waste, vegetable waste and paper waste combinations with the production of vermicompost during *rabi* season of 2011-12 under glasshouse condition at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. Experiment was laid out in completely randomized design comprising ten treatment combinations, replicated thrice. The homogenized sample from each experimental were collected with the help of auger at 30 days interval and analyzed to monitor the changes in nutrient content. It is evident from results that the significant increase in total nitrogen, phosphorus, potassium, micronutrients (Fe, Mn, Cu and Zn) and significant decrease in organic carbon, C:N ratio, E.C. with the use of earthworm *Eudrilus eugineae* is due to the vermic activity in laboratory conditions. Mango litter + Vegetable waste was found to be the best source for rapid composting (70 days) followed by Mango litter + Home waste (73 days). As far as the manorial value is concerned, Mango litter + Vegetable waste were found to be the best from the point of total phosphorus and micronutrients (Fe, Mn, Cu and Zn). Thus, vermicomposting is the best technology for the recycling of mango litter waste and production of good quality manure from different wastes by using earthworm (*Eudrilus eugineae*).



Biofortification of Speciality Corn with Zinc

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A field experiment entitled “Biofortification with zinc in Speciality corn” was conducted on sandy loam soils of Maize Research Center, Agricultural Research Institute, Rajendranagar during *khari*, 2013 to study the effect of zinc (Zn) nutrition in Speciality corn.

The experiment consisted of eighteen treatments *viz.*, combination of three types of Speciality corn [Pop corn, Sweet corn and Quality protein maize (QPM)] and six Zn levels [Zn₀: no Zn, Zn₁: 12.5 kg ZnSO₄ ha⁻¹ as soil application, Zn₂: 25 kg ZnSO₄ ha⁻¹ as soil application, Zn₃: Zn₁ + 2 foliar sprays at tasseling and milking stage, Zn₄: Zn₂ + 2 foliar sprays at tasseling and milking stage, Zn₅: 2 Foliar sprays at tasseling and milking stage. A fertilizer dose of 180 kg N, 60 kg P₂O₅ and 50 kg K₂O ha⁻¹ was commonly applied to all the treatments, which were replicated thrice in a randomized block design.

The results revealed that three different types of corn and zinc levels significantly influenced the growth parameters like plant height, LAI, dry matter production and yield attributes like cob number, no. of grains per cob, cob girth and yield. Maximum values were registered with 25 kg ZnSO₄ ha⁻¹ along with two foliar sprays i.e at tasseling and milking stage. Sweet corn registered significantly higher number of cobs, longer cobs and maximum cob girth compared to QPM and Pop corn. Number of grain rows per cob of Pop corn was superior to QPM and Sweet corn. Number of grains per row of QPM was significantly superior over Pop corn and Sweet corn. Green cob yield of Sweet corn was significantly high and highest and lowest grain yields were recorded with QPM and Pop corn respectively. Likewise Sweet corn produced maximum green fodder yield compared to stover yield of QPM and Pop corn.

Nutrient uptake (N, P and K) by stover was maximum in QPM and in higher dose of ZnSO₄ (25 kg ha⁻¹ as soil + 2 foliar sprays) whereas nutrient uptake by grain was maximum in Sweet corn. Higher Zn uptake and Zn concentration in plant (leaves) was noticed with QPM and in case of grain, Zn uptake is more with Sweet corn and Zn content in QPM. Zinc fortification was maximum (Zn content and Zn uptake) with 25 kg ZnSO₄ ha⁻¹ along with 2 foliar sprays at tasseling and milking stage (Zn₄) both in plant (leaves) and grain.



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Effect of Chromium Toxicity on Soil Microbial Activity

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Heavy metal pollution in soil is one of the emerging problems in and around the urban industrial cities of India. Among the heavy metals, chromium (Cr) is a highly toxic, mobile and an important environmental contaminant, which exists in soil environments, natural water, and other geological and biological systems in two different stable oxidation states Cr (III) which is non toxic to plant while Cr (VI) is highly mobile in soil and aqueous solutions. It is released into the groundwater, soil and sediments because of extensive use of its salts in industries like tannery, metallurgy, dye and pigment, wood preservative, refractory material, catalysts, metal polish, plating and metallurgical industries etc. Farmers are using unknowingly this effluent water for irrigation. This is an alarming situation in India where untreated wastewater is extensively used for irrigation or is disposed off in water resources. The tannery effluents contain high concentration of Cr. Its toxicity affects biological and biochemical properties of soil that are most closely related to nutrient cycles, including soil respiration, microbial biomass, nitrogen mineralization capacity and the activities of soil enzymes and are useful for detecting the deterioration of soil quality. Keeping these in view a laboratory experiment was conducted to study the effect of Cr on carbon mineralization and microbial activity in soil. Graded doses of Cr (0, 5, 10, 15, 20, 40, 80 and 100 ppm) through $K_2Cr_2O_7$ were applied to 100 g soil, and CO_2 evaluation as well as enzymatic activities (dehydrogenase activity, alkaline phosphate and fluorescein diacetate) was measured up to 45 days. Increasing concentration of Cr (0 to 100 ppm) reduced the cumulative CO_2 evolution from 354.2 to 122.47 mg CO_2 / 100 g soil up to 45 days. Preliminary results, showed that increasing concentration of Cr (0 to 100 ppm) reduced the dehydrogenase activity (40%), alkaline phosphatase (56%) and fluorescein diacetate (41%) over control. The inhibitory effect of Cr on soil enzymatic activity was significant beyond 20 ppm.



Impact of Organic Farming on Soil Properties and Nutrient Removal by Maize-Onion Cropping System

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A study is in progress since *kharif*, 2003 at the College of Agriculture, Rajendranagar to evaluate the impact of organic farming practices in comparison to chemical farming practices on soil quality, yield, and quality of crops in a maize-onion cropping system. The experiment had seven treatments, *viz.*, a pure organic treatments wherein the entire RDF was supplied through vermicompost (33%), FYM (33%) and neem cake (33%) on N equivalent basis and organics along with biofertilizers like *Azotobacter* and PSB, Organic nutrient management coupled with agronomic management practices, an integrated treatment 50% FYM + 50% chemical fertilizers and a pure inorganic treatment where the entire recommended dose of nutrients were supplied through mineral fertilizers. In all the organic treatments, a significant decrease in bulk density was noticed when compared to initial bulk density of 1.43 Mg m⁻³ and inorganic fertilizers only treatment (1.34 Mg m⁻³). Available water content of the soil was higher with organic nutrition treatments. The mean content of organic carbon over 10 years was 0.68%, 0.58% and 0.52% with organic, integrated and chemical treatments when compared to initial status (0.36%). Improvement in organic carbon with organic nutrient management was 77-89% when compared to initial status. When compared to conventional inorganic nutrient management, integrated nutrient management had 11.8% higher organic carbon and organic nutrient management had 22.6 to 30.9% higher organic carbon. Available nitrogen was not influenced by nutrient management practices. Build up of available phosphorus was observed over the ten year period by 38% in chemical farming and 43 to 63% under different organic nutrient management practices. Available potassium also registered an increase of 8.0% with application of fertilizes alone and 16.2 to 43.1% with various organic nutrient management practices. Considerable differences in dehydrogenase activity were observed with different nutrient management practices. Activities of dehydrogenase and alkaline phosphatase were highest in treatment where bio-fertilizers, *viz.*, *Azospirillum* and PSB were applied together with organic sources of nutrients. Nutrient management through chemical fertilizers recorded lowest dehydrogenase activity. Highest activity of acid phosphatase was noticed in treatment wherein along with organic nutrient management agronomic practices like incorporation of weeds were practiced. Average nutrient removal by the system at the end of 10th crop cycle was less in organic treatments when compared to INM and fertilizer treatments.



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Effect of Long-term Fertilizers and Manure Application on Microbial Biomass and Microbial Activity in Jute-Rice-Wheat System

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Impacts of 42 years fertilizers and manure application on some aspects of soil quality were investigated in a jute-rice-wheat system. The treatments included 50% NPK, 100% NPK, 150% NPK, 100% NP, 100% N, 100% NPK+FYM, and control. Application of FYM plus NPK fertilizer significantly increased SOC (5.6 g kg⁻¹ to 8.90 g kg⁻¹), microbial biomass carbon (221 to 435 mg kg⁻¹) and microbial quotient (3.95 to 4.89). Soil dehydrogenase, phosphatase and fluorescein diacetate hydrolyzing activities were also increased by FYM application. Acid phosphatase activity (139 to 275 µg PNP g⁻¹ h⁻¹) was found to be much lower than alkali phosphatase activity (479 to 616 µg PNP g⁻¹ h⁻¹). The enzymes assayed showed significant correlation with build up of microbial-C and organic C. The multifaceted effects of integrated nutrient management (NPK+FYM) that result in beneficial soil conditions were reflected in terms of significant increase in fibre yield of jute, and grain yield of rice and wheat even over 100% NPK. In conclusion, long term application of integrated use of organic and inorganic supplements helped in accumulation of organic matter, which in turn had substantial effect on soil biological indicators.



Effect of Copper Contamination on Soil Biochemical Activity and Performance of Green Gram (*Vigna radiata* (L.))

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The objective of this study was to determine the effect of soil contamination with $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ in different concentrations (0, 50, 100, 150, 200 and 250 mg kg^{-1} soil) on the activity of soil enzymes (dehydrogenases, urease, acid and alkaline phosphatase) and microbial properties. A pot culture experiment was carried out in red sandy loam soils with green gram cultivation. The plant samples were analyzed 45 days after sowing and recorded yield at harvest. The results indicated that low level of copper concentrations (50 mg kg^{-1}) showed a significant increase in the number of nodules per root, dry matter yield and nutrient content, while higher concentrations (100 to 250 mg kg^{-1}) decreased the nodules, dry matter production and nutrient content of green gram. Soil contamination with copper had a negative effect on the yield of green gram. The enzyme activity in the soil samples was determined at 15, 30, 60 DAS and at harvest. The enzyme activities increased upto 30 DAS which later decreased at harvest. Soil contamination with $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ of 100, 150, 200 and 250 mg Cu kg^{-1} soil significantly inhibited the activity of dehydrogenases, urease, acid and alkaline phosphatases. The soil enzymes can be arranged in terms of their sensitivity to copper as follows: dehydrogenases > urease > alkaline phosphatase > acid phosphatase. Dehydrogenases and urease appeared to be better indicators of soil contamination with copper, as their activity was more strongly inhibited by copper than the activity of phosphatases.

Microbial activities such as respiration, rhizobial population, C and N mineralization, nitrification and biological nitrogen fixation can be measured to monitor heavy metal pollution. The rate of both N mineralization and nitrification are inhibited at around 100 to 250 mg Cu kg^{-1} soil. Copper also reduced rhizobial population but only at or above the soil concentrations of more than 250 mg kg^{-1} . A drastic decline in N_2 -fixation by rhizobium in association with green gram is observed in soil containing 100 mg Cu kg^{-1} soil. The microbial biomass C of 203.5 mg kg^{-1} observed in the control was decreased to 157.4, 151.8, 126.6 and 98.4 mg kg^{-1} due to copper applications of 100, 150, 200 and 250 mg Cu kg^{-1} . A marked decrease in the microbial biomass N was also found with increasing Cu concentrations. However, there was no significant change in biomass C/N ratio for all the Cu treatments. Copper is highly toxic to micro organisms if present in excess concentration which consequently changes soil biological equilibrium with adverse effect on both soil fertility, plant development and yield.



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***Bacillus aryabhatai* Inoculation Improves the Zinc Content of French Bean**

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Zinc is one of the essential elements required for the proper functioning of many enzymes and multiple biological functions, hence it is recommended in our daily intake in the range of 12-15 mg for men and women. Zinc deficiency in the human diet is an important nutritional problem, next only to iron deficiency. It is a well known fact that zinc is a critical plant nutrient, and its deficiency limits crop production, nutritional quality of the produce and human health. In this context, it is essential to find out methods to enhance the zinc concentrations in foods. The use of microbial inoculants to increase the availability of the native unavailable zinc through dissolution is a low cost, safe and eco-friendly approach. In view of this, the present study was initiated to identify efficient zinc solubilising bacteria from different horticultural ecosystems of Karnataka. Five rhizobacterial isolates were selected based on their zinc solubilization efficiencies, and evaluated for their ability to enhance the zinc content of French beans, an important leguminous vegetable in the Indian diet. Of the five isolates, *Bacillus aryabhatai* strain Bel 6 was found to enhance the zinc content in the biomass, green pods and seeds of French beans. Application of a carrier based formulation of *B. aryabhatai* at 15 kg ha⁻¹, significantly increased the Zn (22.4 ppm), Fe (209.8 ppm), Mn (43.2 ppm) and Cu (9.2 ppm) contents of the plant biomass, compared to the uninoculated control. The accumulation of micronutrients *viz.*, Zn (72.8ppm), Fe (86.3ppm), Mn (13.0 ppm), and Cu (6.2 ppm) in the green pod (before seed formation), was significantly higher in *B.aryabhatai* inoculated plants compared to uninoculated control. *B. aryabhatai* inoculation also enhanced the Zn content of French bean seeds by 23.9% compared to uninoculated control. It is therefore proposed that the inoculation of *B. aryabhatai* can be a viable alternative for the enhancement of the micronutrient contents of french beans.



Effect of Organics and Inorganic P on Acid and Alkaline Phosphatase Activity and Yield of Soybean (*Glycine max* L.) on a High P Alfisol

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A field experiment was conducted during *khariif*, 2012 in a sandy clay loam, high P Alfisol at college farm, College of agriculture, Rajendranagar, Hyderabad to study the response to P levels (0, 30 and 60 P₂O₅ ha⁻¹) either alone or in combination with PSB @ 5 kg ha⁻¹, biochar @ 5 t ha⁻¹, humicacid @ 20 kg ha⁻¹ and citricacid @ 10 mM on the acid and alkaline phosphatase activity in the rhizosphere soils and dry matter production at harvest stage of soybean. Alkaline phosphatase activity in the rhizosphere was higher as compared to acid phosphatase activity. Both the enzymes showed higher activity at flowering stage of soybean than at harvest. Mean acid and alkaline phosphatase activity decreased with increasing inorganic P levels and the activity of both the enzymes was significantly lower when inorganic P was applied @ 60 kg P₂O₅ ha⁻¹ in combination with organics, corresponding decrease was from 138.2 to 100.3 and 199.9 to 180.3 µg *p*-nitrophenol g⁻¹ soil h⁻¹ at flowering. Mean activity of both acid and alkaline phosphatases were higher with biochar in combination with inorganic P the values being 152.3 and 206.6 µg *p*-nitrophenol g⁻¹ soil h⁻¹ at flowering and 109.3 and 186.6 µg *p*-nitrophenol g⁻¹ soil h⁻¹ at harvest.

Significantly higher alkaline phosphatase activity was facilitated by biochar alone applied at 5 t ha⁻¹ both at flowering and at harvest with the corresponding activities of 221.5 and 199.4 µg *p*-nitrophenol g⁻¹ soil h⁻¹. Application of 60 kg P₂O₅ ha⁻¹ to soybean resulted in a significant reduction in acid phosphatase activity to 84.3 and 79.9 µg *p*-nitrophenol g⁻¹ soil h⁻¹ respectively at flowering and harvest as against the corresponding activities of 167.6 and 122.4 µg *p*-nitrophenol g⁻¹ soil h⁻¹ with biochar alone. Among all the organic treatments, biochar showed higher acid and alkaline phosphatase activity. Application of inorganic P in combination with organics showed a significant increase in mean seed yield of soybean from 1389 kg ha⁻¹ in the control to 1899 kg ha⁻¹ with 30 kg P₂O₅ ha⁻¹, there after it showed a decline. Mean seed yield of 2144 kg ha⁻¹ was obtained with biochar across the inorganic P levels, which was higher against all other combinations. Application of different organics integrated with inorganic P in terms of mean haulm yields followed the order; biochar > humicacid > no organics > PSB > citricacid. Among all the combinations tested, significantly higher seed and haulm yields of 2653 and 4008 kg ha⁻¹ were obtained with the application of 30 kg P₂O₅ ha⁻¹ combined with biochar.



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Effect of Long-Term Fertilization on Changes in Soil Enzyme Activity and Nutrient Fractions during Monsoon Fallow and Cropping Period with Hybrid Maize

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In TNAU, Coimbatore Long-Term Fertilizer Experiment (LTFE) is in progress since 1972, in which effect of continuous application of manures and fertilizers in a fixed cropping sequence of finger millet-maize is being studied. In order to evaluate the long-term effects of different fertilizer schedules adopted over the years in the LTFE on the soil properties, fertility status, enzyme activity and nutrient fractions studies were undertaken in monsoon fallow period followed by 101th crop of hybrid maize. There were ten treatments each replicated four times in randomized block design *viz.*, T₁ - 50% NPK, T₂ - 100% NPK, T₃ - 150% NPK, T₄ - 100% NPK+hand weeding, T₅ - 100% NPK+ZnSO₄, T₆ - 100% NP, T₇ - 100% N alone, T₈ - 100% NPK+FYM, T₉ - 100% NPK (-S) and T₁₀ - Absolute control. The results revealed that there was no significant change in pH and EC due to the different fertilizer schedules adopted over years. However, there was greater increase in the enzymes activity (acid phosphatase, alkaline phosphatase, urease and dehydrogenase) when manure was applied along with inorganic fertilizers. In monsoon fallow period, enzyme activity increased after the rain fall stage for the urease and dehydrogenase whereas acid and alkaline phosphatase activities recorded lower values after the rainfall stage. Available N, P and K status as well as build-up in organic carbon content of the soil increased significantly in 100% NPK+FYM treatment. Monsoon fallow period registered a higher level of all fractions of N, P and K except organic fractions which were found to be less affected by monsoon season. Integration of organics with inorganic had a complementary effect in improving all total nutrients and their fractions. Application of 100% optimal NPK along with 10 t FYM ha⁻¹ recorded the highest level of total N, P and K in soil. Continuous application of P fertilizers prevented the depletion and led to a marginal build up of total P except control and treatment receiving 100% N alone which registered lowest total P than the initial total P content. Continuous cropping and fertilization had a deleterious effect on total K level of soil except 100% NPK with FYM and 150% NPK treatments which could maintain the total K status of soil.

Among different treatments, the grain and straw yield as well as total uptake of N, P and K by maize were significantly higher in the treatment that received 100% NPK+FYM than inorganic fertilizer alone. An increase in grain yield of 12.62% was recorded in treatment receiving 100% NPK+FYM over application of 100% NPK alone. The apparent nutrient recovery and response ratio for N, P and K at harvest stage of maize was also found to be higher in treatment with 100% NPK along with FYM recording highest apparent nutrient recovery of 19.3, 11.3 and 67.3% for N, P and K, respectively.

The results emanated from this study clearly ascertain that the soil enzymatic activities were closely related with the C inputs and the enhanced levels of enzymes activity due to the conjoint use of manure and fertilizer which would have promoted the recycling of nutrients and transformation of added nutrients into different labile pools in continuous intensive cropping system. Further the present investigation stresses the vital importance of including organic manure in the fertilizer schedule for enhancing yield and maintaining the soil fertility in order to sustain soil productivity over a long run.



Microbial Diversity in Jute Retting Water

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Jute (*Corchorus* sp.) is one of the important commercial crops of Eastern India and West Bengal in particular. Retting, a bio-chemical process is the major post-harvest operation separates useful bast fibres (ligno-cellulose) from non-fibrous parts (mainly pectin, hemicellulose). So, retting liquor is a rich source of diversified micro-organisms that are able to degrade various components of jute plant. The main objective of the study was to assess the community level physiological profiles (CLPPs) and the functional diversity of the microbial population related to the jute retting using the standard microbiological methods as well as Biolog ECO plate for metabolic fingerprinting. Thirty four jute retting water samples were collected from five intensively jute growing districts of West Bengal. The study reveals that pectin and xylan degraders constitute major part of the total microbial load of jute retting water as evidenced by the bacterial count as well as by community analysis. An initial “LAG” phase was observed for first 24 hours of incubation followed by a sharp increase in D-galacturonic acid and D-xylose degradation, the building block of pectin and xylan respectively. The initial lag phase may be the result of time required for the increase in population up to 10^8 cells ml^{-1} . The bacterial strains then attack the lipid and wax components as evidenced by the degradation of tween 40 and tween 80, although the principal components of the community belongs to the polysaccharide degraders. Retting water samples from North 24 Parganas district were the most active compared to other districts. Around 30% of the total C-sources were utilized with partial utilization in 6 wells within 24 hours. About 90% of all the substrates were utilized in all the samples after 72-96 hours of incubation, indicating the fact that the microbial communities were active and able for another round of retting operation



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Evaluation of Carrier Based and Liquid Bioinoculants for their Comparative Performance in Soybean Grown on Vertisol

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Field experiment was conducted during 2013-14 at Research farm Department of Soil Science and Agricultural chemistry, VN Marathwada Krishi Vidyapeeth, Parbhani in soybean on Vertisol. The experimental soil was moderately alkaline in reaction, low in organic carbon, medium in N and P and high in available potassium. The treatments comprising inoculation with carrier based and liquid inoculants of *Bradyrhizobium* and *Bacillus megaterium* (PSB), Total eight treatments of bioinoculants were replicated six times in RBD. Seed treatment was done immediate before sowing with carrier based bioinoculants @ 25 g kg⁻¹ seed and liquid bioinoculants @ 6 mL kg⁻¹ seed. The crop was raised following recommended agronomic practices and appropriate procedures were adopted for soil and data analysis.

Number of nodules, fresh nodule weight and dry nodule weight of soybean at 60 DAS was recorded and found significantly influenced by N- fixing and P solubilizing bioinoculants. Maximum numbers of nodules were noted with liquid dual inoculation (*Rhizobium* + PSB) followed by *Rhizobium* alone and PSB alone but at par with their respective treatment applied with carrier based bioinoculants. Grain and straw yield of soybean was also significantly influenced by seed treatments of N-fixer and P solubilizing bioinoculants. Significantly higher grain and straw yield of soybean was recorded in dual inoculated treatment (*Rhizobium* + PSB) as compared to uninoculated control and RDF alone. Highest soil N and P availability after harvest of soybean was recorded with combine inoculation of *Rhizobium* and PSB to soybean followed by their single inoculation and this increase was noted significantly higher over uninoculated control and RDF alone. Soil microbial biomass carbon (SMBC), bacteria, actinomycetes and fungi were estimated from representative soil samples after harvest of soybean. Significant impact of bioinoculants alone or in combination in increasing SMBC, bacteria, actinomycetes and fungi as compared to uninoculated control and RDF alone.



Response of Mycorrhiza, Organic Sources, Secondary and Micro Nutrients on Soil Microbial Activities and Yield Performance of Colocasia in Alfisols

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Response of integrated use of mycorrhiza, inorganic and organic manures on microbial variables and yield performance of colocasia (*Colocasia esculenta* L.) was studied for two consecutive *kharif* seasons during 2011-13 in an acid Alfisol of Odisha. The experimental soil is sandy loam, acidic (pH 5.11), non saline, and having 3.4 g kg⁻¹ organic C, 0.056% total N, 142, 18.6 and 184 kg ha⁻¹ of available N, P and K, respectively. Significantly highest mean cormel yield (14.13 t ha⁻¹) was recorded due to application of 150% NPK. The yield response was highest due to application of K rather than N and P. Highest N use efficiency (126 kg cormels kg⁻¹ N) was observed due to integrated application of ZnSO₄ + lime + FYM + ½ NPK, whereas highest P use efficiency (182 kg tubers kg⁻¹ P) was noticed due to application of lime + FYM + ½ NPK. However, the K use efficiency was highest due to integrated application of lime + FYM + ½ NPK + ZnSO₄ (122 kg tubers kg⁻¹ K). Significantly highest dry matter (24.63%) and starch (18.53%, fresh weight basis) were recorded due to integrated application of lime + FYM + ½ NPK + MgSO₄.

Integrated application of lime + FYM + ½ NPK + ZnSO₄ has recorded highest dehydrogenase activity (2.048 µg TPF h⁻¹ g⁻¹) and fluorescein diacetate hydrolysis assay (1.855 µg g⁻¹ h⁻¹). Highest acid and alkaline phosphatase activities (77.67 and 51.18 µg PNP g⁻¹ h⁻¹, respectively) were observed due to inoculation of AM in combination with lime + FYM + ½ NPK. All the soil properties showed significant relationship with dehydrogenase activity of the soil and the 'r' values were found to be 0.68**, 0.83**, 0.92**, 0.80**, 0.67** and 0.86** in respect of pH, organic C, total N, available N, P, and K. Available P content of the soil had highly significant relationship with acid phosphatase activity (r = 0.88**) rather than alkaline phosphatase activity (r = 0.84**). Dehydrogenase activity showed highly significant relationship with cormel yield, starch, sugars and dry matter of colocasia and the 'r' values were found to be 0.95**, 0.88**, 0.88** and 0.85**, respectively. Acid phosphatase activity had highly significant relationship with cormel yield (r = 0.90**), starch (r = 0.89**) and dry matter (r = 0.84**). Dehydrogenase and phosphatase activities had highly significant relationship with cormel yield and bio-chemical constituents of colocasia. The study emphasized the conjunctive use of balanced inorganic fertilizers and organic manures to enhance the enzymatic activities and to realize higher crop yields of colocasia in acid Alfisols.



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Influence of Integration Bio-inoculation in Nutrient Management for Jute Crop Grown in Acid Alluvial Soil

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Field experiment was conducted in Kendrapada districts of Odisha to study the influence of integrated nutrient management practice on Jute crop grown in acid (pH_s 5.04) alluvial loam soil having organic carbon content of 6.9 g kg⁻¹ soil, available N of 309 kg ha⁻¹, Brays'1 available phosphorus of 14.3 kg ha⁻¹, ammonium acetate extractable K of 77 kg ha⁻¹ and 0.15% CaCl₂ extractable S of 11.8 kg ha⁻¹. The high yielding variety of Jute "Shrestha" had received eight (8) treatments, namely : (i) Absolute control, (2) Biofertilizers alone, (3) 100% NPK (STD), (4) STD + BF, (5) STD + PMS, (6) STD + PMS + BF, (7) 75 % STD + BF, (8) 75% STD + PMS + BF. The soil test based 100% NPK dose for jute crop was 80-18-50-26 kg N-P-K-S ha⁻¹ supplied through Navaratna (20-20-0-13), urea, MOP, respectively. The soil acidity in T₅, T₆, and T₈ was ameliorated by adding paper mill sludge @ 5 q ha⁻¹. The biofertilizer input for for the crop was consortia of micro-organisms like *Azotobactor*, *Azospirillum* and PSM, applied @ 4 kg each ha⁻¹, after inoculation to prelied (5%) vermicompost in 1 : 25 ratio, incubated for 7 days at 30% moisture and applied in the rhizosphere on the day of sowing of Jute seeds.

In response to the INM treatments, the fibre yield of jute varied between 8.4 and 45.7 q ha⁻¹, lowest due to absolute control and highest due to optimum dose of STD integrated with PMS and BF_s. Use of BF_s alone, or with STD or with STD+PMS increased fibre yield by 16,19 and 14 per cent compared to the yields without of BF_s of 8.4, 29.9 and 40.3 q ha⁻¹, respectively. Integrated use of BF_s narrowed down the fibre : stick ratio. The apparent recovery of N, P, K and S through jute crop increased from level of 35 to 72 per cent, 56 to 80 per cent, 128 to 209 per cent and 29 to 39 per cent, respectively under the influence of integrated use of lime and BF_s. The nutrient cycling through jute leaf litter varied significantly with the INM treatments. The fresh biomass of leaf litter addition ranged from 24-108.3 q ha⁻¹, the N addition ranged from 11.4 to 52.0 kg ha⁻¹, P from 2.8 to 11.5 kg ha⁻¹, K from 24.0 to 76.3 kg ha⁻¹, Ca from 8.2 to 31.8 kg ha⁻¹, Mg from 5.7 to 26.2 kg ha⁻¹, S from 1.8 to 5.8 kg ha⁻¹ and Na from 3.9 to 14.6 kg ha⁻¹ which were recycled and benefited the subsequent crop rice. There was considerable increase in organic carbon status in the post harvest soil through leaf litter addition.

The present study was concluded with the application of soil test based fertilizers after supplementation of deficient nutrients in soil, amelioration of acid soil with paper mill sludge @ 5qha⁻¹, integrated with di-azotrophs and PSM for a potential yield of 45.7 qha⁻¹ of jute crop.



Biodegradation of Xenobiotics Using Rhamnolipid Biosurfactant Produced by *Pseudomonas Aeruginosa*

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The prospective of bioremediation in the treatment of soils is one of latest technologies being adopted and *in-situ* bioremediation is attracting global attention due to its practicability and cost effective engineering and the techniques of biostimulation and Bioaugmentation which involves the addition of nutrients, native micro flora respectively are being adopted extensively. The native flora in the presence of nutrients can actively remediate the contaminated soils. Anthracene is a polycyclic aromatic hydrocarbon (PAH) which is also a xenobiotic, that presents a high pollution potential relative toxicity and health risk has been used as a model for degradation studies.

This study aimed to evaluate anthracene degradation by the addition of native micro flora which is acclimatized to anthracene in the presence of rhamnolipids produced by *Pseudomonas aeruginosa* and addition of nutrients. Lab-scale experiments were carried out in trays containing soils spiked with Anthracene. The growth of the cultures and % degradation of anthracene were assessed through out the study. The results showed that there is considerable degradation of anthracene in bioaugmentation when compared with biostimulation and natural attenuation. The decrease in TOC value to 80%, increase in biomass concentration and degradation in anthracene content in the treatment where rhamnolipids were added clearly indicates the role of biosurfactants in biodegradation.



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Assessment of Resilience of Inceptisols with Rice-Rice Cropping System

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Soil resilience is a key component of soil quality. We determined such resilience for Inceptisols supporting rice-rice cropping system. Twenty soil samples were collected from historical rice growing areas belonging to Harit series of Hooghly. Analyzing a large number of physical (bulk density, mechanical analysis), chemical (soil pH, cation exchange capacity, organic C, total N, available N, P and K, and DTPA extractable cationic micronutrients such as Zn, Cu, Fe, Mn) and biological [microbial biomass carbon (C_{mic}) and few enzymes such as dehydrogenase (DHA), fluorescein diacetate hydrolyzing (FDHA) and β -glucosidase assay] attributes, soil quality index (SQI) were computed for all the soils screening β -glucosidase, soil organic C, pH and bulk density as master indicators. Such soils with different SQI values were then used for pot experiments for three years with rice-rice cropping system imposing four management practices viz., T₁: keeping soils under natural fallow for recovery; T₂: fallow + rehabilitation measures with cocktail of treatments; T₃: rehabilitation measures with the cocktail of treatments along with cropping and T₄: farmers' practices for measuring soil resilience. Results showed that soils under natural fallow treatment had negative resilience index and thus failed to show any recovery of their lost functions; whereas soils with T₂ and T₃ treatments had positive values of resilience index recovering significantly their lost functions.



Inoculation Effect of *Bradyrhizobium* on Wheat (*Triticum aestivum* L.) Growth and Yield in a Vertisol

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The objective of this study was to determine inoculation effect on spring wheat (*Triticum aestivum* L.) yield with *Bradyrhizobium* under soybean-wheat cropping system in a Vertisol under recommended fertility levels and also to establish the effective soybean rhizobial cell counts in rhizosphere for next succeeding soybean crop. A field experiment on wheat Var. (GW 366) was conducted at Soil Science and Agricultural Chemistry research field, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in *rabi* season during 2013 in a Vertisol having pH 7.09, EC 0.18 dS m⁻¹, available N 213.24 kg ha⁻¹, P 16.21 kg ha⁻¹ and K 257.3 kg ha⁻¹. The experiment was laid out in Complete Randomized Block Design with eight treatments and four replications. The treatments were: (T₁)-Unfertilized Uninoculated (UFUI), (T₂)-Unfertilized Uninoculated (UFUI), (T₃)-Unfertilized Inoculated (UFI), (T₄)-Unfertilized Inoculated (UFI), (T₅)-RDF+ Uninoculated (RDF UI), (T₆)-RDF+ Uninoculated (RDF UI), (T₇)-RDF+ Inoculated (RDF I), and (T₈)-RDF+ Inoculated (RDF I), seed inoculation through soybean rhizobia (strain R-30). In this study, sequentially two treatments were same because it was planned to sow soybean as succeeding crop during *kharif* season with the following treatments taking into consideration the treatments under preceding wheat crop : T₁ UFUI (*rabi*) + UFUI (*kharif*), T₂ UFUI (*rabi*) + UFI (*kharif*), T₃ UFI (*rabi*) + UFUI (*kharif*), T₄ UFI (*rabi*) + UFI (*kharif*), T₅ RDF UI (*rabi*) + RDF UI (*kharif*), T₆ RDF UI (*rabi*) + RDF I (*kharif*), T₇ RDF I (*rabi*) + RDF UI (*kharif*) and T₈ RDF I (*rabi*) + RDF I (*kharif*). N, P and K were applied @ 120:60:40 kg ha⁻¹, as recommended dose to the fertilized plots.

For the purpose of interpretative of results of wheat mean of two similar treatments has been considered. Higher total chlorophyll content (4.95 mg g⁻¹), ear length (8.00 cm ear⁻¹), No. of effective tillers (3.55 hills⁻¹), grain yield (4996.8 kg ha⁻¹) and straw yield (7586.5 kg ha⁻¹) was found with the treatment where RDF was given used with *Bradyrhizobium* inoculation followed by RDF without inoculation. Minimum chlorophyll content (3.90 mg g⁻¹), ear length (6.35 cm ear⁻¹), No. of effective tillers hills⁻¹ (1.95), grain yield (2784.3 kg ha⁻¹) and straw yield (5309.3 kg ha⁻¹) was found under unfertilized and uninoculated treatment. *Rhizobium* is an important symbiont for legumes but it plays an important role as PGPR with non-legumes by colonizing their roots and producing growth hormones. So it is concluded that conjunctive application of RDF with seed inoculation through *Bradyrhizobium* in wheat is more beneficial with additional advantage of establishing soybean rhizobial population in soil for succeeding soybean crop.



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Impact of Zinc Solubilizing Microbial Isolates on Nutrient Availability, Enzymatic Activity in Soil and Yield of Bt Cotton Grown on Vertisol

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Field experiment was conducted during *kharif* season of 2013-14 at Research farm Department of Soil Science and Agricultural Chemistry, Vasant Rao Naik Marathwada Krishi Vidyapeeth, Parbhani on Vertisol to evaluate nutrient mobilizing activities, soil enzymatic activity and effect of these selected strains on yield of Bt cotton. Total eight treatments of microbial bioinoculants were replicated three times in RBD. Bioinoculants used were *Burkholderia cepacia*, *Burkholderia cenocepacia*, *Pseudomonas fluorescence*, *Pseudomonas striata*, *Trichoderma viridae*, *Trichoderma harzanium* and *Bacillus megaterium*. The fifteen days old Bt cotton seedlings already established in polythene bags were transplanted in field at specified spacing and a week later the liquid broth of isolates @ 1L /acre diluted in required quantity of water was applied through drenching. Five plants from each plot were tagged for observations. Seed cotton and dry matter yield was recorded picking wise and finally calculated as kg ha⁻¹. Soil samples were collected from root rhizosphere. Soil enzymatic activity and nutrient availability in soil were determined as per standard procedures. The results emerged out indicates that *Trichoderma viridae*, *Pseudomonas striata* and *Burkholderia cepacia* were better strains in increasing seed cotton yield, soil enzymatic activity (dehydrogenase, phospho monoesterases) and nutrient mobilization in Bt cotton grown soil. Significantly more increase in all the major nutrients were recorded in the treatment receiving *Trichoderma viridae*, *Pseudomonas striata* and *Burkholderia cepacia*. Among the microbial strains *Trichoderma viridae*, *Pseudomonas striata* and *Burkholderia cepacia* were found to increase soil available zinc and microbial population significantly over only fertilizer applied plots and numerically over other microbial strains. Enzymatic activity in soil was also significantly influenced by liquid bioinoculants. Significantly greater values of soil dehydrogenase were recorded in *Trichoderma viridae* and *Pseudomonas striata* treated plots which were at par which each other followed by *Burkholderia cepacia*. However, all treated plots showed significantly more values of soil dehydrogenase. Significantly higher values of alkaline phosphatase were also noted in treatments receiving *Trichoderma viridae*, *Pseudomonas striata* and *Burkholderia cepacia* and these were statistically at par with each other. *Trichoderma viridae* was found to increase soil acid phosphatase significantly over other strains but was found at par with *Pseudomonas striata* at 60 DAS, 90 DAS and at harvest.



Standardization of Method for the Assay of L-asparaginase in Soil

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The present experiment was conducted to standardize the method for the assay of L-asparaginase enzyme in soils. The L-asparaginase is the enzyme which converts amides present in soil organic matter into L-asparatic acid and subsequent release of ammonium ion making it available for crop growth. For the purpose of standardization, 5 Alfisols and 5 Vertisols with varying physicochemical properties were selected. These soils were incubated for different incubation periods ie (0 and 120 hours). At each incubation interval the amount of ammonium ion NH_4^+ released in soil was estimated by two methods i.e. Nessler's involving the colorimetric determination NH_4^+ released by measuring the light brownish color intensity at 436 nm and steam distillation method using MgO. Among these two methods Nessler's method resulted in higher amounts of NH_4^+ while steam distillation method using MgO recorded comparatively lesser amount of NH_4^+ at different periods of incubation. There was a positive and significant correlation at 2 hours between the two methods ($r= 0.989^{**}$). The amount of NH_4^+ released increased with the incubation time and reached maximum at 96 hours. From the results it could be observed that an incubation period of 2 hours with the substrate could be used as a standard method for the assay of enzyme L-asparaginase in soil. Based on the positive and significant correlation obtained with Nessler's method involving the colorimetric determination of NH_4^+ and steam distillation method using MgO, it was suggested that Nessler's method could be used as it has been to be simple highly sensitive and can be used for a wide range of soils.



Influence of Long-Term Nutrient Management Practices in Sorghum-Sunflower Cropping System on Enzyme Activity and Sorghum Performance in an Alfisol

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Impact of long-term continuous nutrient management practices in sorghum-sunflower cropping system on the enzyme activity and sorghum performance in an Alfisol was studied by monitoring the long-term fertilizer experiment in progress at the research farm of Directorate of Oilseeds Research, Hyderabad in its 15th cropping cycle. The soil is sandy loam in texture and at the initiation of the experiment (in 1999) was slightly alkaline in reaction and non saline. It was medium in OC, available N and P and high in available K. Treatments (12) consist of different combinations of nutrients and integrated nutrient management *viz.*, Control (0-0-0), 100% N (60-0-0), 100% NP (60-30-0), 100% NPK (60-30-30), 50% NPK (30-15-15), 150% NPK (90-45-45), 100% NPK+FYM (INM with 5 t FYM ha⁻¹), NPK+CR (INM with sunflower crop residues), NPK+S (gypsum in *rabi*), NPK+B (borax in *rabi* in alternate years), NPK+Zn (ZnO in *rabi*), NPK (S+B+Zn) in randomized block design with 3 replications.

Integrated nutrient management practice by applying FYM or crop residues along with optimum NPK fertilizers (*i.e.*, NPK+FYM and NPK+CR) increased the sorghum grain yield over application of only fertilizers (100% NPK). Sorghum yield increased with increasing NPK levels only up to 100% NPK but super optimal dose of fertilizers (150% NPK) did not increase the yield over optimum dose (100% NPK). Application of only nitrogen (100% N) resulted in reduced yields due to the imbalanced nutrient application. Additional application of phosphorus (100% NP) increased the yield over 100% N, while there was no significant yield increase with application of potassium, sulphur, boron or zinc. Application of phosphorus, potassium and zinc significantly increased their uptake by the crop but application of nitrogen or sulphur did not increase their uptake. The enzyme (urease, dehydrogenase and phosphatase) activity increased with the age of the crop till flowering stage and decreased at maturity. The highest enzyme activity was recorded with INM treatments at all the stages. INM increased the activity significantly over that in 100% NPK. The super optimal dose of fertilizer treatment (150% NPK) recorded lower activity of enzymes than INM treatments. Optimum balanced application of nutrients (100% NPK) resulted in higher enzyme activity than imbalanced fertilization (N, NP treatments). Application of FYM along with fertilizer NPK *i.e.*, integrated nutrient management using FYM (100% NPK+FYM @ 5 t ha⁻¹) proved the best for higher yields and better soil health for sorghum followed by INM with sunflower crop residues (100% NPK+CR). They improved the available nutrients and enzyme activity in the soil and resulted in higher nutrient uptake and crop yields over application of only fertilizers (100% NPK).



Enzyme Activities as an Index of Soil Fertility of Rice-Rice Cropping System in Vertisol

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The present experiment was undertaken to study the long term effects of integrated nutrient management practices of rice-rice production system in Vertisols on the enzyme activities in a flooded soil. The enzymes chosen for the study were urease, acid and alkaline phosphatase which have a bearing on the mineralization and transformation of organic nitrogen and phosphorus and dehydrogenase activity which is an indicator of biological activity of soil. This experiment was initiated during the year 1989. The treatments consisted of T1- Control (no fertilizer and manure), T2 - 100% NPK + Zn + S, T3 - 50% recommended dose (RDF) of NPK + 50% N through green manure, T4 - 50% RDF of NPK + 50% N through FYM, T5 - 50% RDF of NPK + 25% N through FYM + 25% N through Green manure, T6 - FYM @ 10 t ha⁻¹, T7 - 100% RDF of NPK + FYM @ 5 t/ha and T8 - 50% RDF of NPK + *Azospirillum* @ 2.5 kg/ha. Urease enzyme activity was assayed by determining the amount of ammonium liberated upon incubation with substrate. Acid and alkaline phosphatase was assayed by determining the amount of paranitrophenol released. Dehydrogenase activity was determined by measuring the amount of triphenyl formazon upon incubation with TTC. The results indicated that significantly lower activities of urease ($\mu\text{g of NH}_4^+\text{-N g}^{-1}\text{ soil } 2\text{h}^{-1}$), acid and alkaline phosphatase ($\mu\text{g p-nitrophenol g}^{-1}\text{ soil h}^{-1}$) and dehydrogenase ($\mu\text{g of TPF g}^{-1}\text{ soil day}^{-1}$) enzymes were noticed in the control which did not receive any of the fertilizer or manures (13.5, 120.6, 388.8 and 29.6, respectively). On the other hand the treatment receiving 100% NPK through inorganic fertilizers recorded significantly lower enzymatic activities (11.2, 119.1, 474.1 and 29.65, respectively) as compared to either integrated nutrient management practices (16.8, 122.2, 358.4 and 32.5, respectively) or the treatment receiving organic sources (14.6, 156.2, 448.5 and 30.75, respectively). An increase in the enzymatic activity with the application of either organic manures alone or in combination with 50% recommended dose of nitrogen could be attributed to increase the population of microbes due to increased availability of substrates through manures which in turn release extracellular enzymes into soil solution. An increase in dehydrogenase activity which could be attributed to increased root activity, microbial activities near the rhizosphere and availability of substrates through the decomposition of organic manures which could be seen in a significant increase in the organic carbon content of soils under these treatments. Hence it could be concluded that the treatment with 50% RDF of NPK + 50% N through various organic manure is found to be increasing and sustaining the yields but also improves soil properties particularly biological activities and enhancing the carbon status in soil for sustained productivity.



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Biofilms: Their Persistence in Soil

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Soil is considered to be a storehouse of microbial activity, though the space occupied by living organisms is estimated to be less than 5% of the total space. Soil samples were collected from the waste lands of *Parthenium* rhizosphere soils in college farm, Rajendranagar, Hyderabad and isolated different rhizobacteria namely *Bacillus subtilis* (7) isolates, *Pseudomonas fluorescens* (2) isolates and *Trichoderma viride* (1) isolate from soil by serial dilution and plate count method. *Rhizobium leguminosarum* (1) strain is collected from Biofertiliser unit, Agriculture Research Institute (ARI) Rajendranagar for the preparation of a biofilm. A biofilm is an aggregate of microorganisms in which cells are stuck to each other and/or to a surface. Plant-associated microorganisms fulfill important functions for plant growth and health. Such beneficial biofilms can be developed *in vitro* and be used as biofertilizers (Biofilmed Biofertilizers, BBs) and biocontrolling agents for different crops, when applied at high cell densities. The research studies conducted so far in this field with special attention into development of biofilms of N₂-fixing, P-solubilizing, and disease control bacteria and fungi. Four types of biofilms namely *B. subtilis* – *T. viride*, *P. fluorescense* – *T. viride*, *R. leguminosarum* – *T. viride* *B. subtilis* – *P. fluorescense* – *R. leguminosarum* – *T. viride* biofilms were prepared. The biofilms were characterized in terms of Protein estimation, NH₃ production, HCN Production, Siderophore production, IAA production, Phosphate solubilization, and Antagonism towards selected phyto-pathogenic fungi. Biofilm formation is a dynamic process involving quorum sensing for successful attachment and colonization. But the major problem associated with the success of microbial inoculants have been their colonization to roots and persistence in the soil. Regarding the persistence studies of biofilms in soil; the four types of biofilms were incubated in soil. Initial microbial populations were recorded. After 90 days of incubation, in *B. subtilis* – *T. viride* biofilms with 55% reduction in *Bacillus* population and around 51% decline in the counts of *Trichoderma*, in *P. fluorescense* – *T. viride* biofilms with 56% reduction in *Pseudomonas* population and around 49% decline in the counts of *Trichoderma*, in *R. leguminosarum* – *T. viride* biofilms with 73% reduction in *Bacillus* population and around 55% decline in the counts of *Trichoderma*, *B. subtilis* – *P. fluorescense* – *R. leguminosarum* – *T. viride* biofilms with 57% reduction in *Bacillus subtilis* population, 54% in *Pseudomonas* population, 59% reduction in *Rhizobium leguminosarum* population and around 55% decline in the counts of *Trichoderm*, respectively were recorded.



Release of Phosphorous and Potassium from Tri-calcium Phosphate and Waste Muscovite by P and K-solubilizers

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The present investigation entitled “*In-vitro* study on release of nutrients from insoluble minerals by P and K solubilizers” involved a laboratory study, which was conducted at the Soil Microbiology Laboratory, Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the year 2012-13. To study whether P-Solubilizer release phosphorus from tri-calcium phosphate and K-solubilizers release K from mica. Study focused on P and K solubilization potential of different bacterial isolates from tri-calcium phosphate and waste mica, respectively. To fulfil the objectives of the investigation five isolates of potassium solubilizing bacteria (KSB₁, KSB₁₁, KSB₁₃, KSB₁₆, KSB₃₀) and five isolates of phosphorus solubilizing bacteria (PSB₅₇, PSB₄₀, PSB₃₀, PSB₂₇, PSB₂₀) were used. Isolates were analyzed for their morphological characteristics (Colony characteristics, zone of solubilization, slime production, gram staining) and quantitative estimation (K-released from muscovite, P-released from tri-calcium phosphate), pH and electrical conductivity in broth culture. Data recorded on various aspects were statistically analysed using FCRD to draw the valid conclusion. All the bacterial isolates were gram positive and rod shaped. Zone of solubilization significantly increased with increase in incubation period. At 14 days, zone of solubilization increased >87% as compared to zone of solubilization at 7 DAI. At 7 DAI, colony diameter ranged from 1.12 to 1.43 cm and at 14 DAI, it varied from 1.35 to 1.82 cm. Mean solubilization index on Aleksandrov agar medium was in the range of 2.21 to 2.46. Release of P and K from tri-calcium phosphate and waste mica were significantly influenced by different bacterial isolates as well as different incubation. Maximum amount of K-release was recorded at 21 DAI (6.62 $\mu\text{g mL}^{-1}$). It was noticed that the isolates of KSB and PSB both solubilised K from waste muscovite. PSB₅₇ showed maximum and significantly more K-solubilization as 8.60 $\mu\text{g mL}^{-1}$ at 21 days of inoculation. Phosphorus released from tri-calcium phosphate was significantly influenced by DAI and different bacterial isolates. Higher amount of P release from broth was observed at 21 DAI (10.14 $\mu\text{g mL}^{-1}$) followed by 14 DAI (8.00 $\mu\text{g mL}^{-1}$) and minimum at 7 DAI (4.88 $\mu\text{g mL}^{-1}$). All the isolates showed lower pH value in comparison to un-inoculated control and the lower pH value was recorded with increase in incubation periods of Pikovskaya's as well as in Aleksandrov broth. EC of broth culture at 21 DAI increased with increasing incubation periods and it was significantly higher than EC at 7 and 14 DAI. However, EC caused due to PSB isolates was higher as compared to KSB. This needs further detail study about their potentiality as well as capacity to solubilize the potassium from muscovite and phosphorus from insoluble sources in *in vivo* condition.



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Addition of Organic Amendments Facilitates Microbes to Diminish Adverse Impact of Salinity in Soils Irrigated with Saline Water

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Soil microorganisms play an important role in transformation and recycling of organic matter and soil nutrients for plant growth. In addition, increased availability of organic substrates in saline soils was shown to reduce adverse effects of high salt concentrations on microbial activity. Therefore, ability of four different organic amendments varying in composition were investigated to strengthen microbial activity in saline soils (sandy clay loam) irrigated with saline water in an incubation study. Soil samples (0-30 cm) for the study were collected from an ongoing long-term field experiment on saline water irrigated soil at PAU farms since 2007 with three water treatments: 1) non-saline irrigation water (normal water); 2) saline water having electric conductivity (EC) 6 dS m⁻¹; and 3) EC 12 dS m⁻¹, respectively. For the incubation study, 4 finely ground organic amendments namely biochar, FYM, rice straw (RS) and glucose were added to 3 saline water irrigated soils at two rates i.e. @1% and at 2.5% C, respectively. In addition, one control treatment was kept where no organic amendment was added. Soil samples with and without added organic amendments were moistened to 60% water holding capacity and incubated at 25 °C to study soil respiration over a period of 8 weeks. Samples were destructively harvested at 1) two weeks; 2) at the end of the incubation period (8 weeks) and were analyzed for dissolved organic carbon (DOC) in different treatments. Cumulative respiration (CR) was negatively correlated with EC, irrespective of the source and amount of added C. Higher respiration values and DOC concentrations were found when organic substrates were added @ 2.5% C than at 1%. Among the organic amendments, decrease in cumulative respiration with increasing EC was greatest with glucose followed by rice straw > FYM > biochar. Although, glucose had most easily available form of carbon but less respiration rates may have been caused by nitrogen limitation to microbes. With biochar, low cumulative respiration rates suggest presence of more recalcitrant carbon. Further, DOC was positively correlated with salinity and at the end of incubation, DOC concentration increased in order: glucose > rice straw > biochar > FYM. With glucose, higher DOC concentration suggests that less of the added C was utilized by microbes, which is supported by the lower respiration. Therefore, availability of C from added organic amendments to saline soil determines the affect they will have on microbial activity. Moreover, biochar addition to saline soils comes as a viable option to sequester more C than rice straw and FYM.



Effect of Different Potassium Management Practices on Soil Microbial Activity and Nutrient Availability to a Rice Crop Grown on an Acid Soil

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In order to investigate the effect of different potassium management practices on soil microbial activity and nutrient availability, a *rabi* crop of rice cv. Lalat was grown on an acid soil of the Central Research Farm of Orissa University of Agriculture and Technology, Bhubaneswar. The experiment was laid out in RBD with three replications and nine treatments T₁: K₂O @ 40 kg ha⁻¹, T₂: 60 kg ha⁻¹, T₃: 80 kg ha⁻¹, T₄: K₂O @ 20 kg ha⁻¹+ straw @ 3 t ha⁻¹, T₅: K₂O @ 30 kg ha⁻¹+ straw @ 3 t ha⁻¹, T₆: K₂O @ 40 kg ha⁻¹+straw @ 3 t ha⁻¹, T₇: rice straw@ 3 t ha⁻¹, T₈: K₂O @ 40 kg ha⁻¹+ foliar spray @ 1% KNO₃, T₉: control. Field study of one season with rice crop showed mixed effect of K management practices on soil microbial activity. Increase in K level had positive impact on the bacteria population, dehydrogenase and urease activity and negative impact on fungi population. Phosphatase activity was not influenced by the K level. Similarly, straw incorporation positively influenced the bacteria and fungi population and improved the urease activity but had no effect on phosphatase activity.

K management practices did not have any significant influence on SOC content after one season of cropping. Increase in K application had positive effect on N and K availability but not on P availability. Application of K at 80 kg ha⁻¹ had negative impact on P availability. With increased dose of the K, the grain yield showed an increasing trend up to 60 kg ha⁻¹ or 30 kg ha⁻¹ and thereafter the trend was negative. Highest yield of 3.84 t ha⁻¹ was obtained in T₈ which received 40 kg ha⁻¹ along with foliar spray of 1% KNO₃.



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Impact of Cultivation of *Bt* Cotton on Soil Properties

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A study was carried out to understand the impact of cultivation of *Bt* cotton on soil properties by collecting geo-referenced soil samples from fields of farmers of Warangal district during *kharif* season of 2013. Sampling sites involved, 15 samples from fields under *Bt* cotton for more than 8 years, 12 samples from fields under *Bt* cotton for 2-5 years and 8 samples from non *Bt* cotton fields. Results clearly indicated that cultivation of *Bt* cotton either for prolonged period (> 8 years) or short term (2-5 years) did not bring out any significant change in soil pH, EC, CEC and organic carbon content when compared to non *Bt* cotton cultivation. Except available phosphorus, the availability of nitrogen, potassium, sulphur and micronutrients did not show significant changes. Available phosphorus status was found to be significantly high in soils under >8 years of *Bt* cotton.

Further, multiple years of cultivation of *Bt* cotton did not affect the functional bacterial population in rhizosphere soil. The population of total microbes, *Azotobacter* and *Pseudomonas* (PSB) remained statistically on par in both non *Bt* soils and in soils under *Bt* cotton soil for long time. With regard to soil enzymes, the activities of dehydrogenase and alkaline phosphatase were higher in soils under non *Bt* while urease activity higher in soils under *Bt* for long term. However, all these variations were insignificant and suggest that multiple years of *Bt* cotton cultivation pose little or no environmental risk.



Effect of Integrated Nutrient Management on Soil Enzyme Activity in Clusterbean (*Cyamopsis tetragonoloba* L. Taubert)

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A field experiment was conducted during *kharif* 2013, at college farm, College of Agriculture, Rajendranagar, Hyderabad to study the effect of integrated nutrient management on soil enzyme activity in clusterbean crop with 10 treatments *viz.*, T₁ (absolute control), T₂ (100% RDN through urea), T₃ (50% RDN through urea + 50% RDN through FYM), T₄ (50% RDN through urea + 25% RDN through FYM + *Rhizobium*), T₅ (50% RDN through urea + 25% RDN through FYM + *Rhizobium* + PSB), T₆ (100% RDN through FYM + PSB), T₇ (100% RDN through FYM + *Rhizobium* + PSB), T₈ (*Rhizobium* + PSB), T₉ (*Rhizobium*) and T₁₀ (PSB) in randomised block design with 3 replications. The soil enzyme activities *i.e.* dehydrogenase, urease, acid phosphatase and alkaline phosphatase were studied at three different growth stages *viz.*, vegetative, flowering, harvesting stages. The soil enzyme activities were increased with the age of the crop, attained highest activity at flowering stage and gradually decreased at harvesting stage. Soil dehydrogenase activity (8.75, 10.71, 9.02 mg of TPF produced g⁻¹ soil 24 h⁻¹ at vegetative, flowering and harvesting stages, respectively) and urease activity (65.5, 75.3, 59.1 µg of NH₄⁺-N released g⁻¹ soil 2h⁻¹ at vegetative, flowering and harvesting stages, respectively) were found highest with the application of 100% RDN through FYM + *Rhizobium* + PSB followed by 100% RDN through FYM + PSB. Significantly high acid phosphatase activity (31.8, 50.4, and 36.7 µg of p-nitrophenol released g⁻¹ soil h⁻¹ at vegetative, flowering and harvesting stages, respectively) was recorded with the application of 50% RDN through urea + 50% RDN through FYM followed by 100% RDN through FYM + *Rhizobium* + PSB and the values were on par with each other. Alkaline phosphatase activity (66.2, 89.3 and 72.3 µg of p-nitrophenol released g⁻¹ soil h⁻¹ at vegetative, flowering and harvesting stages, respectively) was found highest with 50% RDN through urea + 50% RDN through FYM. This improvement of soil biological activity with biofertilizers, organic manures along with chemical fertilizers suggests the importance of integrated nutrient management.



Physicochemical Properties of Compost during Vermicomposting of Rice Straw Inoculated with Lignocellulolytic Fungi

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Composting of rice straw can be a viable option against burning of rice straw. During composting decomposition of rice straw is slow under natural conditions because the high lignin content restricts the enzymatic and microbial access to cellulose in rice straw. Cellulose degrading microorganisms hasten the biodegradation of crop residues and such cultures have been used for composting. The recycling of rice straw through vermicomposting is also a desirable option. Therefore, an investigation was taken up to study the dynamics in physicochemical properties of rice straw compost during degradation with lignocellulolytic fungi (*Trichoderma viridis*) and *Eisenia foetida*. The rice straw was chopped and amended with animal dung (FYM) in the ratio 1:1 and kept for 2 weeks for thermal stabilization, initiation of microbial degradation and softening of waste. Six treatments comprising rice straw + cowdung (T₁), rice straw + cowdung + earthworms @1.25 kg q⁻¹ rice straw (T₂), rice straw + cowdung + earthworms + microorganisms (*Trichoderma viridis*) @ 30 g q⁻¹ (T₃), rice straw + cowdung + earthworms + micro-organism (*Trichoderma viridis*) @ 60g/q (T₄), paddy straw + cowdung + microrganisms (*Trichoderma viridis*) @30g/q (T₅) and paddy straw + cowdung + micro-organisms (*Trichoderma viridis*) @ 60 g q⁻¹ (T₆) were imposed in cemented rings (0.9 m diameter with 0.4 m height) at the farm of Department of Soil Science, Punjab Agricultural University, Ludhiana during January 2014 in completely randomized design. Moisture level in each ring was maintained around 80% throughout the study period. Periodic samples of compost at different intervals were collected and analyzed. Results of the study indicated that decomposition rate was faster in T₄ followed by T₃, T₆, T₂, T₅ and T₆. C:N ratio of compost ranged from 15.1-17.9, 16.5-20.1 and 22.4-25.7 under earthworm, fungi and control treatments respectively. Earthworms and *Trichoderma viridi* in combination has increased decomposition rate, more so @ 60 g q⁻¹ compared to all other treatments. The C:N ratio of the compost prepared with *Trichoderma viridi*, and *Esienia fetida* treatment was narrow indicating improved quality of the compost compared to control. Significant increase in total N was observed in compost prepared with *Esienia fetida*. Bulk density of the compost increased with days of composting. Maximum bulk density of the compost was 0.75, 0.68, 0.65, 0.53, 0.47 and 0.41 kg m⁻³ under T₄, T₃, T₆, T₂, T₅ and T₆, respectively at 95 days of composting.



Isolation of Native Phosphorus Solubilizing Bacteria From Alfisols and Exploitation of Potent Strain as Biofertilizer

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Phosphorus is the second most important growth limiting nutrient for crop and soil microorganism despite being abundant in soil in both organic and inorganic form. Acid soils are poor in available phosphorus owing to chemical fixation of applied soluble phosphates and is generally available in negligible amount for plant uptake. Different soil microorganisms have been reported to be active in solubilizing insoluble organic phosphates in higher efficiency.

A laboratory experiment was conducted in the Department of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar to isolate and characterize the most efficient native strain of phosphorus solubilizing bacteria from acid soils of Odisha. In all eight (8) nos. of rhizospheric soil samples were collected from five randomly selected acid soil regions of Mayurbhanj, Keonjar and Khordha district and indexed *viz.*, Baripada Sadar (BS₁ and BS₂), Shyamakhunta (SK₁ and SK₂), Keonjhar Sadar (KS), Jhumpura (Jh), Central Horticultural Research Station, OUAT, Bhubaneswar (O₁ and O₂). The soil samples were analyzed for soil physicochemical (pH, exchange acidity, exchangeable aluminium and organic carbon) and microbial parameters (total heterotrophic bacteria, actinomycetes, P-solubilizing bacteria and microbial biomass carbon). The collected soil samples showed a pH range of 4.47 to 4.99 with highest PSB population ($188 \times \text{CFU} \times 10^3 \text{ g}^{-1} \text{ soil}$) and microbial biomass carbon ($286.1 \mu\text{g of C g}^{-1} \text{ soil}$) in sample SK₁. However, sample Jh recorded the highest heterotrophic bacteria ($213 \times \text{CFU} \times 10^4 \text{ g}^{-1} \text{ soil}$) and actinomycetes population ($223 \times \text{CFU} \times 10^4 \text{ g}^{-1} \text{ soil}$).

The PSB isolates (23 nos.) were pure cultured and spot inoculated on NBRIP media to evaluate their phosphorus solubilizing efficiency. The isolate S₉ (sample SK₁) showed highest P-solubilizing efficiency (220.0%) with P-solubilization index (3.2). The chosen isolate S₉ was further subjected to biochemical and molecular characterization. Results showed that isolate S₉ was rod shaped, gram negative bacteria having cell dimension $862 \text{ nm} \times 543 \text{ nm}$.

Following Bergey's manual of Systemic Bacteriology and 16s rDNA amplification, the isolate S₉ was identified as *Burkholderia cepacia* (Gene bank accession no.- KM030037). Further, the antibiogram profile of isolate S₉ revealed broad spectrum resistance to antibiotics except Ciprofloxacin, Tetracycline and Chloramphenicol. The preferred P source for the identified strain was in the order $\text{Ca}_3(\text{PO}_4)_2 > \text{FePO}_4 > \text{Fe}_3(\text{PO}_4)_2 > \text{AlPO}_4$. It was functionally active within the pH range (4.5-7.0) with an optimum pH 6.0. The above criteria qualifies *Burkholderia cepacia* (KM030037) a superior candidate for biofertilizer capable of utilizing both organic and mineral P substrates to release absorbable phosphate ions for plants.



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Effect of Liquid Biofertilizers (*Bradyrhizobium* and PSB) on Growth and Yield of Soybean (*Glycine max* L.)

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A field experiment was conducted during the year 2013-14 at the research farm of Oil Seed Research Station on fine textured Vertisol of Latur. The recommended variety MAUS -81 of soybean was used for this experiment along with sixteen treatment combinations containing four levels of liquid *Bradyrhizobium* (0ml, 5ml, 10ml, and 15ml kg⁻¹ seed) and four levels of liquid PSB (0, 5, 10, and 15 kg⁻¹ seed). The experiment was conducted in factorial randomized block design with three replications.

The results obtained from this study revealed that the individual seed inoculation with 10 mL each of *Bradyrhizobium* and PSB recorded maximum plant height, number of branches, number of functional leaves and root length at all the critical growth stages of soybean followed by individual seed inoculation with 15 mL of both the biofertilizers. The beneficial effect of *Bradyrhizobium* and PSB on dry matter yield was observed due to seed inoculation with their 10 mL and 15 mL level at all the growth stages of soybean. Significantly higher number of pods and grains plant⁻¹ were observed with treatment 10 mL of *Bradyrhizobium* as well as PSB over rest of the treatments but they were at par with 15 mL of *Bradyrhizobium* and PSB. Significantly higher grain and straw yield were obtained due to individual seed inoculation with 10 mL of each *Bradyrhizobium* and PSB followed by the seed inoculation with 15 mL of both *Bradyrhizobium* and PSB. The increase in grain yield due to seed inoculation with 15 mL of *Bradyrhizobium* and PSB over control was 9.61 and 9.48 per cent, respectively.

Commission 2.4: Soil Mineralogy



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Clay Mineralogy and Elemental Composition of Black, Red and Red Laterite Soils in Semi Arid Tropical Region of Tamil Nadu

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The X-ray diffraction pattern of soil clay fraction of one red soil pedon from Maize Research Station, Vagarai of Dindigul district, one black soil pedon from Cotton Research Station, Veppanthatai (Perambalur District) and one red laterite soil from Dryland Agricultural Research Station, Chettinad of Sivaganga district of Tamil Nadu was carried out to distinguish the distribution of clay minerals and the mineral composition was assessed semiquantitatively. The black soil pedon revealed the dominance of smectite in association with small quantities of illite and kaolinite. The red soil pedon clay fraction was “mixed” with smectite, illite and kaolinite type of clay minerals. The dominant clay mineral was kaolinite with small quantities of illite in red laterite soils pedon. The chemical composition of soils exhibited the siliceous nature with broad and large silica/sesquioxides and silica/alumina ratios. The wider ratios of $\text{SiO}_2/\text{R}_2\text{O}_3$ and $\text{SiO}_2/\text{Al}_2\text{O}_3$ (4.64 to 5.61 and 5.75 to 6.94) were found in the black soils pedon followed by red soils pedon (4.55 to 5.01 and 7.78 to 9.64), respectively where smectite and illite were the dominant clay minerals. The narrow silica/sesquioxides and silica/alumina ratios (2.23 to 2.56 and 4.13 to 5.37) were found in red laterite soils where kaolinite was dominant clay mineral in semi arid tropical region of Tamil Nadu.

Commission 3.1: Soil Evaluation and Land Use Planning



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Evaluation of Different Soils and their Properties for Geomedicinal Values

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The relationship between geologic materials and human health has been known for centuries. Most of the elements present in the earth's crust are useful to human being. More than 2000 years ago Chinese texts describe 46 different minerals that were used for medicinal purposes. Indian Ancient Literature Vedas also describe use of soil as a medicine. In the present day context it is need of hour to co-relate the myths of use of soil as a medicine with sound scientific base. In Marathwada region of India there are many such places where the local residents use natural resources for disease and health management. Considering this knowledge of local people, it was thought to conduct scientific study on these soils so as to build data on basic soil properties that are enforcing the medicinal value. Hence, the investigation on "Evaluation of different soils and their properties for Geo-medicinal values" was conducted during the year 2011-12. Representative soil samples and to find out relationship between soil properties and medicinal parameters. Soil Physical and Physico-Chemical Properties studied were Soil Colour, Soil Structure, Soil Texture, Density, Electrical Conductivity, Organic Carbon, Free CaCO₃, Plant Available Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, DTPA extracted zinc, iron, copper and manganese, heavy and light minerals, special elemental analysis : Iodine (I), Arsenic (As), Selenium (Se) and Microorganisms like bacteria, fungi, actinomycetes. In all 12 different soils were collected. These are 1. Calcium Carbonate Rich Soil 2. Soil from Sulphur Deposits 3. Soil from *Lonar* Crater 4. Soil of *Gadhi* 5. *Multani* Soil 6. Soil from Ants' Living home 7. Red Soil 8. Soil from *Janwal* Butte 9. High Clay Soil 10. Forest Soil 11. Soil under Banyan Tree : 12. Normal Soil. The results showed that the physical properties of soil *viz.*, soil colour, soil texture, soil structure, bulk density, porosity was influenced due to nature of soil. Their study is essential to know the mineral makeup and influence of soil forming factors on soil genesis and nature of soil. Soils having higher pH *viz.*, soil from ant's living home used for washing of hairs due to presence of swell-shrink clay and sodium (high pH). Soils containing high organic matter is a resource for antibiotics. *Multani* soil contains lowest organic matter and high salt concentration, hence suitable for cosmetic industry. Due to presence of high calcium carbonate highly calcareous soil used for cloth washing. Depletion of nutrients specially N, P and K in cultivated soil may pose a problem of malnutrition. Calcium carbonate content rich soil contained low zinc and iron which is one of the reasons of prevalence of anemia in the region. Soil from sulphur deposits are used as a disinfectant due to its high content of sulphur. Cultivated soil showed low concentration of Iodine, Arsenic and Selenium and did not show consistency in results.



Characteristics, Classifications and Soil Site Suitability Evaluation of Sugarcane Growing Soils of Latur District (Maharashtra)

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The study area is located in Latur district, Maharashtra in between 17° 52' to 18° 50' N latitude and 76° 18' to 79° 12' E longitude. The geographical area of the district is 7157 sq. km. The climate of the area is hot, dry and sub-humid with annual rainfall of 794 mm. The mean maximum and minimum temperature are 32.7 °C and 18.1 °C, respectively. Nine (09) representative pedons from different physiographic unit of Latur district were characterized, classified and the soil site suitability was carried out.

The sugarcane growing soils of Latur district are shallow to very deep, black (10YR2.5/1) to yellowish brown (10YR 5/6) in colour, granular to angular blocky structure, clay loam to clay in texture (37.8 to 64.6 %). The bulk density of these soils varies from 1.31 to 1.84 Mg m⁻³, PAWC varies from 57.60 to 377.48 mm and saturated hydraulic conductivity varies from 4.12 to 19.4 cm hr⁻¹. The soils are slightly to moderately alkaline in nature (pH 7.25 to 8.53) the electrical conductivity less than 1dSm⁻¹. Low to moderate in organic carbon (0.24 to 0.76%) whereas low to high calcium carbonate content (0.5 to 15.5%) and high in cation exchange capacity (26.24 to 74.31cmol (P⁺) kg⁻¹). The calcium was the dominant cation followed by magnesium, sodium and potassium. The base saturation percent is >90 per cent. Taxonomically these soils are classified as Typic Ustorthents, Typic Haplustepts and Typic Haplusterts.

The yield of sugarcane varied from 72.0 to 130.5 t ha⁻¹. The maximum yield of sugarcane (122.6 to 130.5 t ha⁻¹) was recorded at Typic Haplusterts followed by Typic Haplustepts and Typic Ustorthents. The soil site suitability as per Sys *et.al* (1993) and FAO (1983) indicated that the Typic Haplusterts soils are highly suitable (S1) for sugarcane whereas Typic Haplusterts and Typic Ustorthent soils are moderately suitable (S2) for sugarcane. This indicated that Typic Haplusterts (Vertisols) soils are highly suitable (S1) for sugarcane followed by Typic Haplustepts (Inceptisols) and Typic Ustorthents (Entisols) in this area.



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Production Potential Appraisal of Soils in Banaganapalle Mandal of Kurnool District in Andhra Pradesh

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Plains (nearly level) and upland (very gentle sloping) topography, affected by erosion and moisture stress, is the unique feature of Banaganapalle region. Soils developed from dolomite and granite-gneiss parent material under varying land use were studied for their morphological characteristics, physical and physico-chemical properties. These soils were slightly alkaline to strongly alkaline in reaction, non-saline, deep to very deep in depth. Soils were low to medium in available nitrogen, medium to high in available phosphorus, low to high in available potassium and high in available sulphur. The DTPA extractable Zn and Fe were deficient whereas DTPA extractable Cu and Mn were sufficient. All the soils of the study area fall under agricultural land with land capability classes ranging from II to IV. Further, the lands have limitations of slope and erosion. Soil productivity and productive potentiality increased from plains to upland topography. Soil productivity class ranged from extremely poor or nil (13.38) to good (45.90) while the potential productivity of soil class ranged from average (29.16) to excellent (90.00). The Coefficient of improvement (Ci) varied from 1.85 to 3.92 indicating the implementation of judicious soil and water management practices suggested for the sustainable management of Banaganapalle mandal.



Soil-Site Suitability Evaluation for Commonly Growing Crops of Central and Eastern Parts of Prakasam District in Andhra Pradesh

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Seven typical pedons from Lakkavaram, Thalamalla, Surareddypalem, Kothavaripalem, Uppalapadu, Kandulur and Marlapudi villages from the central and eastern parts of Prakasam district, Andhra Pradesh were evaluated for their suitability to major crops *viz.*, rice, cotton, chickpea, tobacco and sorghum. The suitability classes ranged from highly suitable (S1) to permanently not suitable (N2) to these crops. Among the seven pedons studied, the pedons 2, 3, 5 and 7 were marginally suitable and pedons 1, 4 and 6 were permanently not suitable for rice. Pedons 1 and 3 were moderately suitable and pedons 2, 4, 5, 6 and 7 were marginally suitable for cotton. All the pedons (except 4) were marginally suitable for chickpea while pedon 4 was temporarily not suitable. Pedons 5 and 7 were marginally suitable for growing tobacco and the remaining five pedons were temporarily not suitable. Pedon 3 was highly suitable, pedons 1, 5, 6 and 7 were moderately suitable, pedon 2 was marginally suitable and pedon 4 is temporarily not suitable for growing sorghum crop. Shallow soil depth, wetness, low organic carbon and pH were limitations in all the pedons. High calcium carbonate content was a limitation in all the pedons except in P7. Heavy texture was limiting in all the pedons except P3 and P4. In addition, alkalinity was also a limiting factor in P5. The limitation levels of land characteristics varied from crop to crop. Suitable conservation and remedial measure were also suggested to improve the soil productivity on sustainable basis without deteriorating soil quality.



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Effect of Different Tree Species on Soil Properties in a Semi Arid Environment

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Block plantation (of one hectare) of five multipurpose tree species of arid and semi arid region viz. *Prosopis cineraria*, *Dalbergia sissoo*, *Acacia nilotica*, *Eucalyptus tereticornis* and *tamarix aphylla* of about 15-20 years old were selected for determining the physico-chemical properties of soil. Soil samples of the depth of 0-4, 4-15, 15-30, 30-60, 60-90, 90-120 and 120-150 cm were collected from the soils under each tree species and also from the soil which were devoid of trees. The physico-chemical properties of these soil samples were determined by adopting standard procedures. The organic carbon, pH, EC, bulk density, particle density and CaCO₃ content were decreased in control as well as under all tree plantations significantly with the increase in depth. In comparison to control, the pH, EC, bulk density and CaCO₃ content were lower in soils under all the tree species. The higher amount of organic carbon content in soils under tree plantations as compared to control may be the probable reason for this type of nature of physico-chemical properties.



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Evaluation of Nutritional Status of Northern Tahsils of Parbhani District by Soil Analysis

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A field survey was undertaken during the year 2013-14 in Jintur, Selu and Pathri tahsils of Parbhani district in order to study the physicochemical properties, status of available macronutrients and micronutrients in soil and relationship between physico-chemical characteristics and available nutrients in soil. In all 225 surface soil samples were collected from Jintur, Selu and Pathri tahsils and 15 villages have been selected from each tahsil and five representative surface soil samples (0-15cm) depth from each village were collected. These samples were analysed for their physicochemical, available N, P, K and S as well as available Fe, Mn, Zn and Cu status of soil. The data revealed that the soils of Jintur, Selu and Pathri tahsils of Parbhani district are normal to alkaline in soil reaction, within safe limit of electrical conductivity, low to medium organic carbon with non-calcareous to calcareous in nature. Thus, deficiencies of N, S and Zn are soil nutritional constraints observed in soils of Jintur, Selu and Pathri tahsils of Parbhani district.



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Evaluation of Contrasting Land Use Systems for their Effects on Soil Carbon Pools, Carbon Storage, Carbon stratification and Carbon Management Index

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Six contrasting land use systems including Eucalyptus, Oil Palm, Sugarcane, Fallow – Tobacco, Paddy – Tobacco and Green Manure (Sunhemp) Tobacco were evaluated for their effects on soil carbon (C) storage, stratification, C fractions and carbon management index (CMI). The total organic carbon (TOC) content was significantly greater in surface soil layer (0.00-0.15 m) under all the land use systems and showed a decreasing trend with increase in soil depth. The TOC in 0.00-0.05 m soil layer was maximum under Oil Palm (8.52 g kg⁻¹), while it was least in Fallow- Tobacco system (3.54 g kg⁻¹). The highest and lowest soil organic carbon storages were recorded in Eucalyptus system (34.77 Mg ha⁻¹) and the Fallow - Tobacco system (20.46 Mg ha⁻¹), respectively. The labile fraction of SOC also showed a decrease with increasing soil depth. The oil palm system that received organic manures showed relatively large quantity of labile carbon (C_L) (480 mg kg⁻¹) in surface soil (0.00-0.05 m). The CMI, an index of soil quality, was highest (71) under Eucalyptus system and lowest (35) in Fallow-Tobacco system at surface layer as compared to the forest soil as reference having CMI value of 100. Stratification ratio of TOC for Green manure (sunhemp) – Tobacco system has uniform values at all the depths, indicating that this system has maintained uniform TOC at all the depths. The lowest SOC storage as well as CMI observed for Fallow – Tobacco may be attributed to the fact that entire plant biomass (leaves, stems and roots) is generally taken off the field. This study demonstrates that the monocropping (i.e Fallow – Tobacco) of tobacco leads to a depletion of soil organic carbon and its quality, and hence calls for use of organics at liberal rates for sustaining the soil quality and production sustainability.



Natural Resource Management for Enhancing Crop Production in Drylands: A Case Study

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In Punjab the region called the “Kandi (submontane)” area occupies about 5.38 lakh ha and is about 10% of the total geographical area of the state. About 24% of the kandi area is rainfed and just 20% of the area has assured irrigation facilities. About 35-50% of the rainwater goes as runoff, which is ultimately lost to plains along with sediments and nutrients. The agricultural productivity in the region thus lags behind the rest of Punjab.

A project was undertaken to develop a micro-watershed model in 28 hectares of farmers land to demonstrate latest technologies of soil and water conservation at Dada village of Hoshiarpur with the financial support from Nawajbai Ratan Tata Trust. The objectives were to develop and demonstrate a runoff farming system on a micro-watershed basis for sustainable productivity, to demonstrate the soil and water conservation technologies to the farmers of the region and to test and refine the location-specific and low-cost indigenous technologies of soil and water conservation.

Various interventions include introduction of drought resistant crop varieties of maize and wheat, introduction of drought tolerant crops like gram, lentil, sesamum, linseed, moong, mash etc, in-situ moisture conservation practices and soil test based fertilizer application to different crops. The grain yield of maize was more than doubled with introduction of drought tolerant varieties of maize like JH3459 and PMH1. Application of fertilizers on soil test basis resulted in 18% increase in maize and wheat yields. Mulching was done with locally available lantana weeds, cannabis (bhang) and other weeds and it was observed that mulching increased grain yield of maize by 14.5%. The grain yield increased from 1.84 t ha⁻¹ to 1.93 t ha⁻¹ under mulched conditions. The residual effect of mulching also resulted in 4.7% higher yield of succeeding wheat as compared to un-mulched plots. The grain yield of wheat increased from 2.05 to 2.14 t ha⁻¹ under mulched conditions. Profile moisture storage was higher at 15-30 cm, 30-60 cm and 60-100 cm under mulched conditions as compared to un-mulched conditions. The yield of maize was higher by 10% under across the slope cultivation treatment as compared to along the slope cultivation. The grain yield of maize increased from 1.84 to 1.93 t ha⁻¹ in across the slope cultivation treatment. In case of wheat the yield was higher by 8.8% under across the slope cultivation treatment as compared to along the slope cultivation treatment. The grain yield of wheat increased from 2.05 to 2.23 t ha⁻¹ in across the slope cultivation treatment. Profile moisture storage was higher under across the slope cultivation treatment at all 0-15, 15-30, 30-60 and 60-100 cm depths. These interventions need to be promoted in holistic manner and their demonstrative effect may lead to more adaption of such technologies leading to efficient natural resource management.



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Preparation of GPS and GIS based Soil Fertility Maps of Angul District, Odisha

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Soil fertility maps of Angul district of odisha were prepared by using Global positioning system (GPS) and Geographical information system (GIS). Total 516 numbers of surface (0-15 cm) soil samples were collected from all the 8 blocks of Angul district using Garmin 76MAPCSx MAKE GPS instrument. These GPS based soil samples were analysed in the laboratory for texture, soil reaction, organic carbon, available nitrogen, available phosphorus, available potassium and available sulphur. The above soil characteristics were entered in attributed table and linked with the GIS software to develop a relational database. The analogue soil fertility maps on 1: 250000 scale were geo-referenced and digitized by using ArcGIS software. Thematic layer were developed for block boundaries to prepare the base map. Superimposing polygons (Spatial coverage) of block units and the base map, soil fertility maps were prepared. These maps were integrated in GIS to generate a composite database of GPS based soil of Angul district. These maps were divided in to 8 mapping units (8 blocks of Angul district) most of the soils of the district were found to be sandy loam in texture; acidic in reaction; low to high in soil organic carbon content; low in available nitrogen content. The mean available phosphorus content (Brays) was founded to be medium except Kishorenagar, Kaneha and Talchar blocks where it is low. The average available potassium content was founded to be medium to high; the average available sulphur content was sufficient in Talchar block where as in other blocks it is deficient to sufficient. Fertilizer recommendation for different crops grown in different blocks of Angul district has been suggested on the basis of soil test values.



Soil Resources of Bolangir Subdivision, Odisha - Their Interpretative Groupings and Suitability Evaluation for Different Crops

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Bolangir subdivision of Bolangir district, Odisha with 224949.1 ha area was selected for the present study, which is a part of Mahanadi basin and falls under AESR 12.1 i.e. hot moist sub-humid ESR with medium AWC and LGP of 180-210 days with mean annual rainfall of 1627mm. Reconnaissance soil survey of 1:50,000 scale was carried out with the base information obtained from Survey of India toposheets viz 64O/8;64P/2,5,6,9,10 and Satellite Imageries (IRS-P6 LISS III) and ASTERDEM of 30 m resolution. Soil map was prepared by studying its geomorphological units and used as the basis for soil classification and suitability evaluation for different agricultural crops. Soil orders identified in the district are Inceptisols, Alfisols and Vertisols which occupy about 31.2 per cent, 38.7 percent and 16.9 per cent area respectively while two suborders of Alfisols i.e. Haplustalfs and Rhodustalfs occupy 35.8 and 2.9 percent area respectively developed on three main geomorphological units viz. uplands, dissected and undulating plain and alluvial plain over the parent materials of Granite-Gneiss, Charnokite, Khondalite and Plutonic Anorthosite. Seventeen soil series have been identified and they are mapped in thirteen soil series associations. About 64.2 percent of TGA is slightly eroded followed by 22.6% area under moderate erosion. The dominant area is under moderately well drained soils (36.7%), followed by well drained soils in 25.5 % of TGA and somewhat excessively drained soils in 24.7 % of TGA. Moderate acidity is observed in 28.3 % soils of TGA, followed by 13.2 % area under moderately alkaline soils, while neutral soils cover about 40.4 % area. The soils are dominantly sandy loam surface texture (42.0% TGA) with low O.C % (69% TGA). Moisture availability of the soils as expressed through AWC values show that about 13.9 % soils have low (<50 mm/m) values showing acute moisture stress while medium (50-150 mm/m), high (150-200mm/m) and very high (200-250 mm/m) values are observed in 36.1%, 15.7% and 21.0% TGA respectively. The soil mapping units have been grouped into eight land capability subclasses viz. (IIIf, IIIIf, IIIIf, IIIIf, IVst, IVtf, IVwts, VIwst). The major soil problems are gravelliness, soil depth, poor soil fertility and imperfect drainage conditions. Depending on landform, climate and soil properties the soils are evaluated for suggested crop planning. The Banipalli soils are mainly forest covered and some deforested areas may be cultivated for maize, pigeon pea in *kharif* season. Soils of Madhyapali, Kutenai and Barhatika series are presently under rainfed paddy cultivation but have good potential for cultivation of maize, pulses, sesame and groundnut with irrigation facilities. Most of the soil series occurring in very gently sloping undulating plains viz Santika, Pipirda, Manhira are mainly cultivated for paddy, maize in *kharif* season but with proper soil and water conservation measures major cereal and vegetable crops can be grown in both *kharif* and *rabi* seasons. In Sakoma soil series occurring in very gently sloping plains, paddy in *kharif* season and oilseeds (groundnut and mustard) and pulses (green gram, black gram) etc can be successfully grown in *rabi* season with irrigation facilities.



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Spectral Signatures of Some Typical Vertisols of Vidarbha, Maharashtra

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The knowledge of spectral signature of soil is important for the analysis and interpretation of remote sensing data. Spectral signature of soil is defined by their reflectance or absorbance, as function of wavelength in the electromagnetic spectrum owing to variation in soil organic carbon, clay minerals, colour, iron oxides, anion and cations, moisture etc. The present paper describes the spectral signature of some Typical Vertisols of Vidarbha region of Maharashtra state. Four Vertisols pedon one each from Gondia in Bagargaon village (P1) (fine chromic Haplustert), Nagpur in Mendhe Pathar village (P2) (very-fine Leptic Haplustert), Yavatmal in Sarka village (P3) (fine chromic Haplustert) and Akola in Paral village (P4) (very-fine Sodic Haplustert) were characterized for their physical, chemical and spectral reflectance properties (350-2500 nm) in laboratory. Pedon P1 had its colour in hue 2.5Y, P2 in 10YR, P3 in 2.5 YR and P4 in 7.5 YR. These pedons have variable clay and fine clay in their control section but sub-soil of P3 possessed relatively higher proportion of silt than other pedons.

The spectral curves of all the soils indicated prominent absorption feature at 1400 and 1900 nm. Bagargaon soils showed relatively high reflectance because of lighter colour whereas soils of Mendhe Pathar, Paral and Sarka showed relatively low reflectance due to variation in their morphological, physical and chemical properties. In general, soil reflectance spectra of all horizons showed similar pattern of shape of curve indicating the presence of similar elemental composition and clay minerals in soil with depth except Bagargaon. Relatively broad absorption feature around 900 nm in soil of P3 pedon, indicating the dominance of iron oxides in soils and very strong absorption feature at 1900 nm but weak 1400 and 2200 nm indicating dominance of smectitic group of clay minerals in soils.

Commission 3.2: Soil and Water Conservation



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Influence of Different Moisture Regimes on the Yield and Water Expense Efficiency of Mungbean–Barley Cropping Sequence in South-West Region of Punjab

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A field experiment was carried out to find the effect of different levels of irrigation on the yield and yield attributing characteristics and water expense efficiency of mungbean-barley cropping pattern in loamy sand soil at Punjab Agricultural University, Regional Research Station, Bathinda from 2008-13. The experimental field was non saline and alkaline in reaction having EC 0.143 dS m⁻¹ and pH 8.4, organic carbon (0.35%), available phosphorus 12.4 kg ha⁻¹ and available potassium 394 kg ha⁻¹. The treatments consist of three levels of irrigation *viz.* optimum (I₁), sub optimum (I₂) and sub-sub optimum (I₃) corresponding to IW/CPE ratio of 0.7, 0.5 and 0.3 in barley; and 3, 2 and 1 irrigations in mungbean, respectively. During the years under experimentation, mungbean and barley was sown in the month of July and November in *kharif and rabi* season, respectively. The recommended package and practices of Punjab Agricultural University were followed for raising the crops. The results of the experiment revealed that during *kharif* season, irrigation regimes didn't differ in terms of mungbean yield. However, in *rabi* season, the maximum yield of barley (3717 kg ha⁻¹) was obtained in optimum level of irrigation whereas minimum was obtained in sub-sub optimum level of irrigation. The highest water expense efficiency was recorded in sub-sub optimum treatment in both mungbean and barley crop in the sequence. The organic carbon status of the soil also improved with mungbean-barley cropping system.



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Quantification and Economics in Reusage of Wastage of Water During Distilled Water Preparation

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Water is fuel for agriculture, urbanization, industrialization as well as research laboratories in particular soil science. Availability of good quality of water getting depleted day by day due to its over exploitation of ground water and polluting surface water bodies along with shortage of electricity. Now-a-days there will be great concern over saving and effective utilization of each drop of water and electric power among the scientific community. In general almost all scientific labs and in particular to soil science labs, instruments and its accessories huge amount of distilled water is required and experiments were incomplete without it. In this regard study was undertaken to assess water gets wasted during distilled water preparation by condensation process. Nearly 60 and 120 liters of good quality of tap water which is kept run and is being wasted for collection of one liter of distilled water, for this both single and double distillation unit of 1.5 liter/hour output with energy consumption of 1.5 kw electric energy was run and tested. In order to conserve water which to be wasted from condensation process, different methods were compared and economics was calculated. Among them installation of water sintex of 1000 liter capacity proved to be best not only by saving 0.8835 Rs/liter for distilled water preparation and also Rs 74450 for cooling hot water compared to heat exchanger instrument. It is economical, power saver and small labs can offered this technology.

Here, the problem seems to be very simple but just think how many laboratories in the country? and world? How much water gets wasted? How much energy, infrastructure invested to bring water to laboratory. This is our little effort made you to think scientific utilization of water. Hence, the dependency on water could be curtailed to the some extent.



The Potential of Rice-Lentil *Utera* Cropping in Rice-Fallows: Soil Moisture Utilization and Crop Productivity through Conservation

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Rice-lentil *utera* is gone down into oblivion cropping system in Gangetic alluvium of eastern India. Opportunity to utilize carry-over residual soil moisture to produce pulse crop in rice fallows was one of the basic and strategic research of this experiment. Soil drying pattern of short duration (110 days) rice-lentil *utera* was slower and sustained 10% higher soil moisture than long duration (140 days) rice-lentil at surface and subsurface soil layers. Late sown lentil faced soil drying during flowering to pod formation stage. Soil drying out period was reduced by keeping stubble height of 20 cm. Soil moisture depleted double in crops under long duration than the short duration. Lentil in 20 cm stubble cutting height retained 9, 11 and 12% more soil moisture at vegetative, flowering and pod formation stages, compared to 10 cm stubble height. Stress occurred when soil moisture content was <20% and the intensity of stress was more in long duration rice with 10 cm stubble cutting height. A total of 100 mm water was used for lentil cultivation in rice-lentil *utera* system. Lentil in short duration rice yielded 17% higher than lentil in long duration. Lentil in 20 cm cutting height of stubbles produced 17% higher yield and 19% more WUE than 10 cm cutting height. Broadcasting of lentil seed on 2nd to 3rd week of October (with short duration rice) produced 12-20% higher yield as compared to 21 days delay (with long duration rice).



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Categorization of Underground Water for Irrigation in Talwandi Sabo Block of Bathinda District, Punjab

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Punjab is one of the most intensively (190%) cultivated areas where 97% land is irrigated, in which 73% irrigation is given by ground water using tubewells. At present the state is facing a number of problems like soil salinity and alkalinity, waterlogging and scarcity of good quality ground water. Further increase in agricultural production can be achieved only by improving the productivity of marginal lands, bringing the barren lands under cultivation and through proper and optimal management of water resources. Knowledge about the ground water potential with respect to its quality parameters is essential, for this the present study was an attempt to evaluate the ground water quality of the Talwandi Sabo Block in Bathinda district of Punjab. Based on electrical conductivity (EC) and residual sodium carbonate (RSC) values suitability of water is categorized for irrigation purpose. To assess the potential for irrigation, 65 waters samples from different villages of Talwandi Sabo block were collected during the months of January to December in the year 2013. Based on EC only 26% water could be used without any possible risk of soil salinization except in case of high water table and clayey soils, which had an electrical conductivity of $< 2 \text{ dS m}^{-1}$. Further, 42% water was rated as marginal (EC, 2 to 4 dS m^{-1}) with regard to their suitability for irrigation and 32% water was not suitable for irrigation due to their higher electrical conductivity. On the basis of residual sodium carbonate (RSC), 62% water is safe (RSC, $< 2.5 \text{ me L}^{-1}$), 21% water is marginal (RSC, 2.5 to 5.0 me L^{-1}) and 17% water is unsafe for irrigation (RSC, $> 5.0 \text{ me L}^{-1}$). Taking into consideration both salt concentration and residual sodium carbonate, about 17% water was fit for irrigation purpose while 52% water was marginal, used for irrigation only after adopting recommended farm management practices and 31% water was unfit for irrigation.



Effect of Irrigation Scheduling on the Productivity and Water Use Efficiency of Oilseed Crops in Chambal Command

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In recent years, sulphur (S) deficiency has been aggravated in Indian soils due to tremendous increase in cropping intensity and adoption of cultivation of high yielding varieties. Use of S free high grade fertilizers is other important factor responsible to it. Oilseed crops have relatively higher S requirement owing to their high content of S containing amino acids and essential oils. In this view a field experiment was conducted during *kharif* season of 2008-09 to 2010-2011 at Morena. The experimental soil had sandy loam to clay loam in texture having 0.45% organic carbon, pH-7.5, KMnO_4 N-185 kg ha^{-1} , Olsen's P_2O_5 -19.5 kg ha^{-1} and 1N ammonium acetate extractable K_2O -382 kg ha^{-1} . The experiment was laid out in split plot design with four replications. The treatments were 2 irrigation schedule I_1 (40 DAS \pm 5) and I_2 (40 + 75 DAS \pm 5), 2 sulphur levels S_1 (30 kg ha^{-1}) and S_2 (40 kg ha^{-1}) and 3 oilseeds crop *i.e.* sunflower, mustard and safflower. The observations were recorded at their critical stages.

Yield components, WUE, production efficiency and S use efficiency of different oil seed crops were significantly enhanced by different irrigation schedules. The maximum seed yield per plant (77.97 g), test weight (35.91 g), production efficiency (15.25 $\text{kg ha}^{-1} \text{ day}^{-1}$) were registered with application of irrigation water at 40 and 75 DAS. However, higher WUE (110.75 kg/ha-cm) and S use efficiency (53.35 kg seed/ kg S) were observed under the application of irrigation water at 40 DAS. Application of 40 kg S ha^{-1} maintained significantly higher value of seed yield/plot, test weight, WUE, production efficiency and sulphur use efficiency over application of 30 kg S ha^{-1} . Among the oil seed crops, sunflower achieved significantly higher seed yield per plant (111.45 g). However, maximum test weight was recorded with safflower. Mustard crop found more suitable for recording maximum WUE, production efficiency and sulphur use efficiency over sunflower and safflower. Seed yield and straw yield were significantly improved due to irrigation schedules, S levels and oil seed crops. Significantly higher seed yield were noticed with the application of two irrigation at 40 and 75 DAS (1.89 t ha^{-1}), application of 40 kg ha^{-1} sulphur (1.84 t ha^{-1}) and mustard (2.15 t ha^{-1}). The economic analysis indicated that maximum gross returns, net returns, additional income and B:C ratio were achieved in treatment combination of two irrigation at 40 and 75 DAS + 40 kg S ha^{-1} + mustard crop.



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Water Management and Usage of Nallamada Drain Water – A Qualitative Assessment

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The Krishna Western Delta of Andhra Pradesh is drained naturally by 7 major natural drains, out of which Nallamada drain is very important feeder of agriculture, which falls in Guntur and Prakasam districts of Andhra Pradesh. Peak outflow in all the years was observed in the month of November. It was found that the total quantity of water flow in Nallamada drain in a year was 49 TMC, Out of which, only 6 TMC of water was used for all the lift irrigation schemes and for all the crops under Nallamada command in Krishna Western Delta. The remaining 43 TMC of quantity of water joins sea every year.

Collected monthly and annual discharges from Nallamada drain and water samples at fortnightly interval both from Nallamada drain above Kommamuru Canal, Nallamada drain below Kommamuru canal and Kommamuru canal (Appapuram Canal) for time series analysis and comparative studies. The water samples were analysed for the electrical conductivity and pH to study the suitability of Nallamada drain water for irrigating the crops. The electrical conductivity of Nallamada drain water below Kommamuru canal zone during cropping season is found well below 1.5 dS/m and during pre-monsoon season it ranges between 4 to 14 dS m⁻¹ from the year 2010-2013, which is due to back water flow from the sea to the drain till 21.2 km.

The pH of the drain and canal water remained almost constant falling in between 7-9 at any given point of time from the year 2010-2013 both above and below kommamuru canal zone. During 2009-10 to 2010-11, the farmers grew cotton, chillies, tobacco and maize due to availability of water from the lift irrigation scheme on Nallamada. But later on, the flows have increased, but flow is getting drained into sea at impulse rated due to high intensity rainfalls, which forced the farmers to diversify their cropping pattern by adding other crops like bengalgram, green gram, paddy, blackgram, soyabean, fodder jowar, white jowar and clusterbean, as a measure to combat the water and saline stresses on their cropping systems. The maize crop showed substantial tolerance against salinity of drain water used for irrigation. The quality analysis of Nallamada water and nearby canal (Kommamuru Canal) revealed that they can be planned for conjunctive use for getting assured irrigation with better quality throughout the season.

Commission 3.3: Soil Fertility and Plant Nutrition



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Influence of Organo Tank Silt on Nutrient Availability in Soil

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The addition of tank silt to the agricultural field is an age old practice and it is a good source of essential nutrient elements like K, Ca, Mg, S and certain micronutrients. The nutrient content of tank slit can be improved by blending with organic manures. Investigation was carried out at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal to evaluate the efficiency of tank silt with organic manures *viz.*, pressmud (PM), sewage sludge (SS), farmyard manure (FYM), water hyacinth compost (WHC), and spentwash (SW) etc., with remaining through fertilizer (RTF) and recommended dose of fertilizer (RDF) using bhendi as a test crop. The experimental soil was sandy loam in texture (*Fluventic Haplustept*), pH-7.56, EC-0.095 dS m⁻¹, Organic carbon-4.10 g kg⁻¹, CEC-20.70 cmol(p⁺)kg⁻¹, KMnO₄-N-212.7 kg ha⁻¹, Olsen-P 29.04 kg ha⁻¹, NH₄OAc-K-198.8 kg ha⁻¹. The tank slit used for the experiment contained 60.40% clay, CEC-47.15 cmol(p⁺)kg⁻¹, KMnO₄-N-186.4 05 mg kg⁻¹, Olsen-P-13.05 mg kg⁻¹ and NH₄OAc-K-555.4 mg kg⁻¹. The results revealed that the organic carbon and KMnO₄-N status of the soil was found to be higher (4.95 g kg⁻¹) and (200.5 kg ha⁻¹) in TS+SS+100%RDF treatment. Application of TS+PM+RTF recorded higher values of Olsen-P-(46.91 mg kg⁻¹), NH₄OAc-Ca (44.34 mg kg⁻¹) and NH₄OAc-Mg (23.53 mg kg⁻¹). Application of TS+PM registered higher values of NH₄OAc-K (218.2 kg ha⁻¹), whereas, blending tank slit with FYM had been found to enhance CaCl₂-S (47.50 mg kg⁻¹). Application of tank silt with organic manures increased the availability of nutrients in soil.



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Long-term Effect of Different Nutrient Management Practices for Maintenance of Soil Fertility and Crop Productivity of Alfisol under Dryland Condition in Karnataka

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A long term fertilizer experiment with finger millet-groundnut cropping system was carried out at AICRP for Dry Land Agriculture UAS, GKVK, Bangalore, India since 1978 in a randomized block design using inorganic (NPK) fertilizer, FYM and maize residues (MR). The effect of organic and inorganic fertilizer on soil nutrient status and yield of finger millet-groundnut under both rotation (from 1992) and monocropping (from 1978) system was studied. The nutrient status during 35th year (1978 to 2012) indicated that soil pH, OC, N, P₂O₅, K₂O, Ca, Mg and S were increased significantly in FYM @ 10 t ha⁻¹ or MR @ 5 t ha⁻¹ + 100% Rec. NPK (50:40:25) under both rotation and monocropping system. There was no significant difference in micronutrients availability (Fe, Mn, Cu and Zn) with application of organic and inorganic fertilizer but control plots had lower availability of micronutrients. The pooled data for 10 years of rotation with groundnut indicated that, the mean grain yield of finger millet was higher (3884 kg ha⁻¹) with FYM @ 10 t ha⁻¹ + Rec. NPK as compared to application of Rec. NPK alone (2517 kg ha⁻¹) or FYM + 50% Rec. NPK (3633 kg ha⁻¹). Under crop rotation with groundnut as compared to mono-cropping. The pooled data for 35 years under finger millet mono-cropping indicated that, the INM treatments viz; FYM @ 10 t ha⁻¹ or MR @ 5 t ha⁻¹ + 100% Rec. NPK continued to record higher grain yield (3195 & 3036 kg ha⁻¹, respectively), followed by a similar treatment with 50% Rec. NPK (2845 & 1972 kg ha⁻¹, respectively) as compared to application of 100% Rec. NPK alone (2051 & 1958 kg ha⁻¹ respectively). The INM treatment (FYM + Rec.. NPK) with mono-cropping (35 years) recorded higher Sustainability Yield Index (SYI-0.69) followed by a similar treatment (0.68) with rotation (10 years) Rec. NPK alone recorded lower SYI (0.34 & 0.33 respectively). A similar trend was observed with MR series also. Although grain yields were generally lower than FYM series. Application of inorganics fertilizers with FYM or Maize residues sustains the soil fertility and maintains the soil productivity of the system.



Nutrient Indexing of the Soils of District Jhabua

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Fertility survey of soil under soybean wheat cropping system of six development blocks of district Jhabua (namely-Jhabua, Thadala, Meghnagar, Ranapur and Petalabad) was conducted in 2011 to generate information about their nutrient status. The soils of the study area is sandy loam in texture. Soil samples were collected before soybean sowing and again after harvesting of soybean from 0-30 cm depth. Processed samples were analyzed for pH, Electrical conductivity, Organic Carbon, CaCO₃ Available N, P, K and S. The pH of soil ranged from 6.1-8.5 with a mean value of 7.3, Electrical conductivity range from 0.002-0.38 dsm⁻¹ with a mean value of 0.13 dsm⁻¹. Organic carbon range from 2.3-5.1 g kg⁻¹ with a mean value of 3 g kg⁻¹ and CaCO₃ range from 4-10 per cent with a mean value 7 per cent. The entire sample had low organic carbon status. The available N, P, K and S content of the soil varied from 90-250 kg ha⁻¹, 9-15 kg ha⁻¹, 150-500 kg ha⁻¹ and 7-14 ppm. Almost all the samples were low in available nitrogen whereas 96 per cent low to medium in available Phosphorus. The available potassium status of the soil was also high. About 80 per cent of the sample were low and rest is medium in available S. Crops grown on these soils are likely to suffer largely from deficiency of nitrogen and Sulphur. Correlation coefficient between available major nutrient and soil properties showed that organic carbon was positively correlated with available N whereas pH was significantly and positively correlated with K. Balance use of these nutrients is essential for realizing the full potential of the crops and also to obtain maximum profit from the use of costly inputs.



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Effect of Sulphur and Boron on Yield and Quality of Mustard (*Brassica juncea* L.) in an Eroded upland Vindhyan Soil

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Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm (*Elaeisguineensis* Jacq.). Among the seven edible oilseed cultivated in India, rapeseed-mustard (*Brassica spp.*) contributes 28.6% in the total production of oilseeds. It is the second most important edible oilseed after groundnut sharing 27.8% in the India's oilseed economy. The global production of rapeseed-mustard and its oil is around 38–42 and 12–14 mt, respectively. India contributes 28.3% and 19.8% in world acreage and production, respectively.

Brassica has the highest sulphur requirement owing to the presence of sulphur-rich glucosinolates. Similarly, boron also plays a vital role in cell wall synthesis, root elongation, glucose metabolism, nucleic acid synthesis, lignifications and tissue differentiation. Since meagre information is available on the effect of sulphur and boron in relation to response of oilseed crops coupled with wide spread deficiency of sulphur and boron, the present investigation was undertaken with the aim to study the effect of sulphur and boron on growth, yield and quality of mustard.

A field experiment was conducted during *Rabi* season of 2013-2014 taking Mustard (*Brassica juncea* L.) Var. Varuna as test crop. The initial soil had sandy loam texture, pH-6.1, EC-0.12 dSm⁻¹, organic C 4.8 g kg⁻¹, available S and B were 8.5 and 0.41 mg kg⁻¹, respectively. The experiment was laid out in randomized block design having seven treatments (T₁-control, T₂-RDF, T₃- RDF + 40 kg S ha⁻¹, T₄- RDF + 1 kg B ha⁻¹, T₅- RDF + 2 kg B ha⁻¹, T₆- RDF + 40 kg S + 1 kg B ha⁻¹ and T₇- RDF + 40 kg S + 2 kg B ha⁻¹) and three replications. The maximum seed yield (19.7 q ha⁻¹) was recorded in treatment T₇ (RDF +40 kg S ha⁻¹ + 2 kg B ha⁻¹) followed by T₆ (18.7 q ha⁻¹). Treatments T₇ and T₆ showed an increase of 34% and 27%, respectively over T₂ (RDF). The minimum seed yield (6 q ha⁻¹) was noticed in control (T₁) followed by 14.7 q ha⁻¹ in treatment T₂ (RDF).

The maximum oil content in seed (40.8 %) was observed in T₇ (RDF+40 kg S ha⁻¹+ 2 kg B ha⁻¹) followed by 38.8 % in T₆ (RDF + 40 kg S + 2 kg B ha⁻¹), which were 10 and 5 % higher than RDF, respectively. The minimum oil content in seed (32.3 %) was found in treatment T₁ (control). The maximum protein content in seed (24 %) was observed in T₇ (RDF+40 kg S ha⁻¹+ 2 kg B ha⁻¹) followed by 23.3 % in T₄ (RDF +1 kg B ha⁻¹), which were 10 and 6.8 % higher than RDF, respectively. The minimum protein content in seed (20.9 %) was found in treatment T₁ (control). Thus the application of 40 kg S and 2 kg B ha⁻¹ along with RDF is recommended for upland Vindhyan soils of Mirzapur.



Soil Phosphorus Dynamics as Influenced by Phosphorus Fertilization and Microbial Inoculants under Maize-Wheat Cropping System

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Phosphorus (P), an essential element, plays vital role in plant metabolism. However, it is often a limiting factor in crop production due to its low concentration and solubility. Therefore, understanding its distribution in different P fractions, and its modification consequent to P management options seems pertinent with respect to enhancing P use efficiency. The present investigation was, therefore, undertaken on a Typic Haplustept, to evaluate the interactive effect of different P application rates and microbial inoculants on soil P fractions, crop yields, P uptake and P use efficiency in maize-wheat cropping system. Twenty treatments were evaluated in a split plot design, comprising five P fertilizer rates *i.e.*, No P (control), 33% recommended P, 50% recommended P, 100% recommended P and 100% recommended P in 3-splits as main plot and four microbial inoculations; un-inoculated (control), arbuscular mycorrhiza (AM), P solubilizing bacteria (PSB) and AM+PSB as sub-plot in three replications.

The result shows that when averaged across fertilizer P and microbial inoculants, different inorganic P fractions were in the order: Ca-bound P > reductant P > Fe-bound P > Al-bound P > loosely-bound P. Increasing rates of P application resulted in an increase in all inorganic P fractions. Microbial inoculations, however, increased loosely-bound and organic P fractions only. Application of fertilizer P at recommended rate (26 kg ha⁻¹) increased the grain yield of maize by 16% and that of wheat by 31% over no P-control. Corresponding yield gain due to conjoint inoculation with AM and PSB, averaged over P rates, was around 14.5% in both crops. Total P uptake by maize and wheat also registered a significant increase due to fertilizer P as well as microbial inoculation. Dehydrogenase, alkaline and acid phosphatase activities studied at tasseling (maize), panicle emergence (wheat) and harvest (maize and wheat) showed an increase with microbial inoculation, the effect being more pronounced under AM+PSB treatment. Enzyme activities generally increased at lower P rates over no P, but showed a decrease thereafter with increasing P application rate. Performance of microbial inoculants in affecting soil P fractions, yield and uptake was in the order: AM+PSB > PSB > AM. Phosphorus use efficiency, measured as apparent recovery and agronomic efficiency, was highest in maize and wheat when the crops received 50% of recommended P along with AM+PSB inoculation. Results indicated beneficial effect of microbial inoculants, especially AM+PSB, on enhancing crop yields and P use efficiency provided these are used with curtailed P rates. The study suggested for evaluation of interactive effects of fertilizer P and inoculants in different soil types and cropping systems to explore the possibility of curtailing fertilizer P demand.



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Enhanced Use Efficiency Fertilizers Effect of Greenhouse Gas Emissions in Rice

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A field experiment was carried out during *kharif* 2013 at college farm, college of agriculture, Rajendranagar, ANGRAU, Hyderabad in India. The experiment was laid out in split plot design with two types of rice ecosystems i.e., puddle and aerobic as main plots and five treatments *viz*; T₁ – control i.e., without addition any fertilizer; T₂ – nitrogen in the form of prilled urea; T₃ –Neem coated urea (NCU); T₄ – Karanjin coated urea (KCU); T₅ – Vitex negundo leaf extract coated urea as sub plots. Nitrogen @ 120 kg ha⁻¹ was applied in all the treatments except T₁. Phosphorus and potassium were applied @ 60kg ha⁻¹ in all treatments. Rice variety MTU-1010 was raised with recommended management practices. The greenhouse gas emissions were monitored throughout the crop growth period by using closed static chamber (Hutchinson and Moister method). The results revealed drastic reduction in CH₄ emission in aerobic rice compared with puddle rice whereas nitrous oxide emissions increased under aerobic rice cultivation. Among the nitrification inhibitors Karanjin coated urea produced more methane followed by neem coated urea and Vitex negundo coated urea. Methane emission was reduced by 50 per cent in aerobic rice than that of puddle rice. Within each ecosystem the highest N₂O emission was observed in prilled urea applied plots followed by coated urea applied plots. The total N₂O emission during entire crop growth period was around 45% more than that of coated urea plots. The study also revealed that, coating of the urea with natural plant extract *viz*; neem, karnajin and vitex, enhanced fertilizer use efficiency and reduced the N₂O emission.



Influence of Cutting Schedule and Nutrient Management on Growth and Forage Yield of Oats (*Avena sativa* L.)

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A field experiment was conducted to study the response of forage oats (*Avena sativa* L.) to cutting schedule and nutrient management at instructional Farm, Junagadh Agricultural University, Junagadh during *rabi* seasons of 2006-07 and 2007-08 on a calcareous clayey soil. Sixteen treatment combinations comprising: two levels of cutting schedule (C_1 - One cut at 75 DAS and C_2 - Two cuts-one at 55 DAS and second at 90 DAS); Four levels of recommended dose of fertilizer D_1 - 50% D_2 -75%, D_3 -100% and D_4 - 125% RDF of 80:30 N:P₂O₅ kg ha⁻¹ and two levels of organic manure (0 and 15 t FYM ha⁻¹). The results indicated that the treatment of cutting schedule C_1 significantly produced taller plants, large number of tillers and leaves per plant than that of C_2 . Cutting schedule C_1 and C_2 recorded 119.65 and 84.57 cm plant height; 1.60 and 1.49 numbers of tillers per plant and 13.35 and 9.02 numbers of leaves per plant, respectively. Cutting schedule C_2 significantly produced 24.2 and 23.6 per cent higher green forage and dry fodder than that of C_1 , respectively. The application of 125% RDF (D_4) produced significantly taller plants, more number of tillers and leaves per plant, green forage and dry fodder yields over rest of fertilizer levels. The application of 125% RDF produced 19.35 and 23.57 per cent higher green forage and dry fodder yield, respectively, as compared to application of 50% RDF. The application of 15 t FYM ha⁻¹ (F_1) significantly increased the plant height and number of leaves per plant, green forage and dry fodder yields as compared to F_0 (without FYM). The application of 15 t FYM ha⁻¹ produced 11.07 per cent higher dry fodder yield as compared to control (without FYM). It is concluded from study that the crop should be cut two times (one at 55 DAS and second at 90 DAS) and should be fertilized with 125% RDF (100:40 N: P₂O₅ kg ha⁻¹) along with 15 t FYM ha⁻¹ for getting higher green forage and dry fodder yield of oats.



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Effect of Nitrogen and Sulphur Levels on Growth, Yield and Nutrient Uptake of Single Cross Hybrid Maize

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Experiment was conducted during Kharif, 2013 at College farm, college of Agriculture, Rajendranagar, Hyderabad to evaluate the effect of nitrogen and sulphur on growth, yield and nutrient uptake of maize. The soil of the experimental site was sandy loam in texture, neutral in reaction, low in organic carbon, available nitrogen, medium in available phosphorus and sulphur and high in available potassium. The experiment was carried out with two nitrogen levels (N_1 180 kg ha⁻¹, N_2 :225 kg ha⁻¹) as first factor or and five sulphur levels (S_0 : 0 kg ha⁻¹, S_1 : 20 kg ha⁻¹, S_2 : 40 kg ha⁻¹, S_3 : 60 kg ha⁻¹ and S_4 : 80 kg ha⁻¹) as second factor comprising ten treatment combinations were laid out in randomized block design with factorial concept replicated thrice. With respect to levels of nitrogen growth parameters like plant height, leaf area index (LAI), dry matter production per plant were improved significantly at harvest with N_2 (225 kg ha⁻¹). Grain and stover yield were recorded highest and significantly higher than N_1 . The increase in yield with increasing N levels due to beneficial effect of nitrogen on plant metabolism, which affects the plant physiological processes and also improving growth and yield attributes which ultimately increased the grain and stover yields. Significantly higher nutrient uptake and crude protein content in grain was observed with N_2 (225 kg ha⁻¹) than N_1 (180 kg ha⁻¹). Application of sulphur levels showed positive effect on growth and yield of maize. In case of growth parameters like plant height, leaf area index (LAI), dry matter production per plant were recorded highest with S_3 (60 kg ha⁻¹) and it was significantly higher than S_2 (40 kg ha⁻¹), S_1 (20 kg ha⁻¹) and S_0 (0 kg ha⁻¹) and it was on par with S_4 (80 kg ha⁻¹). With increasing the levels of sulphur the grain and stover yield increased upto S_3 (60 kg ha⁻¹) but the decreasing trend observed in S_4 (80 kg ha⁻¹). The per cent increase in grain yield was 8.2, 13.8, 23.2 and 20.6 and 20.6 with S_1 (20 kg ha⁻¹), S_2 (40 kg ha⁻¹), S_3 (60 kg ha⁻¹) and S_4 (80 kg ha⁻¹), respectively over S_0 (0 kg ha⁻¹). The stover yield, crude protein content and nutrient uptake in grain and stover at harvest improved significantly with S_3 (60 kg ha⁻¹) over others. With increasing levels of sulphur application upto S_3 (60 kg ha⁻¹) there was improved nutrient absorption, photosynthesis which resulted in increased yields of maize. Due to combined application of N and S there was improved the growth and yield attributes of maize and ultimately increased the grain and stover yield. Application of N and S @ 225 and 60 kg ha⁻¹ respectively recorded highest drymatter, grain and stover yield among other nitrogen and sulphur combinations but it was on par with N and S @ 225 and 80 kg ha⁻¹, respectively.



Fortification in Fingermillet for Enhanced Yield and Grain Quality

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Malnutrition and undernourishment are the major problems of Indian population and hence there is need for other sources of healthy food to overcome these problems. Now a days millets are becoming alternative sources of human food in India due to their nutrient rich grain. In Andhra Pradesh minor millets are cultivated in 4.75 lac ha area. Among millet crops fingermillet is an important food crop. The cultivated area of fingermillet is gradually increasing in Chittoor district of Andhra Pradesh. Even though it is minor millet, its grain has greater nutritional value when compared to rice and wheat. Besides this, application of important micronutrients such as zinc and iron to fingermillet crop helps to improve quality of food/value addition by fortification of grains and to overcome the imbalance of nutrients in produce. Keeping this in view, the present investigation was taken up during *kharif* 2013 with an objective of to find out the effect of zinc and iron on nutrient uptake, yield and quality of fingermillet. The experiment was conducted at Agricultural Research Station, Perumallapalle, Andhra Pradesh in randomized block design with 12 treatments and replicated thrice. Recommended dose of phosphorus (40 kg ha^{-1}) and potassium (30 kg ha^{-1}) were applied as basal. Nitrogen was applied as per treatments (100% RDN: 60 kg ha^{-1} and 150% RDN: 90 kg N ha^{-1}). Basal application of $\text{Zn SO}_4 @ 0.2\%$ were done at 30 and 45 days after planting. The results revealed that the highest grain yield (35.07 q ha^{-1}), was recorded with application of 100% RDN along with basal application of $\text{Zn SO}_4 @ 50\text{ kg ha}^{-1}$. The highest zinc and iron uptake by grain (584.2 and 84.3 mg kg^{-1} , respectively) was recorded with treatment consisting of 150% RDN + $\text{Zn SO}_4 @ 50\text{ kg ha}^{-1}$ + foliar spray of $\text{Fe SO}_4 @ 0.2\%$ at 30 and 45 days after planting. The recovery of zinc and iron with this treatment was 364.9 and 20.4 mg kg^{-1} over 100% RDF. The highest N uptake by grain (61.3 kg ha^{-1}) and protein content (8.42%) in grain was recorded in application of 15% RDN + foliar spray of $\text{Zn SO}_4 @ 0.5\%$ + foliar spray of $\text{Fe SO}_4 @ 0.2\%$ at 30 and 45 days after planting and it was at par with 150% RDN + $\text{Zn SO}_4 @ 50\text{ kg ha}^{-1}$ + foliar spray of $\text{Fe SO}_4 @ 0.2\%$ at 30 and 45 days after planting. The highest straw yield was recorded with 150% RDN + foliar spray of $\text{Fe SO}_4 @ 0.2\%$ at 30 and 45 days after planting. Application of 150% RDN + $\text{Zn SO}_4 @ 50\text{ kg ha}^{-1}$ (as basal) + foliar spray of $\text{Fe SO}_4 @ 0.2\%$ at 30 and 45 days after planting has resulted in increased fortification of grain with zinc and iron and found beneficial to increase nutrient quality of grain in finger millet crop.



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Effect of Integrated Nutrient Management on Crop Yield, Nutrient Uptake and Soil Nutrient Status in Maize (*Zea mays* L.)- Spinach (*Spinacia oleracea*) Cropping System

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The basic concept underlying the principles of integrated nutrient management (INM) is the maintenance and improvement of soil fertility for sustaining crop productivity (both quantity and quality wise) on a long-term basis. A field experiment was conducted on a sandy loam soil at College Farm, College of Agriculture, Rajendranagar, Hyderabad during rabi (maize) and summer (spinach) seasons of 2009-2010 with a view to study the effect of organic manures and inorganic fertilizers on yield, plant nutrient and soil available nutrient status in maize-spinach cropping system. During rabi, an experiment was laid out in randomized block design with 12 treatments, replicated thrice. Among the different combinations application of 75% RDF + 25% through vermicompost (VC) recorded significantly the highest grain and stover yield (52.38 and 60.77 q ha⁻¹, respectively) at harvest but, on par with 75% RDF + 25% through poultry manure (PM) and 75% RDF+25% through FYM. The spinach crop grown during summer responded favorably to the residual and cumulative treatments and the highest fresh leaf yield (14.68 t ha⁻¹) was recorded. Application of 75% RDF + 25% through VC, PM and FYM to the maize crop showed the highest uptake of N, P and K at vegetative, tasseling and at harvesting stages. The highest leaf yield and nutrient of N, P and K by spinach at harvest was in plots receiving 100% organic manures. The highest available N (240.3 kg ha⁻¹) and K₂O (335.8 kg ha⁻¹) in soil at the end of maize-spinach cropping system showed significantly highest values with 100% VC addition. Whereas available P₂O₅ (40.43 Kg ha⁻¹) was highest under 100% PM treated plots. The results of the experiment showed that the performance of maize and spinach crop improved significantly with integrated use of VC, PM or FYM and N fertilizers rather than only application of either recommended doses of fertilizer N or organic manures alone.



Nutrient Management in Rainfed Finger millet in *Melia azaderach* based Agri Silvi System

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A field experiment was conducted during *kharif*, 2013 at agroforestry research block, earlier Acharya N.G. Ranga Agricultural University campus, Rajendranagar, Hyderabad. The experiment was laid out in Randomized block design with three replications and nine treatments. The treatments comprised of sole application of manures and mineral fertilizers as well as integration of both manures, biofertilizers along with chemical fertilizers. The details of treatments are T1-FYM 10 t ha⁻¹; T2-100% RDF (40:20:20 NPK kg ha⁻¹); T3-75% RDN + 25 % N FYM; T4 -75% RDN + 25% N Vermicompost; T5 — 75% RDN + 25% N Poultry manure; T6-75% RDN + Azospirillum @ 5 kg ha⁻¹; T7-75% RDN + PSB @ 5 kg ha⁻¹; T8-75% RDN + Azospirillum + PSB @ 5 kg ha⁻¹ each and T9 sole crop without trees. The experimental soil was sandy loam texture with pH (7.57), EC (0.195 dS m⁻¹) and OC (0.75%). Pertaining to nutrient status, the soil was medium in available N, P (259.2, 40.85 kg ha⁻¹) and high in K (352.1 kg ha⁻¹). The highest grain (2681 kg ha⁻¹) resulted with sole crop on par with 75% RDN + 25% Poultry manure (2405 and 4733 kg ha⁻¹) and 100% RDF (2393 and 4745 kg ha⁻¹). The lowest grain (1583 kg ha⁻¹) and straw yield (3402 kg ha⁻¹) was found with control i.e. FYM 10 t ha⁻¹). Among the nutrient management practices, 75% RD N + 25% poultry manure and 100% RDF on par with sole crop significantly increased NPK content at harvest respectively over control. The NPK content in grain at harvest was found highest with integrated use of 75% RD N + 25% N poultry manure and 100% RDF on par with sole crop. The total NPK uptake by finger millet was significantly higher in sole crop without trees (76.94, 12.44, 148.50 kg ha⁻¹) than control (45.72, 6.95, 80.80 kg ha⁻¹). The soil OC content build up (0.88%) was found with conjoint use of 75% RD N and 25% N poultry manure which was on par with 100% RDF (0.87%) and sole crop (0.92%). Available N, P, K increased significantly in 75% RD N + 25% poultry manure (291.84, 39.04, 355.34 kg ha⁻¹) and 100% RDF (283.9, 38.72, 354.8 kg ha⁻¹) which was on par with sole crop (316.9, 37.76, 366.1 kg ha⁻¹) compared to control (213.3, 27.94, 322.6 kg ha⁻¹). Tree parameters (tree height, girth, canopy spread) and tree-crop interactions (per cent decrease in light penetration) were found to be non-significant with regard to nutrient management practices followed in finger millet crop. This indicate that inter crops can be grown successfully in young plantations of *Melia* tree species. Gross monetary returns (Rs.42,747 ha⁻¹), net monetary returns (Rs. 26,987 ha⁻¹) and B:C ratio (2.71) were highest with sole crop followed by 100% RDF and 75% RD N + 25% poultry manure compared to other treatment combinations. Finally it can be inferred that, among nutrient management practices tested, 75% RDN + 25% N poultry manure and 100% RDF in agri silvi culture system was better in realizing higher grain and straw yield, nutrient content and economic returns apart from sustaining organic carbon content and available nutrient status on sandy loam soils of Southern Telangana.



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Productivity of Soybean as Influenced by Integrated Nutrient and Agronomic Management in Subhumid Punjab

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Soybean (*Glycine max* (L.) Merr.) – Wheat [(*Triticum aestivum* (L.) emend Fibri & Paol.)] can prove as a viable diversified cropping system replacing the predominant rice-wheat. Soybean is a highly nutrient-exhaustive legume and requires higher amounts of nutrients than other legumes. Moreover, continuous imbalanced use of fertilizers also has deteriorated soil health. A healthy soil can sustain optimum productivity over the years with proper cropping patterns and integrated nutrient management. Other than added nutrients the response of any crop is also influenced by several eco-edaphic factors and management practices. Thus, the present investigation was designed to study the influence of integrated nutrient and some other agronomic management practices on growth, yield and nutrient uptake by soybean in subhumid Punjab. A field experiment was conducted at the research farm of KVK Langroya (District SBS Nagar) falling under subhumid region of Punjab. The results revealed that significant increase in the yield of soybean was observed with the application of FYM with NP or NPK over NP or NPK alone treatment. There was no significant increase in soybean yield with additional application of 30 kg N ha⁻¹ at pre-flowering or at pod initiation over the basal dose of NP applied at sowing. Use of 4 tonnes wheat straw mulch + 30 kg N, 60 kg P₂O₅ and 30 kg N, 60 kg P₂O₅ ha⁻¹ showed similar effect on seed yield of soybean. Conventional flat sowing and bed sowing of soybean were equally effective in influencing the soybean yield. Pre-emergence application of pendimethalin at 1.5 l ha⁻¹ along with one hand weeding at 40 days after sowing (DAS) and two hand weeding at 20 and 40 DAS were equally effective for weed control and in influencing the soybean yield. Significant improvement in the uptake of N, P and K by soybean occurred with the application of N, P, K, FYM, in different treatments, and with *Bradyrhizobium japonicum* treatment and sowing on beds. The inclusion of FYM in the fertilizer treatment resulted in maximum increase in the uptake of these nutrients. The available N and P of soil also increased but the changes in available K remained inconsistent with different growth factors. The organic carbon content of the soil increased in different treatments where FYM was applied.



Hardening of Tissue Culture Banana (var. Nendran) using Fortified Potting Mixture

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Tissue cultured banana plantlets has become an important planting material in banana (Var. Nendran) cultivation. Quite often these plantlets show secondary and micronutrient deficiencies immediately after planting in main field. Hence a research work has been carried out in College of Agriculture, Padannakkad, Kerala in completely randomized block design to study the effect of fortification of the potting mixture for tissue culture banana plants using calcium, magnesium, and sulphur along with boron as foliar spray. Observations were made two months after treatment imposition. The results showed that the application of these nutrients have positive effect on biometric characters of the plant in certain combinations. Fortification with 75 and 150 ppm calcium on the potting mixture and foliar sprays of boron as 0.25% and 0.5% solutions significantly increased plant height. Interactions of calcium with magnesium, calcium with sulphur, as well as magnesium with sulphur, and magnesium with boron had significant effects. The three factor interaction of magnesium, sulphur and boron was also significant. Magnesium application at the rate of 25 and 50 ppm increased the leaf number significantly. Calcium with magnesium, magnesium with sulphur, and calcium, sulphur and boron, as well as magnesium, sulphur and boron interactions were also found significant. Application of 0.25% and 0.5% boron as foliar spray significantly increased the leaf length and leaf breadth. Calcium with magnesium, calcium with sulphur, magnesium with sulphur, magnesium with boron, and magnesium, sulphur and boron interactions also significantly increased leaf length and leaf breadth.



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Zinc Requirement to Rice in High Phosphorus and Zinc Sufficient Soil

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An investigation was carried out at Radiotracer laboratory, Agricultural Research Institute, Rajendranagar during *khari*f, 2013-14 to determine the zinc requirement in high phosphorus soils with sufficient zinc status using rice as test crop under net house conditions. The experiment was conducted employing seven treatments of zinc (Zn1-0 (No application of Zn), Zn2- Soil application of 12.5 kg ZnSO₄ ha⁻¹, Zn5- Zn2+ 2 FS (Ist spray at 21 DAT & 2nd spray at P1 stage) of zinc Sulphate @ 2 gm l⁻¹, Zn6 – Zn3 + 2 FS & Zn7 – Only 2 FS of Zinc Sulphate @ 2 gm l⁻¹ (at 21 DAT and at P1 stage) and three levels of phosphorus (P1 = No. P application, P2 = 100% Recommended dose of P to crop (60 kg P₂O₅ ha⁻¹) and P3 = 70% Recommended dose of P to crop (Employed as thumb rule when soil available nutrient is high) to a high P-Zn sufficient soil (97kg P₂O₅+ and 1.02 mg kg⁻¹ soil). Application of phosphorus @100% RDP and 70% RDP resulted in similar grain and straw yield in high P soil over zinc treatments. The increment in the yield of rice grain was in the range of 6.96 to 10.81% due to P application in high P-Zn sufficient soil. Application of zinc @ 12.5 kg ZnSO₄ ha⁻¹ to soil was found to be beneficial to rice crop and helped in realizing 7% higher yield over control in spite of its DTPA-Zn is above critical limit of 0.6 mg kg⁻¹ soil in this high P-Zn sufficient soil. Application of other zinc treatment to soil alone or in conjunction with foliar sprays were not found to be superior to influence yield of rice in this soil. Application of 12.5 kg ZnSO₄ha⁻¹ to soil helps in maintaining relatively higher levels of N,K,S and Fe in plant without any antagonistic relations with Zn or P to realize good yields.



Phosphorus Requirement and Its Use efficiency in Rice-Rice Cropping System on P Accumulated Soils

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A field experiment was conducted continuously for four years from 2010-2013 at College Farm, College of Agriculture, Rajendranagar in P accumulated soil to study the phosphorus requirement and its use efficiency in rice-rice cropping system using ^{32}P radioisotope. The four years mean data indicated that the highest dry matter yield, P content and P uptake at maximum tillering were observed when 75 & 50% RDP was applied both in *kharif* and *rabi*. Significantly higher grain yields of rice were also observed at 50 & 75% RDP in soil with accumulated P indicating 25 to 50% saving in P fertilizer application when rice was raised in sequence during *kharif* and *rabi*. Thus in the total cropping system 30kg P_2O_5 can be reduced out of total requirement of 60kg $\text{P}_2\text{O}_5 \text{ ha}^{-1}$ in high P soil having initial available P_2O_5 status of more than 100kg ha^{-1} . P-32 isotope was employed once in two years to know the use efficiency of P fertilizer in high P-soils. The radioassay data revealed that the per cent P derived from fertilizer and fertilizer P uptake by rice dry matter at maximum tillering stage varied significantly due to different levels of P application to it. Significant increase was observed with respect to fertilizer P- uptake by the crop with increasing the P levels from 25 to 100%RDP. The applied P use efficiency by the crop at maximum tillering stage significantly tended to increase with the decrease in P application from 100 to 25% RDP.



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Soil Fertility Status of Rajgarh District (M.P.) and Preparation of Soil Health Card

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Preparation of Soil health Card project was initiated in soil testing laboratory of Krishi Vigyan Kendra, Rajgarh (MP) on March 2011. Six blocks of Rajgarh district were selected for preparation of Soil Health Card of each farmer from 239+ villages. Representative soil samples (8521) from farmer's fields of 239+ villages were collected and analyzed by following standard procedures for different parameters and nutrient content. Soil pH and EC of all samples were in normal range, which indicates that soil reaction normal and free from salt hazards. Organic carbon content was low in 59.85% samples and medium in 38.79% and samples showed low to medium status in over all six blocks and low in Rajgarh district as a whole. Available N content was low in 89.80% samples and medium in 10.01% samples with over all low status as per nutrient indices for six blocks. Available P content was low in 69.08% samples and medium in 30.85% samples with over all low status as per nutrient indices for six blocks. Available K content was medium in 65.14% soil samples and high in 34.43% soil samples. The Available K status was medium in four blocks and high in two blocks as per nutrient indices and over all high K status in Rajgarh district. With respect to sulphur, 56% of soil samples were deficient. As regards to micro nutrients status, viz. Zn, Fe and Mn, were deficient in 35.98, 4.85 and 0.21% soil samples, respectively out of 8521 soil samples.

Recommendations were made for individual farmer for major crops viz. Soybean, Wheat and Gram for balance fertilization based on soil testing. Certain recommendations on organic inputs were also made. Prepared Soil Health Cards were distributed to farmers through SADOs of six blocks with the help of DDA of Department of farmer welfare and agriculture development of Rajgarh district.



Effect of Long-term Use of Manures and Fertilisers on Soil Carbon Pools and Major Nutrient Status in Soil in Rainfed Cotton in Vertisols

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Cotton is the major commercial crop extensively grown in Andhra Pradesh particularly in Guntur district on deep black soils for the past few decades. Permanent manurial trial is being carried out at RARS, Lam from 1991-92 onwards. Continuous cultivation of cotton with optimum fertilisation and organic manuring would build up the soil nutrient status. The initial soils are slightly alkaline (pH=8.39), non saline (0.550 dS m⁻¹), low in organic carbon (0.35%) and available N (196 kg ha⁻¹), low in available P₂O₅ (22.4 kg ha⁻¹) and high in available K₂O (392 kg ha⁻¹). The experiment was taken up in RBD design with 11 treatments and 3 replications. The treatments were (1) T₁ - Control, (2) T₂ - 50% of the recommended dose of NPK, (3) T₃ - 100% of the recommended dose of NPK, (4) T₄ - 150% of the recommended dose of NPK, (5) T₅ - 100% of the recommended dose of NP, (6) T₆ - 100% of the recommended dose of N, (7) T₇ - T₃ + FYM @ 10 tons ha⁻¹, (8) T₈ - T₃ + ZnSO₄ @ 50 kg ha⁻¹, (9) T₉ - T₃ + MgSO₄ @ 50 kg ha⁻¹, (10) T₁₀ - 200% of the recommended dose of NPK, (11) T₁₁ - T₃ + Gypsum @ 500 kg ha⁻¹. Recommended dose of NPK for cotton is 90:45:45 kg ha⁻¹. During *Kharif* 2013-14, the highest kapas yield of 21.81 q ha⁻¹ was recorded in the treatment of 100% RDF + FYM @ 10 t ha⁻¹ of NPK followed by 21.35 q ha⁻¹ recorded in treatment of 150% RDF and both the treatments were on par. During this season (2013-14), effect of different manures and fertilisers on soil organic carbon pools and major nutrient status was studied at initial, flowering and harvesting stages of cotton crop. The results indicated that all the carbon pools viz. soil organic carbon content (%), active carbon (µg g⁻¹) and microbial biomass carbon (µg g⁻¹) at all growth stages were significantly high in T7 treatment where FYM was applied @10 t ha⁻¹ followed by T4 where 150% Rec.dose of NPK was given. Similar trend was noticed in major nutrient status in soil and the highest available N, P₂O₅ and K₂O contents at all growth stages were noticed in T7 treatment where FYM was applied @10 t ha⁻¹ followed by T4 where 150% Rec.dose of NPK was applied.



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Direct and Residual Effect of Graded Doses of Zinc Application with RDF in Rice-Rice Cropping System Grown in Laterite Soils of Odisha

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Rice-rice cropping system being one of major cropping system of Odisha suffers from low yield due to imbalance nutrient application. Macronutrients can be better utilised in presence of micronutrients. From delineation study of micronutrients in Odisha, deficiency of Zn was found to be highest next to boron and widespread in distribution. Though research studies conducted earlier produced response upto 5 kg Zn ha⁻¹. But research is lacking whether Zn application is required in small doses every year or alternate year or high dose of once application. With this background, an experiment is conducted in central farm acidic sandy loam soil deficient to moderate in Zn status by taking 4 doses of Zn (2.5, 5, 7.5 & 10 kg) applied to a rice-rice cropping system where first crop in sequence receiving the Zn application second crop being grown on residual Zn but with RDF only. The four Zn treatments were applied once, alternate year and each year thereby constituting 13 treatments. In the first year experiment four treatments were repeated thrice in each replication. Design was RBD with 3 replications. Rice (cv Lalat) was raised in both the seasons. Plant and soil samples were collected at different growth stages like tillering, panicle initiation and at harvest and analysed for nutrient concentration. Grain and straw yields were recorded at appropriate moisture content. Results revealed that a yield response of 15 to 30 % was obtained due to different Zn treatments over RDF only by the *kharif* rice receiving Zn treatments. Rice responded to Zn application upto 7.5 kg Zn only after which yield declined but yield was higher than no Zn control. *Rabi* rice grown on residual Zn produced a yield range of 30 to 41 q ha⁻¹. Here also yield increased upto 7.5 kg Zn ha⁻¹ with Zn utilisation percent gradually decreasing with increase in Zn dose. Though yield declined after 7.5 kg Zn but Zn uptake increased progressively with increase in Zn dose. Sufficient Zn remained in soil after two crops and Zn utilization percent decreased with increase in Zn dose. Since this is a continuous experiment so proper result with respect to dose, method and frequency of its application is yet to be established for red laterite soils of Odisha.



Effect of Phasing of Boron Application on Yield and Quality of Rice-Vegetable Cropping System

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Yield level of many crops is now stagnated due to declining soil fertility and due to imbalanced fertilisation. Application of major nutrients also does not suffice to increase yield up to desired level. Under such conditions balanced fertilization with application of major and micronutrients is one of the best option left with farmers. Micro or stress elements are now playing significant role in increasing crop yields. Micronutrient status in soil which are in declining state are mostly B, Zn, Mo in Odisha. With small application of soil or foliar spray can increase yield upto 5-10%. So through GPS based micro and secondary nutrient delineation study, Boron deficiency in Odisha soils is found to be upto 51%. Since there is a narrow gap between deficiency and toxicity of boron, judicious application of this micronutrient is highly important. Keeping this in view an experiment was conducted in boron deficient acidic Inceptisol of Odisha to study the effect of graded doses of Boron application for rice-vegetable cropping system by phasing its application. The experiment was conducted by taking 4 graded doses of boron which were applied once, alternate year, every year with one absolute control constituting 13 treatments, replicated thrice in a randomized block design. The graded doses of boron constitute B@0.5, 1.0, 1.5 & 2.0 kg ha⁻¹. Every year during *kharif* rice was grown with graded doses of boron and after harvest of rice, vegetables (Tomato) was taken as residual crop.

Initial soil properties of the experimental site were acidic (pH 5.4), non saline in reaction, low in organic matter (0.32 %), sandyloam in texture in surface layer. Hot water soluble boron content in surface layer was 0.30 mg kg⁻¹.

Rice grain yield (cv Lalat) varied between 40.33 to 49.44 q ha⁻¹ due to different graded doses of boron. Rice yield increased significantly upto 1.0 kg B ha⁻¹ with response of 23 % over control thereafter yield declined. Yield range of Tomato grown on residual graded boron was 14.94 -22.14 t ha⁻¹ where succeeding vegetable crop Tomato (Cv Utkal kumari) responded to higher dose of B @ 1.5 kg ha⁻¹ indicating that boron applied to *kharif* rice is leaching down which is better utilized by succeeding vegetable crop. Not only yield but Boron application increased various quality parameters like lycopene, ascorbic acid, TSS etc. Hence application of B @ 1.5 kg once to a rice-vegetable cropping system can increase yield of both direct and residual vegetable crop and its quality.



Effect of Sulphur and Boron on Yield and Quality of Mustard Grown in Acidic Soils of Odisha

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The field experiment was conducted with a soil deficient in boron and sulphur to the effect of interaction between sulphur and boron on their uptake and quality parameters of mustard (*Brassica juncea* L.). The soils of the experimental field was typic haplustalf having pH-5.6, clay-16.5%, CEC- 11.5 cmol(p⁺) kg⁻¹, O.C 3.2 g kg⁻¹ and deficient in S (7 kg ha⁻¹) and boron (0.84 kg ha⁻¹). Four levels of each sulphur (0, 20, 40 & 60 kg ha⁻¹) and boron (0, 0.5, 1.0 & 1.5 kg ha⁻¹) were applied in a randomized block design, replicated thrice through gypsum and Borax respectively. A uniform dose of NPK was applied with 50 kg N, 30 kg P₂O₅ and 30 kg K₂O ha⁻¹ through DAP, MOP and Urea, respectively. The results indicate that the stover and seed yield of mustard crops increased with increasing levels of boron and sulphur. The stover yield of mustard increased from 22.44 qha⁻¹ in control to 27.33 qha⁻¹ at 60 kg S application. Similarly, it significantly increased from 23.0 qha⁻¹ to 26.55 qha⁻¹ with increasing levels of boron. The interaction effect between B and S significantly influenced the stover yield of mustard which was observed to be the highest at 1.5 kg ha⁻¹ of applied B in conjunction with 60 kg ha⁻¹ S. The per cent increase stover yield of mustard by application S was 21.76 over control. Similarly boron application resulted in 15.44% increase in stover yield over control. The seed yield of mustard increased from 9.69 q ha⁻¹ in control to 11.96 q ha⁻¹ at 60 kg ha⁻¹ of S application, which resulted in about 23.40% increased over the control. The seed yield due to boron application increased from 9.86 q ha⁻¹ in control to 11.75 q ha⁻¹ at 1.5 kg ha⁻¹ of boron application. As for as interaction effect of boron and sulphur is concerned, a significantly higher seed yield of mustard (11.96 q ha⁻¹) was obtained by the application of 60 kg ha⁻¹ sulphur in combination with 1.5 kg ha⁻¹ of boron. The boron uptake of stover was found to increase from 0.091 kg ha⁻¹ in control to 0.16 kg ha⁻¹ at 60 kg ha⁻¹ of applied sulphur and from 0.102 kg ha⁻¹ in control to 0.15 kg ha⁻¹ at 1.5 kg ha⁻¹ of applied boron. Boron uptake by mustard seeds increased from 0.37 kg ha⁻¹ in control to 0.68 kg ha⁻¹ with increasing levels in control to 0.65 kg ha⁻¹ with increasing level of boron. Sulphur uptake by mustard seeds increased to 15.28 kg ha⁻¹ with increasing levels of sulphur and from 11.56 kg ha⁻¹ to 14.88 kg ha⁻¹ with increasing levels of boron. The interaction effect of boron and sulphur on the sulphur uptake was found statistically significant at all levels for mustard seed. Sulphur uptake by mustard stover increased from 4.93 kg ha⁻¹ in control to 9.54 kg ha⁻¹ with increasing levels of sulphur and 6.15 kg ha⁻¹ in control to 8.36 kg ha⁻¹ with increasing levels of boron. The interaction effect of boron and sulphur on the S uptake was found statistically significant. The oil content in seeds significantly increased from 38.07 to 44.56 % with increasing levels of sulphur and 40.6 to 43.98 % with increasing levels of boron. The per cent increase in oil content of mustard with application of sulphur was found to be 14.24 and with boron 7.98 over the control. Significantly higher oil content (46.78 %) was obtained due to interaction effect of both the nutrients (S₆₀ B₂) which was 22.94 % more over control. The protein content of mustard seed increased from 19.94 to 23.50 % with increasing levels of sulphur and from 19.79 to 23.24 % with increasing level of boron. The percentage increase in protein content in mustard seeds with application of sulphur was 17.85. Similarly the per cent increase in protein content of mustard seeds with application of boron was 17.43. The highest value of protein content recorded in mustard seeds was 23.50 % at 60 kg ha⁻¹ of applied sulphur in combination with 1.5 kg ha⁻¹ of boron.



Soil Fertility Status of Oilseed and Pulse Growing Fields of Bhitwar Block of Gwalior District

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Soil fertility refers to the inherent capacity of a soil to supply essential nutrient to plant in adequate and right proportion for optimum growth. Decline in soil fertility is the main cause of low crop productivity. Soils of India are generally poor in fertility, as these have consistently been depleted of their finite nutrient resources due to continuous cultivation for many centuries.

Gwalior district is situated in the arid agro climatic zones of Madhya Pradesh. The soils of the district are under the broad group of alluvial soils and medium black soils. In patches the farmers of Bhitwar block grown Sesame/greengram/ blackgram in *kharif* and mustard/ chickpea in *rabi* season under rainfed area. Cropping systems play an important role in sustainable soil health. Legume based cropping system show higher fertility status as compared to cereal based cropping system; but the information of soil fertility build up/depletion under different cropping system is lacking for the Gwalior districts of M.P. Hence the efforts have been made to study the fertility status in oilseed and pulse growing soil. One hundred twenty surface (0-15 cm) soil samples collected from oilseed (sesame & mustard) and pulse (greengram/blackgram & chickpea) growing fields of Bhitwar block of Gwalior district in the year 2012-13.

Results indicate that the Soil pH and electrical conductivity were more or less same in different cropping system. Status of available N, P, K & S (kg ha^{-1}) in studied field ranged from 128.2-304.2, 8.6-35.6, 104.6-386.2 & 8.4-32.5 with an average value of 216.5, 16.3, 202.2 & 16.8 kg ha^{-1} , respectively. Under different cropping pattern, maximum average value of available N, P, K & S was recorded in Fallow-Gram cropping system. Leguminous based cropping system show higher status of available nitrogen, oilseed based cropping system show low status of available potassium and sulphur in soils as compared to pulse growing cropping system. Soil pH and Electrical Conductivity (EC) do not show any specific relationship with NPK&S under different cropping system. In general, organic carbon content of the soils of investigated area, showed positive relationship with N, P, K & S under different cropping system.

Considering the concept of soil nutrient index, the soils of Bhitwar block of Gwalior district were found in category of low fertility status for nitrogen, phosphorus and sulphur and medium with respect to potassium. The value worked out from nutrient index for N, P, K and S were 1.42, 1.58, 1.83 and 1.52 respectively, against the nutrient index values <1.67 for low, 1.67-2.33 for medium and >2.33 for high fertility status.



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Phosphorus Budget in Soils of Eastern Dry Zone, Karnataka and Modified Soil Test Ratings-based Soil Categorization

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Soil based site specific P recommendation for sustainable crop productivity mainly relies on status, availability and fractions of phosphorus. The current categorization of soils into low, medium and high are developed prior to green revolution felt need for modification for precision agriculture. Representative soil samples (250) from different agro-ecological regions of Eastern Dry Zone (EDZ) of Karnataka were analysed for P status and randomly collected samples were analysed for P fractions. Soils were tentatively classified into four category *viz.*, Very Low (VL), Low (L), Medium (M) and High (H) if soil available P_2O_5 (AvPs) was < 15, 16-30, 31-45 and 46-60 $kg\ ha^{-1}$, respectively. Six different locations in each category were identified and soil samples were collected and filled in pots. Graded levels of P were applied and maize was grown using CRD design. Available P (AvP) ratings were determined by plotting relative per cent dry matter yield versus initial AvPs and soils were categorized. Results revealed that, AvPs ranged 12.74 to 94.70; 11.21 to 49.55; 10.70 to 98.32 and 10.22 to 64.05 $kg\ ha^{-1}$ in Bangalore Rural, Tumkur, Kolar and Chikkaballapura districts, respectively. Among P fractions, total-P (range: 1218.90-3383.08 $mg\ kg^{-1}$), organic-P (range: 624.95-3461.85 $mg\ kg^{-1}$), reductant soluble-P (range: 132.56-364.55 $mg\ kg^{-1}$), occluded-P (range: 7.38-49.69 $mg\ kg^{-1}$) and Ca-P (range: 6.21-38.76 $mg\ kg^{-1}$) content increased as the P fertility of soil increased and decreasing trend was recorded for Saloid-P (range: 38.31-63.23 $mg\ kg^{-1}$), Al-P (range: 61.49-164.31 $mg\ kg^{-1}$) and Fe-P (range: 35.23-109.87 $mg\ kg^{-1}$) fractions. Soil test P_2O_5 ratings proposed were <15.50, 15.51-28.00, 28.10- 48.50 and >48.50 $kg\ ha^{-1}$ as very low (VL), low (L): medium (M): high (H), respectively. Categorization of soils based on modified ratings were VL:L:M:H and percentage of soils in EDZ comes under different category are followed the order as L (30.80%) > M (27.20%) > H (21.20%) > VL (20.80%). Total account of phosphorus is a necessary tool for soil based P recommendation under both irrigated and rainfed agriculture. Approach of soils categorization based on modified four soil phosphorus ratings is a step towards best P management in soils of different P fertility for precision farming.



Interaction Effect of Zinc and Iron on *Rajmash* Crop

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Cultivation of pulses is gaining importance all over the country due to their increasing demand and high market value. Among such crops, *rajmash* commonly known as kidney bean, is becoming popular due to its higher productivity and consequently higher profit in comparison to other pulses. However, farmers of north Bihar are not able to harness full potential of this crop due to non adoption of high yielding varieties and non application of proper fertilizers, particularly zinc and iron. The high yielding varieties are relatively new introduction and therefore, with the objective to gather information regarding their zinc and iron requirement the present investigation was undertaken.

A field experiment was conducted on calcareous soil during winter (rabi season) of 2011-12 at Research Farm, Rajendra Agricultural University, Pusa, Samastipur. The initial composite soil had pH 8.5, EC 0.55 dSm⁻¹, organic carbon 4.3 g kg⁻¹, DTPA-Zn 0.47 mg kg⁻¹ and DTPA Fe 6.4 mg kg⁻¹. Different combinations of four levels of Zn (0, 2.5, 5.0 and 10.0 kg Zn ha⁻¹) and three levels of Fe (0, 10 kg Fe ha⁻¹, two foliar spray of 0.5 % ferrous sulphate) were replicated three times in two factor RBD. Different treatments were applied as basal dose through zinc sulphate and ferrous sulphate as per treatments. Uniform application of 90 kg nitrogen (half at the time of sowing and half after one month of sowing) through urea, 50 kg phosphorus ha⁻¹ through single super phosphate and 30 kg potash ha⁻¹ through muriate of potash at the time of sowing. *Rajmash* variety PDR-14 was sown in 30 cm x 10 cm spacing on 20th November, 2011. Plant samples were collected at the time of harvest and analysed. Post harvest soil samples were also collected for estimation of available Zn and Fe.

The results indicate that grain and straw yields of *Rajmash* crop increased from 15.4 to 18.5 q ha⁻¹ and from 24.9 to 30.4 q ha⁻¹, respectively with increasing levels of Zn from 0 to 10.0 kg Zn ha⁻¹. The grain and stalk yields of *Rajmash* crop increased from 15.3 to 19.5 q ha⁻¹, respectively with increasing levels of Fe from 0 to 10 kg ha⁻¹ and foliar spray. The per cent increase in seed yield of *Rajmash* at highest Zn and Fe levels were 20.1 and 26.8 %, respectively. The straw yield of *Rajmash* increased from 24.9 to 30.4 and 25.6 to 29.9 q ha⁻¹, respectively with increasing levels of Zn and Fe. The Zn uptake by seed, straw and total uptake significantly increased due to Zn and Fe application, however, the interaction effect was non significant. The Zn uptake by *Rajmash* seed, straw and total uptake varied from 34.9 to 68.6, 60.8 to 133.0 and 95.7 to 201.6 g ha⁻¹, respectively. The total Zn uptake by *Rajmash* increased from 111.7 to 183.4 g ha⁻¹ due to Zn application and from 130.2 to 165.0 g ha⁻¹ due to Fe application. The highest Zn uptake of 201.6 g ha⁻¹ was noted at treatment combination 10 kg Zn + 0.5 % Fe foliar spray. Fe uptake by *Rajmash*, seed, straw and total uptake varied from 43.8 to 80.9, 149.8 to 293.6 and 193.5 to 374.4 g ha⁻¹, respectively. Iron as well as zinc application significantly increased Fe uptake by *Rajmash*, however, interaction effect was non-significant.



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Soil Fertility Status in Sugarcane Growing Soils of Bihar

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Sugarcane is an agro-industrial crop mainly cultivated in tropical and subtropical regions of the country. It covers an area of about 5.06 million ha with an average productivity of 66.9 t/ha. Productivity of sugarcane in sub-tropical region of India is less than the tropical region and also the national average. Amongst the various factors, soil fertility is one of the most important factor which affects sugarcane productivity. Enhancing sugarcane productivity in sustainable manner with high sugar recovery is the key option to fulfil the ever-increasing requirement of sugar with limited land resources. With aim to maintain soil fertility for enhancing sustainable sugarcane productivity in subtropical part of the country, a study has been conducted in sugarcane growing soils of Bihar for assessing the present soil fertility status. Under the study, soil sampling was carried out from sugarcane growing areas of Bihar before autumn planting of sugarcane in 2013 by collecting soil samples randomly from four sugar mills representing one sugar mill each from Harinagar, Gopalganj, Sitamarhi and Hasanpur districts of the State. Ten representative soil samples were collected from each sugar mill command area and analysed for physico-chemical properties through standard procedures. Soil analysis data revealed that pH, electrical conductivity and organic carbon content ranged from 7.0-9.1, 0.11-0.57 dSm⁻¹ and 0.20-0.97 per cent respectively. The available nitrogen, phosphorus and potash was found to be 233.66, 25.15 and 168.50 kg ha⁻¹, respectively. Thus, on the basis of nutrient index values, sugarcane growing soils of Bihar were found low in available N and P₂O₅ whereas medium in available K₂O. DTPA extractable soil micronutrients, i.e. iron, manganese, and copper were found above the critical limits whereas, about 37.5 per cent soil samples were found below the critical limit of zinc. Significant positive correlation was found with soil organic carbon and available nitrogen, phosphorus (P₂O₅), potash (K₂O) and DTPA extractable micronutrient (Zn, Fe, Cu & Mn), which proved that organic carbon is an indicator of overall soil fertility status in sugarcane growing soils of Bihar.



Effect of Organic Manures on Yield of Groundnut and Soil Quality

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Organic manures, crop residues and bio-fertilizers to bridge the gap between nutrient demand and supply for giving boost to agricultural production keeping the Socio-Economic aspects of the farmers at the center is the only viable alternative, rain fed farmers are invariably using. Irrespective of the region, soil type or crop, quality improvement is the only criteria with the advent of WTO in agriculture. In Rayalaseema, groundnut is the mandatory crop without any substitute, it is therefore the need to create quality concern in the farmers mind in the interest of export orientation. Hence the study is being conducted since seven years from 2007 at Regional Agricultural Research Station, Tirupati to know the influence of different organic manures on groundnut yield and soil quality. The experiment was laid in big plots and four different sources of organic manures viz., FYM @ 10 t/ha, Vermicompost @ 2.5 t ha⁻¹, Poultry manure @ 4 t ha⁻¹, Press mud cake @ 10 t ha⁻¹ were evaluated with RDF as one plot. Same treatments were being imposed in same plots since the initiation of the study. Among the different sources, Press mud cake applied treatment recorded the highest pod yield of 1496 kg ha⁻¹ followed by RDF (1459 kg ha⁻¹). The lowest pod yields was recorded with Vermicompost applied plot (1347 kg ha⁻¹). Similar trend was observed with haulm yield. The highest 100 kernel weight was recorded in FYM treated plot (41.1 g) followed by Press mud cake (36.38 g) and the lowest was recorded with RDF treatment (34.7 g). Highest shelling percent was observed in Poultry manure treatment followed by RDF. No significant differences were observed with soil pH and EC whereas buildup of organic carbon was observed in Poultry manure and Press mud cake applied treatments. Soil available Phosphorus is also high in Poultry manure applied plot followed by Press mud cake. Whereas highest soil available Potassium was seen in Press mud cake applied treatment followed by RDF. It may take some more time to stabilize the yields and quality of soil.



Strategies for Phosphorus Management in Finger Millet under Eastern Dry Zone of Karnataka

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Experiments were conducted in five selected farmer's fields in Bangalore Rural district under Eastern dry zone of Karnataka with six treatment combinations comprising of 100 % NPK (T_1), 100 % N + $\frac{1}{2}$ P + 100 % K (T_2), 100% N + $\frac{1}{2}$ PK+ 5t FYM (T_3), 100% N + $\frac{1}{2}$ PK+ Lime (T_4), 100% N + $\frac{1}{2}$ PK+ 5t FYM + Lime (T_5) and Farmers practice (T_6) with finger millet as a test crop. The selected fields were low to high in phosphorus and potassium status. The results revealed that application of fertilizers as 100 % N + $\frac{1}{2}$ P + 100 % K (T_2) resulted in significantly higher grain yield (45.46 q ha⁻¹) followed by 100% N + $\frac{1}{2}$ PK+ 5t FYM (44.39 q ha⁻¹) and these treatments were superior over farmer practice (26.61 q ha⁻¹) and 100 per cent NPK (37.29 q ha⁻¹). There was no reduction in the yield level when phosphorus and potassium application was reduced by 50 per cent. However, when the nutrients were applied in combination with organic manure (FYM) and lime the yield of crop was higher compared to farmer practice. It was noticed that there was a saving of 50 percent in the cost of phosphorus fertilizers without compensating the yield of the crop and also nutrient uptake. Application of lime, FYM along with reduced levels of P and K indicated that the available P content increased up to 46 percent over the initial value in the post harvest soil. Whereas the total P content increased to 6 per cent over initial status. Further available K and total K were enhanced by 21 and 3 per cent respectively over the initial status. This suggested that phosphorus and potassium application to the crop at varied levels had contributed to the total and available pool. Higher net returns were recorded in 100 % N + $\frac{1}{2}$ P + 100 % K (Rs. 78,378.00 followed by 100% N + $\frac{1}{2}$ PK+ 5t FYM (Rs. 76,535.00) and 100% N + $\frac{1}{2}$ PK+ 5t FYM + Lime (Rs. 74,878.00) and the B:C ratio was higher in T_2 , T_3 and T_4 treatments (2.66, 2.48 and 2.45 respectively). Farm yard manure plays a considerable role in nutrient availability to the crop. Management of nutrients through organic and inorganic fertilizers in combination with lime and FYM could perform better in terms of yield. Balanced nutrients application could maintain soil properties for better crop growth. It can be concluded that it is not necessary to apply phosphorus fertilizers to every crop when the soil has high phosphorus status.



Effect of Dates of Sowing and Nitrogen Levels on Nitrogen Use Efficiency and Nitrogen Uptake of Hybrid Maize under Irrigated Conditions

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Optimum time of sowing and nitrogen levels are the critical inputs to sustain the productivity of irrigated maize crop. This study was carried out during 2009 and 2010 *Kharif* season on a sandy soil, at Agricultural Research Institute, Rajendranagar, Hyderabad, Telangana state. It evaluated the effect of dates of sowing (7-July, 21-July, 6-August and 22-August in 2009 and 18-June, 02-July, 17-July and 02-August in 2010) as main plots and five nitrogen levels (0, 100; 200; 300 and 400 kg N ha⁻¹) as sub-plots replicated thrice. Results indicate that, crop sown on 21 July in 2009 and 18 June in 2010 recorded higher NUE, in terms of kg grain produced per kg N applied (25.5 kg and 24.5 kg, respectively). Apparent N recovery (AR) was also higher when crop was sown on 21 July (40%) in 2009 and 18 June in 2010 (35.8%). The highest nitrogen uptake of 1.57 g plant⁻¹ was observed in 21 July sown crop and on par uptake was observed in 7 July sown crop during 2009. But in 2010 the highest N uptake of 1.59 g plant⁻¹ was observed in 18 June sown crop and was on par with 2 July sown crop. With regard to the nitrogen levels, the highest total N uptake of 1.93 and 2.00 g plant⁻¹ was found with 400 kg N ha⁻¹, which was however, on par with 300 kg ha⁻¹ and 200 kg N ha⁻¹ and control recorded the lowest N uptake of 0.23 g plant⁻¹. Even though highest total N uptake was observed with 400 kg N ha⁻¹ and was comparable with 300 kg N ha⁻¹ and 200 kg N ha⁻¹ during both the years of study at silking and maturity stages. But increasing levels of nitrogen application showed reduced agronomic efficiency and apparent nitrogen recovery. Even with increased levels of N beyond 200 kg ha⁻¹, the recovery was only 100 kg ha⁻¹. Simulation scenarios obtained through DSAAT seasonal analysis also confirmed that increased levels of nitrogen beyond 200 kg ha⁻¹ subjected to leaching losses.



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Effect of Nitrogen, Vermicompost and Herbicide (clodinafop propargyl) on Yield and Nitrogen, Phosphorus and Potassium uptake of Wheat (*Triticum aestivum* L.)

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With the improvement in the agricultural technologies and release of high yielding dwarf varieties of cereals, demand for fertilizers has increased manifold and nitrogenous fertilizers in particular. So, we have to think about the cheap and easily available alternate source of nutrients. Thus, demand for fertilizers can be lowered by supplementing the nutrients through organic manures. Among different sources of organic manures, vermicompost is the most important source and is being used since long as a nutrients supplement to crop production. Presence of herbicide may affect the population of soil fauna and flora adversely and ultimately soil fertility. Keeping this in view, the pot experiment was conducted at screen house, Department of Soil Science, CCS HAU, Hisar to assess the effect of nitrogen and vermicompost in presence of herbicide (clodinafop propargyl) on wheat yield and nutrients uptake. The soil used was sand in texture having pH 8.10, EC (1:2) 0.15, OC 0.15 per cent available N, P and K were 54.51, 8.00 and 83.7 mg kg⁻¹, respectively. The treatment combinations comprised five levels of nitrogen (0, 50, 100, 150 and 200 mg kg⁻¹) applied through urea, two levels of vermicompost (0 and 1 per cent on dry wt. basis) and three levels of herbicide (0, 60 and 90 g a.i. ha⁻¹). Complete randomized design was followed by keeping three replications.

Application of nitrogen @ 150 mg kg⁻¹ soil significantly increased the grain and straw yield of wheat from 2.70 to 8.24 and 4.97 to 9.44 g pot⁻¹, respectively over control. Application of vermicompost @ 1 per cent alone increased the grain and straw yield of wheat from 2.70 to 4.81 and 4.97 to 6.60 g pot⁻¹, respectively over control and in combination with nitrogen @ 150 mg kg⁻¹ soil further improved from 4.81 to 10.73 and 6.60 to 11.89 g pot⁻¹, respectively. Application of clodinafop propargyl @ 60 and 90 g a.i. ha⁻¹ significantly decreased the grain yield of wheat from 4.74 to 3.60 and to 2.93 g pot⁻¹, respectively and that of straw yield from 7.16 to 5.87 and to 4.31 g pot⁻¹, respectively over control (without clodinafop propargyl). The yield of wheat (grain and straw) also decreased significantly with the application of clodinafop propargyl (60 to 90 g a.i. ha⁻¹) in presence of both vermicompost and nitrogen. Application of nitrogen significantly increased the nitrogen uptake in grain and straw of wheat (25.92 to 149.56 mg pot⁻¹ and 15.40 to 54.72 mg pot⁻¹) with the increasing level of nitrogen upto the level of 200 mg kg⁻¹ soil. Application of vermicompost alone increased the nitrogen uptake in grain and straw of wheat (25.92 to 63.49 mg kg⁻¹ and 15.40 to 27.06 mg pot⁻¹) and in combination with nitrogen @ 200 mg kg⁻¹ soil from 63.49 to 193.41 mg pot⁻¹ and 27.06 to 73.70 mg pot⁻¹. Application of nitrogen significantly increased the phosphorus uptake in grain and straw of wheat (11.07 to 57.59 mg pot⁻¹ and 3.74 to 18.24 mg pot⁻¹) with the increasing level of nitrogen upto the level of 200 mg kg⁻¹ soil. Application of vermicompost (@ 1 per cent) alone increased the phosphorus uptake in grain and straw of wheat (11.07 to 26.45 mg pot⁻¹ and 3.74 to 6.60 mg pot⁻¹) and in combination with nitrogen 200 mg kg⁻¹ soil from 26.45 to 71.55 mg pot⁻¹ and 6.60 to 25.86 mg pot⁻¹, respectively. Application of nitrogen significantly increased the potassium uptake in grain and straw of wheat (13.23 to 40.87 mg pot⁻¹ and 46.71 to 143.78 mg pot⁻¹) with the increasing level of nitrogen upto the level of 200 mg kg⁻¹ soil. Application of vermicompost (@ 1 per cent) alone increased the potassium uptake in grain and straw of wheat (13.23 to 25.97 mg pot⁻¹ and 46.71 to 65.34 mg pot⁻¹) and in combination with nitrogen @ 200 mg kg⁻¹ soil from 25.97 to 51.42 mg pot⁻¹ and 65.34 to 178.43 mg pot⁻¹. Application of clodinafop propargyl @ 60 and 90 g a.i. ha⁻¹ significantly decreased the nitrogen, phosphorus and potassium uptake by wheat grain and straw.



Soil Nutrient Status and Leaf Nutrient Norms in Oil Palm (*Elaeis guineensis* Jacq.) Plantations Grown on West Coastal Area of India

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Oil palm is a heavy feeder of nutrients and requires balanced and adequate supply of nutrients for optimum growth and yield. Information regarding soil nutrient status and leaf nutrient concentration in oil palm plantations is very much required for proper fertilizer application. Therefore, a survey was conducted for assessment of soil nutrient status and leaf nutrient concentration in 64 oil palm (*Elaeis guineensis* Jacq) plantations in the state of Goa lying in west coastal region of India. Soil pH, electrical conductivity (EC), organic carbon (OC), available K (NH₄OAc-K), phosphorus (P) (Olsen-P), exchangeable calcium (Ca) (Exch. Ca) and magnesium (Mg) (Exch. Mg), available sulphur (S) (CaCl₂-S) and hot water soluble boron (B) (HWB) in surface soil layers ranged from 4.25 to 6.77, 0.05 to 1.06 dS m⁻¹, 5.07 to 48.4 g kg⁻¹, 58.1 to 1167 mg kg⁻¹, 1.80 to 415 mg kg⁻¹, 200 to 2997 mg kg⁻¹, 36.0 to 744 mg kg⁻¹, 3.00 to 87.7 mg kg⁻¹ and 0.09 to 2.10 mg kg⁻¹ respectively. Diagnosis and recommendation integrated system (DRIS) norms were established for different nutrient expressions and it was used to compute DRIS indices. As per DRIS indices, the order of requirement of nutrients in the region was found to be P > Mg > K > nitrogen (N) > B. Optimum leaf nutrient ranges as per DRIS norms varied from 1.64 to 2.79%, 0.36 to 0.52 %, 0.37 to 0.75 %, 0.89 to 1.97 %, 0.35 to 0.63 %, 0.89 to 1.50 %, 3.10 to 13.9 mg kg⁻¹, 10.0 to 32.2 mg kg⁻¹, 35.0 to 91.1 mg kg⁻¹, 206 to 948 mg kg⁻¹, 895 to 2075 mg kg⁻¹ for N, P, K, Ca, Mg, S, B, copper (Cu), zinc (Zn), manganese (Mn) and iron (Fe) respectively. On the basis of DRIS derived sufficiency ranges, 14, 5, 11, 6, 6, 6, 8, 2, 3, 6 and 16 per cent leaf samples had less than optimum concentration of N, P, K, Ca, Mg, S, B, Cu, Zn, Mn and Fe, respectively. The optimum ranges developed can be used as a guide for routine diagnostic and advisory purpose for balanced utilization of fertilizers.



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Effect of Foliar Supplementation of Water Soluble Fertilizers on Grain Yield and Fodder Quality of Sorghum under Rainfed Conditions

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Field experiments were conducted at Gunegal Research Farm (GRF) and Hayatnagar Research Farm (HRF) during *khariif* 2013 and 2014, respectively to study whether application of water soluble fertilizers through foliar sprays during the vegetative stage can enhance the sorghum grain yield and fodder quality and also to study whether foliar sprays of water soluble fertilizers can influence some of the plant physiological processes and in-turn help minimize the yield reduction due to drought/insufficient soil moisture conditions. In both the years the experimental block was divided into three parts of size 20 × 20 m wherein three treatments were superimposed in the three blocks. At GRF during 2013 the treatments superimposed were a) T1: Recommended dose of fertilizer, b) T2: T1 + Spray of Plant Agro Magic (4g/l) at 30 DAS and c) T3: T1 + Spray of 0.5% water soluble fertilizer (19-19-19) at 30 DAS. At HRF during 2014 the treatments superimposed were a) T1: only basal application of recommended fertilizers ie 20 kg and 20 kg P₂O₅ was applied + spraying of 0.5% water soluble fertilizer (19-19-19) at 30 DAS ; b) T2= T1+ top dressing with 20 kg N and spraying of 0.5% water soluble fertilizer at 30 DAS and c) T3: T1 + top dressing of 20 kg N at 30 DAS. At GRF, highest grain yield, fresh and dry weight of sorghum fodder was recorded under T3 treatment as compared to other two treatments. Results of the analysis of leaf samples collected at the flag leaf stage revealed that the highest chlorophyll content was recorded under T3 treatments as compared to the other two. Also, application of water soluble fertilizers altered the chemical constituents like crude fibre, protein content in leaf and stem. Analysis of plant samples collected after one month of spraying of water soluble fertilizer at HRF revealed that in treatment T2 wherein spraying of water soluble fertilizer was taken up along with recommended application of fertilizers, the content of chlorophyll A, B & total and nitrate reductatase activity were highest as compared to the other two treatments indicating that the application of recommended dose of fertilizers + spraying of water soluble fertilizer at 30 DAS helps the crop to remain more green in colour and also helps in utilization of added nitrogen more efficiently. Highest grain and fodder yield of sorghum was recorded under T2 as compared to the other two treatments.



Long-term Soil Fertility Experiments - Experiences in Rice

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Long-term soil fertility experiments are critical to monitoring long-term changes in soil parameters and its productivity. Long-term fertilizer experiments are one of the means to measure sustainable management systems in agriculture and provide an insight into the changes that occur with time in soil and crop productivity. In order to monitor and relate crop productivity with soil fertility as a function of time and nutrient management, long term studies were initiated in three major rice growing regions under All India Coordinated Rice Improvement Project (AICRIP) 25 years back in 1989 and the results are discussed in the context of long term trends for determining appropriate soil fertility management strategies for sustainable rice production over time. Field experiments with well-defined nutrient management treatments *viz.*, Control; 100% PK; 100% NK; STCR recommendation; 100% NP; 100% NPKZnS (RDF); 100% NPKZnS + FYM/PM @ 5t/ha; 100% NPK -Zn; 100% NPK - S; 100% N+50% PK; 50 % NPK; 50 % NPK + Biofertilizer; 50%NPK+ 50% GM-N; 50% NPK + 50% FYM-N; 50% NPK + 25% GM-N+25% FYM-N and FYM @ 10 t/ha were conducted at 3 selected locations representing major rice growing regions and cropping systems *viz.*, Mandya (MND) in Karnataka (rice-cowpea, Deccan Plateau), Maruteru (MTU) in Andhra Pradesh (rice-rice, Delta system) and Titabar (TTB) in Assam (rice-rice, Alluvial soils) to study the dynamics of soil and crop productivity in relation to management for identifying the constraints that affect the sustainability of a production system. The results of the 25th year are presented here. In the 25th year, the results indicated the consistent superiority of conjunctive use of 100% RDF + 5t FYM ha⁻¹ over all other treatments at all three locations and FYM alone increased grain yield by 25% over RDF at Mandya. Omission of N, P, K, Zn & S and reduction of 50% nutrients resulted in significant yield reduction at all locations. Improved nutrients uptake with supplementary use of organics indicated the beneficial effect of organic manures for nutrient uptake, which has ultimately resulted in higher grain yields. Soil fertility status at the end of *kharij*-2013 indicated an improvement of organic carbon, available nutrient status and bulk density values with supplementary and/ or complete organic manuring compared to inorganic fertilization alone at all locations and most of these values were maximum with 50% NPK + 25% GM-N +25% FYM-N/ 100% RFD ZnS/ FYM@ 10 t ha⁻¹ and control plots recorded the lowest values. Linear trends of rice productivity over 25 years indicated slightly negative growth rate at Maruteru; improved growth at Titabar and a negative growth rate at Mandya (-3, 14 and -43 kg grain ha⁻¹ year⁻¹, respectively, at MTU, TTB and MND) with current RDF and a positive growth of about 100 kg ha⁻¹ year⁻¹ at all locations with a supplementary dose of 5 t FYM/ PM along with RDF.



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Growth, Yield and Nutrient Uptake by KRH-2 Paddy Grown in Aerobic and Flooded Ecosystem Influenced by Different Levels of FYM, Urea and DAP

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A field experiment was conducted in farmers fields at Doddaganjur village, Chintamani taluk, Chikkabalapura district, eastern dry zone of Karnataka, to assess the effect of levels of FYM, urea and DAP on growth and yield of KRH-2 paddy in aerobic and flooded ecosystems. The experimental design adopted was RCBD with seven fertilizer levels. (150% RDF, 100% RDF+FYM, 50% RDF+FYM, 100 %N equivalent as urea and 100 % N equivalent as DAP, 100% N as FYM and control). Growth parameters like plant height, number of tillers and total dry matter production of paddy recorded was higher in aerobic ecosystem compared to flooded ecosystem whereas, yield parameters like number of panicles per plant, spikelet's per panicle and test weight recorded a reverse trend. Nutrient uptake was also higher in flooded paddy than aerobic paddy. Among nutrient levels application, 100% RDF+FYM @10 t ha⁻¹ was found significantly superior compared to all other treatments in improving growth characteristics, yield characteristics and nutrient uptake in both aerobic and flooded ecosystems.



Influence of ZnSO₄ and Zn-EDTA on its Content and Uptake in Aerobic and Wetland Rice

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Field experiments were conducted during *khari*f-2009 at Doddajala, Bangalore, Karnataka to evaluate the effect of different Zn fertilizers on their uptake by rice under aerobic and wetland rice. These experiments were conducted separately for aerobic and wetland rice with nine treatments and three replications in factorial Randomized Complete Block Design using Anagha as test cultivar. The details of the treatments are T₁: Control (NPK only); T₂: T₁+ZnSO₄ soil application {20 kg ZnSO₄ ha⁻¹}; T₃: T₂+ZnSO₄ foliar spray (0.2%) @ flowering; T₄: T₁+ZnSO₄ soil application {30 kg ZnSO₄ ha⁻¹}; T₅: T₄+ZnSO₄ foliar spray (0.2%) @ flowering; T₆: T₁+Zn-EDTA (12% Zn) soil application {0.75 kg Zn-EDTA ha⁻¹}; T₇: T₆+Zn-EDTA foliar spray (0.2%) @ flowering; T₈: T₁+Zn-EDTA (12 % Zn) soil application {1.5 kg Zn-EDTA ha⁻¹}; T₉: T₈+Zn-EDTA foliar spray (0.2%) @ flowering. A known quantity of sample (grains, straw) was digested using microwave digestion system. The digested samples were subjected for analysis of Zn in AAS. The results revealed that grain and straw yield and Zn content and its uptake by grain and straw as influenced by different sources of Zn fertilizers showed significant difference among the conditions and treatments. The interaction effect between conditions (aerobic and wetland) and treatments in the grain and straw yield and Zn content and its uptake by grain and straw was found to be non-significant in the present investigation. The grain and straw yield was significantly higher in wetland rice with a mean of 5.1 t ha⁻¹ and 6.1 t ha⁻¹, respectively compared to the aerobic rice with a mean of 4.4 t ha⁻¹ and 5.2 t ha⁻¹, respectively. There was a significant difference in grain and straw yield between the control and treatments receiving Zn fertilizers. The treatment T₄ and T₅ was on par with T₈ and T₉ and recorded significantly higher grain and straw yield among the treatments receiving Zn. The grain and straw Zn content was significantly higher in aerobic rice with a mean of 39.2 mg kg⁻¹ and 85.8 mg kg⁻¹, respectively compared to the wetland rice with a mean of 38.1 mg kg⁻¹ and 80.8 mg kg⁻¹, respectively. There was a significant difference in the grain and straw Zn content between the control and the treatments receiving Zn fertilizers. Among the treatments receiving Zn, T₅ recorded significantly higher grain and straw Zn content irrespective of Zn source. The grain and straw Zn uptake was significantly higher in wetland rice with a mean of 196.6 mg kg⁻¹ and 496.9 mg kg⁻¹, respectively compared to the aerobic rice with a mean of 172.1 mg kg⁻¹ and 448.3 mg kg⁻¹, respectively. Among the treatments receiving Zn, T₅ and T₄ was on par and recorded significantly higher grain and straw Zn uptake irrespective of Zn source. Therefore, wetland rice recorded higher grain and straw Zn uptake compared to aerobic rice although Zn content in grain and straw was observed to be higher in aerobic rice. Among the two sources of Zn, ZnSO₄ performs better but Zn-EDTA was comparable to ZnSO₄.



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Effect of Boron Sources and Levels on Maize and Their Residual Effect on Cowpea

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A field experiment was conducted in a Typic Chromic Haplusterts during 2011-12 in central dry zone of Karnataka to find out the effectiveness of graded levels of boron (B) fertilizers borax and granubor in supplying B to maize and its effect on residual cowpea crop. The texture of the soil was sandy clay loam with a pH of 8.37 and 0.51 % organic carbon. The experimental field was deficient in available B status. Maize was raised as main crop and cowpea was raised as a residual crop on the same field without any alternation in treatments. Borax and granubor were used as sources of B with and without FYM. Boron at 0, 2, 4 and 8 kg ha⁻¹ was applied in the above two formulations at the time of sowing. The experiment was laid out in split-split plot design and replicated thrice. Results showed that higher yield attributes and yield (6.28 t ha⁻¹) of maize were recorded in recommended dose of fertilizers + 8 kg B ha⁻¹ treated plots. B concentration in grain and stover of maize increased significantly with increase in boron levels. Application of FYM + Rec. NPK + 8 kg B ha⁻¹ as granubor recorded significantly higher grain yield (4 q ha⁻¹) than borax application. The interaction between two sources showed that performance of borax and granubor were equally effective in increasing yield, concentration of B in grain and stover/haulm with increase in B levels. Granubor was found superior over borax. Significant correlations existed between B availability and B concentration in grain and stover/haulm B uptake with yield and thus, indicated that the application of B to proceeding crop will help to boost the yield of residual pulse crop.



Diatomite as a Silicon Source for Improving the Yield and Quality of Potato

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The application of Silicon (Si), a beneficial element, has proven to perform well in terms of yield, protection from fungal diseases and improved uptake of other essential nutrients. Although, information on the effect of soil and foliar application of silicon on potato are available, use of diatomite as a silicon source in potato is of primary importance as the material is a naturally occurring sedimentary rock and a rich source of Si. Hence, a study was taken up to determine the effect of different levels of Agri Power diatomite (*Melosiragranulata* species) as a Si source for improving yield and quality of potato. Field experiments were conducted at College of Agriculture, Hassan, Karnataka for two seasons during *Kharif* 2012-13 and 2013-14. The experiments were laid out in a Randomised Block Design with nine treatments and three replications with potato variety *Kufri Jyoti*. The Diatomite was tested at 150, 300 and 600 kg ha⁻¹ with 50 and 100% of Package of Practice (POP). The Recommended Dose of Fertilizer (125: 100:125 kg of N:P: K ha⁻¹) + 25 t ha⁻¹ of Farm Yard Manure was used as control besides an absolute control (without any fertilizers) in the field experiment. The observations on growth, yield and quality parameters of potato as well as potato late blight disease incidence were taken periodically during the crop growth period. The tuber and haulm yields of potato were significantly influenced by an application of Diatomite in both the seasons. The pooled data indicated that Diatomite application at 150 kg ha⁻¹ + 50 % POP recorded significantly higher potato tuber yield (24.28 t ha⁻¹) than control (17.51 t ha⁻¹) and 100 % POP (21.51 t ha⁻¹), which is 12.87 % increase over the 100 % POP alone treatment. Application of Diatomite at different levels with 100 % POP gave lower yield compared to different levels of Diatomite with 50% POP. This may be due to higher late blight disease incidence recorded with 100 % POP compared to 50% POP. Application of Diatomite significantly reduced the incidence of late blight disease to the extent from 37.72 % (100 % POP alone) to 9.41 % (50 % POP + Diatomite at 600 kg ha⁻¹). Application of Diatomite has influenced significantly tuber size and the tubers of grade >75 g has increased (64 numbers/plot) with application of Diatomite at 600 kg ha⁻¹ compared to 100% POP alone (34 numbers/plot). Application of Diatomite created a favourable soil environment with an optimum soil nutrient content, higher Si uptake and reduction in disease incidence, which ultimately resulted in higher dry matter production and the yield.



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Phosphorus Uptake by Maize (*Zea mays* cv. HQPM-1) as Affected by Gamma Irradiation in High Available Phosphorus Soil

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Low levels of gamma radiation evoke a stimulatory response in plants in terms of growth and yields. However this response is dose dependent and there are intra-species as well as inter-species variations in crop plants. This stimulatory effect is known as hormosis. Phosphorus (P) deficiency is considered as major limiting factor in crop productivity, especially in the tropics and subtropics. Compared to other major nutrients, P is by far the least mobile and least available to plants in most soil conditions. Plant species differ in their P efficiency, i.e. the P content in soil needed to reach their maximum yield. The differences in external P requirements can be attributed to either a lower internal P requirement for optimum growth or higher uptake efficiency of the plant. In contrast to N, P is a non-renewable natural resource and there is growing concern that the natural reserves of rock phosphate, the source of P fertilizer, are limited. One of the approaches to overcome the burden of fertilizer application is to enhance the plant's efficiency to acquire soil P. The objective of this research was to investigate the effect for different doses of gamma irradiation on P accumulation by maize crop from high available P content soil. Maize seeds cv. HQPM-1 were irradiated with different doses of gamma viz. 0.0025, 0.005, 0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.75, 1.0 and 2.0 kGy with ⁶⁰Co γ -radiation source. Irradiated seeds were grown in high available P soil. Plants were harvested at maturity and stover and grain yields were recorded. After harvesting grain and stover samples were washed first in tap water, then dilute hydrochloric acid (HCl; 0.1 N HCl solution) and finally in deionized water and dried in an electric oven at 70 °C. Grain and straw samples were finely ground in a stainless steel grinder. Finely ground plant sample (1 g) was digested in di-acid mixture [nitric acid (HNO₃): perchloric acid (HClO₄) 3:1 v/v]. Phosphorus in the digests was determined by phospho-vanadomolybdate complex method on a visible range spectrophotometer at 420 nm. Results showed that grain yield significantly increased with increasing gamma dose and highest grain yield was recorded at 0.2 kGy dose. Above 0.2 kGy treatments, crop growth was substantially reduced. Further, P uptake by grain significantly increased in irradiated treatment as compared to non irradiated treatment and highest P uptake was recorded 0.1 k Gy treatment. Results from this study indicate that there is stimulating effect of low level of gamma radiation on yield and P uptake of maize crop and 0.1 kGy Gamma dose can be used as a threshold dose for enhancing P uptake by Maize plants. Further, these results need to be confirmed by conducting more trials in different soil types.



Soil Test Based Fertilizer Prescription through IPNS for Rainfed Maize on an Inceptisol

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A field experiment was conducted with TNAU maize hybrid Co6 at Maize Research Station, Vagarai, Dindigul District under rainfed conditions to develop fertilizer prescription equations (FPEs) for maize through refinement of the existing FPEs for irrigated hybrid maize based on targeted yield model (Ramamoorthy *et al.*, 1967). The experimental soil was red sandy loam (Typic Ustropept), non-calcareous with a pH of 6.97 and EC of 0.39 dS m⁻¹ and available N, P and K were 176.0, 12.3 and 276 kg ha⁻¹, respectively. The design was RBD with three replications and nine treatments viz., STCR-NPK alone-4, 5 and 6 t ha⁻¹, STCR-IPNS-4,5 and 6 t ha⁻¹, Farm Yard Manure (FYM) @ 6.25 and 12.5 t ha⁻¹ alone and absolute control. For STCR treatments, based on the pre-sowing soil test values of each plot, fertilizer N, P₂O₅ and K₂O doses were computed. For STCR-IPNS treatments, the recommended dose of FYM @ 12.5 t ha⁻¹ was applied and fertilizer N, P₂O₅ and K₂O doses were adjusted accordingly. At harvest, plot wise grain and stower yields were recorded and analysed for their N, P and K contents. The results revealed that the grain yield ranged from 2316 to 5590 kg ha⁻¹ with a mean value of 4136 kg ha⁻¹ and N, P and K uptake varied from 36 to 103.6, 4.8 to 18.2, 33.8 to 48.2 kg ha⁻¹ with a mean of 67.7, 12.5 and 43.7 kg ha⁻¹, respectively. Rainfed maize requires 16.2 kg N, 6.9 kg P₂O₅ and 13.1 kg K₂O for producing one ton of grain yield. The per cent contribution of N, P₂O₅ and K₂O from soil was 20.93, 39.52 and 13.26 and from fertiliser was 50.20, 45.61 and 76.04 per cent, respectively. The contribution of nutrients from FYM was 26.24, 18.78 and 30.12 per cent N, P₂O₅ and K₂O respectively. FPEs for rainfed maize were developed based on the basic parameters. FPEs under IPNS are FN = 32.3 T - 0.42 SN - 0.52 ON; FP₂O₅ = 15.1 T - 1.98 SP - 0.94 OP ; FK₂O = 17.3 T - 0.21 SK - 0.48 OK; where, FN, FP₂O₅ and FK₂O are fertilizer N, P₂O₅ and K₂O in kg ha⁻¹, respectively; T is the yield target in t ha⁻¹; SN, SP and SK, respectively are alkaline KMnO₄-N, Olsen-P and NH₄OAc-K in kg ha⁻¹ and ON, OP and OK are the quantities of N, P and K in kg ha⁻¹ supplied through FYM. Application of FYM @ 12.5 t ha⁻¹ (with 32% moisture, 0.50%, 0.21% and 0.49% NPK, respectively), can save 22, 17 and 20 kg of fertilizer N, P₂O₅ and K₂O, respectively. For an initial soil test value of 200,12 and 280 kg ha⁻¹ of available N, P and K and the yield target of 4,5 and 6 t ha⁻¹, the nutrient doses required are 45,37, and 15; 78,52 and 28; 110,60 and 45 kg ha⁻¹ of fertilizer N, P₂O₅ and K₂O, respectively along with FYM @ 12.5 t ha⁻¹.



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Interaction Effects of Nitrogen and Potassium on Soil Nutrient Fractions and Nutrient Uptake by okra (*Abelmoschus esculentus* L.)

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Bhendi is one of the important vegetable crops having nutritional value, medicinal and industrial importance. In general crop responds well to N and K application. Nitrogen and potassium are present in different inorganic forms and contributes to nutrient uptake by plants. The present investigation was carried out to study the influence of different levels of N and K and their interactions on soil nitrogen and potassium fractions and nutrient uptake by okra. The experiment was conducted on a sandy loam soil (*Alfisol*) at Student Farm, College of Agriculture, Rajendranagar, Hyderabad with four levels each of nitrogen (N_0-0 , N_1-60 , N_2-120 and N_3-180 kg N ha⁻¹) and potassium (K_0-0 , K_1-30 , K_2-60 and K_3-90 kg K₂O ha⁻¹). The experiment was laid out in factorial randomized block design. The results of the experiment revealed that there was significant increase in okra pod yield with application of different levels of nitrogen and potassium. However the highest pod yield (126.17 q ha⁻¹) was recorded with combined application of 180 kg N ha⁻¹ (N_3) and 90 kg K₂O ha⁻¹ (K_3). The N and K uptake significantly increased with increase in the levels of nitrogen and potassium at all the growth stages viz., 30, 60 and 90 DAS. The okra pods were also analyzed for their N and K uptake at harvest (90 DAS). The total nutrient uptake by okra (plants + pods) at harvest was computed and found significant increase in total N and K uptake (kg ha⁻¹) with application of N @ 180 kg ha⁻¹ (N_3) and K₂O @ 90 kg ha⁻¹ (K_3). With regard to interaction effects, N_3K_3 has recorded highest total N (83.83 kg ha⁻¹) and K (75.19 kg ha⁻¹) uptake. The soil samples collected at harvesting stage were analyzed for inorganic N (NH_4^+ and NO_3^- -N) and K (water soluble, exchangeable and 1N HNO₃-K) fractions. The interaction effect of N×K revealed that there was significant increase in contents of all forms of N and K at higher levels of N and K fertilization to okra. Among the different forms of nitrogen and potassium, both NH_4 -N and NO_3 -N forms of nitrogen and readily available forms of potassium viz., water soluble K and exchangeable K contributed to pod yield and total N and K uptake, which was evidenced by their significant correlation with these plant parameters.



Soil Nutrient Index at Lohara Tahsil of Osmanabad District (Maharashtra State)

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An investigation was carried out to study the status of available nutrients in soils of Lohara tahsil of Osmanabad district. For this purpose 180 representative soil samples were collected from 30 different villages of Lohara tahsil. The collected soil samples were grouped into three orders, viz Vertisol, Inceptisol, Entisol. Out of the total surveyed soil samples, 37 per cent soil samples were grouped under the order Vertisol while 40 per cent and 23 per cent soil samples were grouped under the order Inceptisol and Entisol, respectively and order wise analysis was carried out.

These soil samples were analyzed for physico-chemical properties, exchangeable Ca^{2+} , Mg^{2+} and available N, P, K and some micronutrients (Fe, Mn, Zn and Cu). In physical analysis, particle density, bulk density, porosity and colour were determined. The average particle density, bulk density and porosity of the soil was 2.48 Mg m^{-3} , 1.51 Mg m^{-3} and 38.66 per cent, respectively.

The soils of Lohara tahsil were alkaline in reaction having safe limit of electrical conductivity. These soils were calcareous in nature with low to medium organic carbon. According to nutrient index value, the soils of Lohara tahsil were low in available N, P, S and Zn, while high with respect to available K, exchangeable Ca^{2+} , Mg^{2+} and DTPA- Fe, Mn and Cu.

The pH showed negative correlation with available K, exchangeable Ca^{2+} , Mg^{2+} and DTPA-Fe, Mn and Zn, while significant and positive correlation with available N. EC established negative relationship with available N, P and exchangeable Mg but it was significant with only available N. Organic carbon showed positive correlation with available N, P, K, S, exchangeable Mg^{2+} , DTPA-Fe, Zn and Cu. However, CaCO_3 showed negative correlation with available N, K, S, exchangeable Ca^{2+} and DTPA-Mn but it was significant with available N, P and K.



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Studies on Available Nutrient Status of Agricultural Botany and Horticulture Farms of the University

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The investigation was carried out to study the physico-chemical properties and available nutrient status of Agril. Botany and Horticulture farms, College of Agriculture, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli during the year 2013-14. The results revealed that the pH of the soils of the Agril. Botany and Horticulture farms varied from 5.1 to 6.55 indicating that soils of both the farm were strongly acidic to moderately acidic in reaction while electrical conductivity varied from 0.01 to 0.016 dS m⁻¹, and it was normal and good for seed germination and healthy crop growth. The organic carbon content in the soils of both the farms varied from 0.27 to 2.91 per cent. The available nitrogen, phosphorus and potassium ranged from 94.08 to 476.62, 3.51 to 43.72, 215.04 to 443.52 kg ha⁻¹, respectively. The soils were high to very high in organic carbon, very low to medium in available N, medium to very high in K. There was marked variation in the content of available P ranging from very low to medium. The available Fe, Mn, Zn and Cu content in soils of both farms were found to vary from 25.74 to 99.68, 16.98 to 97.78, 0.12 to 1.34 and 1.70 to 5.78 mg kg⁻¹, respectively. The soils were well supplied with available Fe, Mn and Cu, However, 71 per cent soil samples were found to be deficient in Zn. The positive and significant correlation of Fe and Mn with sand, negative correlation of Zn and Cu with silt & pH were observed. The organic carbon content of soil showed highly significant and positive correlation with available N.

The fertility index of the soils of both the farms with respect to available N, available P, available K and organic carbon was 1.64, 1.21, 2.58 and 2.92, respectively.



Evaluation of Soil Test Crop Response Targeted Yield Equation-based Fertilizer Management in Pigeon Pea

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Pulses are important sources of protein for India's large and growing population. Pigeon pea is one of the most important leguminous crops and constitutes chief sources of protein for majority of population of India depending totally on vegetarian diet. Pigeon pea occupies 16.9 lakh ha⁻¹ area with total production 32.1 lakh tonnes and productivity 1899 kg ha⁻¹ in Morena District of Madhya Pradesh.

Farmers are still applying the fertilizer in imbalance manner in the Chambal division. An on farm trails was conducted in farmers field of adopted village during *khari* seasons 2011-12 to evaluate the soil test crop targeted yield equation based fertilizer management in pigeon pea. The quantity of fertilizer were calculated on the basis of soil test values of N,P,K, and targeted yield (T=20q/ha). The value were put up in the equation $F(N) = 7.82T - 0.39SN$, $F(P_2O_5) = 5.34T - 3.47SP$ and $F(K_2O) = 3.61T - 0.16SK$ and adjusted the recommended dose of N, P, K (kg ha⁻¹). In the on farm trails, the adjusted average RDF N:P:K (kg ha⁻¹) were 52:69:44 and in farmer's practices the dose of N:P:K (kg ha⁻¹) were 30:50:0.

The data revealed significant improvement in grain yield i.e. 21.40 q ha⁻¹ net return Rs 55843/- ha⁻¹ and B:C ratio 3.97 over the farmers practices 15.82 q ha⁻¹, Rs 39234/- ha⁻¹ and B:C ratio 3.46. The higher yield was received in STCR based RDF as it fulfilled need of all major nutrient of crops than in farmers practices. N and P were applied in imbalance manners. The economics was also better as net return Rs 55843/- ha⁻¹ and B:C ratio 3.97 were observed in demonstration plots as compared to farmers practice (Rs 39234/- ha⁻¹ B:C ratio 3.46). Since soil test based fertilizers recommendation strikes a balance between nutrient supply both from soil and fertilizer sources to the plant it leads to attainment of maximum possible yield with higher economic return to the farmers.



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Evaluation of Site Specific Nitrogen Management on Yield, Nitrogen Use Efficiency in Rice (*Oryza sativa* L.)

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A field experiment was conducted on a sandy loam soil during *kharif* season of 2012 with a view to study the effect of Site specific nitrogen management in rice on N use efficiency and grain yield. The leaf colour chart (LCC) and SPAD based N management can be used to optimize N application with crop demand or to improve existing fixed split N recommendations. We conducted a field experiment to determine the LCC and SPAD critical value for N application in irrigated rice. Treatments included 3 LCC based and 3 SPAD based N management contained the combination of three critical levels of LCC shade values (4, 4.5, 5) and three critical levels of SPAD (37, 39 and 41) values with different levels of N application were compared with recommended fertilizer dose (RFD) and soil test crop response (STCR) equation based fertilizer application. Nitrogen was applied in the form of urea as per treatment schedule and the SPAD and LCC assessed at 10 days intervals starting from 15 DAT. Result showed a considerable opportunity to increase yield, N use efficiency (NUE) through improved N management with LCC and SPAD values. The critical SPAD value of 41 with 30 Kg N ha⁻¹ and critical LCC value of 4.5 with 30 kg N ha⁻¹ were found to be suitable for guiding N application to achieve the highest grain yield. The N received by the crop under different treatments ranged from 90 to 210 kg ha⁻¹ in 3 to 7 splits. The effects of different treatments were evaluated in terms of rice grain yield, N use efficiency. The lowest N dose of 90 kg ha⁻¹ was received in T₃ (N₃₀ if SPAD value < 37) 3 split applications and the highest N dose of 210 kg ha⁻¹ was received in T₈ (N₃₀ if LCC value > 5) in 6 splits.



Optimising Copper Requirement for Enhancing Yield and Yield Attributes Of Onion (*Allium cepa* var. *aggregatum*)

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Onion (*Allium cepa*.L) is an important vegetable and a rich source of carbohydrates, minerals, proteins and vitamin C. India ranks second in area and production of onion with an area of 1.01 m ha and productivity of 16.6 t ha⁻¹. Micronutrient deficiency has become a major constraint for crop productivity in many Indian soils. In India, almost 39.9 per cent of the soils are deficient in Zn, 13 per cent in Fe, 6.0 per cent in Mn and 4.3 per cent in Cu. Recent reassessment status in soils of 19 districts of Tamil Nadu revealed that micronutrients deficiency especially Zn and Cu deficiency increased from 58 to 66.3 and 6 to 31.2 per cent, respectively. Cu²⁺ is a component of large number of proteins and enzymes which plays important roles in growth and metabolism of plants. Onion is highly responsive to Cu, and hence optimising the dose of Cu for onion crop is essential. Field experiments were conducted at eight locations in farmer fields in red sandy loam soils during *Rabi* 2013, to optimize the dose of Cu for enhancing the yield and yield attributes of onion. The initial analysis of experimental soil was neutral to slightly alkaline in reaction with low in available N and P and medium in available K. The soil was sufficient in all micronutrients except Cu, which was deficient in status. The experiment was laid out in a randomised block design replicated thrice with seven levels of Cu application viz., 0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 kg ha⁻¹ as CuSO₄ along with recommended fertiliser dosage 60:60:30 kg N, P₂O₅ and K₂O kg ha⁻¹. The results revealed that application of 1.5 kg Cu along 100 % RDF of NPK @ 60:30:30 kg ha⁻¹ significantly registered the highest onion bulb yield ranging from 20.5 to 22.1 t ha⁻¹ and it was 32 to 43 per cent increase over control besides enhancing plant growth and yield parameters; content and uptake of Cu and this level might be optimum for increasing the onion production.



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Influence of Tank Silt on Yield and Quality of Bhendi

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To evaluate the efficiency of tank silt, pot culture experiment was conducted at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal using Bhendi as test crop with thirteen treatments, where in absolute control and application of 100 % recommended dose of fertilizer (RDF) was compared with application of tank silt (TS) alone @ 2 t ha⁻¹ and different organic manures viz., press mud (PM), sewage sludge (SS), water hyacinth compost (WHC), FYM and spent wash (SW) alone @ 2 t ha⁻¹. The same set treatments were repeated with 100 % RDF. The experimental soil was sandy loam in texture, taxonomically it was *Fluventic Haplustept*. The soil is having pH - 7.29; EC - 0.095 dS m⁻¹; CEC - 20.70 cmol (P⁺) kg⁻¹. The organic carbon content was 5.80 g kg⁻¹. The KMnO₄-N, Olsen-P and NH₄OAc-K contents were 214, 29.7 and 204 kg ha⁻¹, respectively. The tank silt used in the experiment was clayey in texture (64.7 % clay) with bulk density of 1.08 Mg m⁻³ and pore space of 48.94 %. The CEC of tank silt was 47.15 cmol(p⁺)kg⁻¹. The results revealed that the fruit length, girth and weight were more with application of either FYM or sewage sludge along with TS+RDF. The fruit yield was higher with TS+PM+RDF and it was comparable with RDF, TS+RDF and TS+PM+RDF. With regard to the quality of fruits, the chlorophyll and ascorbic acid content was higher in TS+WHC+RDF and TS+PM+RDF, respectively. The mucilage and starch content were more with TS+SW+RDF. The absolute control treatment recorded the highest crude fibre content and physiological loss in weight.



Effect of Long-term Manuring and Fertilization on Yield and Nutrient Uptake by Wheat under Sorghum-Wheat Sequence in Vertisols

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The long term fertilizer experiment is being continued since 1988-89 at Dr. PDKV, Akola to study the changes in soil quality, crop productivity and sustainability. The experiment comprises various fertilizer treatments along with organics. The present investigation was carried out to study the long-term effect of integrated nutrient management on soil quality, crop productivity and sustainability under this sorghum-wheat sequence after 26th cycle (2013-14). The results indicated that application of 100% NPK + FYM @ 5 t ha⁻¹ recorded significantly highest grain (41.05 q ha⁻¹) and fodder yield (97.90 q ha⁻¹) of sorghum. The grain yield of sorghum with the application of 100% NPK along with sulphur @ 37.5 kg ha⁻¹ was recorded 30.75 per cent higher yield as compared to without sulphur application. Similarly, application of Zn @ 2.5 kg ha⁻¹ recorded 6.88 per cent higher grain yield of sorghum as compared to without Zn application. The magnitude of response was observed in the order 100% N < FYM < 50% NPK < 100% NP < 75% NPK + FYM < 100% NPK (-S) < 100% NPK < 100% NPK + Zn < 100% NPK + S < 150% NPK < 100% NPK + FYM. The trend in the productivity of wheat was observed almost similar as sorghum. The application of 100% NPK + FYM @ 5 t ha⁻¹ resulted improvement in the status of available N (317 kg ha⁻¹), P (19.98 kg ha⁻¹) and K (473 kg ha⁻¹) after harvest of wheat. The uptake of N (131 kg ha⁻¹), P (40 kg ha⁻¹) and K (143 kg ha⁻¹) was also influenced significantly with the application 100% NPK + FYM @ 5 t ha⁻¹. The application of 100% NPK + FYM @ 5 t ha⁻¹ significantly influenced the content of organic carbon to the extent of 7.91 g kg⁻¹ after harvest of wheat (2012-13).



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Effect of 29-years of Long-term Integrated Nutrient Management Practices on Soil Chemical Characteristics and Productivity of Rainfed Groundnut (*Arachis hypogea*) in an *Alfisols* in Arid Region of Andhra Pradesh, India

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The soil nutrient dynamics and groundnut pod yields was studied in the ongoing long-term integrated nutrient management for groundnut experiment initiated during rainy (*khariif*) season 1985 at Agricultural Research Station, Anantapur, A.P, comprised of ten treatments including inorganics with and without recyclable farm wastes *viz.* FYM and groundnut shells replicated three times in RBD with the objective to study the long-term effects of recycling of farm wastes along with or without chemical fertilizers 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. Significantly higher soil organic carbon (%) was recorded in treatments applied with organics alone or organics along with inorganics. The initial available phosphorous content (44 kg/ha) increased with only inorganics (116 kg/ha) applied plots. In the control, initial available phosphorous (P_2O_5) levels of 44 kg/ha was reduced to 22 kg/ha over 29 years. Mean differential yield was at par in both RFD (941 Kg/ha) and HRFD+FYM @ 4t/ha (960 kg/ha). However, control (732 kg/ha) recorded lowest mean pod yield over 29 years. Without application of fertilizers and manures after 21 years (since 1993) in depletion studies, recommended fertilizers dose of 20-40-40 N, P_2O_5 , K_2O kg/ha, HRFD(10-20-20 N, P_2O_5 , K_2O kg/ha) + FYM @ 4t/ha and FYM @ 5 t/ha applied plots are giving more or less similar yields to that of 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) along with FYM @ 4 t/ha is giving at par groundnut pod yields compared to full recommended fertilizer dose (20-40-40 N, P_2O_5 , K_2O kg/ha) which not only gave sustainable yields but also enhanced the soil health.



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Nutrient Release Pattern of Konkan Annapurna Briquettes with Different Coating Materials in Lateritic Soils of Konkan Region of Maharashtra

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The incubation study was conducted during the year 2013-14 for studying the nutrient release pattern of Konkan Annapurna Briquettes (KAB) with and without coated materials. Accordingly, Konkan Annapurna Briquettes developed by Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli by using Urea: Godavari (14:35:14) in 1.5:1 ratio were coated with different material viz; wax, jaggary and tar. These briquettes with different coating materials (KAB, W-KAB, J-KAB and T-KAB) were used in the pot culture experiment to study the incubation study i.e. nutrient release pattern of the coated fertilizer briquettes. For this, pot of 3 kg soil was selected and filled with soil of experimental plot. The four treatments i.e. deep placement of T₁-KAB without coating, T₂-Wax coated KAB (W-KAB), T₃-Jaggary coated KAB (J-KAB) and T₄- Tar coated KAB (T-KAB) were taken and replicated four times in complete randomized design. The initial soil analysis was carried out for available N, P₂O₅ and K₂O status. The coated/uncoated KAB was deep placed at 5 to 7 cm deep in each pot. The nutrient release pattern was studied at 8, 15, 30 and 45 days after application of briquettes by analyzing the soil properties for available N, P₂O₅ and K₂O status. The moisture condition in the pot was maintained at field capacity by adding the known quantity of water every day.

The tar coated Konkan Annapurna Briquettes (KAB) was found to be superior for the slow release of the nutrients up to 45 days after application in the incubation study. It was observed that the available nitrogen varied from 2.22 to 6.69 g pot⁻¹ in the soil where tar coated KAB was applied. It showed the significant results at all soil sampling stages with respect to available nitrogen. The available phosphorus and potassium showed the non significant results at 8, 15, 30 and 45 days after deep placement of the briquettes, respectively.



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Growth, Yield and Nutrient Uptake of Safflower as Influenced by INM under Irrigation and Rainfed Planting

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Field experiment on “Growth, yield and nutrient uptake of safflower as influenced by INM under irrigation and rainfed planting” was conducted during *rabi*, 2013 at College Farm, Hyderabad with the objectives to study the effect of inorganic fertilizers and INM, soil test based fertilizers and irrigation impact on growth and yield of safflower. The experiment was laid out in a split plot design with two main treatments : (M₁) irrigation at rosette, branching and flowering, M₂: rainfed planting; and seven sub treatments viz., S₁: Control (no fertilizers), S₂: RDF, S₃: soil test based fertilizers, S₄: RDF + FYM @ 5 tons ha⁻¹, S₅: soil test based fertilizers + FYM @ 5 tons ha⁻¹, S₆: RDF + vermicompost @ 2 tons ha⁻¹ and S₇: Soil test based fertilizers + vermicompost @ 2 tons ha⁻¹, replicated thrice.

Results reveal that irrigations at critical stages recorded higher plant height, dry matter production per plant, seed, stalk yield and higher nutrient uptake than rainfed planting. With respect to sub-treatments integration of organics and soil test based inorganic fertilizers S₇ (soil test based fertilizers + vermicompost @ 2 tons ha⁻¹) recorded higher plant height, dry matter production per plant, seed and stalk yield compared to S₆ (RDF + vermicompost @ 2 tons ha⁻¹) followed by S₅ (soil test based fertilizers + FYM @ 5 tons ha⁻¹), S₄ (RDF + FYM @ 5 tons ha⁻¹), S₃ (soil test based fertilizers) and S₂ (RDF). Interaction effect on plant height, dry matter production, yield and nutrient uptake of safflower crop as influenced by main and sub treatments were found to be non-significant.



Effect of Soluble Fertilizers on Yield and Quality of Soybean (*Glycine max* (L.) Merrill.)

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A field experiment was conducted during *kharif* 2011-12 on the Research Farm of Soil Science and Agricultural Chemistry Department at MKV, Parbhani to study the effect of soluble fertilizers on yield and quality of soybean (cv. MAUS-71). The treatments comprised of basal, N, P₂O₅, K₂O, S soil application dose @ 30:60:30:20 kg ha⁻¹ and foliar applications of starter (11:36:24 NPK), booster (08:16:39 NPK) and multi micronutrient notified grade- II (Zn-3%, Fe-2.5%, Mn-1%, Cu-1%, B-0.5%, Mo-0.1%). The experiment was laid out in Randomized Block Design with ten treatments and replicated thrice. The soil and plant samples were collected at flowering and pod development stages of growth. The result obtained in the study indicated that the physico-chemical properties *viz.*, pH, EC, CaCO₃, in soil did not varied significantly during different nutrient combination treatments, while OC of soil affected significantly at harvest stage.

The nutrient combination of 100% RDF + two sprays of starter and booster recorded maximum plant height, LAI. Treatment of 100% RDF + two sprays of starter and booster showed higher availability of N, P, K and S throughout the growing period of crop. The treatment combination of 100% RDF + multimicronutrient Grade II four sprays noticed maximum availability of micronutrients (Zn, Fe, Mn, Cu, Mo and B in soil). The concentration of N, P, K and S recorded highest in treatment of 100% RDF + two sprays of starter and booster in plant. Micronutrient concentration in plant observed maximum with of 100% treatment RDF + multimicronutrient Grade II 4 sprays. Uptake of N, P, K and micronutrients (Zn, Fe, Mn, Cu, Mo and B) observed highest in treatment 100% RDF and two sprays of each starter and booster.

The application of 100% RDF + two sprays of starter and booster recorded highest grain yield, straw yield, protein content, oil content and seed index.



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Effect of Different Organic Manures alone and in Combination of Chemical Fertilizers on Productivity of Pearl millet-Wheat Cropping System

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A long term field experiment was started in 1995 at Research Farm of Department of Soil Science CCS HAU Hisar to study the effect of various combinations of organic manures and fertilizers on yield and soil properties in pearl millet-wheat cropping sequences. The ten treatment combinations viz $T_1 = N_{75} + P_{30}$, $T_2 = N_{150} + P_{60}$, $T_3 = \text{FYM @15 t /ha}$, $T_4 = \text{FYM @15 + N150}$, $T_5 = \text{FYM @15 + N150 + P30}$, $T_6 = \text{Poultry manure @ 5 t /ha}$, $T_7 = \text{Poultrymanure @ 5 + N150 + P30}$, $T_8 = \text{Pressmud @ 7.5t/ha}$, $T_9 = \text{Pressmud @7.5 + N75 + P30}$, $T_{10} = \text{Pressmud @ 7.5 + N150 + P30}$ were applied in every year before sowing of Rabi crops. The present study was conducted after completing 19 cycles of crop rotation. The lowest grain and straw yield of wheat crop was recorded when only organic manures (15 t FYM or 5 t poultry manure or 7.5 t pressmud ha⁻¹) were applied. With the application of N in conjunction with organic manures, there was a substantial increase in the crop yield which was comparable with recommended dose of applied NP alone or NP applied in combination with organic manures. There was an increase of about 115, 95 and 92 % in wheat grain yield upon application of 15 t FYM, 5t poultry manure and 7.5 t pressmud ha⁻¹ along with recommended N and half of P over manures applied alone, respectively. Continuous application of organic manures alone or in conjunction with NP fertilizer decreased the soil pH. However, a reverse trend was observed in case of EC. Organic carbon content of soil decreased from its initial value, when only NP fertilizers were applied and increased significantly with the application of organic manures applied alone or with NP fertilizers. The highest organic C content of soil was found in plot receiving 15 Mg FYM+150 kg N + 30 kg P₂O₅ ha⁻¹. The application of organic manures with or without NP fertilizers could not sustain the original level of N. However, their application increased the available P and K in soil. Thus the application of P and K can be avoided with the application of organic manures.



Effect of Plant Densities and Nitrogen Levels on Dry Matter Production, Partitioning and Nutrient Uptake on Hybrid Maize

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A field experiment was carried out at College farm, Rajendranagar, Hyderabad with the objective of improving the efficiency of nitrogenous fertilizers under variable plant densities during *kharif* 2013 with three plant densities of 60x25 cm (66,666 plants ha⁻¹), 45x25 cm (88,888 plants ha⁻¹), and 45x20 cm (1,11,111 plants ha⁻¹) as factor one and four nitrogen levels (120 kg ha⁻¹, 180 kg ha⁻¹, 240 kg ha⁻¹ and 300 kg ha⁻¹) as factor two in randomized block design with factorial concept, replicated thrice. The results revealed that population density of 88,888 plants ha⁻¹ was economical with significant increase in dry matter and nitrogen uptake per unit area but it was on par with 1,11,111 plants ha⁻¹. However population density of 66,666 plants ha⁻¹ recorded more dry matter production (256 g plant⁻¹), dry matter partitioning towards leaf (30 g plant⁻¹), stem (33 g plant⁻¹), cob (188 g plant⁻¹) and nitrogen uptake on per plant basis (2.21 g plant⁻¹). Application of 300 kg N ha⁻¹ recorded significantly higher dry matter production (268 g plant⁻¹), dry matter partitioning to leaf (28 g plant⁻¹), stem (39 g plant⁻¹), cob (202 g plant⁻¹) and nitrogen uptake (2.28 g plant⁻¹) over 120 kg N ha⁻¹ and 180 kg N ha⁻¹. But application of 240 kg N ha⁻¹ was on par with that of 300 kg N ha⁻¹.



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Response of Rice to Silicon Fertilization in the Intensively Rice Growing Soils of Periyar Vaigai Command Area, Tamil Nadu

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The Periyar Vaigai Irrigation System is one of the oldest and second largest irrigation systems in India existing since 1898 and rice is grown as mono crop. High accumulation of Si in rice has been demonstrated to be necessary for healthy growth and high stable production. Depletion of plant available Si in traditional rice soils from the continuous monoculture of high yielding varieties could be a possible limiting factor contributing to declining or stagnating yields in many rice growing countries. For this reason, Si has been recognized as an “agronomically essential element” in Japan and silicate fertilizers have been applied to paddy soils. In order to assess the response of rice to the applied Si for arriving at the optimum dose, a pot culture experiment was conducted using the bulk soil samples representing the major rice growing tract of Periyar Vaigai Command area with five levels of Si (0, 75, 150, 225 and 300 mg kg⁻¹) replicated twice in a completely randomized design using rice variety ADT -45 as test crop. The relationship between grain yield of rice and the applied Si was established in quadratic response function for optimization purpose. The various yield attributes *viz.* number of productive tillers per hill, panicle length, number of filled grains per panicle and percentage of chaffy grains were recorded. The grain and straw samples were analyzed for Si content for computing the uptake values.

A progressive increase in plant height was observed from tillering to harvest irrespective of different treatments. The maximum number of tillers per hill was recorded at 225 mg kg⁻¹ Si level which was on par with 300, 75 and 150 mg kg⁻¹ Si levels. Increasing levels of Si addition enhanced the number of productive tillers per hill and maximum value was observed at 225 mg kg⁻¹ Si level. The highest panicle length was recorded at 225 mg kg⁻¹ Si level followed by 75, 150 and 300 mg kg⁻¹ Si levels. Silicon application had remarkable influence on number of filled grains per panicle and ultimately reduced the chaffy grains. The grain and straw yields of rice were found to increase with Si application up to 225 mg kg⁻¹ level, beyond which they declined. Based on optimization study, the physical and economic optimum levels of Si for the study area were fixed as 368 and 310 mg kg⁻¹ respectively. Addition of Si caused a conspicuous increase in Si uptake in rice up to 225 mg kg⁻¹ level beyond which the uptake decreased. Application of Si at 300 mg kg⁻¹ level was found to register maximum amount of available Si in soil, while the lowest amount of available Si was recorded at control.



Effect of Sulphur and Zinc Nutrition on Yield and Quality of Chickpea (*Cicer arietinum* L.)

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A field experiment was conducted at the instructional farm of Rajasthan College of agriculture, Udaipur during *Rabi* season of 2011-2012 with the objectives to work out the most appropriate doses of sulphur and zinc for chickpea cultivation in Udaipur soil.

The soil of experiment site was medium in available sulphur (8.8 mg kg⁻¹) and zinc (1.58 mg kg⁻¹). The experiment consisting of 16 treatments combinations comprising four levels of sulphur (0, 15, 30, and 45 kg S ha⁻¹) in integration with four levels of zinc (0, 2.5, 5.0 and 7.5 kg Zn ha⁻¹). The experiment was laid out in Factorial randomized block design with three replications.

The results of experiment indicated that application of 30 kg S ha⁻¹ significantly increased the overall growth of the crop in terms of plant height, branches per plant, pod per plant, grain and haulm yield. Nitrogen, phosphorus, potassium, sulphur, iron, copper, zinc and protein content in grain and nitrogen, potassium, sulphur and iron, manganese, copper and zinc in haulm significantly increased. Potassium, iron and zinc uptake by grain and nitrogen, phosphorus, potassium, sulphur and iron and manganese uptake by haulm was significantly increased irrespective of Zn application. While application of 45 kg S ha⁻¹ significant increased the nitrogen, phosphorus, sulphur, manganese and copper uptake by grain, phosphorus and copper uptake by haulm and chlorophyll content in leaves. Available N, P, S, Fe, Mn and Cu in soil after harvest increased significantly with increasing levels of sulphur upto 45 kg S ha⁻¹. However, available zinc was adversely affected by increasing levels of sulphur.

Application of 5 kg Zn ha⁻¹ irrespective of S applications, improve the overall growth of the crop in terms of plant height, branches per plant, pod per plant, grain and haulm yield, protein content in grain, nitrogen, phosphorus, potassium, sulphur, iron and zinc content in grain and phosphorus, potassium, iron and zinc uptake by grain, nitrogen, phosphorus, potassium, sulphur, iron and zinc uptake by haulm. While application of 7.5 kg Zn ha⁻¹ significantly increased nitrogen, sulphur, copper and manganese uptake by grain, copper uptake by haulm and chlorophyll content in leaves.



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Evaluation of Extractants for Prediction of Available Potassium in Rice Soils of Canal Ayacut Kurnool District, Andhra Pradesh

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Evaluation of nutrient status in soils is important for nutritional, environmental and economical aspects. The soils of Kurnool district are put to intensive cultivation with rice crop in canal ayacut to meet the urban demand. Generally, potassic fertilizer scheduling is done on the basis of available K in soils measured by N N NH₄OAc. However, there are reports indicating that N N NH₄OAc fails to predict the response of K in illite dominated soils. Hence there is a need for evaluating the suitability of the extractants for available potassium in these soils in order to supplement the crop with proper amounts of potassium fertilizer. Surface soils (15cm) were collected from eleven mandals of rice growing soils of canal ayacut of Kurnool district. The texture of the soils ranged from sandy loam to clay. The soils were neutral to slightly alkaline with a mean pH value of 7.83 and EC ranging from 0.06 to 1.71 dS m⁻¹. The CEC of the soils was ranged from 14.43 to 31.65 C mol (p⁺) kg⁻¹. The organic carbon content of the soils was in the range of 0.32 to 0.87%. The soils were low to medium in available N, medium to high in available P and medium to high in available K status.

The efficiency of extractants used in the present study are in the order of 1 N HNO₃ > Mehlich-3 > 0.2 M NaBPh₄ > 1 N NH₄OAc > AB-DTPA > 0.02M citric acid > 0.01M CaCl₂ > Distilled water. Higher amounts of K was extracted by 1 N HNO₃ with a mean value of 528 mg kg⁻¹ where as distilled water extracted lower K with an average value of 34 mg kg⁻¹. The amount of potassium extracted by 1 N HNO₃ serves as a better index of available potassium in the investigated soils as it showed positive correlation with dry matter yield and plant uptake. For comparing the efficiencies of different extractants Mc. George's modified Neubauer's experiment was conducted and found significantly positive correlation was found between 1 N HNO₃ and shoot K content (r=0.353*).



Validation of Soil Test-based N, P and K Fertilizer Recommendation for Targeted Yield of Different Crops in NCR, Delhi

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Based on soil test crop response (STCR) concept, nineteen verification trials on pearl millet (*Pennisetum glaucum*), rice (*Oryza sativa*), wheat (*Triticum aestivum*), and mustard (*Brassica campstries*) were conducted during 2012-13 at farmers field in three village namely Kumbhawash (Gurgaon, Haryana), Badarpur said (Faridabad, Haryana) and Peernagar Soodna (Hapur, Uttar Pradesh) to ascertain the validity of developed fertilizer adjustment equations based on Soil Test Crop Response for targeted yield. These equations were compared with other fertilizer practices *viz*, farmer's practice and general recommendations. Fertilizer doses of different crop under STCR based fertilizers application treatment were calculated using fertilizer adjustment equations for targeted yield. The use of fertilizer based on soil test for targeted yield has increased by about 16.5%, 29.9 %, 12.7% and 28.6 % to obtain average wheat yield of 5.94, mustard yield of 2.43, rice yield of 5.5 and pearl millet yield of 2.7 t ha⁻¹ from 6.0, 2.5, 5.5 and 3.0 t ha⁻¹ targeted yield of the crops over general fertilizer recommendation respectively. The highest net profit for mustard, rice, wheat and pearl millet were found Rs. 32825, 27922, 22704 and 10726 ha⁻¹ respectively with STCR based fertilizer recommendation as compared to other fertilizer recommendations. Among the different fertilizer practices, STCR based fertilizer recommendations were found more economically viable within the agro-ecological zone and achieved more than 95 % of targeted yield of different crops except pearl millet. Therefore, STCR based fertilizer application may be recommended for the farmers of NCR, Delhi.



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Effect of Phosphorus and Sulphur on Yield and Nutrient Uptake of Soybean

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A field experiment was conducted on Typic Haplustept at Instructional Farm of Rajasthan College of Agriculture, Udaipur during *kharif* 2012 to assess the effect of phosphorus and sulphur fertilization on yield and nutrient uptake by soybean [*Glycine max* (L.) Merrill]. The soil of experimental site was medium in available phosphorus (20.73 kg ha⁻¹), nitrogen (281.30 kg ha⁻¹) and low in available sulphur (8.9 mg kg⁻¹). The experiment was laid out in factorial randomized block design with three replication and consisted four levels of phosphorus (0, 20, 40 and 60 kg P₂O₅ ha⁻¹) and four levels of sulphur (0, 15, 30 and 45 kg S ha⁻¹). The results revealed that increase the levels of phosphorus and sulphur significantly increased the grain and stover yield over the control. N, P, K, S, Fe, Mn, Cu and Zn were observed significantly uptake by grain and stover over the control. The results of experiment indicated that application of 60 kg P₂O₅ ha⁻¹ and 30 kg S ha⁻¹ recorded significantly better yield and N, P, K, S, Fe, Mn, Cu and Zn uptake by grain and stover of soybean.



Effect of Phosphorus Rich Compost with and without PSB and Vermiculture on Growth and Yield of Maize (*Zea mays* L.)

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An experiment was conducted during *kharif* 2013 on clay loam soil of Instructional Farm, Rajasthan College of Agriculture, Udaipur, to study the effect of phosphorus rich compost with and without PSB, Vermiculture on growth and yield of maize (*Zea mays* L.). The experiment was conducted in a completely randomized block design with factorial arrangement using three replications. Treatments included: control, 100% RDP through DAP; 100% RDP through SSP; 25% RDP through PRC + 75% RDP through DAP; 25% RDP through PRC+PSB + 75% RDP through DAP; 25% RDP through PRC + Vermiculture + 75% RDP through DAP; 25% RDP through PRC + PSB + Vermiculture + 75% RDP through DAP; 100% RDP through PRC; 100% RDP through PRC+PSB; 100% RDP through PRC+ Vermiculture and 100% RDP through PRC+Vermiculture + PSB. Results indicated that among phosphorus sources (DAP, SSP and PRC incubate with and without PBS and Vermiculture) application of 25% RDP through PRC + Vermiculture + PSB + 75% RDP through DAP (T₆) significantly improve plant height, dry matter, grain, stover and biological yield and harvest index of maize crop over other treatments. However, it was statistically at par with treatment T₁ (100% RDP through DAP), T₂ (100% RDP through SSP), T₄ (25% RDP through PRC + 75% RDP through DAP), T₅ (25% RDP through PRC + Vermiculture + 75% RDP through DAP), T₈ (100% RDP through PRC+PSB) and T₁₀ (100% RDP through PRC+Vermiculture + PSB).



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Effect of Aquatic Weed Compost on Nutrient Content, Uptake, Grain Yield of Rice (*Oryza sativa* L.)

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A pot culture experiment was conducted on a clay soil during *kharif* season of 2013 with a view to study the effect of weed compost on performance of rice (BPT 5204 var.) in terms of dry matter production and grain yield. The pot culture experiment was conducted to determine the effect of integrated application of weed compost on nutrient content, uptake and grain yield of rice. Experiment consists of ten treatments *i.e.*, T₁ 100% Recommended dose of fertilizer nitrogen (RDFN). T₂, T₃, T₄, are 75% RDFN + 25% replacement of nitrogen through *Eichhornia*, *Ipomoea* compost and Farm yard manure (FYM), T₅, T₆, T₇ are 50% RDFN + 50% - N through *Eichhornia*, *Ipomoea* compost and FYM respectively and T₈, T₉, T₁₀ are 25 % RDFN + 75% RDN through weed compost and FYM. The nitrogen was applied in the form of urea as per treatment schedule, phosphorus and potassium were applied uniformly to the all treatments as per the recommended dose. Results showed there was significant increase in nutrient uptake (N, P and K), dry matter production, grain yield of rice in 75 % RDFN + 25 % replacement of nitrogen through weed compost compared to T₁ (100 % RDFN) alone .



Influence of High Nutrient Management on Yield and Nutrient Uptake of Elite Groundnut Genotypes under Irrigated Conditions

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Majority of the groundnut growing soils in the Southern zone of Andhra Pradesh are light textured, poor in organic carbon, exhibiting deficiencies of not only major nutrients but also secondary and micronutrients such as S, Ca, Zn, Fe and B. Farmers generally use suboptimal doses of nutrients and there is a wide gap between the current average productivity and the potential achievable yield. There is an opportunity to maximize the yields in groundnut through high and improved nutrient management. In this context, the present experiment was conducted for two years viz., 2012 and 2013 under irrigated conditions during season with split plot design replicated thrice. Four promising groundnut genotypes were selected as main plots for evaluation under high nutrient management. Four nutrient levels were imposed as subplots viz., T1:100% RDF(30: 40: 50), T2: 150% RDF(45: 60: 75), T3: T1+ ZnSO₄ @ 50 kg ha⁻¹ + Borax @10 kg ha⁻¹ and T4: T2+ ZnSO₄ @ 50 kg ha⁻¹ + Borax @ 10 kg ha⁻¹. All other agronomic practices were followed as per package of practices. Data was recorded on yield, yield attributing characters, nutrient uptake at harvest and post harvest soil analysis as per standard procedures. Among the four groundnut varieties tested, TCGS 1157 recorded significantly the highest pod yield of 2.392 t ha⁻¹ followed by TG 47 (2.298 t ha⁻¹). Whereas the lowest pod yield was recorded with TCGS 750 (2.183 t ha⁻¹). However, highest haulm yield was recorded in TCGS 750 (5.062 t ha⁻¹). Highest shelling percent of 69% was recorded in TGS 1157. Among the nutrient levels, 100% RDF along with micronutrients viz., ZnSO₄ @ 50 kg ha⁻¹ + 10 kg ha⁻¹ Borax recorded significantly the highest pod yield of 2.384 t ha⁻¹ which was on par with 150% RDF (2.267 t ha⁻¹). TCGS 1073 recorded the high pod yield even at lower nutrient level i.e 100% RDF. Significantly highest nitrogen uptake was recorded in TG 47 followed by TCGS 1157 whereas lowest uptake was seen in TCGS 1073. However highest P uptakes was recorded in TCGS 1157 followed by TG 47. Similar trend was observed with K uptake. The results of the study indicated that for higher pod yields, the groundnut crop has to be supplemented with micronutrients viz., Zn & B along with 100% recommended dose of fertilizers in Southern agro climatic zone of Andhra Pradesh.



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Influence of Levels of Potassium on Its Use Efficiency and Balance of NPK under Maize Cultivation

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A field experiment was conducted at Zonal Agricultural research station, V.C farm Mandya, UAS, Bengaluru in Kharif 2012-13, to study the influence of split application of potassium on maize cultivation. The nine treatments were replicated thrice using RCBD with control, 75, 100 and 125 per cent of recommended dose of Potassium (40 kg ha^{-1}) using recommended dose of N and P ($150 \text{ \& } 75 \text{ kg ha}^{-1}$). 75, 100 and 125 per cent of K were tested with 2 splits and as well as basal. Considering the initial soil test values to checked the use efficiency of K and balance of NPK. Potassium use efficiency by maize crop was worked out by considering the yield of potassium fertilizer added plot and control plot. Balance sheet of nitrogen, phosphorus and potassium was worked out with the initial soil available N, P_2O_5 and K_2O status, amount of N, P_2O_5 and K_2O added through FYM and fertilizers and uptake of N, phosphorus and K_2O . Expected balance of N, P_2O_5 and K_2O was calculated by subtracting uptake of NPK by plant with total N, P_2O_5 and K_2O .

The total uptake of N and K by maize significantly increased to the applied graded levels of potassium. The highest uptake of nitrogen and potassium was recorded due to the application of recommended NP + 125 per cent recommended K in splits, which was antagonistic to phosphorus, the higher P uptake was recorded with the application of recommended NPK. Split application of potassium increased the efficiency and availability nutrients. However the higher potassium use efficiency (49.34 per cent) was recorded with the application of recommended NP + 125 per cent of recommended K in two splits (basal and at the time of topdressing), and the least K use efficiency was recorded in recommended NP + 75 per cent of recommended K as basal with a value of 28.31 per cent. While actual balance of nitrogen was higher with recommended NP + 75 per cent of recommended K in two splits (basal and at the time of topdressing) and the net negative balance of N was higher with recommended dose of NP only without application of K and net positive balance was higher with recommended dose of NP + 125 per cent of recommended dose of K as basal. Higher phosphorus balance noticed with recommended NPK as per UAS (B) package and net negative balance was higher with application of recommended NP only and net positive balance was recorded only in absolute control. Actual potassium balance was higher with recommended NP + recommended K in two splits (basal and at the time of topdressing). Net positive balance was high with the application of recommended NP + 125 per cent of recommended K in two splits.



Impact of split application of potassium at different intervals on maize growth, yield and nutrient content

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A field study was conducted with the graded levels of potassium in combination to recommended NP during kharif season 2012 at Zonal Agricultural Research Station, V.C. Farm, Mandya, UAS, Bengaluru to study the impact of split of potassium under irrigated Maize (*Zea mays L.*) in southern dry zone of Karnataka. The treatments consisted of graded levels of potassium (75 percent, 100 per cent and 125 per cent of recommended K) with and without split application along with recommended NP and absolute control. Growth and yield parameters like plant height, number of leaves, cob length, cob girth, test weight, grain and straw yield of crop were recorded. The plant samples were analyzed for N, P, K, Ca, Mg and Zn at 45 DAS and at harvest of the crop. Soil samples collected after harvest of the crop and analyzed for pH, EC, OC, N, P, K, Ca, Mg and Zn.

Maize plant height increased significantly at all the stages (60, 90 DAS and at harvest stage) of crop growth due to split application of potassium along with 100 per cent NP followed by the treatment recommended NP + 125 per cent of recommended K as basal. Application of high potassium dose (125 per cent of recommended K) in splits with 100 per cent NP combination resulted in increased number of maize leaves. Synergistic effect of higher potassium levels on nitrogen, potassium, sulphur and zinc, these nutrients content in maize was recorded high by the application of more than recommended K (125 per cent recommended K) with recommended NP. Concentration of phosphorus, calcium and magnesium in maize was recorded high with the application of recommended NPK. Higher potassium levels were antagonistic to the P, Ca and Mg in maize. Cob length, cob girth and hundred grain weight of maize was more with the combined application of recommended NP and 125 percent of recommended K in splits. Application of 125 per cent of recommended K in two splits (basal and at the time of topdressing) along with recommended NP increased the high nutrient uptake which leads to higher grain and stover yield.



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Study of Available Zinc and Copper Content and their Correlation with Other Properties of Soil

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A study was conducted at Agricultural College, Shimoga, to characterize the soils of Krishnarajpet taluk, Mandya district Karnataka, India, with an objective to evaluate status of zinc and copper content and their relation with other properties of soil. Results of the study indicated that the clay content in these soils varied from 3.80 to 28.70 per cent and sixty two per cent of the soils recorded sandy loam texture. The soils were acidic to alkaline in nature (4.01-8.47), Electrical conductivity ranged from 0.01 to 0.32. Organic carbon content ranged from 0.11 to 0.82 per cent and CEC of these soils was found to be low and it was in the range of 3.12 to 14.80 cmol(p+) kg⁻¹. The CaCO₃ equivalent of the soils was low and it varied from 0.14 to 1.49 per cent. The DPTA extractable Zn ranged from 0.07 to 0.85 mg kg⁻¹ soil. Eighty five per cent of the soils were deficient in zinc and it had a positive and significant correlation with clay ($r= 0.409^{**}$), soil organic carbon content ($r= 0.678^{**}$), pH ($r= 0.288^{**}$), CEC ($r= 0.389^{**}$) and CaCO₃ equivalent ($r= 0.293^{**}$) of soil. But, it showed a negative and non significant correlation with electrical conductivity of soils. Copper ranged from 0.082 to 4.634 mg kg⁻¹. Ninety nine per cent of soils were sufficient in available copper (0.382 to 4.634 mg kg⁻¹) and the available copper had a positive and significant correlation with organic carbon content ($r= 0.409^{**}$) and clay contents of soils.



Crop Productivity of Finger millet –Maize Cropping Sequence in Four Decades of Long Term Fertilizer Experiment of TNAU, Coimbatore

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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 plant nutrients at various combinations both organic and inorganic forms on the yield of finger millet - maize cropping system. Totally this experiment consisted of ten treatments which were replicated four times in randomized block design (RBD).

The experimental soil (Periyanaickenpalayam soil series) is sandy clay loam in texture and taxonomically grouped under *Vertic Ustropepts*. The highest grain and straw yield was recorded in the treatment that received 100% NPK+FYM followed by the treatment that receiving 150 % NPK whereas the lowest grain and straw yield recorded in the control. At the time of start in 1972 the soil was low in available N and P and high in available K. In the last 40 years 100 crops were raised. From the beginning improved varieties and hybrids of maize are being tested in LTFE. From 2010 onwards revised rate of 250:75:75 kg N, P₂O₅ and K₂O ha⁻¹ is followed for hybrid maize.

In finger millet, grain yield did not increase sensibly in 40 years of experimentation. Among the periods, the grain yield of finger millet was the highest (3.362 t ha⁻¹) during 1992-97. Among the treatments the highest grain yield was recorded in 100% NPK+FYM (INM) (3.296 t ha⁻¹) which was 17.5 per cent higher than 100% NPK. With the imposition of levels of NPK as 50, 100 and 150% there was response noted in terms of proportional increase in grain yield. However, high yield attained under 150% NPK (2.992 t ha⁻¹) was 9.2 per cent lower than INM.

Single nutrient application of 100% N reduced grain yield up to 48.1 per cent when compared to 100% NPK. Grain yields under 100% NPK and 100% NP were comparable. Over years grain yield of maize increased progressively from 1.598 to 4.996 t ha⁻¹. Yield improvement over years in maize was due to high productive varieties and hybrids used. Grain yield under 150% NPK was lower than INM. The highest yield was obtained under INM (3.851 t ha⁻¹) which was 19.2 per cent higher than the yield (3.230 t ha⁻¹) recorded under 100% NPK. Application of 150% NPK recorded grain yield of 3.535 t ha⁻¹ which was 9.2 per cent lower than INM indicating the superiority of INM over heavy rates of inorganic fertilization. Under 100% N grain yield (1511 kg ha⁻¹) recorded was very low indicating a reduction of 53.2 per cent when compared to 100% NPK. Due to high available K status of soil yield under 100% NPK (3.230 t ha⁻¹) and 100% NP (3070 t ha⁻¹) were similar, indicating least requirement of fertilizer K addition.



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Evaluation of Blackgram Genotypes to the Ferrous Sulphate Application in Calcareous Soil

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In calcareous soil, the iron chlorosis can limit the crop yield. The utilization efficiency of applied fertilizers under calcareous field conditions is relatively low which results in loss of a costly input and accentuates the environmental degradation. Some plants respond to iron deficiency stress by inducing biochemical reactions making iron available for absorption by the roots. These plants are classified as Fe efficient. Other plants unable to develop such mechanisms are classified as Fe inefficient. Iron inefficient genotypes planted on calcareous soil have foliage that becomes chlorotic at early stages of development. The leaves may recover during the growing season, but in general, plant production is reduced. Therefore, the development of genotypes with improved nutrient use efficiency is an important contribution to sustainable production system.

Blackgram is an important source of protein in India. Yield losses due to iron deficiency chlorosis have been observed in some blackgram genotypes when they were grown in high pH calcareous soils. However, information on differences in susceptibility to iron deficiency among blackgram genotypes grown in the field has been poorly documented. In view of this, a field experiment was carried out during 2011 with blackgram genotypes. Among the genotypes tested in this experiment, on the basis of chlorophyll content, plant growth, shoot DMP and yield, the COBG 6 excelled over other genotypes and it was followed by ADT 3 with relatively lesser growth and yield. The COBG 6 had higher total chlorophyll content both in the control and $\text{FeSO}_4 @ 50 \text{ kg ha}^{-1}$ applied plots. The COBG 6 registered higher mean total chlorophyll content (1.44 mg g^{-1}) followed by ADT 3, and TMV1. It also recorded the highest growth performances and yield under with and without ferrous sulphate application and recorded higher shoot dry weight of 510 kg ha^{-1} with a mean seed yield of 715 kg ha^{-1} . Based on the above observations, the COBG 6 considered to be Fe efficient in calcareous soils.



Development of Ready Reckoner for Attaining Yield Targets and Optimum Fertilizer Doses for Maximum Grain Yield, Profit and Desired Rate of Return based on Regression Models in Maize (*Zea mays*)

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Based on a field experiment conducted on maize (*Zea mays*) in a semi-arid alfisol at Hyderabad in India with 18 fertilized and 3 unfertilized treatments of N, P₂O₅, K₂O and vermicompost (VC) in *khari*f 2012, a statistical basis for deriving soil test based optimum fertilizer doses for attaining different yield targets has been developed. The study was conducted in a Randomized Block Design with 3 replications. The fertilizer treatments were selected based on 4 levels each of N @ 0, 60, 120, 180; P₂O₅ @ 0, 30, 60, 90; K₂O @ 0, 20, 40, 60 kg ha⁻¹ and VC @ 0, 2.5 and 5 t ha⁻¹. Significant correlation was found between soil, plant uptake and applied fertilizer nutrients with maize grain and dry matter yield. Based on the effects of fertilizer treatments on maize grain and dry matter yield, soil and plant uptake of N, P₂O₅, K₂O nutrients, estimates of nutrient requirement (NR, kg/q) from all the 63 plots (54 fertilized and 9 unfertilized), contribution from soil (CS, %) from 9 unfertilized plots and contribution from fertilizer (CF, %) from 54 fertilized plots were derived. Using the basic data of NR, CS and CF, fertilizer adjustment equations of N, P₂O₅ and K₂O were derived for prescribing optimum fertilizer doses based on soil test values for attaining maize yield targets of 4.0, 5.0 and 6.0 t ha⁻¹. The nutrient requirement was found to be 2.67 kg of N, 1.64 kg of P₂O₅ and 2.27 kg of K₂O for attaining one quintal of yield. The CS was found to be 21.6% for N, 85.2% for P₂O₅ and 11.3% for K₂O, while the CF was found to be 69.8, 1001.1 and 239.9% for the 3 nutrients respectively. The contribution from VC was found to be 47.5% for N, 59.0% for P₂O₅ and 51.1 for K₂O. The analysis indicated that we could attain a response of 15.6 kg of maize yield per kg of nutrient application in semi-arid alfisols. The optimum fertilizer doses based on soil test values could be used for attaining yield targets under similar soil and agro-climatic conditions.



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Prescription of Soil Test Based Fertilizer Recommendations for Specific Targeted Yield of *rabi* Castor in Alfisol Soils of Telangana

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Soil Test Crop Response (STCR) field experiment was conducted on castor during *rabi* 2012-13 in Alfisol soils of Palem, Mahabubnagar district, with an objective of developing soil test based fertilizer recommendations for attaining yield targets under IPNS. With the help of nutrient uptake, soil test values and average basic data (i.e nutrient requirement of N,P and K, percent contribution of N,P & K from soil, fertilizer and vermicompost) required for making fertilizer recommendations for different castor production levels (2.5 t ha⁻¹ and 3.0 t ha⁻¹) were calibrated. The basic data was transformed into simple workable fertilizer prescription equations for calculating fertilizer doses based on initial soil test values by the procedures laid by Ramamoorthy et al. (1967) and Velayudham and Rani Perumal (1976). Based on the study, the estimates of nutrient requirement (kg) for obtaining 1 quintal seed yield of castor were found to be 1.55 for N, 0.99 for P and 2.40 for K. The nutrient contribution from soil, fertilizer and vermicompost were found to be 22.87, 9.95 and 20.19 for N, 135.53, 21.03 and 12.65 for P and 22.18, 50.49 and 22.51 for K respectively. The response yard stick (kg output /kg input) was found to be 4.00 based on target yield coefficients. Using the fertilizer prescription equations, a fertilizer ready reckoner was developed for interpolating soil test based optimal fertilizer doses for attaining desired castor yield targets in alfisol soils of Telangana.

Fertilizer prescription equations

$$FN = 15.54 T - 2.30SN - 2.03 VC N$$

$$FP_2O_5 = 4.72T - 6.44SP - 0.60VC P \quad FK_2O = 4.75T - 0.44SK - 0.45 VC K$$



Effect of Nitrogen Levels Supplied through Various Sources on Yield, N Concentration and Uptake by Wheat

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The legume residues can serve as source to replace commercial fertilizers if the effect of these residues on yield and uptake of nutrients is known. Keeping in view the above, a screen house and laboratory experiment was conducted to study yield and uptake of N and N content of the soil amended with different legume residues. Four levels of N viz. 40, 80, 120, 160 mg N Kg⁻¹ soil were applied through urea and legume residues. The shoot and root dry matter yield in wheat increased significantly with increasing levels of N applied through different legume residues and urea up to 160 mg N Kg⁻¹ over control. The dry matter yield of wheat varied from 2.84 g pot⁻¹ in control to 11.35 g pot⁻¹ with urea applied at 160 mg N kg⁻¹soil. N concentration of shoot and root increased significantly with application of graded levels of N supplied through different legume residues and urea over control. Among urea and legume residues, higher N concentration was recorded with application of urea as compared to legume residues. The uptake of N also increased significantly with increasing levels of N applied through different legume residues and urea over control. Total and mineral N in the post harvest soil increased with increasing N levels supplied though urea and legume residues. But the level was different in soil amended with different sources. Organic carbon content of post harvest soil remained unaffected with the application N through urea. However, N applied though legume residues significantly increased the organic carbon of the soil over control.



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Response of Rice (*Oryza sativa*) to NPK and Zn Nutrients in Farmers' Fields of Telangana State

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On-farm experiments were conducted in 24 farmers' fields spread across Warangal district of Telangana State during *kharif* and *rabi* seasons 2010-11 to study the influence of NPK and Zn nutrients on rice in the context of changing management practices in rice-rice cropping system with six treatments *viz.*, T₁- Control, T₂- 120 kg N ha⁻¹, T₃- 120,60 kg NP ha⁻¹, T₄ - 120,40 kg NK ha⁻¹, T₅- 120,60,40 kg NPK ha⁻¹ and T₆- 120,60,40 and 50 kg NPK and Zn ha⁻¹ replicated 24 times (each field constitutes one replication) in randomised block design.

The results obtained across the locations revealed that balanced application of NPK and Zn significantly increased the grain yield of *kharif* rice (BPT 5204) (4.929 t ha⁻¹) compared to NPK (4.559 t ha⁻¹), NP (3.937 t ha⁻¹), NK (3.383 t ha⁻¹) and N alone (2.859 t ha⁻¹). Application of "N" increased the grain yield of rice by 48% over control across the locations while "P" application further improved the yields by 38% over the application of N alone. Potassium application also increased the rice yields significantly (18%) over N application alone. Balanced application of NPK increased the grain yield over application of N alone (59%) or NP (16%) or NK (35%). Basal application of Zn along with NPK increased the grain yield of rice by 8% over no application. *Rabi* experiment reiterated the above results, with the balanced application of NPK and Zn nutrients to rice crop (MTU-1010) resulting in higher yields of grain (5.012 t ha⁻¹) than the alone application of N or NP or NK or NPK.

Application of N significantly improved the soil N status after the harvest of *rabi* rice across the locations compared to no application while it was unaffected by the application of P, K and Zn. The 'P' status of the soil was not affected by the individual or combined application of N, P and K. However, application of K along with N and P had positive effect in the soil K status by the end of two seasons compared to non application. Compared to the initial soil status, N and P were depleted, where they were not applied, while K was reduced in all the plots including the plots where K was applied. The other chemical properties of the soil *i.e.*, pH, EC and Organic carbon content were not appreciably altered by the application of N, P and K either individual or combined through chemical fertilizers.



Physico-chemical Properties and Forms of Sulphur in Soils of Central Dry Zone of Karnataka

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A survey was conducted on distribution of soil physico-chemical properties in soils of Central dry zone of Karnataka. About ninety surface soil samples were drawn from surface soils covering Chitradurga district of Central dry zone. The collected soils were analyzed for various physico-chemical properties and also fractionation of soil sulphur forms was carried out in the laboratory by following standard procedures. The results revealed that the soils of the study area fall under medium texture category and the common texture of soils were loam, sandy loam, sandy clay loam and clay loam. All the soils were neutral to alkaline in their reaction (7.02 to 8.32). Electrical conductivity was normal in all the soils of different taluks. The salts concentration varied from 0.05 to 0.14 dSm⁻¹. Organic carbon content was low to medium which varied from 0.49 to 0.61 per cent. Among the taluks the soils of Hosadurga were low in organic carbon. Available N ranged from 228.51 to 374.90 kg ha⁻¹. Available P₂O₅ varied from 6.07 to 39.66 kg ha⁻¹. Potassium ranged between 227.94 to 349.31 kg ha⁻¹. Majority of the soils were low to medium in available N, P and K status.

Available sulphur status ranged from 8.00 to 13.10 mg kg⁻¹. Sulphur deficiency was observed in more than 80 per cent soils of Chitradurga district. Among micronutrients few soils showed low Zn status. Manganese content was higher than iron in all soils except in soils of Hosadurga taluk. Some soils of Hiriyur taluk showed deficiency of Cu and Fe.

Total sulphur content in soils varied from 347.73 to 552.90 mg kg⁻¹. Organic sulphur was the dominant fraction contributing to a major portion of total sulphur. The organic sulphur ranged between 126.30 to 279.23 mg kg⁻¹. Non sulphate sulphur was the second major contributor to total pool and its content varied from 95.77 to 257.97 mg kg⁻¹. The contribution of water soluble sulphur and sulphate sulphur was low among all fractions, the water soluble sulphur varied from 15.83 to 29.03 mg kg⁻¹. The order of sulphur fractions in soils was Organic-S>Non-sulphate-S>Water soluble-S>Sulphate-S.



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Variations in Physico-chemical Properties and Forms of Sulphur in Vertical Sections of Soil Profiles of Chitradurga District of Karnataka

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A study was undertaken during 2013 with an objective to study the variations in soil physico-chemical properties and forms of sulphur in vertical sections of soils in Chitradurga district of Karnataka. Eighteen representative profile samples were collected at different depth intervals (0-15, 15-30, 30-45 and 45-50 cm) from all the taluks of Chitradurga District. Three profile samples were collected per taluk as per the standard procedure.

The data indicated that among sand, silt and clay, sand decreased depth wise, silt distribution was irregular and clay content increased with depth. BD decreased depth wise and PD varied irregularly along the depth in all the profiles. Soil reaction was alkaline in surface and neutral in subsurface and decreased with depth in all profiles, EC showed irregular distribution and soils were non saline. Organic carbon content in majority of soils was low and few were in medium range. Nitrogen content of soil decreased with depth where as phosphorus showed no definite trend. Available N was low in all the profiles with decreasing depth and available P_2O_5 and K_2O content were low to medium which showed irregular distribution.

The secondary nutrients (Ca, Mg and S) distribution in all the profiles did not follow a definite trend and S status decreased with depth. Available N was low in all the profiles and decreased with depth and available P_2O_5 and K_2O content were low to medium which showed erratic variations. Majority of profile samples were low to medium in sulphur. Micronutrients distribution was irregular, low to high content was observed in all the profiles and generally the content decreased with depth.

Organic sulphur is the dominant fraction among all fractions of S followed by non sulphate sulphur which is the second dominant contributor to total S pool. Water soluble sulphur and sulphate sulphur contributed lesser to the total pool. Total sulphur in soil profiles of Chitradurga district was higher in Chitradurga taluk followed by Hiriyyur taluk and others.



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Effect of Different Levels of Nitrogen and Phosphorous on Growth, Nutrient Uptake and Biomass Yield of Kalmegh

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A field experiment was carried out on effect of different on nitrogen and phosphorous on growth, uptake of nutrients and biomass yield of Kalmegh in Kharif season during the year 2012-13 at Department farm. The experiment was laid in factorial randomized block design with three replication consisting of four N levels (0,40,80 and 120 kg ha⁻¹) and four levels of P(0,20,40 and 60 kg ha⁻¹). The results obtained from this investigation clearly depicts that the growth , uptake of N and P and biomass of Kalmegh were significantly influenced by different levels of N and P. Application of 120 kg N and 60Kg P ha⁻¹ significantly improved growth parameters in term of plant height , number of leaves, number of branches , fresh herbage yield and dry herbage, Yield ha⁻¹ as well as significantly improved uptake on nutrient at all the stages of Kalmegh followed by application of 80 Kg N and 40 Kg P ha⁻¹

Thus, it can be concluded that application of 120 Kg N and 60 Kg ha⁻¹ found to be significantly superior over control in improvement of growth, nutrient uptake and biomass of Kalmegh



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Response of Potassium Levels Alone and in Combination with FYM on Sunflower under Rainfed Condition

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An experiment was conducted at Zonal Agricultural Research Station, Solapur during year 2012-13 to study the response of potassium levels alone and in combination with FYM on sunflower (cv. Bhanu) under rainfed agriculture to study the effects of potassium levels alone and in combination with FYM on yield of sunflower and the effects of foliar sprays of nutrients on available nutrients as well as uptake of nutrients. Different treatments with different potassium levels like NPK 50:25:25 kg ha⁻¹, NPK 50:25:50 kg ha⁻¹, NPK 50:25:25 kg ha⁻¹ + 2.5 t FYM ha⁻¹, NPK 50:25:50 kg ha⁻¹ + 2.5 t FYM ha⁻¹, 1% KCl foliar spray at 30 & 45 days after sowing and 1% 19:19:19 foliar spray at 30 & 45 days after sowing are applied to the sunflower during kharif season. Among all the treatments application of NPK 50:25:50 kg ha⁻¹ + 2.5 t FYM ha⁻¹ was found significant for grain (15.28 q ha⁻¹) and straw (20.67 q ha⁻¹) yield which was statistically on par with treatments viz., NPK 50:25:25 kg ha⁻¹, NPK 50:25:50 kg ha⁻¹ and NPK 50:25:25 kg ha⁻¹ + 2.5 t FYM ha⁻¹. Similar trend was indicated in case of straw yield. The all treatments showed non-significant influence on oil content of sunflower. MUE for grain (5.70 kg ha⁻¹ mm⁻¹) was recorded the highest in NPK 50:25:50 kg ha⁻¹ + 2.5 t FYM ha⁻¹ treatment. The morphological parameters like plant height, plant population per plot & 100 grain weight of sunflower did not show much variation. Maximum N, P and K uptake were recorded with the application of NPK 50:25:50 kg ha⁻¹ + 2.5 t FYM ha⁻¹ (64.21 kg ha⁻¹, 10.73 kg ha⁻¹ and 110.80 kg ha⁻¹ respectively). The treatment NPK 50:25:50 kg ha⁻¹ + 2.5 t FYM ha⁻¹ recorded higher soil available nitrogen (157 kg ha⁻¹), phosphorus (20.4 kg ha⁻¹) and potassium (699 kg ha⁻¹),



Effect of Long-term Organic Manuring and Inorganic Fertilization on Soil Fertility and Productivity of Soybean-Safflower Cropping Sequence in Vertisol

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A Long-term fertilizer experiment was started in 2006 at Research farm, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra) to study the effect of organic manuring and inorganic fertilization on soil fertility and productivity under soybean-safflower cropping sequence in Vertisol. The experiment was framed in Randomized Block Design (RBD) consisting four replications and twelve treatments *viz.*, T₁-50% NPK, T₂-100%NPK, T₃-150% NPK, T₄-100% NPK+ Hand weeding, T₅-100% NPK+25 kg ZnSO₄ ha⁻¹, T₆-100% NP, T₇-100% N, T₈-100% NPK+FYM@ 5 Mg ha⁻¹, T₉-100% NPK-Sulphur, T₁₀-Only FYM@ 10 Mg ha⁻¹, T₁₁-Absolute control and T₁₂-Fallow. The recommended dose of fertilizer (RDF) applied to soybean (JS-335) and safflower (PBNS-12) was 30:60:30 and 60:40:00 kg N, P₂O₅ and K₂O ha⁻¹, respectively. After 7th cycle (2012-13) results indicated that, soybean and safflower grain yield (2.563 and 1.720 t ha⁻¹) and straw yield (2.697 and 4.409 t ha⁻¹) were significantly increased with 100% NPK+FYM @ 5 Mg ha⁻¹ as compared to other treatments. However, the sustainability yield index (SYI) of soybean and safflower was also recorded maximum with 100 % NPK + FYM @ 10 t ha⁻¹ and it was comparably near to the super optimal dose of fertilizer (150% NPK). In respect of soil fertility, it was significantly enhanced in terms of availability of N, P and K over its initial status with the application of optimal dose of fertilizer having 100 % NPK + FYM @ 10 t ha⁻¹, whereas availability of S and Zn was maintained by this treatment as compared to other treatments. However, a significant buildup of available Zn due the supply of zinc sulphate along with 100% NPK was noticed in the T₅-100% NPK+25 kg ZnSO₄ ha⁻¹ treatment.



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Effect of *Bt* Cotton on Soil Properties in Guntur District

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A field study was conducted to study the effect of *Bt* cotton on soil properties. A survey was conducted in cotton growing belt of Guntur district. Thirty representative surface soil samples were collected under three categories viz., six samples from non *Bt* cotton areas and twelve each from areas under *Bt* cotton for 2-5 years and 8-10 years. They were analyzed for physical, physico-chemical, chemical properties. Soils under *Bt* cotton were low in bulk density. All the soils were slightly alkaline and non saline. When compared to non *Bt* cotton areas, soils under continuous cultivation of *Bt* cotton for 2-5 years were less in available nitrogen. 8-10 years continuous cultivation of *Bt* cotton further decreased the available N content in soil. Similar trend was followed by other nutrients like potassium, sulphur and micronutrients (Zn, Fe, Mn and Cu) but available P content was less in soils under *Bt* cotton when compared to non *Bt* cotton areas. The soil samples were medium to high in phosphorus, very high in potassium, sufficient in sulphur and micronutrients like manganese, copper and deficient in iron. Soils under *Bt* cotton were deficient in zinc content but sufficient available zinc content was noticed in soils under non *Bt* cotton.



Evaluation of Plant Available Boron in Major Soil Types and Cropping Systems of Southern Karnataka

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A study was conducted to determine the plant available boron content in major soil types and cropping systems of Southern Karnataka. For assessing available boron status, Samples were drawn from the dominant soils and cropping systems: Northern dry zone, Central dry zone, Eastern dry zone, Southern dry zone, Southern transitional zone, Northern transitional zone, Hilly zone and Coastal zone representing the map units of 1:250,000 scale. In this study, climatic data recorded by Indian Meteorological Department from 1966 to 2002 from these zones was used to arrive at climatic parameters. Available boron was estimated with Azomethine-H solution with absorbance of spectrophotometer at a wavelength of 420nm. The results revealed that hot water soluble boron of soils ranged from 0.01 to 1.55 mg kg⁻¹. A map has been prepared showing the available boron status of Karnataka soils at 1: 250000 scale. The data obtained was super imposed to prepare maps of available boron status of soils with the help of satellite imaginary interpretation. The data showed that boron deficient soils were more frequently encountered in Udupi (Coastal zone), Chikmagalore (Hilly zone), Kodagu (Hilly zone), Shimoga (Southern Transitional zone), Hassan (Southern Transitional zone), Chamarajnagar (southern dry zone), some parts of Uttar kannada (Coastal zone), Belgaum (Northern Transitional zone) and Tumkur (Eastern dry zone) and 40 soil samples (48 %) were sufficient in available boron. Northern dry zone recorded higher soil available boron (1.55 mg kg⁻¹soil) and Coastal zone least (0.01 mg kg⁻¹soil) and for others boron content ranged from 0.11 mg kg⁻¹ soil to 1.09 mg kg⁻¹soil. Deficiency of available boron was noticed in rice based cropping systems of coastal and Hill zone experiencing of high rainfall. Amount of boron adsorbed was more in Northern dry zone and least in Southern dry zone. Climatic analysis can tell about the chances of boron deficiency, as deficiency of boron in soil is always associated with heavy rainfall due to leaching of highly soluble boron by rain water and that the acid conditions may delay the weathering of boron-bearing minerals like tourmaline. The methodology should be useful in determining the effects of soil management practices on soil boron status and in monitoring changes in boron distribution with time due to the various soil practices.



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Effect of Zinc Application on the Nutrient Content of Wheat (*Triticum aestivum* L.) Irrigated with Different Saline Waters

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



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Effect of Phosphorus Fertilization in Conjunction with Organics on Soil Nutrient Status of Rice in a Phosphorus Rich Vertisols

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Rice is the staple food in South-East Asia and also one of the most important cereals grown in India and occupies second position in cultivation after wheat. The advent of high yielding varieties after green revolution could be led to a major shift from organic based nutrient application to chemical fertilizers. Consequently, there was not only a reduction in the consumption of organic manures but also excess use of the high analysis fertilizer in an unbalanced manner. Phosphorus is one of the most important nutrients, but management of P in Vertisols is complicated owing to their high fixation capacity. A field experiment was conducted in paddy in a high soil available P vertisols under K.C. Canal ayacut at Regional Agricultural Research Station, Nandyal, Andhra Pradesh to study the influence of levels of phosphorus either alone or in conjunction with FYM and green manure on soil properties and yield during *kharif* 2011. The influence of phosphorus alone or in conjunction with green manure or farmyard manure on pH and EC shows non-significant results. The available nutrient status of soil at different stages and yield (grain and straw) of rice differs significantly due to different treatments. Among all the treatments application of 50% recommended dose of phosphorus along with farm yard manure recorded highest available nitrogen, phosphorus and potassium at different stages of crop growth. The higher yields were observed with application of 50% recommended dose of phosphorus along with green manure. It suggests that in high P available Vertisols application of 50% recommended dose of phosphorus to paddy along with farm yard manure or in combination with green manure resulted in higher nutrient status and higher yield.



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Influence of Integrated Nutrient Management Practices on Growth and Yield of Little Millet (*Panicum miliare*)

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Intensive cropping systems with fertilizer responsive crops that rely on high input of inorganic fertilizers often lead to non-sustainability in production and also pose a serious threat to soil health. However, considering economics and physiological potential of varieties, entire dependence on organic sources of nutrients may not be adequate to attain the highest productivity. Hence integrated nutrient management with both organic and inorganic fertilizers was investigated. A field experiment was conducted to study the effect of organic manures and bio-fertilizers in combination with inorganic fertilizers on growth and yield of two varieties (Peddasama & OLM-203) of little millet at Agricultural Research station, Vizianagaram. Plant height, length of the inflorescence, grain weight, straw weight and yield were influenced by different treatments. Highest grain yields were recorded in the treatment 100% RDF + Neem cake @ 1 t ha⁻¹ which is on par with the treatment 75% RDF + Neem cake @ 1 t ha⁻¹ + *Azospirillum* @ 5 kg ha⁻¹ + PSB @ 5 kg ha⁻¹. Lowest yields were obtained from the treatment 75% RDF + FYM @ 5 t ha⁻¹ + *Azospirillum* @ 5 kg ha⁻¹ + PSB @ 5 kg ha⁻¹ in both the varieties. Further, Peddasama variety was recorded significantly higher yields compared to OLM-203 in all the treatments. Peddasama variety has got unique ability of non-shattering of seeds during maturity and bunch type inflorescence the grain yield has enhanced by 10-15 percent.



Seasonal Variation in Soil Fertility Status of Rajsamand District of Rajasthan

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A survey study was conducted for both pre and post monsoon seasons in Rajsamand district of Rajasthan and it was found that the pH of the soil varied from 6.86 to 9.17 in pre monsoon and 6.85 to 9.12 in post- monsoon season with the mean values of 7.93 and 7.89 respectively. Soils of the study area were found non saline normal soils as 92.97% soil sample in pre monsoon season and 90.62 % samples in post monsoon season found to had EC less than 1.5 dSm⁻¹. Soils were low to medium in organic carbon having ranged from 0.12 to 0.90 per cent in pre monsoon and 0.10 to 0.84 per cent in post monsoon with mean values of 0.47 and 0.44 per cent respectively. Soils were found medium (84.37 per cent samples fall under medium category) in available nitrogen which varied from 103.00 to 776.39 Kg ha⁻¹ and 86.20 to 724.08 Kg ha⁻¹ during pre and post monsoon seasons respectively with mean values of 404.38 and 382.12 Kg ha⁻¹. Soils of study area varied from 16.25 to 78.29 kg P₂O₅ ha⁻¹ in pre monsoon and 14.91 to 72.52 kg P₂O₅ ha⁻¹ in post monsoon with the mean values of 35.88 and 32.46 kg P₂O₅ ha⁻¹ respectively. In pre monsoon 91.40 % samples whereas 87.50 % samples in post monsoon were medium in available phosphorus. Available potassium in soils was high in pre and post monsoon, varied from 202.18 to 1011.85 kg ha⁻¹ in pre monsoon and 194.55 to 1003.91 kg K₂O ha⁻¹ with mean values of 432.48 and 426.31 kg K₂O ha⁻¹ respectively. In pre monsoon 76.56 per cent sample and in post monsoon 74.22 per cent samples fall under high category. In micronutrients Zinc (24.22 %) and iron (50 %) were deficient while copper and manganese were sufficient to support plant growth. Soil salinity (EC), available potassium and iron of soil found significantly correlated with most of the groundwater quality parameters in both pre and post monsoon seasons.



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Soil Uptake Studies in Medicinal Plants Based Agroforestry System

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Andrographis and aswagandha were intercropped in existing plantations of amla and terminalia at College of Agriculture, Rajendranagar, Hyderabad during *Kharif* seasons of 2008 and 2009. The soil of the experimental site was red sandy loam in texture and belongs to order alfisols. The chemical analysis of the soil samples revealed that soil was low in organic carbon content and available nitrogen and medium in available phosphorus and available potassium in open area (treeless) whereas the soil in both the tree plantations (amla and terminalia) was medium in organic carbon content, available nitrogen, phosphorus and potassium.

The treatments consisted of three cropping systems as main plot treatments (sole cropping, intercropping in amla and terminalia) and six INM treatments as sub plot treatments laid out in split plot design and replicated thrice in both andrographis and aswagandha agri horticultural systems. The total gross and net monetary returns from the system (tree + crop) were the highest with andrographis intercropped in terminalia when compared to sole cropping of andrographis. In aswagandha also the same trend was observed. Intercropping of andrographis in terminalia with the application of 20 kg N ha⁻¹ through urea + Vermicompost @ 2 t ha⁻¹ gave maximum total gross monetary returns from the system (tree + crop). N, P and K uptake by andrographis and aswagandha was more under sole cropping. Soil available N, P and K content after crop harvest were more under terminalia intercropping situation followed by amla intercropping situation with low status in sole cropping in both the medicinal plants of andrographis and aswagandha.



Long-term Fertilizer Application Impacts on Soil Fertility in Maize-Wheat Cropping System

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Long-term fertilizer experiments are vital tools to quantify the impacts of fertilizer management on soil health and crop sustainability on long term basis. A long-term fixed experiment with maize-wheat-cowpea (fodder) cropping sequence on a loamy sand soil (*Typic Ustochrept*) was initiated at Punjab Agricultural University, Ludhiana, Punjab in 1971 consisting ten fertilizer treatments. The experiment was laid out as a Randomized Block Design. Ten treatments included: T₁: 50% recommended dose of N, P and K, T₂: 100% recommended dose of N, P and K with weedicides, T₃: 150% recommended dose of N, P and K, T₄: 100% recommended dose of N, P and K, T₅: 100% recommended dose of N, P and K with zinc, T₆: 100% recommended dose of N and P, T₇: 100% recommended dose of N, T₈: 100% recommended dose of N, P, K and FYM (10 Mg ha⁻¹), T₉: 100% recommended dose of N, P and K without sulphur and T₁₀: control (conventional cultivation without any fertilizer or amendment). Each treatment was replicated four times till 1994 and thrice afterwards in a plot size of 12x15 m². The surface soil (0-15 cm) is loamy sand in texture, alkaline in reaction (pH 8.2) and has cation exchange capacity (CEC) of 5.1 cmol (+) kg⁻¹. Continuous use of chemical fertilizers and farmyard manure for 42 years affected pH of the soil significantly which tended to decrease with time. The pH of the treated plots decreased significantly from its initial values of 8.2 to 7.14 (T₃) - 7.62 (T₁₀). The EC remained more or less unaltered with the continuous application of fertilizers in all the treatments over the years. The organic carbon content increased from 2.2 (initial) to 2.8 g kg⁻¹ in control and 5.4 g kg⁻¹ in NPK+FYM due to recycling of plant residues (root, root exudates, stubbles etc.) and addition of FYM in soil over period of time. Soil available N increased significantly from 100.4 in control to 142.2 kg ha⁻¹ in integrated nutrient management. Continuous application of P over the years resulted in build-up P in soils. Soil P status of the plots with all rates of phosphate fertilizer application raised from its initially low (9.0 kg ha⁻¹) to very high status (98.7 kg ha⁻¹) in 100%NPK+FYM treatment. The available K content in soil increased from its initial values of 88.0 kg ha⁻¹ to 93.0 – 121.3 kg ha⁻¹ in K amended plots. However, initial level of available K 88.0 kg ha⁻¹ declined to 76.9 kg ha⁻¹ when K fertilizer was omitted. There was improvement in micronutrients (Zn, Fe, Mn and Cu) content of soil with integrated use of FYM and fertilizers.



Direct and Residual Effect of Boron on Boron Nutrition in Raya-Maize Cropping System

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Intensive cropping, improved crop varieties with high crop productivity have caused depletion of plant nutrients, more so that of micronutrients. There is misconception that soils in India are adequate in boron so crops do not need B fertilization. Its deficiency is found in nearly 30% soils of the country and in about 10-15 percent soils of Punjab. Furthermore, its deficiency in plants is more wide-spread in soils, which are coarse textured, low in organic matter and high calcium carbonate content. Most of the studies were focused to study the response of crops to boron application individually but reports regarding B requirement involving cropping system are rather limited. Field experiment was conducted on to study the response of boron in raya –maize cropping system on a loamy sandy soil deficient in available boron (0.42 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 kg ha^{-1}) which were applied once and every year. Basal recommended dose of nitrogen, phosphorus, and potassium were applied to both the crops. The crops were harvested at maturity. Application of boron increased the grain yield of raya (1st crop) at all rates of its application over crop control. But the significant increase in grain yield of raya was obtained with the application of boron at the rate of 0.75 kg ha^{-1} with both the modes of applications and resulted in 13 percent increase in grain yield whereas maximum increase (20%) was obtained with application of 1 kg B ha^{-1} . Application of boron registered higher B content and total uptake by grain and straw. After the harvest of first crop of raya, boron at the rate of 0.5 kg B ha^{-1} was not effective in raising the status of deficient soil to sufficient soil however rest of boron (0.75 to 2.0 kg B ha^{-1}) treatments has built up/ maintained the available status of deficient soil to the sufficient level (above critical level 0.5 mg kg^{-1} soil). No significant increase in grain and straw yields of maize (2nd crop) was observed with the residual effect resulting from the application of different rates of boron application. For the third crop of raya, in case of boron applied once amount of available boron remaining in the soil was above the critical deficiency level of 0.50 mg kg^{-1} soil with the application of 1.5 kg B ha^{-1} which. This showed that application of 1.5 kg B/ha provided adequate residual boron to increase significantly the grain yield of raya. When boron was applied every year amount of available boron remaining in the soil was above critical limit with the application of 0.75 kg B . The application of $0.75 \text{ kg B ha}^{-1}$ every year to raya was able to register a significant increase in grain yield of raya. It is, therefore, suggested from this study that application of $0.75 \text{ kg B ha}^{-1}$ is required to be applied to every year for getting significant higher yields, whereas 1.5 kg ha^{-1} applied once was sufficient to take care of boron requirement of both the crops for obtaining optimum yield of both the crops in this cropping sequence.



Effect of Integrated Nutrient Management on Yield and other Attributes of Brinjal (*Solanum melongena* L.)

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A study was conducted to study the efficiencies of selected protocols for integrated management of nutrients in Brinjal (*Solanum melongena* L.) at Central Research Farm of Bidhan Chandra Krishi Viswavidyalaya at Gayeshpur, Nadia during 2011 with Brinjal (cv. F₁- hybrid VNR -60) as test crop. The experiment has been laid out in a 4 x 4 factorial Design with three replications and was conducted with recommended doses of NPK supplemented with selected bio-fertilizers (PSB and *Azotobacter* along with micronutrients (Fe, Zn, B) fertilizers. Integrated management of nutrients through supplementation of NPK by bacterial fertilizers along with micronutrients inputs increased basal girth, plant height, no. of shoots/plant, no. of fruits/plant and average fruit weight significantly over values obtained under administration of the recommended dose of NPK alone. Maximum increments in basal girth, plant height, no. of shoots/plant, no. of fruits/plant and average fruit weight thus obtained remained to the tune of 36.09, 20.84, 43.95, 123.52 and 60.00% respectively over control. Maximum increments in *Brinjal* yields thus obtained remained to the tune of 60 % over control. The economic benefits of different management systems were observed to be to the tune of 19.25 – 60.00 % more net return over the control counterparts (recommended dose of NPK only). This calls for judicious management of natural resources and evolving cost-efficient technologies which can push up vegetable production at a lesser cost rather than expanding the area.



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Influence of Levels of Farm Yard Manure on Zinc Fractions in Alfisol for its Nutrition of Ragi (*Eleusine coracana* L.)

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Zinc deficiency is a major constraint towards crop productivity and is widespread in Alfisols commonly used for cultivation of ragi (*Eleusine coracana* L.). Laboratory and field experiments were thus conducted to study the efficacy of farm yard manure (FYM) in mobilizing Zn in such a soil. Three levels of FYM viz., 7.5, 15.0 and 22.5 t ha⁻¹ with and without recommended dose of fertilizer (RDF) were evaluated for the purpose. Changes in available (DTPA extractable) and different fractions of Zn in soil were monitored in relation to Zn concentration in ragi with the above treatments. Application of FYM at all levels, with or without fertilizers, caused significant increase in DTPA-Zn, the effect being more pronounced at higher levels. It also increased the water soluble, sorbed, easily reducible manganese bound, carbonate bound and organic bound fractions of Zn with little changes in Fe and Al bound and residual fractions in soil compared to that with only RDF and also control treatments. All the fractions except residual one had positive and significant correlation with each other indicating the existence of a dynamic equilibrium among them. The treatment receiving FYM @ 22.5 t ha⁻¹ + RDF was superior over others with respect to grain (3.03 t ha⁻¹) and straw (1.89 t ha⁻¹) yield and their content and uptake of zinc. Application of FYM even at 7.5 t ha⁻¹ helped to maintain an adequate amount of available Zn in soil for zinc nutrition of ragi.



Effect of Phosphorus, Sulphur and PSB on Growth and Yield of Mustard [*Brassica juncea* (L.)] on Haplustepts

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A field experiment was carried out during rabi season of 2012-13 and 2013-14 on sandy loam textured soil at Agronomy Instructional Farm, Krishi Vigyan Kendra Chittorgarh (MPUAT Udaipur), Rajasthan to study the effect of phosphorus, sulphur and PSB on growth and yield of mustard [*Brassica juncea* (L.)] on Haplustepts. The experiment was laid out in randomized block design with factorial concept of thirty two treatment combinations comprising of four levels of phosphorus (0, 30, 40 and 50 kg P₂O₅ ha⁻¹), four levels of sulphur (0, 30, 40, and 50 kg S ha⁻¹) and two levels of PSB seed inoculation with three replications. The results showed that application of phosphorus up to 40 kg ha⁻¹ significantly enhanced the plant height, dry matter production, number of branches plant⁻¹, number of siliquae plant⁻¹, number of seeds siliqua⁻¹, test weight. Ultimately due to increased yield attributes, seed and straw yield increased significantly with increasing levels of phosphorus up to levels of 40 kg P₂O₅ ha⁻¹. Application of 30, 40 and 50 kg P₂O₅ ha⁻¹ increased the seed and straw yield over control by 13.89, 29.46 and 34.38 per cent in seed and 13.75, 31.77 and 35.58 per cent in straw. The maximum seed and straw yields (1.973 and 5.048 t ha⁻¹) and net returns (Rs.39053 ha⁻¹) and benefit:cost ratio (1.87) was recorded at 50 kg P₂O₅ ha⁻¹. The better development of yield attributes with phosphorus fertilization might be due to its key role in root development, energy translocation and metabolic processes of plant through which increased translocation of photosynthesis towards sink development might have occurred. An application of sulphur 40 kg ha⁻¹ significantly increased the plant height, dry matter production, number of branches plant⁻¹, number of siliquae plant⁻¹, number of seeds siliqua⁻¹ and test weight as compared to control and 30 kg S ha⁻¹. Application of 30, 40 and 50 kg S ha⁻¹ increased the seed and straw yield over control by 16.5, 23.91 and 28.07 per cent in seed and 11.08, 18.20 and 21.01 per cent in straw, while the differences between 40 to 50 kg S ha⁻¹ was found at par in yield. The maximum seed and straw yields (1.939 and 4.814 t ha⁻¹) and net returns (Rs.38172 ha⁻¹) and benefit:cost ratio (1.88) was recorded at 50 kg S ha⁻¹. The increase in these characters might be due to the important role of sulphur in energy transformation, activation of enzymes and in carbohydrate metabolism. Supply of sulphur in adequate and appropriate amount also helps in flower primordia initiation for its reproductive part, which in turn governs the yield attributes affected significantly. The inoculation of seed with PSB application significantly influenced the plant height, dry matter accumulation and branches plant⁻¹ number of siliquae plant⁻¹, number of seeds siliqua⁻¹ and test weight as compared to control and 30 kg P₂O₅ ha⁻¹ in mustard. Application of seed inoculation with PSB recorded significantly highest plant height at harvest (191.76 cm), branches plant⁻¹ (23.13) and dry matter accumulation at 60 DAS (22.13 g) and test weight (5.63 g) over control (no inoculation). On the pooled data analysis seed yield (1.814 t ha⁻¹) reflected in marked effect as well as straw yield (4.704 t ha⁻¹), net returns (Rs. 34793 ha⁻¹) and B: C ratio (1.74) with inoculation of seed with PSB having significant over no inoculation of seed with PSB. This fact of phosphorus on growth of crop might be due to readily availability of applied phosphorus.



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Phosphorous Balance under Long-term Fertilizer Application in Maize-Wheat Cropping System

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Long-term fertilizer experiments are vital tools to quantify the impacts of fertilizer management on soil health and crop sustainability on long term basis. A long-term fixed experiment with maize-wheat-cowpea (fodder) cropping sequence on a loamy sand soil (*Typic Ustochrept*) was initiated at Punjab Agricultural University (PAU), Ludhiana (India) in 1971 consisting ten fertilizer treatments. The present study present the long-term application of no fertilizer (T_1), 100%N (T_2), 100%NP (T_3), 50%NPK (T_4), 100%NPK (T_5), and NPK+FYM (T_6) on soil P balance and uptake after 42 cycles of maize-wheat crop rotation. The 100%NPK recommendation consist of 120 kg N ha⁻¹, 60 kg P₂O₅ ha⁻¹ and 30 kg K₂O ha⁻¹ to both maize and wheat. Farmyard manure at 10 t ha⁻¹ was applied every year before the sowing of maize crop. Continuous cultivation of crops with and without fertilizer application significantly improved soil P status. Soil P increased from its initial level of 9.0 kg ha⁻¹ (1971) to 15.3, 18.4, 43.4, 84.2 and 98.7 kg ha⁻¹ in T_1 , T_2 , T_3 , T_4 , T_5 and T_6 treatments, respectively. There was improvement in grain + straw yield of wheat (2011-12) form 4.2 t ha⁻¹ in control (T_1) to 11.8 t ha⁻¹ in T_2 , 13.8 t ha⁻¹ in T_3 , 11.3 t ha⁻¹ in T_4 , 14.6 t ha⁻¹ in T_5 and 163.7 t ha⁻¹ in T_6 treatment. The combined yield of maize grain and straw (2012) was 5.15 t ha⁻¹ in T_1 which significantly improved to 7.92, 9.52, 8.36, 11.14 and 13.9 t ha⁻¹ in T_2 , T_3 , T_4 , T_5 and T_6 , respectively. The correspondence uptake of P in maize-wheat sequence during 2011-12 was 5.7 kg ha⁻¹ in T_1 , 21.1 kg ha⁻¹ in T_2 , 30.1 kg ha⁻¹ in T_3 , 23.8 kg ha⁻¹ in T_4 , 33.6 kg ha⁻¹ in T_5 , and 39.6 kg ha⁻¹ in T_6 treatment. The overall balance of P status considering all the gains and losses of applied P after 42 cycles of rotation showed that percent utilization of applied P was only 50.2, 39.7, 56.0 and 66.0 in T_3 , T_4 , T_5 and T_6 treatment, respectively. The per cent of added P which was not utilized by crops and accumulated in the soil to build up soil P status was 34.0, 44.0, 49.8, 60.3 in T_6 , T_5 , T_3 and T_4 treatment. The results indicated that maximum utilization of applied P was obtained under balanced and integrated use of fertilizers.



Impact of Balance Application of Fertilizer along with Lime or Organic Matter in Sustaining Crop Yield of Wheat under Farmers Field Condition in Acid Soil Region of Ranchi District

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To popularize the lesson learnt from LTFE experiments among tribal farmers, on farm trails four in number, keeping selected treatments namely NP, NPK, NPK + Lime, NPK +FYM and Farmers Practice were taken for farmers field trail. The experiment site at Nagrabera village, Angara Block was located at 85° 19'E 23°17' N and 625 m asl and represents hot-moist sub-humid climate of Chotanagpur Plateau agro ecological sub region. The soil was sandy loam in texture, acidic in soil reaction (pH -5.3), low in organic carbon (0.48%), medium in available phosphorus and potassium. The trail was initiated during kharif 2013 with Maize-wheat cropping system. Wheat cv. K-9107 was sown during second week November and harvested during last week of April. The individual plot size was 500 sq.m. Recommended NPK rate was 120:60:40 kg/ha. In NPK+FYM treatment, 10 t FYM ha⁻¹ was applied on fresh weight basis and lime @ 0.3t ha⁻¹ was applied in furrow in NPK+Lime treated plot. In farmers practice plot NPK was applied @ 80:20:0 with FYM@ 2 t ha⁻¹ on fresh weight basis.

The results indicate that grain yield of wheat showed a significant variation for different treatments. Among the treatment NPK+Lime & NPK+FYM produced highest grain yield *ie.* 4.278 and 4.330 t ha⁻¹ respectively and was found significantly superior to NP (2.4 t ha⁻¹) and farmers practice (2.09 t ha⁻¹). A yield advantage of 17-19% was found over the NPK treatment where lime or FYM was applied along with NPK. A yield loss of about 31.6 per cent was noticed in NP treatment where K was not applied. These trails help in developing understanding among poor tribal farmers about the importance of balance application of fertilizer as well as role of liming or FYM in modifying crop response.



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Effect of Different Residue Management Practices on the Yield of Rice-Rice Cropping System

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A field experiment was conducted in clay loam soils during *kharif* and *rabi*, 2009 at Regional Agricultural Research Station, Warangal, Telangana, to assess the various straw management options in rice- rice cropping system, under Randomised Block Design with six treatments and for replications. The various treatmental combinations are straw removal, burnt ash (5 t ha⁻¹), Straw incorporation @ 5 t ha⁻¹, incorporation of straw (5 t ha⁻¹) along with 25% N & P, straw incorporation along with green manure (5 t ha⁻¹), microbial inoculated straw (5 t ha⁻¹) incorporationa and all the treatments were applied along with recommended dose of fertilizers. In all the above treatments straw was incorporated 20 days before transplanting. Yield data indicated that highest grain yield (4990 kg ha⁻¹, 5915 kg ha⁻¹) was recorded in incorporation of straw (5 t ha⁻¹) along with green manure (5 t ha⁻¹), followed by paddy ashing (4582 kg ha⁻¹, 5866 kg ha⁻¹) but onpar with other treatments during *kharif* and *rabi* respectively. Straw yields also followed the similar trend as that of grain yield. Adoption of different residue management practices were found non- significant with regards to tillers m⁻², grain and straw yield in transplanted rice of rice – rice cropping system.



Influence of Free Calcium Carbonate on Available Major and Micronutrient in Relation to Yield of Nagpur Mandarin in Vidarbha, Maharashtra

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Nagpur mandarin is a main cash crop of western Vidarbha region of Maharashtra and the orchards are established on black and calcareous soils. Twenty one mandarin orchards were studied in Nagpur district to know the influence of CaCO_3 on soil available major and micronutrient in relation to yield of Nagpur mandarin. The mandarin orchards were surveyed and selected on the basis of visual observations and information from the farmers regarding the performance of Nagpur mandarin on calcareous soils. 12-13 years old mandarin orchards were preferably selected on medium to deep soils and having common management practices. The soils were clay loam to clay in texture, high available water capacity (8.3 to 22.5%) and very poorly drained to moderately well drained with hydraulic conductivity 0.1 to 4.86 cm hr^{-1} . The soils were slightly to strongly alkaline (7.0 to 8.8), non-saline, Ca was dominant cation followed by Mg, Na and K with CEC 41.5 to 61.8 $\text{cmol (p}^+) \text{ kg}^{-1}$ and high base saturation (84 to 99 %) showing its fertility potential. The soils of mandarin orchards content high free CaCO_3 (1.2 to 31.4 %) and carbonate clay (0.2 to 12.8 %) was due to aridity of the climate prevailing in this area. The available Nitrogen, Phosphorus and Potassium content in soil were 190.2 to 345.2 and 8.4 to 34.2 and 285.6 to 460.0 kg ha^{-1} respectively, whereas, DTPA Zn, Cu, Fe and Mn content were 0.2 to 1.31, 0.43 to 4.12, 5.2 to 28.4 and 3.2 to 16.9 mg kg^{-1} , respectively.

The production of Nagpur mandarin was found governed by the clay content, available water capacity, CEC, Ca on exchange complex, drainage condition, CaCO_3 and soil fertility. These parameters showed significant relationship with yield of mandarin and its quality parameters like juice and TSS. The major and micronutrients showed significant relationship with yield. The availability of nitrogen and phosphorus in the soil was highly influenced by CaCO_3 as it showed negative significant correlation with them (r value 0.71 for nitrogen and 0.75 for phosphorus, respectively), whereas Potassium showed no significant relation. The availability of all the micro nutrients (Zn, Fe, Cu, Mn) were found negatively correlated with CaCO_3 and in particular DTPA-Zn in most of the orchards found far below the critical level of 0.6 mg kg^{-1} . Therefore CaCO_3 was found responsible for poor availability of major and micronutrient thereby high reduction in yield of Nagpur mandarin as they showed negative significant correlation with yield (-0.82). It was further confirmed from the step up statistical model that CaCO_3 explains the 72 % variation present in yield as the coefficient of determination R^2 showed 0.7223.



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Effect of Fertilizer Application on Crop Yield, Nutrient Uptake and Nutrient Use Efficiency in Maize-Wheat Cropping System

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Efficiency of fertilizer N, P and K is becoming increasingly important owing to increasing food requirement and growing concern about environments. The use of organic manures as a source of plant nutrients in achieving high productivity offers a new soil management possibilities in a modern day agricultural production system. Our objective was to study the effect of fertilizer application, alone and/or along with farm yard manure (FYM) in a maize-wheat cropping was investigated on crop yield (grain/straw), nutrient uptake (N, P and K) and nutrient use efficiency at three different farmers' field locations. Four treatments viz. farmers' practice (FP), recommended NPK (NPK), FP+FYM, NPK+FYM and an absolute control (CK) were compared at each experimental site in an irrigated sub-tropic area of Ropar district of Punjab (India). Fertilizer application (FP/NPK) has resulted in a significant increase in crop (maize/wheat) yield (grain/straw) at all three experimental sites, over the CK. Further, the application of FYM (FP+FYM/NPK+FYM) has resulted in a significant improvement in crop yield, as compared to alone fertilizer application (FP/NPK). However, crop yield differed non-significantly among FP+FYM and NPK+FYM treatments at all three experimental sites. Nitrogen, P and K uptake by crop (maize/wheat) grain and straw was significantly higher in the treatments involving integrated use of organic and inorganic fertilizers (FP+FYM/NPK+FYM). Crop (maize/wheat) agronomic efficiency, physiological efficiency, recovery efficiency and reciprocal internal use efficiency of N, P and K also improved significantly with FYM application along with inorganic fertilizers over other compared treatments. The economical analysis revealed the beneficial effect of the integrated use of inorganic fertilizers with FYM over the CK and/or alone fertilizer application treatments.



Testing Iron Bioavailability in Pigeon Pea Varieties using Rat Model

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The objective of the present study was to determine the bioavailability of iron from different varieties of pigeon pea by measuring per cent absorption and degree of retention of Fe in the liver, the kidney and femur bone as indices of intestinal absorption and deposition in rats.

The Fe-efficient and Fe-inefficient varieties of pigeon pea were used with twenty-four Weaned Wistar rats obtained from the National Centre For Laboratory Animal Sciences, NIN Hyderabad. The three groups were supplied experimental diets a control and received purified diet. for 21 days.

The diets of the rats were prepared following the standards outlined in AIN-93G with a minor modification such that iron was not included in the mineral mixture. The iron was provided through freshly purchased and dried FeSO₄(D₀) as a reference source of dietary iron and from pigeon pea varieties viz. pigeon pea control (D₁), pigeon pea inefficient (D₂) and pigeon pea efficient (D₃). Feeds were prepared with deionized distilled water in the form of pellets weighing 25-30 g each and baked in microwave oven before feeding. The feces, blood serum, kidneys, liver and femur were wet digested using a diacid mixture and analyzed for iron content.

The hematological parameters were estimated using an automated hematology-analyzer (Nihon Kohden Model Celltac Alfa, Japan) and found statistically similar.

The feed efficiency in D₀, D₁, D₂ and D₃ group was recorded as 2.76±0.12, 3.19±0.17, 3.48±0.23 and 3.02±0.13, respectively. The treatment groups D₀, D₁ and D₃ did not differ from each other but were different from Pigeon pea Inefficient (D₂) group.

The absorption of Fe was the highest i.e. 416.15±26.24 µg day⁻¹ in rats fed standard diet followed by Pigeon pea efficient group (347.09±29.21 µg day⁻¹) which did not differ from it. The iron concentration in the liver on standard and pigeon pea efficient diets was found statistically similar but they differed from D₁ or D₂ groups. The Fe contents of femur and kidney in the rats were significantly higher in rats fed standard diet compared to other diets. The data on iron absorption and its deposition (µg/g) in liver in pigeon pea efficient (D₃) diet was comparable with standard diet.

Thus, bioavailability of Fe from pigeon pea efficient variety was comparable with standard diet comprising of ferrous sulphate as an iron source.



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Effect of Foliar Application of Zinc through Various Sources on Yield and Quality of Soybean and Nutrient Use Efficiency

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The present investigation was conducted at Research farm, Department of Soil Science and Agril, chemistry, Dr. Panjabrao Deshmukh Krishi Vidaypeeth, Akola in randomised block design with three replication and sixteen treatments comprised of various sources of zinc *viz*, zinc sulphate, zinc chloride, zinc phosphate, zinc oxide and zinc-EDTA during kharif season 2011-12 in Inceptisol. The investigation was carried out to study the effect of foliar application of zinc through various sources on yield, concentration and uptake of nutrients and quality parameters of soybean. The soil samples collected after harvest of soybean and analyzed for different soil properties. The grain and straw yield of soybean was significantly highest with the foliar application of Zinc sulphate @ 10 gL⁻¹ with lime followed by Zinc -EDTA @ 5 gL⁻¹, and ZnSO₄ @ 5 gL⁻¹ and Zn-EDTA @ 2.5 gL⁻¹. Concentration and uptake of nitrogen, phosphorus, potassium, sulphur and micronutrients at harvest in grain and straw and number of effective nodules at grand growth stage as well as nutrient use efficiency were significantly highest with application of zinc sulphate @ 10 g L⁻¹ with lime followed by zinc -EDTA @ 5 gL⁻¹. It was also noticed that the concentration of zinc in leaves was enhanced after foliar spraying at different growth stages. The highest leaf scorching was observed with the application of zinc chloride followed by zinc phosphate. Zinc sulphate and Zinc-EDTA were found equally effective.



Cationic Micronutrient Status in Erosion Prone Basmati Rice Growing Soils of Jammu

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Micronutrient deficiency is considered as one of the major causes of the declining productivity trends observed in rice growing countries. These nutrients play a vital role for the growth and development of crops. Availability of micronutrients is influenced by their distribution and other physico-chemical properties of the soil. A study on DTPA-extractable micronutrients (Zn, Cu, Fe and Mn) was undertaken from different Basmati rice growing locations of Jammu district and their relationship with various physiochemical properties of the soils was studied. The available micronutrients in these soils showed wide variation. The available, zinc, copper iron and manganese in the surface (0-15cm) varied from 0.02-1.18, 0.05-3.67, 2.40-40.76 and 1.14-11.13 with mean values of 0.25, 0.82, 21.30 and 4.34 mg kg⁻¹, respectively. The available Cu, Zn and Fe showed significant correlation with pH (-0.288**, 0.197 and -0.273, respectively). The available Fe correlated significantly with organic carbon (0.257**) whereas the available Mn showed significant correlation with CEC (0.206*). Other physico-chemical properties of soils showed non-significant correlations with either of these micronutrients. About 90 per cent surface soil samples were observed to be deficient in available zinc, whereas 10 per cent soils samples were found to be deficient in available copper. However, DTPA-extractable Mn and Fe in these soils were found to be adequate i.e. above critical limits. Therefore, to enhance and sustain agricultural productivity, there is an urgent need to apply zinc fertilizers in general and copper fertilizers in deficient Basmati growing soils of Jammu.



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Effect of Long-term Application of Organic and Inorganic Fertilizers on Soil Inorganic Nitrogen and Potassium Fractions in Rice–Rice Cropping System

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A field experiment was conducted to study the effect of long term application of organic and inorganic fertilizers on soil inorganic nitrogen and potassium fractions in rice – rice cropping system under long term fertilizer experiments with twelve treatments and four replications during *kharif* and *rabi* 2010 -11 and 2011-12, at Regional Agricultural Research Station (RARS), Polasa, Jagtial, District Karimnagar, Andhra Pradesh in an Inceptisol (Ustochrept). The soil was slightly alkaline, non saline, high in organic carbon (0.79%) low in available nitrogen (107.6 kg ha⁻¹), medium in available phosphorus (19.6 kg P ha⁻¹) and high in potassium (364 kg K ha⁻¹) while sulphur and micro nutrients were above critical levels. This experiment is a part of the ongoing experiments of All India Coordinated Research Project on Long Term Fertilizer Experiment initiated at RARS, Polasa, Jagtial during *kharif* 2000-01. The treatments comprised of T₁- 50%NPK, T₂- 100%NPK (120-60-40 kg NPK ha⁻¹), T₃- 150%NPK, T₄- 100% NPK +Hand weeding (HW), T₅ - 100% NPK + ZnSO₄ @10 kg ha⁻¹ (in *kharif*), T₆-100% NP, T₇-100% N, T₈-100% NPK +Farmyard manure @ 10 t ha⁻¹ (in *kharif* season only), T₉- 100% NPK-S, T₁₀- FYM @ 10 t ha⁻¹ (in both *kharif* and *rabi* seasons), T₁₁- absolute control (No fertilizer and no manure) and T₁₂- Fallow.

The crop was transplanted under puddle conditions. During both the seasons 30 days old seedlings were transplanted at the rate of two seedlings per hill at a spacing of 15 cm X 15cm. The treatments were fixed at the initiation of the experiment and the same treatments were imposed in the same treatment plots from the initiation of experiment till the present cycle. The initial (before the initiation of the experiment) and plot wise soil samples after *rabi* 2010-11 and 2011-12 were collected at harvest and analysed for inorganic nitrogen and potassium fractions. The ammoniacal nitrogen content varied from 34.4 to 66.3 mg kg⁻¹ and nitrate nitrogen content ranged from 21.9 to 57.4 mg kg⁻¹ in post harvest soils of *rabi* rice (pooled mean for two years). Highest ammoniacal nitrogen (66.3 mg kg⁻¹) and nitrate nitrogen content (57.4 mg kg⁻¹) were recorded in the treatment receiving 100 % NPK + FYM while the lowest was recorded with control (21.9 mg kg⁻¹). Ammoniacal nitrogen content increased by 21.4, 37.1 and 59.6 % with 50,100 and 150% NPK respectively over control and nitrate nitrogen content by 82.0, 92.5 and 116.2 % over control with 50,100 and 150% NPK treatments respectively. Among the inorganic nitrogen fractions, ammoniacal nitrogen fraction forms were higher as compared to nitrate nitrogen. Both the fractions increased with increase in nitrogen levels.

Among the potassium fractions, water soluble and 1N HNO₃ extractable K fractions decreased from initial content (55.8 and 964.4 mg kg⁻¹ respectively) while available and exchangeable K fractions increased. Highest water soluble potassium content (41.6 mg kg⁻¹) and exchangeable potassium content (67.0 mg kg⁻¹) were recorded under 100 % NPK + FYM while the lowest water soluble potassium content was under 100% N (27.8 mg kg⁻¹) and lowest exchangeable K content was in control (34.4 mg kg⁻¹). The highest available potassium content (108.5 mg kg⁻¹) and HNO₃ exchangeable K value (942.5 mg kg⁻¹) were recorded under 100 % NPK + FYM but which was on par with 150 % NPK.



Effect of Different Sources of Zinc Fertilizer on Yield, Zn Uptake and Zn Use Efficiency of Onion, Groundnut and Potato Crops

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Nowadays micronutrient deficiencies in crop plants are widespread and among micronutrients, zinc deficiency is a common disorder in a wide variety of soils and about 58% of the soils used for cultivation in Tamil Nadu are Zn-deficient, which reduce not only the yield but also nutritional quality of the produce. At present for alleviating Zn deficiency, zinc sulphate is the common Zn fertilizer available to the farmers in the market. The use efficiency of the Zn applied to soil is less than 5 per cent which needs to be improved upon. There is a need to study the efficacy of other Zn containing fertilizers for enhancing the crop yield as well as Zn use efficiency. Micromac - Zn is a new source of fertilizer, contains 21%Zn, 18%P and 9%N called as zinc polyphosphate. This Zn fertilizer may be a good additional source to ZnSO₄ for supplying Zn to soil for plant nutrition.

Field experiments were conducted to assess the efficacy of Micromac-Zn for enhancing the crop yield and Zn use efficiency in plains with onion and groundnut crops as well as and in hill soil with potato during 2012 - 2013. Totally 9 treatments having 100% recommended dose of N,P and K as control, 100% recommended dose of N,P K and S with levels of 0.5, 1.0 or 2.5 kg Zn ha⁻¹ from different Zn sources viz., Micromac, ZnSO₄.7H₂O and Zn-EDTA. The highest onion fresh bulb yield of 18.7 t ha⁻¹ was noticed in the treatment, Zn @ 1.0 kg ha⁻¹ as Micromac-Zn with a yield increase of 7.5 % over NPKS control, however it was statistically on par with the same level of Zn as Zn-EDTA (18.6 t ha⁻¹) or ZnSO₄.7 H₂O (18.5 t ha⁻¹). In groundnut, either the addition of 2.50 kg Zn ha⁻¹ as from Micromac-Zn or ZnSO₄.7H₂O significantly registered the highest dry pod yield of 1987 and 1952kg ha⁻¹ with a yield increase of 31.1 and 28.8 per cent respectively over NPKS control (T2). Application of 2.50 kg Zn ha⁻¹ as Micromac-Zn or ZnSO₄.7H₂O was found equally effective in recording the maximum potato tuber yield (19.7 t ha⁻¹). The concentration and uptake of Zn in various plant parts of onion, groundnut and potato crops increased with increasing levels of Zn up to 2.50 kg ha⁻¹ irrespective of Zn sources. The results indicated that application of Zn either from Micromac-Zn or ZnSO₄ produced similar yields in the tests crops and hence Micromac-Zn offers scope for use as an additional source of Zn fertilizer in respect of yield and Zn nutrition of crops.



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Nutrient Status of Red Soils in Block Pahari of District Mirzapur (U.P.)

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A study was conducted during year 2013-14 to identify about the available primary nutrient status present in red soil of four villages i.e. Danti, Kotwan Pandey, Gaura Raja and Rasena of Pahari block, District Mirzapur, U. P. (India). After an intensive survey of the study area, 324 surface soil samples were collected (0 to 15 cm depth) and analyses for N, P, K and other parameters like pH, Electrical conductivity and Organic carbon. The available nutrients status of N, P and K ranged from 212 to 287, 8.3 to 13.6 and 120 to 146 in village of Danti, 120 to 160, 7.1 to 8.6 and 119 to 128 in village Kotwa Pandey, 126 to 190, 7.3 to 9.6 and 116 to 140 in village Gaura Raja and 130 to 180, 7.9 to 10.2 and 118 to 146 kg ha⁻¹ in Rasena, respectively. In the same sequence the pH value of the collected samples were ranged from 6.3 to 6.8, 6.2 to 6.8, 5.7 to 6.2 and 6.2 to 7.3, EC 0.02 to 2.02, 0.04 to 0.49, 0.12 to 0.92 and 0.16 to 0.70 dSm⁻¹ and organic carbon 0.11 to 0.97, 0.11 to 0.45 0.18 to 0.52 and 0.22 to 0.72 per cent, respectively. Results indicated that the available nutrients of red soils as Nitrogen and Phosphorus were found in low amount whereas the amount of potassium was medium of red soils. It is clear from data obtained after analysis of soil samples that most of the samples were of slightly acidic in nature due to presence of accountable amount of iron oxide while, few soil samples indicated neutral to alkaline in nature.



Effect of Zinc and Phosphorus Interrelationships in Low, Medium and High P Soils on Yield, B, Zn and P Contents of Paddy Crop

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Zinc and phosphorus interrelationships, in the past were studied in various soils for many crops in low to medium P or Zn soils employing varying levels of these nutrients. The interpretation of emanating results was seldom done in naturally occurring high P soils or by simultaneous comparison in soils of varying P and Zn regimes. Therefore, a pot culture experiment was conducted in low, medium and high P soils (one each of this category having deficient and sufficient Zn status) with four levels of Zn (0, 2.5, 5 and 10 mg kg⁻¹ soil) and five levels of phosphorus (0, 30, 60, 120 and 180 mg kg⁻¹) with paddy as test crop in all these six soils. It was observed that highest and lowest mean grain yield of 18.20 and 9.57 g /pot was observed in low P soils due to P₆₀+Zn₁₀ and P₁₈₀+Zn₀ combinations, respectively. In medium P soils, highest mean yield (17.00 g pot⁻¹) was recorded due to application of P₆₀+Zn₅ and the lowest (7.20 g pot⁻¹) at P₁₂₀+ Zn_{2.5} combination. In high P soils, highest mean grain yield (20.10 g pot⁻¹) was recorded at P₆₀+ Zn₅ and the lowest (6.38 g pot⁻¹) at higher rates of P and Zn application (P₁₈₀+Zn₁₀ mg kg⁻¹). Application of 180 mg P kg⁻¹ soil with any given rate of Zn registered higher P content of paddy grain in all P regime soils (0.65 in low and 0.78 in medium and 0.65% in high P-regimes). Grain zinc content was highest in all P-regime soils (15.6 in low, 17.9 in medium and 16.2 mg kg⁻¹ in high P-regimes) at lower levels of P i.e., up to 60 mg P kg⁻¹ and up to the rate of 5 mg Zn kg⁻¹ soil. The results indicated that the combined application of P and Zn beyond 60 and 10 mg kg⁻¹ in low P soils, 60 and 2.5 mg kg⁻¹ in medium P soils and 30 and 2.5 mg kg⁻¹ in high P soils registers on par or lesser yields compared to other higher combinations of P and Zn. Reduced yield of paddy was accompanied with decreased content of B in paddy grain upon application of higher levels of phosphorus with or without Zn in all P regime soils as well as due to increase in the initial soil P regime from low to high (5.68 to 3.22 in low, 5.26 to 2.12 in medium and 4.89 to 1.19 mg B kg⁻¹ in high P-regime soils), though all soils in the experiment were found to have available B in sufficient range(>0.52 mg kg⁻¹ soil) . Chaffy grains were noticed in high P regime soil due to application of P₁₈₀ + Zn₁₀ and registered lowest B content of 1.19 mg kg⁻¹.



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Effect of Long-term Fertilization on Soil Organic Carbon, Soil Nutrients and Yield of Hybrid Maize under Finger Millet- Maize Cropping Sequence

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Understanding the effects of long-term use of fertilizers on soil organic carbon (SOC) and nutrient pools and their activities is essential for sustaining soil productivity. The aim was to assess the long-term effect of direct N, P and K fertilizers on soil organic carbon, soil nutrients and grain yield of maize in rotation with finger millet. Continuous application of fertilizers increased SOC (0.50 %) over its initial content (0.30 %). A general increase in SOC was observed throughout the experiment and was highest in 100% NPK + FYM treated plots (0.63 %) when compared to 100 NPK (0.51 %). Responses of maize to simple fertilizer applications were not beneficial in terms of yield returns. The results indicated that long-term additions of organic manure have the most beneficial effects on grain yield among the investigated types of fertilization. Among the ten treatments, FYM + NPK and increasing levels of NPK fertilization significantly increased the available NPK and SOC content in the soil and the biomass yield and uptake of major nutrients. Therefore, the integrated use of NPK and FYM is an important nutrient management option for sustaining finger millet- maize cropping system.

A slight build up in the available N at harvest stage of maize was observed irrespective of the treatments. Among the different treatments, the treatment receiving 100 % NPK + FYM (T_8) recorded the highest available N (229 kg ha⁻¹). The overall available P ranged between 6.67 and 39.73 kg ha⁻¹. Available K decreased from the initial level even in the plots receiving K fertilization. , the conjoint application of 100% NPK along with farm yard manure @ 10 t ha⁻¹ registered significantly higher yield of maize (8558 kg ha⁻¹) than 100 % NPK treatment (7324 kg ha⁻¹) recording 17 % increase.



Genotypic Variation in Nitrogen Use Efficiency in Rice (*Oryza sativa* L.)

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Nitrogen is one of the major essential nutrient elements for the plants. Even though the atmosphere contains highest amount of N (78%), our Indian soils are deficient in available N. Nitrogen is the most important nutrient for Rice. Rice crop takes around 16-18 kg N t⁻¹ of grain yield. Nitrogen use efficiency (NUE) is a parameter which is indicative of the extent of utilization of soil as well as applied N by the crop. Generally not more than 40-50% of the applied N is utilized by the crop. Other 50 – 60 % is lost through several ways in wet land rice soils such as leaching, runoff, volatilization, denitrification etc. Hence, it is desirable to improve NUE in rice. Genotypes differ in their NUE in terms of acquisition by roots or utilization by the plant or both and it is ideal to identify genotypes with better NUE.

Keeping this in view, a field experiment was conducted to study the genotypic variation in NUE for soil and applied N with 11 different categories of rice genotypes like aerobic scented germplasms, germplasm lines, upland Rice varieties, Aerobic Rice, Heat tolerant rice, IRHTN varieties, DRR varieties, A-lines, B-lines and Hybrids during *kharif* 2011, at 2 N levels (N0 and N100 kg ha⁻¹) in Randomised Block Design with 3 replications. Before planting, soil samples were collected in both the plots and analyzed their physico chemical properties like pH (7.42, 7.29), E.C (0.26, 0.28 dS m⁻¹), O.C (0.66, 0.72%), available N (243, 255 kg ha⁻¹), P₂O₅ (50, 63 kg ha⁻¹), K₂O (692, 705 kg ha⁻¹). The pH and E.C were normal % O.C was medium, available N was low, whereas P₂O₅ & K₂O are high in both the plots. KCl N and Urease enzyme were estimated in wet soil samples collected at 4 stages (15, 30, 50 DAT and at maturity).

Plant samples were collected at harvest and were analyzed for per cent N in both grain and straw samples of different rice categories. Based on the per cent N, the genotypes of different groups were identified for their better accumulation efficiency in their grain and straw. Highest mean grain nitrogen concentration was observed in the hybrids in both N0 (1.14 %) and N100 (1.32 %). Next in the order are B lines with a mean value of 1.17 % at N0 and aerobic scented germplasms (1.26 %) at N100. Heat tolerance rice recorded the lowest value (1.04 %). With regard to straw, A lines recorded highest mean Nitrogen concentration in N0 (0.50 %) and N100 (0.62 %) followed by Hybrids in N100 (0.50 %) and DRR varieties at N0 (0.47). Soil KCl N values were higher at 50 DAT in N100 (5.8 mg kg⁻¹ soil). Urease enzyme was also higher at 50 DAT in both N0 (64 µg NH₄ N g⁻¹ soil 2 hr⁻¹) and N100 (154 µg NH₄ N g⁻¹ soil 2 hr⁻¹).

Thus it can be concluded that genotypic variation in NUE exists and this can be better exploited while selecting genotypes for nitrogen limited soil environment.



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Nutrient Indexing for Forecasting Emerging Nutrient Disorders in Intensive Rice-Rice Cropping Systems

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Soil fertility evaluation needs immediate attention since it is now established that reduction in productivity of several crops is due to decreasing soil fertility and imbalanced application of plant nutrients. The deficiency of several macro and micro nutrients such as K, S, Ca, Zn, Fe and B are emerging under intensive cultivation. The nutrient indexing study was taken up in rice-rice cropping system of Anaimalai block, Coimbatore district, Tamil Nadu in order to forecast the emerging nutrient disorders resulting from intensive cropping and management practices. Forty five farm sites representing three major soil series viz. Anaimalai, Irugur and Palladam series, growing continuous rice-rice cropping system were selected during 2008 and were continuously monitored. The grain and straw yields during Kharif and Rabi seasons were recorded besides collecting post harvest soil and plant samples for assessing the nutrient status. Basic data on fertilizers and manures applied, variety planted by the farmers was recorded. All farm soils were having neutral to alkaline reaction (7.00 to 8.80) with electrical conductivity of 0.17 to 0.46 dSm⁻¹. The organic carbon content was low to medium (0.18 to 0.70 per cent). The initial soil fertility of the fields were low in available N, medium in P and medium to high in K and S. Among the micronutrients, Zn was predominantly deficient in Irugur and Palladam soil series. B availability ranged from deficient to sufficient status and rest of the micronutrients were sufficient in status.

The nutrient balance was calculated based on the quantity of nutrients applied by the farmers (input) and crop removal (output) for every crop. The nutrient balance worked out for the rabi 2012-13 crop (tenth crop) indicated negative nutrient balance of K, Fe, Mn, Cu and B in all the three soil series, S in Anaimalai soil series. The negative balance was due to the mismatch between addition and removal of the above said nutrients for the particular crop/season. Rests of the nutrients were maintained at positive balance in all the soil series. Fertility rating of the soils at the end of every rice crop was carried out using the nutrient index values. Based on the nutrient index values, the fertility classes were assessed. When compared to the initial status (2008), after growing ten rice crops (rabi 2012-13), in Irugur and Palladam series, N was maintained at very low level whereas in Anaimalai series, N increased from very low to low level. Phosphorus buildup and K depletion was observed in all the soil series. Sulphur, Zn and B depletion was noticed in Anaimalai series. The status of Fe, Mn and Cu did not change much in all series. The reduction in availability of soil K and micronutrients might be due to the application of suboptimal level of potassic fertilizers, non addition of micronutrient fertilizers and organic manures by many of the farmers. Therefore, it is necessary to go for balanced fertilization using macro nutrients, micro nutrients and organic manures to sustain soil fertility and crop yield in intensive rice-rice cropping system.



Leaf Colour Chart for Effective Nitrogen Management in Rice

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Excessive N application to rice crop can causes environmental pollution, increases the cost of rice farming, reduces grain yield. So optimum rate and timing application of nitrogen N fertilizer are most crucial in achieving high yield in irrigated rice. The leaf colour chart (LCC) based N management can be used to optimize N application with crop demand or to improve existing fixed split N recommendations. In order to assess leaf N status in rice was grown with different N application treatments (90 to 210 kg N ha⁻¹ splited based on the LCC values). A field experiment was conducted on a sandy loam soil during *kharif* season of 2012 with a view to determine the LCC critical value for N application. Treatments included 3 LCC based N management contained the combination of three critical levels of LCC (4, 4.5 and 5) with 30 kg ha⁻¹ of N application if the LCC value less than these values. The other treatments were based on chlorophyll meter (SPAD) based N application, recommended fertilizer dose (RFD) and the one based on fertilizer adjustment equations. The LCC values assessed at every 10 days intervals from 15 DAT. The treatment included LCC shade value <4.5 which received 30 kg N ha⁻¹ each time with a total dose of 180 kg N ha⁻¹ recorded to get the grain yield of 5.879 t ha⁻¹. Result showed a significant increase in yield through improved N management with LCC. The critical LCC value of 4.5 with application of 30 kg N ha⁻¹ each time were found to be suitable for guiding N application to achieve the highest grain yield. It seems that chlorophyll meter provides a simple, rapid, and nondestructive method to estimate the leaf N content, and could be reliably exploited to predict the exact N fertilizer topdressing in rice.



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Effect of Different Fertilizers in Drip Fertigation on Growth and Yield of Tomato and Soil and Leaf N, P, K Status

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With the introduction of micro irrigation, fertigation has become an efficient method of fertilization in modern agriculture system . But in India it is still practiced by only a small section of farmers for only high value crops due to high cost of water soluble fertilizers used in fertigation. Several studies have demonstrated the use of water soluble fertilizers in fertigation . But reports on the efficiency of conventional fertilizers in fertigation are scanty. Hence a study has been conducted to see the effect of conventional straight fertilizers and speciality fertilizers (100% water soluble fertilizers) in drip fertigation on tomato. Field experiments have been conducted at IIHR farm on tomato var. Arka Rakshak using conventional (Straight fertilizers:Urea,Single Super Phosphate and Muriate of Potash) and speciality fertilizers (100% water soluble) in 13 different treatment combinations including two levels (100% RDF and 75 % RDF) of fertilizers and with and without the use of microbial consortium . Observations on growth parameters like height , girth , number of branches, fresh and dry weight of plant were taken at maturity. Soil and leaf samples were collected and analysed for N,P, K status.

Results showed that the height of the tomato plants ranged from 84.5 to 93.4 cm, girth from 4.9 to 5.2 cm and number of branches from 10.9 to 20.5. Plant girth was more when N&K were given through conventional fertilizers through fertigation and P was applied as basal and microbial consortium was added. No significant variation in height of tomato was observed though addition of microbial consortium showed improvement in height. Similar observations were made in number of branches also. The yield data showed that fertigation with 75% RDF of N &K through conventional fertilizers and P given through basal application gave better fruit yield of tomato either with or without microbial consortium . The yield obtained in fertigation with 100% RDF of N&K through speciality fertilizers and microbial consortium was almost on par with the yield obtained in fertigation treatment with 75 % RDF of N &K through conventional fertilizers. Fertigation with either 100% or 75% RDF of all N,P, K nutrients given through speciality fertilizers has not shown any significant benefit in terms of yield either with or without microbial consortium. The data on soil N,P,K showed that soil N content was more in fertigation treatment with 100% RDF of N &K through conventional fertilizers and P given through basal application (160.4 ppm). The N content of soil in fertigation treatment with 100 % and 75 % RDF of N&K given through speciality fertilizers was improved with the addition of microbial consortium. Similar is the case with soil P and K. The leaf N content in fertigation treatment with 100 % N&K given through speciality fertilizers was more than when 100 % N&K given through conventional fertilizers . Where as at 75 %RDF level the leaf N content was almost on par with the use of both the fertilizers. There was not much variation in leaf P content whether it was applied through basal or through drip fertigation. Leaf K content was slightly better in fertigation treatments with speciality fertilizers than with conventional fertilizers. Thus, the preliminary results of the study showed that the performance of the conventional fertilizers is almost on par with the speciality fertilizers in drip fertigation.



Effect of Panchakavya on Growth Parameters and Yield of Onion (*Allium cepa* L.)

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Onion is extremely important vegetable crop and it is a highest foreign exchange earner among the vegetables. Onion is used for flavoring the food, both at mature and immature stages, besides using as salads and pickles. It is being used in several ways as a fresh, frozen and greens. It is also used by processing industry for dehydration in the form of flakes and powder which are in great demand in the world market. India is a second largest producer of onion in the world but, the inadequate and unbalanced fertilization causing very low productivity of onion as compared to other onion producing countries. The quality of vegetables improves through organic manures because of the supply of enzymes, hormones and growth regulators. Among the organic manures, panchakavya is an important and low cost organic product which helps in increasing the yield and soil fertility. Keeping this in view, the field experiment was carried out to study the effect of *panchakavya* on growth parameters and yield of onion at College farm, Agricultural polytechnic, Madakasira, ANGRAU. The experiment was laid out with simple RBD having 8 treatments replicated thrice. The results revealed that the highest yield was recorded with 100% recommended dose nitrogen + panchakavya @ 5% spray 27.18 t ha⁻¹ followed by 50% recommended dose nitrogen through urea + 50% recommended nitrogen through FYM + panchakavya @ 5% spray 26.34 t/ha and the lowest yield was recorded in control 22.34 t ha⁻¹. The growth parameters like days of maturity, no. of leaves, plant height, leaf length, neck thickness, bulb weight, bulb dimensions are recorded.



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Effect of Integrated Nutrient Management on Physico-Chemical Properties of Soil in Bt Cotton under Rain Fed Condition

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A field experiment was conducted at Dry Farming Research Station, Junagadh Agricultural University, Targhadia (Dist:Rajkot, Gujarat) during *kharif* seasons of 2008-2013 to ascertain the effect of various treatments combinations comprising of organic and inorganic fertilizers (NPK), gypsum, castor cake, compost and vermi-compost (total 10 treatments) on post harvest soil fertility in Bt-cotton under rain fed condition..

The results revealed that effect of different treatments on EC, organic carbon, available phosphorus and potash and sulphur status in the soil were found significant and varied from 0.19 to 0.31 dS m⁻¹, 0.547 to 0.689 %, 20.2 to 39.5 kg ha⁻¹, 354 to 402 kg ha⁻¹ and 12.1 to 20.6 ppm, respectively. The maximum and minimum availability of most of the nutrients were recorded with application of compost @ 10 t ha⁻¹ + vermin compost @ 1 t ha⁻¹ + castor cake @ 500 kg ha⁻¹ + bio- fertilizer (Azotobactor +PSM) and absolute control, respectively. In case of micronutrients, availability of Fe, Zn and Mn were significantly differed under various treatments. The maximum and minimum availability of most of the micronutrients were recorded on account of application of compost @ 10 t ha⁻¹ + vermin compost @ 1 t ha⁻¹ + castor cake @ 500 kg ha⁻¹ + bio- fertilizer (Azotobactor +PSM) and absolute control, respectively.

The results further revealed that bulk density, water holding capacity, downward movement of water and infiltration rate were differed significantly under various treatments. Bulk density of soil was found to reduced due to application of organic alone (compost @ 10 t ha⁻¹, compost @ 10 t ha⁻¹ + vermi compost @ 1 t ha⁻¹ + castor cake @ 500 kg ha⁻¹ + bio- fertilizer (Azotobactor +PSM) or integration of organic and inorganic sources of nutrient (N @ 80 kg ha⁻¹ + castor cake 500 @ kg ha⁻¹ and N @ 80 kg ha⁻¹ + compost @ 10 t ha⁻¹ + castor cake @ 500 kg ha⁻¹ + bio- fertilizer. Similar, beneficial effect of integration of organic and inorganic sources of nutrient was also observed on water holding capacity, per cent expansion by weight, downward movement of water and infiltration rate.

It is concluded that the soil physico-chemical properties of soil was improved due to application of organic alone or integration of organic and inorganic sources of nutrient.



Response of *Bt* Cotton to Different Nutrient Management Practices

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To evaluate the nutrient requirement of *Bt* cotton *vis-a-vis* fertilizer practices in vogue, a field experiment was conducted during *khari*f 2013, at research farm of KVK, Malyal, Warangal district with 9 treatments viz., Control, Farmers practice, Recommended dose of fertilizers (RDF-150-60-60 kg NPK ha⁻¹), RDF + S @ 30 kg ha⁻¹, Soil test based fertilizer application (114-104-28 kg NPK ha⁻¹) for an yield target of 2.5 t ha⁻¹, 125% RDF, 125% RDF + S @ 30 kg ha⁻¹, 150% RDF, 150% RDF + S @ 30 kg ha⁻¹ in randomised block design with 3 replications. At different growth stages, higher plant height was recorded with farmers' practice (333-97-142-17 kg NPKS ha⁻¹). Except control, all other treatments recorded higher number of monopodial and sympodial branches than 100% RDF. Increasing doses of fertilizers from 100% to 150% RDF resulted in increased dry matter production, but very high doses of fertilizers as adopted by farmers resulted in lower and or par dry matter production as that of 100% RDF and other fertilizer doses. Incremental doses of fertilizers increased the number of bolls plant⁻¹ but very high doses practiced by farmers did not help in increasing boll number. Nutrient removal at flowering and harvest stages was on par in all the fertilizer treatments and supply of additional or excess fertilizers did not help in uptake of more nutrients. Uptake of micronutrients (Zn, Cu Fe and Fe) was higher in 100% RDF but was on par with that 100% RDF + 30 kg S ha⁻¹. Kapas yield increased with increasing fertilizer dose from 100 to 150% but it was on par with the yield realized in 100% NPK and soil test based fertilizer application treatments. Further, in farmers' practice the yield was even less and on par with that of 100% NPK. Inclusion of 30 kg sulphur along with 100% RDF or with increased doses (125% or 150%) did not result in any additional yield increment. Kapas yield in soil test based fertilizer treatment was higher than the targeted yield of 2.5 t ha⁻¹. This suggests the need for revalidation of existing STCR equations for their use in Warangal district. Quality parameters like seed index, lint index and ginning out turn were not influenced by the fertilizer treatments.



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Effect of Organic and Inorganic Fertilizers on Growth, Yield and Quality of Different Varieties of Green Gram (*Vigna radiata* L. Wilczek) Grown in Acid Soils of Nagaland

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Green gram (*Vigna radiata* L. Wilczek) is one of the protein rich crops grown in India. It has special importance in intensive crop production system of the country for its short growing period. A field experiment entitled "Effect of organic and inorganic fertilizer on growth, yield and quality of different varieties of green gram (*Vigna radiata* L. Wilczek)" was conducted during the *Kharif* season of 2013 at the Experimental Research Farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema. The experiment was conducted in randomized block design with two varieties (SG- 1 Pratap and Type – 1) and six nutritional schedules (T₁ – Control, T₂ – FYM @ 5t/ha, T₃ – Pig manure @ 5 t ha⁻¹, T₄ – 100% RDF, T₅ - 50% RDF + FYM @ 5 t ha⁻¹ and T₆ – 50% RDF + Pig manure @ 5t/ha) and replicated thrice. Application of 50% RDF + FYM @ 5t/ha recorded significantly maximum plant height, root length, root volume, nodules count and fresh weight of nodules. It also produced highest number of pods and length of pods/plant, number of seeds/pod, number of filled pods, grain yield and stover yield and resulted in maximum test weight, harvest index (%), crude protein content (%), N, P and K content of seeds and stover as well as NPK uptake by the plant. In the present study, it has been observed that the application of 50% RDF + FYM @ 5 t ha⁻¹ was found to be the best nutrient management practice among the different nutritional schedules for producing the maximum yield and also in improving the nutrient uptake as well as available soil nutrient status after harvest of green gram. Variety SG – 1 Pratap performed better than variety Type – 1. From the experiment, it can be concluded that among the different nutrient sources, 50% RDF + FYM @ 5 t ha⁻¹ found to be the best in influencing the growth and productivity of green gram and nutrient status of the acidic soils of Nagaland.



Effect of Fertilizers, Biochar and Humic Acid on Soil Enzymes at Different Stages of Maize Growth

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A field study was carried out at college farm, College of Agriculture, Rajendranagar, Hyderabad, Andhrapradesh during *Kharif* 2013 to find out the influence of humic acid and biochar on soil enzymes of maize rhizosphere at different stages. The experiment was laid out in a Randomized Block Design and replicated thrice with three factors comprised of factor-I (fertilizers- 100 % RDF and 75 % RDF), Factor-II (biochar levels- 0, 5 and 7.5 t ha⁻¹) and Factor-III (humic acid levels of 0 and 30 kg ha⁻¹). Dehydrogenase activity at 30 DAS was significantly higher the activity being 16.19 $\mu\text{g TPF g}^{-1}$ soil day⁻¹ with 75% NPK in combination with humic acid. While, at 60 DAS and harvest, significantly higher activity was noticed with biochar @ 5 t ha⁻¹ along with 100 % NPK and 75% NPK respectively with the corresponding activities of 20.72 and 5.594 $\mu\text{g TPF g}^{-1}$ soil day⁻¹. Combined application of 75% NPK, 7.5 t ha⁻¹ of biochar and 30 kg ha⁻¹ of humic acid could result in a significantly higher acid phosphatase which was on par with recommended NPK along with biochar @ 7.5 t ha⁻¹ at all the stages of assay. Alkaline phosphatase activity highest at 30 and 60 DAS (48.93 and 158.6 $\mu\text{g p-nitro phenol g}^{-1}$ soil h⁻¹) with 100 % NPK along with biochar @ 7.5 t ha⁻¹, while at harvest stage higher activity (37.31 $\mu\text{g p-nitro phenol g}^{-1}$ soil h⁻¹) was shown by 75% NPK alone.



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Effect of Different Time of Hifoilar Nutrient Spray on Growth and Yield of Soybean

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Soybean has become famous as the crop that will help feed the world's present and future population and help to solve protein deficiency. The ability of soybeans to attain high yields from traditional soil fertilization is accepted in most cases. However, many reports have indicated increased yields from supplemental foliar fertilizer applications. HiFoliar is a nutrient blend of peptone and inorganic salts. The field experiment was conducted during *Kharif* 2012 at Agricultural Research Station, K. Digraj, Dist-Sangli (M.S.) India to study the effect of different time of hifoilar nutrient spray on growth and yield of soybean. The experiment was laid down in randomized block design with seven treatments and three replications. The experimental initial soil status was pH 8.17, EC 0.35 dS m⁻¹, available N 215 kg ha⁻¹, P 10.18 kg ha⁻¹ and K 2530 kg ha⁻¹. The treatments consist of recommended dose of fertilizer (RDF), RDF + hifoilar nutrient spray @ 3g L⁻¹ at 50 days after sowing (DAS), RDF+ hifoilar nutrient spray @ 3g L⁻¹ at 75 DAS, RDF + hifoilar nutrient spray @ 3g L⁻¹ at 30 DAS and 50 DAS, RDF+ hifoilar nutrient spray @ 3g L⁻¹ at 50 DAS and 75DAS, RDF+ hifoilar nutrient spray @ 3g L⁻¹ at 30 DAS, 50DAS and 75 DAS and RDF + foliar sprays of 2% DAP at 50 and 75 DAS. The basal recommended dose of fertilizer N through urea and P through single super phosphate was applied as per treatments. The results revealed that the recommended dose of fertilizer with foliar nutrient sprays showed significant effect on grain and straw yield of soybean. The significantly highest grain yield (1.701 t ha⁻¹) and straw yield (2.161 t ha⁻¹) were recorded in treatment RDF+ hifoilar nutrient spray @ 3g L⁻¹ at 30 DAS, 50 DAS and 75 DAS over the rest of other treatments. The treatment RDF+ hifoilar nutrient spray @ 3g L⁻¹ at 30 DAS, 50 DAS and 75 DAS was at par with treatments RDF + hifoilar nutrient spray @ 3g L⁻¹ at 30 DAS and 50 DAS, RDF+ hifoilar nutrient spray @ 3g L⁻¹ at 50 DAS for grain and straw yield of soybean. The lowest were observed in treatment in RDF. The 100 grain weight and plant height were significantly influenced by foliar application of hifoilar. The highest 100 grain weight (19.54 g) and plant height (35.97 cm) were recorded in treatment RDF+ hifoilar nutrient spray @ 3g L⁻¹ at 30 DAS, 50 DAS and 75 DAS over the rest of other treatments. The lowest grain, straw yield, 100 grain weight and plant height of soybean were observed in treatment in RDF i.e. without foliar application of hifoilar nutrient spray. The application RDF (50:75 N : P₂O₅ kg ha⁻¹) and hifoilar nutrient spray @ 3g L⁻¹ at 30 DAS, 50 DAS and 75 DAS was improved productivity of soybean.



Influence of Nitrogen Levels in Combination with Zinc and Boron on Soil Fertility, Nutrient Uptake and Yield of Maize

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The field experiment was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during *kharif* seasons of 2010-11 to 2012-13 on Inceptisols to study the effect of nitrogen levels (0, 50%, 100, 150% RDN) in combination with zinc (10 kg ha⁻¹) and boron (1 kg ha⁻¹) on soil fertility, nutrient uptake and yield of maize. The maize crop was sown during *kharif* season under rainfed condition, the recommended fertilizer dose of 100 kg N + 50 kg P₂O₅ + 50 kg K₂O per ha. The nitrogen was applied as per the treatments. Fifty percent N, 100 % P and K was applied at the time of sowing and 50 % N was top dressed after one month of sowing. The crop was harvested at maturity. The observations on yield and yield contributing characters were recorded. The grain yield of maize was recorded significantly highest with the application of 150% RDN alongwith Zn @ 10 kg ha⁻¹ which was found at par with the 100% RDN alongwith 10 kg ha⁻¹. The uptake of nitrogen, phosphorus, potassium and zinc was recorded significantly highest in the treatment combination of 150% RDN alongwith 10 kg ha⁻¹ which was found at par with the 100% RDN alongwith 10 kg ha⁻¹. The grain quality parameters *viz.*, starch and protein content in grains were also noticed highest in the treatment combination of 150% RDN alongwith 10 kg ha⁻¹. The nutrient use efficiency of nitrogen and phosphorus was noticed highest in the treatment combination of 100% RDN alongwith 10 kg ha⁻¹. The treatment combination of 100% RDN alongwith 10 kg ha⁻¹ helped to improve the soil fertility status at harvest of soybean. The boron application @ 1 kg ha⁻¹ also enhanced the grain yield over the control.

It could be inferred that, in zinc and boron deficient Inceptisols for obtaining the higher productivity of maize, uptake of nutrients, improved grain quality and enhanced nutrient use efficiency, the application of zinc @ 10 kg ha⁻¹ through ZnSO₄ and boron @ 1 kg ha⁻¹ through borax in combination with recommended dose of fertilizers (100 kg N + 50 kg P₂O₅ + 50 kg K₂O per ha) is recommended.



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Assessment of Micronutrient Status of BSP Farm (*Khanapur Block-B*) VNMKV, Parbhani

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Studies on assessment of micronutrient status of BSP farm (*Khanapur Block-B*) VNMKV, Parbhani was carried out during the year 2012-13. The BSP farm (Breeder Seed Processing Farm) is spread over 135.49 ha and it is divided into four blocks viz. Block A, B, C and D. These four blocks were surveyed by traversing along the bunds of farm plots and the 110 soil samples were drawn from BSP farm (*Khanapur Block-B*). Surface soil samples (30cm depth) were collected and analysed by standard procedures to assess micronutrient status of BSP farm (*Khanapur Block-B*). Thematic maps of micronutrient parameter were generated. The results emerged out from the present investigation revealed that soils of BSP Farm (*Khanapur Block-B*) are Typic Haplusterts (40 %), Vertic Ustochrepts (36 %) and Lithic Ustorthents (24%). Results indicated that the micronutrient status of DTPA extractable micronutrients and hot water soluble boron from BSP farm (*Khanapur block-B*) soils according to soil groups. The soils are sufficient in DTPA extractable Cu and Mn. Wide range deficiency of available iron was found at BSP farm (*Khanapur Block-B*) i.e 74.55 per cent soils are low, 19.09 per cent soils were medium and only 6.36 per cent soils are high in DTPA extractable iron. Lithic Ustorthents show higher Fe deficiency (80.77 per cent) followed by Typic Haplusterts (72.73 per cent) and Vertic Ustochrepts (72.50 per cent). In respect of DTPA-Zn out of 110 samples, 21 samples (19.09 per cent) found low, 38 samples (35.55 per cent) were medium and rest 51 samples (46.36 per cent) were high in zinc. Vertic Ustochrepts show higher deficiency (24.39 per cent) followed by Typic Haplusterts (16.28 per cent) and Lithic Ustorthents (15.38 per cent). Hot water soluble boron found to be deficient to the tune of 78.18 per cent soil samples while rest 21.82 per cent soils showed boron in medium range of availability. Lithic Ustorthents show higher deficiency (84.62 per cent) followed by Vertic Ustochrepts (80.49 per cent) and Typic Haplusterts (24.39 per cent). Among the micronutrients of BSP farm (*Khanapur Block-B*) Fe was found to be most deficient nutrient followed by Boron and Zinc. The copper and manganese were high in content.



Effect of Sulphur with Recommended Dose of Fertilizers on Growth Yield and Economics of Soybean

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Sulphur is one of the major plant nutrients essential for growth and development of the plants. Use of sulphur increases crop productivity and improve the crop quality as well. Increase in oil content of oilseeds and sulphur containing amino-acids like cystine, cysteine, methionine and plant proteins are important quality factors affected by sulphur application.

Trials on farmers' field were conducted during 2013 at the adopted villages of Krishi Vgyan Kendra, Dewas. The experimental soil had pH 7.8, electrical conductivity 0.40 dSm⁻¹, organic carbon 0.45%, alkaline KMnO₄ extractable N 180 kg ha⁻¹ and 1N ammonium acetate extractable K 395 kg ha⁻¹. There are two practices were adopted [Farmers practices (18 kg N and 46 kg P₂O₅ ha⁻¹) and improved practices (20, 60 and 20 kg N, P₂O₅ and K₂O ha⁻¹) + 25 kg betonoid sulphur ha⁻¹) were applied as soil application. All the doses were applied at the time of sowing. Six farmers' fields were selected for the experiment. A common pest management practices were adopted for the experiment

The growth and yield parameters were influenced by the treatment. Highest pods plant⁻¹ (61.8), branches plant⁻¹ (6.02) and seed yield (1.31 t ha⁻¹) were recorded under improved practices against the farmers practices i.e. pods plant⁻¹ (51.5), branches plant⁻¹ (4.45) and seed yield (1.11 t ha⁻¹). Highest cost of cultivation (Rs. 19749 ha⁻¹) gross return (Rs. 66917 ha⁻¹), net return (Rs. 52464 ha⁻¹) and B:C ratio (3.39) were recorded under improved practices. However, lowest cost of cultivation (Rs. 17622 ha⁻¹) gross return (Rs. 52368 ha⁻¹), net return (Rs. 45945 ha⁻¹) and B:C ratio (2.97) were recorded under farmers practices.



Nutrient Management Practices for Sustaining Pigeonpea Yield on Inceptisol under Dryland Condition

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A field experiment of nutrient management practices for sustaining pigeonpea yield and soil productivity on Inceptisol was conducted during kharif season of 2012 at Mulegaon farm of Zonal Agricultural Research Station, Solapur to study the effect of nutrient management on N, P and K uptake and soil fertility status for sustainable production of pigeonpea. The experiment was conducted in randomized block design with 7 treatments consists of control, RDF (25:50 N:P₂O₅ Kg ha⁻¹), RDF+ 5 t ha⁻¹ FYM, RDF+ 5 t ha⁻¹ FYM +1% K₂SO₄, RDF+ 5 t ha⁻¹ FYM +1% KCl, RDF+ 5 t ha⁻¹ FYM +1% water soluble NPK fertilizer (19:19:19), RDF+ 5 t ha⁻¹ FYM +1% DAP foliar spray at commencement of flowering and pod development stages. The results showed that the grain (0.85 t ha⁻¹), straw (2.69 t ha⁻¹) and protein yield (174.3 kg ha⁻¹) of pigeonpea was found significantly higher in T₆- RDF+ 5 t ha⁻¹ FYM + foliar sprays of 1% water soluble NPK fertilizer (19:19:19) at commencement of flowering and pod development stages. However, it was on par with T₇- RDF+ 5 t ha⁻¹ FYM + foliar sprays of 1% DAP at commencement of flowering and pod development stages. Similar type of results were obtained in case of N, P and K uptake which showed highly significant results with T₆- RDF+ 5 t ha⁻¹ FYM + foliar sprays of 1% water soluble (19:19:19) at commencement of flowering and pod development stages (51.24, 8.59 and 43.48 Kg ha⁻¹ respectively). However, it was on par with T₇- RDF+ 5 t ha⁻¹ FYM + foliar sprays of 1% DAP at commencement of flowering and pod development stages (46.98, 7.60 and 40.28 Kg ha⁻¹ respectively). Maximum MUE for grain (2.06 Kg ha⁻¹mm⁻¹) and straw (6.53 Kg ha⁻¹mm⁻¹) was recorded in treatment T₆- RDF+ 5 t ha⁻¹ FYM + foliar sprays of 1% water soluble NPK fertilizer (19:19:19) at commencement of flowering and pod development stages. The treatment T₆ recorded significantly higher soil organic carbon (0.67%) and soil available N, P and K (143, 15.04 and 610 Kg ha⁻¹ respectively) at harvest.



Effect of Press mud Cake on Pigeonpea Yield and Soil Properties under Dryland Condition

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The field experiment on integrated phosphorus management for pigeonpea (cv. Vipula) under dryland conditions was conducted at Zonal Agricultural Research Station, Solapur to study the response of IPM on yield of grain and straw, MUE, protein yield, nutrient uptake and residual soil fertility with the following treatments *viz.*, control, Recommended dose of N:P₂O₅ (25:50 kg ha⁻¹) chemical fertilizer, Recommended dose PMC (N:P₂O₅; 25:50 kg ha⁻¹), 2/3rd of Recommended dose of phosphorus PMC + 1/3rd of Recommended dose of phosphorus- chemical fertilizer, 1/2 of Recommended dose of phosphorus - PMC + 1/2 of Recommended dose of phosphorus- chemical fertilizer, 1/3rd of Recommended dose of phosphorus - PMC + 2/3rd of Recommended dose of phosphorus- chemical fertilizer. The grain yield of pigeonpea was found significantly higher in 1/2 of recommended dose of phosphorus through PMC + 1/2 of recommended dose of phosphorus through chemical fertilizer (0.834 t ha⁻¹), as compared with rest of treatments. The application of 1/2 of recommended dose of phosphorus through PMC + 1/2 of recommended dose of phosphorus through chemical fertilizer (2.773 t ha⁻¹), 2/3rd RD of phosphorus-PMC + 1/3rd RD of phosphorus-chemical fertilizer (26.08 q ha⁻¹) and recommended dose of fertilizer (2.541 t ha⁻¹) treatments were found statistically equal in respect of straw yield. The least value of MUE for grain was recorded in control treatment (1.40 kg ha⁻¹ mm⁻¹). The significantly higher protein yield of pigeonpea was recorded by 1/2 of recommended dose of phosphorus through PMC + 1/2 of recommended dose of phosphorus through chemical fertilizer (167.1 kg ha⁻¹). The nitrogen, phosphorus and potassium uptake by pigeonpea significantly increased over control due to integrated phosphorus management. Significantly higher N, P and k uptake (50.29, 8.35 and 44.04 kg ha⁻¹ respectively) were recorded by the application of 1/2 of recommended dose of phosphorus through PMC + 1/2 of recommended dose of phosphorus through chemical fertilizer.

The application of recommended dose of P + 2/3rd recommended dose of phosphorus through PMC + 1/3rd recommended dose of phosphorus through chemical fertilizer recorded maximum organic carbon (0.71 %) whereas highest available N, P and K (193, 19.65 and 645 kg ha⁻¹) was recorded in the treatment of 1/2 RD of phosphorus through PMC + 1/2 RD of phosphorus through chemical fertilizers.



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Soil Test Crop Response-based on Integrated Plant Nutrition System for Barley (*Hordeum vulgare L.*) in Inceptisols

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Field experiment on barley was conducted to investigate the correlation between the soil test values as well as fertilizer doses of nitrogen, phosphorus and potassium with the crop response at the agricultural research farm, Institute of Agricultural Sciences, BHU on different fertility gradients. The barley grain and straw yield was significantly increased with the soil test values and fertilizer doses of N and P. Based on the experiment the nutrient requirement for producing one quintal of barley grain was 2.50 kg of N, 0.56 kg of P₂O₅ and 2.93 kg of K₂O. The percent contribution from soil was 21.89, 38.36 and 34.27 respectively. The contribution of fertilizer towards crop response was 55.12, 51.52 and 90.03 % for N, P and K respectively. Coefficient of determination (R²) was found significant (R²=0.832) between yield and soil test values. The basic data was transformed into soil test based fertilizer adjustment equations for specific targets of barley grain. Making use of these basic parameters, fertilizer prescription equations were developed for barley (var.) PL-172 and an estimate of fertilizer doses formulated for a range of soil test values and desired yield targets under NPK alone and IPNS (NPK plus FYM).



Effect of Polysulphate on Yield and Quality of Mustard in the Central Plain Zone Soils of Uttar Pradesh

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A field experiment was initiated at Oilseed Research Farm Kalyanpur, Kanpur, C.S. Azad University of Agriculture & Technology, Kanpur during rabi 2013-14, to find out the effect of polysulphate on yield and quality of mustard. The six treatments combinations i.e. T₁ – control without S and K fertilization (100% NP only through urea, DAP), T₂ – 100% NPK (Urea, DAP and MOP), T₃ – 100% NP + 50% S through polysulphate (Balance K through MOP to make 100% K), T₄ - 100% NP + 75% S through polysulphate (Balance K through MOP to make 100% K), T₅ - 100% NP + 100% S through polysulphate (Balance K through MOP to make 100% K) and T₆ 100% NPK (Urea, DAP and MOP) + 100% S through Gypsum. The treatments were replicated thrice in RBD and mustard variety Varuna was sown during November 2013. The NPK and sulphur were used @ 120: 60: 60: 40 kg ha⁻¹. Results of the experiment indicated that grain and stover yield of mustard significantly increased with the use of potassium and sulphur over without potassium and sulphur. Every increasing dose of polysulphate to meet out the requirement of sulphur significantly increased grain and stover yield of mustard. Maximum grain 2.52 t ha⁻¹ and stover yield 6.80 t ha⁻¹ were recorded with T₅ - 100% NP + 100% S through polysulphate (Balance K through MOP to make 100% K). The maximum response in grain yield of mustard was noted as 0.87 t

ha⁻¹ with percent response 52.73% at T₅ over T₁. Polysulphate as source of sulphur found better than gypsum. The percent sulphur, potassium content in mustard seed increased with the use of potassium and sulphur either through polysulphate or gypsum. The protein content reduced with the use of sulphur. Oil content significantly increased with the use of sulphur at any incremental dose of sulphur. Maximum oil 42.5% recorded with T₅ - 100% NP + 100% S through polysulphate (Balance K through MOP to make 100% K). S content ranged from 0.62 to 0.79%, K content 0.82 to 1.07%, both S and K recorded maximum with T₅ & minimum with T₁. Maximum protein content 23.02% recorded with T₂ – 100% NPK (Urea, DAP and MOP). Polysulphate found superior over gypsum as a source of sulphur in mustard harvesting quality in central plain zone soil of Uttar Pradesh.



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Impact of Additional Application of Foliar Grade SOP (K-leafTM) on Yield and Quality of Maize-Wheat Cropping Sequence in Alluvial Soil of Central Uttar Pradesh

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Field experiments were conducted at Fertilizer Research Farm Uttaripura, Kanpur, C.S. Azad University of Agriculture & Technology, Kanpur during 2013-14. To assess the effect of additional application of foliar grade SOP (K-leafTM) on yield and quality of maize-wheat. The five treatments were used i.e. T₁ - control without K fertilization (100% NP + Zn), T₂ - 100% NPK (MOP) Zn, T₃ - 100% NPK (MOP) Zn + One foliar spray of SOP (K-leafTM), T₄ - 100% NPK (MOP) Zn + Two foliar spray of SOP (K-leafTM), T₅ - 100% N P Zn, 75% K (MOP) + Two foliar spray of SOP (K-leafTM). Results of the experiment revealed that grain and straw yield of maize and wheat significantly increased with the use of potassium over without potassium application and yield further increased significantly when foliar spray of SOP combined with basal dose of potassium. Two spray of SOP increased grain and straw yield of both maize and wheat over single spray of SOP but difference was not significant. The maximum grain yield of maize 5.25 t ha⁻¹ and wheat 4.75 t ha⁻¹ were recorded with T₄ - 100% NPK (MOP) Zn + Two foliar spray of SOP (K-leafTM). Reduced the dose of potassium by 25% with two foliar spray of SOP yielded at par with 100% NPK (MOP) + two foliar spray of SOP. Protein and K content in the grain of maize and wheat increased with the use of potassium over no use of potassium and protein & K content further increased when basal dose of potassium combined with one or two foliar spray of SOP. Two spray of SOP with 75% potassium found better than one spray of SOP with 100% K. The protein percent in wheat ranged from 10.75 to 11.56 % and in maize 11.05 to 11.65%. Potassium content in the grain of wheat and maize ranged from 0.31 to 0.43% and 0.35 to 0.52%, respectively.



Sugarcane Cultivation under Organic Farming

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Under the context of environmental pollution, health hazards and threat for soil sustainability, organic farming is gaining importance even though it has merits and demerits in crop production. Organic manures have been found to enhance the efficiency and reduce the requirement of chemical fertilizers besides improving quality of produce and sustaining soil health. Hence, the present study “Organic farming research in sugarcane” is being conducted from 2007 onwards at RARS, Anakapalle, Acharya N G Ranga Agricultural University, Andhra Pradesh, India in *Inceptisols* to study the feasibility of organic farming in sugarcane. Nutrient management through farmyard manure @ 25 t ha⁻¹ as basal dose and vermicompost @ 3 t ha⁻¹ at 60, 90 and 120 days after planting, sprayings of vermiwash at critical stages of the crop, insitu green manuring of sun hemp between sugarcane rows and incorporation, biofertilizer (azatobactor/ azospirillum) application in every alternate year, application of trash compost @ 5 t ha⁻¹ at cessation of monsoon rains was found optimum to stabilize the sugarcane yield to that of 100 % recommended NPK through chemical fertilizers. As a check 100 % chemical fertilizer treatment was also maintained in another field with same soil texture. Results of the experiment revealed that organic farming is having positive effect on soil physical properties (viz., bulk density, water holding capacity and per cent pore space), soil biology and soil nutrient status. Initial soils were neutral in reaction with normal conductivity. The soil organic carbon (0.52%) and available nitrogen (232 kg ha⁻¹) was low to medium in status and available phosphorus (40.80 kg ha⁻¹) and potassium (269 kg ha⁻¹) status was in medium range. After four years of study the organic carbon raised to 0.55%, available NPK status was 241, 47.10 and 274 kg ha⁻¹ in organic farming plot where as in 100% chemical fertilizer treatment the organic carbon status was slightly reduced (0.50%) from its initial value and available NPK status was 232, 41.50 and 270 kg ha⁻¹, respectively. The key components of soil quality are the biota, in particular the microbial component that plays a very significant role in sustainable systems. Highest Bacteria (386 × 10⁶ c.f.u. g⁻¹ soil) Azatobacter (79 × 10³ c.f.u. g⁻¹ soil, phosphorus solubilizing bacteria (112 × 10⁴ c.f.u. g⁻¹ soil) and fungi (146 × 10³ c.f.u. g⁻¹ soil) was recorded in organic treated plots. Where as in inorganic treated plots it was 322 × 10⁶ c.f.u. g⁻¹ soil, 62 × 10³ c.f.u. g⁻¹ soil, 97 × 10⁴ c.f.u. g⁻¹ soil 137 × 10³ c.f.u. g⁻¹ soil of bacteria, azatobacter, phosphorus solubilizing bacteria and fungi, respectively. Regarding soil physical properties bulk density was slightly reduced in organic farming, whereas in inorganic farming there was no change compared to initial. Water holding capacity and per cent pore space increased in both the plots as compared to initial values recorded at the beginning of the experiment. However more increase was observed in organic plot compared to inorganic plot.



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Evaluation of Different Combination of Crop Residues with Sewage Sludge-based Enriched Compost Material

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Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons of sewage sludge (SS) daily. The sewage sludge amount is expected to increase significantly in the near future as the country strives to attain an industrialized nation status by the year 2020. According to Canellas *et al.* (2001), the use of SS in agricultural lands can be justified by the need of finding an appropriate destination for waste recycling. To develop an appropriate sewage sludge based enriched compost product for sustainable productivity, a pot house experiment was initiated in the year 2012 at IARI, New Delhi with the following treatment combinations: (i) Crop residue (Rice) to sewage sludge ratio: Three ratios (9:1, 6:1 and 3:1), (ii) Lime: Three levels (0, 2% and 4% of composting mass) with three replication. The composting material (crop residues + sewage sludge) with lime was thoroughly mixed. Moisture content was maintained throughout the composting period at 60% of water holding capacity. The turning of compost materials was done at 30 days interval of composting period. The compost becomes ready for field application after 160 days. The data showed that nine sewage sludge based compost were prepared and it contained 1.08 - 1.96% total N, 1.0 - 1.73% total P₂O₅ and 1.10 - 1.54% K₂O with good content of micronutrients (Zn, Fe, Mn and Cu). The dehydrogenase activities (DHA) increased with increasing rates of lime application but it was decreased with increasing concentration of sewage sludge. The heavy metals (Pb and Cd) content was under permissible limit.



Crop Residue Management in Rice-Rice Cropping System under Godavari Zone of Andhra Pradesh

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Intensive agricultural practices in the post green revolution era have begun to show declining trends in crop productivity, which is attributed to imbalanced nutrition and decreasing use of organic resources leading to declining soil quality. Crop residues of cereals are good sources of plant nutrients and are important components for the stability. With the advent of mechanized harvesting, substantial quantities of these residues are being burnt *in situ* to facilitate seeding operations of the next crop, which cause loss of nutrients, organic matter and biological activity in the soil. Instead of removal or burning, recycling of straw can build up soil organic matter, and improve soil nutrient status. An experiment was conducted at Andhra Pradesh Rice Research Institute, Maruteru, West Godavari District, Andhra Pradesh, India during 2007 to 2009 to evaluate management options for utilizing the crop residues (paddy straw) involving microbial cultures, N application and complementation with green manures in rice based cropping systems. The results revealed that application of paddy straw @ 5 t ha⁻¹ incorporated 20 days before planting along with green manure @ 5 t ha⁻¹ along with recommended dose of NPK (90-60-60 kg ha⁻¹) recorded significantly higher grain and straw yields and productive tillers compared to the other treatments in the study. The lowest yields were noticed in the plots where straw was removed. The content and uptake of nutrients of N and K by grain and straw were significantly influenced by the treatments. The straw incorporated along with green manure and recommended dose of fertilizer recorded higher content of Nitrogen (1.20%), Phosphorus (0.43%) and Potassium (0.79%) in the grain. Similarly, significantly higher uptake of N (57.2 kg ha⁻¹), P (20.4 kg ha⁻¹) and K (48.5 kg ha⁻¹) in grain was recorded by the same treatment. Straw removal, in general recorded reduced content and uptake of nutrients in grain and straw. The post-harvest soil analysis indicated the significant increase in soil available N (235 kg ha⁻¹) and available K₂O (420 kg ha⁻¹). Straw incorporation along with green manure resulted in maximum increase in soil organic carbon content (1.55%) among all the treatments during the period of study.



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Soil Health and Crop Productivity of Maize- Sunflower Cropping Sequence in Centenary Old Permanent Manurial Experiment of Coimbatore

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The Permanent Manurial Experiment (PME) was started in the year 1909 and being maintained at Tamil Nadu Agricultural University, Coimbatore. It is the oldest one having historical importance in India as it has crossed 105 years of continuous experimentation. This experiment was conducted to study the continuous application of nutrients on yield and available nutrients status of soil. It has eighteen treatments which comprises of control, either nutrients alone or in combination, organic manures alone and INM etc. are being tested as non replicated trial. From 2008 onwards the treatments of PME was revised to suit the high yielding crops that are being released and recommended currently. The approaches of nutrient addition through FYM/ Poultry Manure, Integrated Nutrient Management, STCR-IPNS, and residue incorporation etc were introduced in the middle strip of PME. Instead of fixed dose of fertilizer nutrients followed earlier, the blanket dose of fertilizer recommended for each crop hybrid is being adopted at present in maize- sunflower cropping system under irrigated conditions.

In the present study the effect of imposed treatments on soil nutrient availability, crop uptake of nutrients and yield for the period from 2008 to 2013 in maize-sunflower cropping sequence has been evaluated. The five years results of total 10 crops revealed the following findings. Application of 250:75:75 kg N, P₂O₅ and K₂O ha⁻¹ as 100% NPK along with FYM @ 12.5 t ha⁻¹ recorded the highest maize grain mean yield of 8,895 kg ha⁻¹ and mean straw yield of 10,210 kg ha⁻¹. The total uptake of NPK by maize hybrid also recorded the highest in INM practice. Application of 60:90:60 kg N, P₂O₅ and K₂O ha⁻¹ as 100% NPK along with FYM @ 12.5 t ha⁻¹ recorded the highest hybrid sunflower mean seed yield of 1,587 kg ha⁻¹ and mean straw yield of 4581 kg ha⁻¹. The total uptake of NPK by hybrid sunflower also recorded the highest in INM practice. Hence, the important finding of PME focuses on the practice of balanced fertilization through INM approaches for achieving the highest yield of crops and sustaining soil health and productivity. The available nitrogen and potassium status were found to be high under INM treatment. In case of available phosphorus, application of poultry manure on nitrogen equivalent basis recorded the highest available P followed by INM and STCR-IPNS. Regarding the micronutrients invariably in all treatment plots recorded almost comparable values with each other. DTPA extractable Fe and Zn was found to be in deficient whereas Cu and Mn seem to be sufficient for crop growth. Microbial population was high under INM treatment of 100% NPK along with FYM @ 12.5 t ha⁻¹ under irrigated condition followed by the plots treated with FYM either N equivalent basis or every year or alternate year treatments.



Balance Sheet of Nutrients as Influenced by Mustard Varieties and Fertility Levels

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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 0.42% organic carbon, KMnO_4 extractable N-195 kg ha^{-1} , Olsen's P_2O_5 -22 kg ha^{-1} , 1N 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 and 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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Response of Clusterbean to Different Fertility Levels in Alluvial Soils of Madhya Pradesh

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Clusterbean {*Cyamopsis tetragonoloba* (L).Taub} is an important, hardy and drought tolerant leguminous crop of *kharif* season in arid and semiarid region of tropical India. Nutrient management is important factors which increased the yield and quality. In this view a field experiment was conducted during *Kharif* season of 2008 to 2010 at Morena. The experimental soil had sandy loam to clay loam in texture having 0.45% organic carbon, pH-7.5, KMnO_4 extractable N-185 kg ha^{-1} , Olsen's P_2O_5 -19.5 kg ha^{-1} and 1N ammonium acetate extractable K_2O -382 kg ha^{-1} . The experiment was laid out in randomized block design with four replications. The treatments consisted of four fertility levels F_1 (100% RDF), F_2 (50 % RDF + 10 t FYM ha^{-1}), F_3 (50 % RDF + 5 t vermicompost ha^{-1}) and F_4 (50% RDF + 5 t FYM ha^{-1} + 2.5 t vermicompost ha^{-1}). The observations were recorded at their critical stages.

The vegetative growth and yield attributing characters of cluster bean varied significantly due to application of fertilizer and manures. The maximum plant height (111.20cm), branches / plant (10.10), pods/plant (74.79), grain/ pod (7.45), seed weight/plant (19.60 g) and 1000 grain weight (35.24 g) were registered with the application of 50% RDF + 5 tonnes FYM + 2.5 tonnes vermicompost ha^{-1} .

Production efficiency was improved significantly due to application of fertilizer and manures. The maximum production efficiency (17.08 $\text{kg ha}^{-1} \text{ day}^{-1}$) was obtained with 50% RDF + 5 tonnes FYM + 2.5 tonnes vermi compost ha^{-1} which was at par with 100% RDF. The significant improvement in seed yield also recorded due to application of fertilizer and manures. The maximum seed yield (2.015 t ha^{-1}) was registered with the application of 50% RDF + 5 tonnes FYM + 2.5 tonnes vermicompost ha^{-1} .

The maximum gross returns (Rs. 38285 ha^{-1}), net returns (Rs. 26350 ha^{-1}) and B:C ratio (3.20) was recorded with the application of 50% RDF + 5 tonnes FYM + 2.5 tonnes vermin compost ha^{-1} . Highest nitrogen, phosphorus and potassium use were observed in F_1 (91.95 kg kg^{-1}), F_4 (42.48 kg kg^{-1}) and F_3 (93.58 kg kg^{-1}), respectively than other treatment.



Response of Mustard to Sulphur through Gyphum in Alluvial Soils of Madhya Pradesh

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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. N, P and K are important and inevitable nutrient and uses of sulphur are responsible for crop yield and its quality.

Trials on farmers' field were conducted with mustard variety Pusa Jai Kisan during 2012 - 13 at the adopted villages of Krishi Vgyan Kendra, Morena. The experimental soil had pH 7.8, electrical conductivity 0.40 dSm⁻¹, organic carbon 0.42%, alkaline KMnO₄ extractable N 215 kg ha⁻¹, Olsen's P 20 kg ha⁻¹ and 1 N ammonium acetate extractable K 370 kg ha⁻¹. There three practices [T₁ 50 kg N, 20 kg P₂O₅, 0 K₂O and S ha⁻¹ (farmer practices), T₂ 100 kg N, 50 kg P₂O₅, 25 K₂O and 30 kg S ha⁻¹ and T₃ 100 kg N, 50 kg P₂O₅, 25 K₂O and 60 kg S ha⁻¹ were adopted for experiment. Five farmers' fields were selected for the experiment. A common pest management practices were adopted for the experiment. Full dose of N, P₂O₅, K₂O, S 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.

The application of balance dose of fertilizers on RDF based in mustard crops enhance the grain yield in T₁ = 28.26% and T₂ = 34.23% over farmers practices. The quality of grain obtained was also superior to farmer practices as per test weight and oil content. If the scientific agriculture techniques adopted by the farmers, the farmers can be benefited in term of yield and price.



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Effect of Zinc Sulphate with Recommended Dose of Fertilizers on Growth Yield and Economics of Garlic

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Garlic is one of the most important spice crops. Farmers of the India are mostly habituated with the use of macronutrients, especially nitrogen, phosphorus and potassium for garlic production but micronutrients particularly also play a vital role in garlic production. Application of zinc increases bulb size, number of clove per bulb and yield of garlic.

Trials on farmers' field were conducted during 2013-14 at the adopted villages of Krishi Vgyan Kendra, Dewas. The experimental soil had pH 7.8, electrical conductivity 0.45 dSm⁻¹, organic carbon 0.45%, alkaline KMnO₄ extractable N 190 kg ha⁻¹ and 1N ammonium acetate extractable K 395 kg ha⁻¹. There are two practices were adopted [Farmers practices (125 kg N, 60 kg P₂O₅ ha⁻¹ and 30 kg ha⁻¹) and improved practices (100, 50 and 50 kg N, P₂O₅ and K₂O) + 30 kg ZnSO₄ ha⁻¹) were applied as soil application. Full dose of P, K and Zn and ½ dose of nitrogen were applied at the time of sowing. Remaining dose of nitrogen was applied at 30 days after sowing for the experiment. A common pest management practices were adopted for the experiment

The growth and yield parameters were influenced by the treatment. Highest diameter of bulb (5.7 cm), and bulb yield (9.6 t ha⁻¹) were recorded under improved practices against the farmers practices i.e. diameter of bulb (4.5 cm), and bulb yield (7.7 t ha⁻¹). Highest cost of cultivation (78289 ha⁻¹) gross return (134785 ha⁻¹), net return (55536 ha⁻¹ and B:C ratio (1.72) were recorded under improved practices. However, lowest cost of cultivation (75915 ha⁻¹) gross return (107879 ha⁻¹), net return (31622 ha⁻¹) and B:C ratio (1.42) were recorded under farmers practices.



Effect of Zinc sulphate with Recommended Dose of Fertilizers on Growth, Yield and Economics of Wheat

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Wheat has played an important role to meet the food security in India. It has contributed impressively in the rural economy. The area under the crop is increasing progressively because of its high economic value. The productivity of wheat crop can be improved considerably by suitable input management viz., water and nutrient. N, P, K, Zn and S are important and inevitable nutrient responsible for yield and its quality, however, in general, it has not reached to the farmers' practices.

Trials on farmers' field were conducted during 2013-14 at the adopted villages of Krishi Vgyan Kendra, Dewas. The experimental soil had pH 7.8, electrical conductivity 0.40 dS m⁻¹, organic carbon 0.45%, alkaline KMnO₄ extractable N 180 kg ha⁻¹ and 1N ammonium acetate extractable K 395 kg ha⁻¹. There are two practices were adopted [Farmers practices (80 kg N and 40 kg P₂O₅ ha⁻¹ and improved practices (120, 60 and 30 kg N, P₂O₅ and K₂O ha⁻¹) + 25 kg zinc sulphate for experiment. All the doses were applied at the time of sowing. Six farmers' fields were selected for the experiment. A common pest management practices were adopted for the experiment.

The growth and yield parameters were influenced by the treatment. Highest tillers/plant (7.0), earhead length (8.4 cm), seed yield (4.25 t ha⁻¹) and 12% increase in yield over farmer practices were recorded under improved practices against the farmers practices i.e. tillers/plant (6.3), earhead length (8.3 cm) and seed yield (3.76 t ha⁻¹). Highest cost of cultivation (19610 ha⁻¹) gross return (55578 ha⁻¹), net return (35968 ha⁻¹) and B:C ratio (3.00) were recorded under improved practices. However, lowest cost of cultivation (18232 ha⁻¹) gross return (49451 ha⁻¹), net return (31219 ha⁻¹) and B:C ratio (2.87) were recorded under farmers practices.

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Amelioration of Zinc Deficiencies in Mustard through Foliar Spray of Zinc and Vermiwash

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An experiment was conducted during *rabi* 2013-14 on clay loam soil of Instructional Farm, Rajasthan College of Agriculture, Udaipur, to study the amelioration of zinc deficiencies in mustard through foliar spray of zinc and vermiwash. The experiment was conducted in a completely randomized block design with factorial arrangement using four replications. Treatments included: control, RDF (60 kg N ha⁻¹; 40 kg P₂O₅ ha⁻¹); RDF + Zn foliar spray @ 0.5%, RDF + Vermiwash @ 10% and RDF + Zn foliar spray @ 0.5% + Vermiwash @ 10%. Results indicated that application of RDF (60 kg N ha⁻¹; 40 kg P₂O₅ ha⁻¹) + Zn foliar spray @ 0.5% + Vermiwash @ 10% significantly increased in growth and yield attributes *viz.*, plant height at harvest, no. of total branches per plant, no. of siliquae per plant, no. of seed per siliqua and test weight over control. However, it was statistically at par with treatment T₃ (RDF + Zn foliar spray @ 0.5%) and T₄ (RDF + Vermiwash @ 10%). The seed yield, stover yield, net return and B:C ratio were found significantly increased over control and statistically at par with rest of treatments. The results of experiment indicated that application of RDF (60 kg N ha⁻¹; 40 kg P₂O₅ ha⁻¹) + Zn foliar spray @ 0.5% + Vermiwash @ 10% recorded significantly better yield, net return and B:C ratio of mustard.



Rapid Detection of Hydrogen Sulphide (H₂S) in Water Sample Quantitatively through a Portable Test Kit

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The water quality and surveillance in most developing countries is inadequate to test all drinking water resource regularly, this is largely due to poor laboratory facilities, widely spread water sources and resource crunch. The standard methods, which are available for detection of fecal contamination in drinking water, require trained analyst, bacteriological media and other supporting materials and facilities of microbiology laboratory. In such a scenario, a reliable and easy to use field test can help in effective monitoring of drinking water and water sources by users themselves. The H₂S method has been extensively studied by a number of investigators in different parts of the world. Such studies include evaluations of the original method, studies on modifications of the method and field-testing, usually with side-by-side comparison to other water quality tests. In some of these comparison studies the data are limited or have not been subjected to rigorous statistical analysis. However, the results of most studies suggest that the H₂S method detects fecal contaminated water with about the same frequency and magnitude as the traditional methods to which it was compared. In general, the sensitivity of the H₂S test appears about the same as other tests for fecal contamination of water, although, this aspect of the test has not been rigorously tested in some of the reported studies. Testing conditions and format, sample size, incubation temperature and incubation time influences test sensitivity and source of water. Because these conditions have differed among the different studies reported in the literature, it is difficult to make consistent comparisons and draw overall conclusions. However when comparisons with other methods of detecting fecal contamination were done, the H₂S method appeared to have sensitivity similar to the other methods, based on finding contaminated samples. Evaluation of hydrogen sulphide test for detection of fecal coliform contamination in drinking water from various sources is possible through this Hydrogen sulphide kit. The Hydrogen Sulfide Detection Kit provides a rapid and inexpensive procedure for detection of hydrogen sulfide in water and sediment. For estimation Hydrogen sulphide in water sample, water sample may be taken directly in to test bottle. For detecting Hydrogen Sulphide in sediment or mud, filter the sample in to clean bottle using mud filtrates. This H₂S detecting kit consists of chemical reagents, without any equipment or instruments. Water sample (25 mL) has to be taken in a container provided in the kit and two reagents are added simultaneously and a filter paper circle provided in the kit is fitted to inner side of the lid of this container and close the container. After two minutes, open the lid of the container and observe the colour shade developed on the filter paper of the lid. Based on the colour shade one can know the amount or level of H₂S present in the water sample ranging from 0.0, 0.1, 0.3, 0.5, 1.0 2.0 and 5.0 mg L⁻¹.



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Comparative Performance of Different Types of Liming Materials for Maize Crop Grown in Acid Soil

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A field experiment was conducted in the Village Bajpur in Khurda district of Odisha during *Kharif* 2013 to study the “Comparative Performance of Different Types of Liming Materials for Maize crop grown in Acid Soil”. The soil was loamy sand in texture, strongly acidic in reaction (pH_w 4.94) having Liming requirement (LR) of $3 \text{ t CaCO}_3 \text{ ha}^{-1}$, EC -0.09 dS m^{-1} , OC content of 5.7 g kg^{-1} soil. The available N, P, K, S values in soil were 169,105,143 and 17 kg ha^{-1} , respectively. The experiment was conducted in a RBD design with 10 treatments and each treatment replicated three times. The soil was ameliorated with three sources of liming materials (Paper mill sludge @ 0.1 LR, Stromatolyte @ 0.1 LR and 0.2 LR and Calcium silicate @ 0.2 LR) added with soil test based N,P and K dose with or without FYM applied @ 5 t ha^{-1} . There was one treatment as absolute control and another as soil test based dose of fertilizers (STD). The 100% soil test based dose for maize crop (cv. Hishell) was 150-30-50-30-10-25 kg of N - P_2O_5 - K_2O - SO_4 -Borax- $\text{ZnSO}_4 \text{ ha}^{-1}$.

The soil samples were collected at 7 days interval, processed and analyzed for pH, exchange acidities, OC, CEC, Exch. Ca^{2+} and Exch. Mg^{2+} etc. The initial and post harvest soil samples were also collected and analyzed for physio-chemical properties of the soil. At the harvest stage the maize cob, root and plant samples were collected and analyzed for nutrient concentrations, uptake and recovery by the crop. Application of liming materials irrespective of the sources neutralized soil acidity, increased the pH from a level of 4.94 to a level ranging from 5.11 to 5.55 and maintained for 14-35 days when lone sources were used. Combined use of liming materials with FYM increased the pH to a level ranging from 5.65-6.08, which was maintained for a period of 28-49 days after application. The acid neutralizing efficiency of liming materials followed the order: ST @ 0.2 LR > CS @ 0.2 LR > PMS @ 0.1 LR > ST @ 0.1 LR. The grain yield of Maize increased by 21.4-44.0% when the liming materials were applied alone with fertilizers but when mixed with FYM increased to a range from 46.0-78.6% over the yield due to STD (2.2 t ha^{-1}). The yield performance due to the lone sources of liming materials followed the order : ST@ 0.2 LR > CS @ 0.2 LR > PMS @0.1 LR > ST @ 0.1 LR. When applied with FYM the sources followed the order: ST@ 0.2 LR > PMS @0.1 LR > CS @ 0.2 LR > ST @ 0.1 LR. The recovery of N (ANR) by maize crop increased from 19-27%, when liming materials are used alone, but from 26-36% when used with FYM. The APR increased from 32-47% when lone sources of liming materials were used, but with FYM increased from 42-66%. Similarly AKR increased from 24-44% with lone sources but with FYM from 42-55%. The ASR increased from 10.2 – 17.4 % with lone sources, but from 18.4 – 28.7 % when applied with FYM. Irrespective of the liming materials used in maize crop production, the post harvest soil turned acidic. The OC content, available P and K status decreased, where as the available S and N status in soil increased by the harvest of the crop.



Identification of Suitable Cropping System for Wastewater Irrigation in relation to Build-up of Pollutants in Soil

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The fast growth in urbanization is leading to associated increase in wastewater generation with disposal related constraints. The use of wastewater for irrigation is common in many peri-urban areas in India. More than 72000 ha area in India are irrigated with urban wastewater (mostly untreated) to produce various crops (predominantly vegetables) in close proximity to city areas. While wastewater irrigation has, its benefits if properly managed with add on risks on soil and water. Long-term irrigation usage of wastewater increased salinity, accumulated heavy metals in soils. This enhances risks of contaminated vegetables grown with wastewater irrigation. In order to minimize the risk, an attempt was made to identify suitable crops or cropping system(s) for wastewater-irrigated area. The irrigation water, soil and crop samples from six identified sites in farmers field were analyzed between 2013 and 2014 for annual budgeting of heavy metals *viz.* Cd, Cr and Pb levels. The soils were analysed for pH, EC, organic Carbon and heavy metals *viz.* Cd, Cr and Pb. The addition of heavy metals in soils through wastewater and their uptake by crops were determined. The mean heavy metal uptake in rice was 11 per cent higher in *rabi* seasons than that in *kharif*. The initial and final concentrations of heavy metals in soils under paddy-paddy system however, showed marginal increase. The rice-okra or rice-tomato or rice-ridge gourd systems appeared safer compared to traditional rice-rice system.



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Effect of Sowing Dates and Irrigation Regimes on the Yield and Economics of Summer Groundnut under Minisprinkler Irrigation System

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A Field experiment on summer groundnut (Var. TAG-24) was carried out consecutively for three years during 2009-2012 at MPKV, Rahuri, Dist-Ahmednagar (M.S.). The soil of the experimental plot had a plain topography, with clay loam texture, medium soil depth, good drainage being alkaline in nature and low in available N and P and high in available K content. The experiment was laid out in split plot design with three main plot treatments of sowing dates at 7th MW, 9th MW and 11th MW and four sub plot treatments of irrigation regimes *viz.*, 0.6, 0.8, 1.0 IW/CPE through microsprinkler irrigation and 1.0 IW/CPE (surface irrigation) and three replications. The maximum dry pod and haulm yields observed in 7th M.W. being significantly superior over sowing in 9th and 11th M.W. In irrigation regimes 1.0 IW/CPE ratio with mini sprinkler irrigation system has given highest dry pod yield of groundnut being significantly superior over 0.6 IW/CPE ratio with mini sprinkler and 1.0 IW/CPE ratio with surface irrigation system. Shelling percentage was significantly superior for 1.0 IW/CPE ratio treatment over all the treatments followed by 0.8 IW/CPE ratio which was significantly superior over 0.6 IW/CPE with minisprinkler and 1.0 IW/CPE surface treatment. The water use efficiency was maximum in 7th MW and 0.8 IW/CPE ratio treatments with mini sprinkler. The 11th MW has water saving of 21.36% in 0.8 IW/CPE ratio treatment with 35.33% increase in yield. The net seasonal income was maximum in 1.0 IW/CPE ratio treatment of micro sprinkler irrigation system followed by 0.8 IW/CPE ratio treatment and 1.0 IW/CPE ratio surface irrigation treatment with highest B:C ratio under minisprinkler irrigation treatment. There was no alarming change in the chemical parameters as far as the sowing dates and irrigation regimes are concerned. Hence, sowing of summer groundnut is recommended in 7th Meteorological week (12th to 18th February) with Micro sprinkler irrigation system with irrigation interval of 3-4 days (Twice in a week) and 0.8 IW/CPE ratio be followed for irrigation depth for getting 38.45% higher yield and 21 per cent water saving with higher water use efficiency.



Effect of Foliar Application of Nutrients on Yield, Nutrient Uptake and Economics of Chickpea under Dryland Condition

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A field experiment was conducted at Dry Farming Research Station, Solapur during the year 2009-10 to 2013-14 to study the response of chickpea to foliar application of nutrients under dryland condition on Inceptisol. The experiment was laid out in randomized block design with three replication. The treatment consists of T₁: Water spray, T₂: GRDF (12.5: 25, N: P₂O₅ kg ha⁻¹+ FYM @ 2 t ha⁻¹), T₃: 6: 12: 6 (N: P₂O₅: K₂O), T₄: 6: 12: 6 (N: P₂O₅: K₂O) + FeSO₄ (0.5%), T₅: 6: 12: 6 (N: P₂O₅: K₂O) + ZnSO₄ (0.5%), T₆: 6:12: 6 (N: P₂O₅: K₂O) + FeSO₄ (0.5%) + ZnSO₄ (0.5%), T₇: 50% RDF + 6: 12: 6 (N: P₂O₅: K₂O), T₈: 50 % RDF + 6: 12: 6 (N:P₂O₅:K₂O) + BF (*Rhizobium* + PSB). Foliar application of nutrients at critical growth stages i.e. branching, flowering and pod filling through DAP (2%) and KNO₃ (1 %) and application of ZnSO₄ (0.5%) and FeSO₄ (0.5%) before flowering was undertaken. The pooled data revealed that application of recommended dose of fertilizer (12.5: 25 kg ha⁻¹ N: P₂O₅ + FYM @ 2 t ha⁻¹) recorded highest grain and straw (13.45 and 14.53 q ha⁻¹) yield which is at par with T₈: 50% RDF + 6:12:6 (N: P₂O₅: K₂O) + BF (12.58 and 13.55 q ha⁻¹). Higher MUE (5.03 kg ha⁻¹ mm⁻¹) was observed in T₂: GRDF (12.5:25 N: P₂O₅ kg ha⁻¹ + FYM @ 2 t ha⁻¹) followed by treatment T₈ (4.96 kg ha⁻¹ mm⁻¹). The higher total nitrogen, phosphorus and potassium uptake (50.60, 9.24 and 44.02 kg ha⁻¹) was observed in treatment T₂: GRDF (12.5: 25 kg ha⁻¹ N: P₂O₅ + FYM @ 2 t ha⁻¹) and it was at par with treatment T₈. Significantly higher value of residual soil available nitrogen and potassium (164 and 10.72 kg ha⁻¹) were recorded in GRDF and it was at par with treatment T₈. Higher B: C ratio (2.31) was observed in treatment T₇: 50% RDF + 6:12:6 N:P₂O₅:K₂O kg ha⁻¹ and it was at par with treatment T₈: 50% RDF + 6:12:6 N:P₂O₅:K₂O kg ha⁻¹ +BF (2.20). It is conclude that application of 50% RDF as a basal dose + seed treatment with biofertilizer and foliar application of 6:12:6 N:P₂O₅:K₂O kg ha⁻¹ at critical growth stages was beneficial for grain and straw yield, moisture use efficiency, net monetary return (Rs.24055/-) and B:C ratio (2.20).



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Assessment of Ground Water Quality in Guntur District, Andhra Pradesh

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Quality of ground water is essential to maintain the soil and crop productivity to higher level without damaging the soil health. Monitoring provides data on groundwater quantity and quality and is an integral aspect of groundwater management. Sampling of groundwater for analysis of its chemical constituents is part of this strategy. Ideally, such sampling and analysis should be carried out on a regular basis where groundwater is being extracted for a variety of uses. Water quality is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices. Suitability of groundwater for irrigation was evaluated based on salinity hazard, sodium percent, sodium adsorption ratio, residual sodium carbonate and US salinity diagram were the dominant groundwater types. An investigation is carried out during month of May, 2014 to assess the ground water quality in relation to irrigation purpose in Guntur district. Two hundred and twenty five water samples were collected from bore wells and open wells and were analyzed for various physico-chemical and chemical properties. The ground water have been grouped in to different classes (based on rating chart of CSSRI, Karnal) and water samples were found to be 49.3 per cent categorized as good water, while 28.4 per cent grouped under marginally saline, 12.0, 4.9 and 4.4 per cent were categorized as high-SAR saline, saline and highly alkali waters, respectively. A total of 186 water samples were found to be low sodium hazard, 20, 11, and 8 water samples were categorized under medium, high and very high sodium hazard. It gives a very reliable assessment of water quality of irrigation waters with respect to sodium hazard, since it is more closely related to exchangeable sodium percentages in the soil than the more simple sodium percentage. The ground water samples were found to be safe in RSC and only 16 and 22 water samples were grouped under marginally and unsafe in RSC, respectively.



Cotton Response to Residue Mulch, Irrigation Frequency and Land Configuration in a Loamy Sand Soil

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Cotton is the main *kharif* cash crop and sensitive to both insufficient and excess moisture. Depleting water resources in many regions of the world calls for efficient water use in crop production. Furrow irrigation in bed or ridge planted crops decreases wetted area; checks weed growth and reduce irrigation water. Delayed first irrigation promotes deeper rooting that can exploit water and nutrient from the deeper soil layers. Residue mulching is likely to provide favorable hydrothermal regime, enhance seed cotton yield and economize irrigation water use. This study examines the combined effects of residue mulch, irrigation frequency and land configuration on cotton yield and irrigation saving. A field study was conducted at the research farm of Department of Soil Science, PAU, Ludhiana for three years (2010-12) on a loamy sand soil by including three irrigation levels viz., I_1 , I_2 and I_3 based on net cumulative PAN-E = 212, 350 and 467 mm where the irrigation water input was 40 and 70 mm for bed and flat, respectively in main plots, with combination of two mulch rates (0 and 6 t ha⁻¹ rice straw) and two land configuration (flood-irrigated flat-sowing, and furrow-irrigated bed-planting in paired rows) in sub plots. Cotton seed was drill manually at 5 cm depth in 1st week of May with recommended doses of N, P₂O₅ and K₂O and seed cotton yield recorded at different dates when bolls were mature. Results indicated that residue mulching lowered maximum and minimum soil temperature during the growing season at 5cm depth by 1.9 to 6.9 °C and 0.4 to 1.6 °C, respectively. It also conserved soil profile moisture besides better crop growth. Bed configuration recorded lower value of soil penetration resistance. Mulching with rice straw @ 6 t ha⁻¹ improved seed cotton yield by 52%, whereas bed configuration recorded 11% more yield. Irrigation response was observed up to I_2 irrigation regimes. An interaction of irrigation and mulch revealed that mulching can save about 110 mm irrigation water besides higher seed cotton yield. Weed biomass was reduced by mulching and bed-furrow formation by 35 and 18%, respectively. Thus, Bt cotton crop raised with mulching and furrow irrigated bed planting faced less competition from weeds resulting in more availability of water and nutrients to the crop and consequently higher seed cotton yield.



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Effect of Organo Tank Silt on Yield of Bhendi

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Investigation was carried out at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal to evaluate the efficiency of tank silt addition with or without blending with organic manures viz., farmyard manure (FYM), press mud (PM), water hyacinth compost (WHC), sewage sludge (SS), and spent wash (SW), as a component of fertilizer schedule as well as an additional application over and above the 100% recommended doses of fertilizer (RDF) using bhendi as test crop with thirteen treatments. The relative performances of these treatments were evaluated by monitoring the growth of bhendi crop through biochemical observation, measurements of yield attributes and fruit yield. The experimental soil used was taxonomically *Fluventic Haplustept* and sandy loam in texture, the pH of the soil was neutral and was non-saline. The CEC of the soil was $20.07 \text{ cmol(p+)}\text{kg}^{-1}$ with dominant proportion of Ca followed by Mg, Na, and K. The organic carbon content was 4.10 g kg^{-1} , $\text{KMnO}_4\text{-N}$ -212.7 kg ha^{-1} , Olsen-P-29.04 kg ha^{-1} , $\text{NH}_4\text{OAc-K}$ – 198.8 kg ha^{-1} . The tank silt used for experiment contained 60.40% clay and CEC was found to be $47.15 \text{ cmol(p+)}\text{kg}^{-1}$.

The results revealed that the yield attributes like plant height (70.75 cm), fruit length (13.95 cm) and fruit girth (5.64 cm) were found to be higher when tank silt blended with FYM +100% RDF, whereas, the fruit weight (13.66 g) was more in tank silt blended with PM +100% RDF treatment. Higher fruit yield was recorded with application of tank silt + FYM + 100% RDF (10768 kg ha^{-1}) TS+PM+100% RDF (9882 kg ha^{-1}) and TS+RTF (9784 kg ha^{-1}) which were comparable. Application of TS+FYM+100% RDF had recorded higher protein and ascorbic acid content.



Use of Fly Ash (IMFA, Chowdwar) in Sesamum and Rice-based Cropping System in Acid Soils of Dhenkanal District of Odisha

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Both on-farm and on-station Field experiments were conducted in acid soils of Dhenkanal, a district in Central Odisha to evaluate the effect of fly ash, a by-product of IMFA, Chowdwar on the growth, yield and quality of some crops grown in *kharif* season under rain fed condition and in *rabi* with the residual moisture and soil health. The on station trial was conducted in the Research farm of Regional Research and Technology Transfer Station of Orissa University of Agriculture and Technology located in Dhenkanal district on *kharif* Sesamum (cv:Prachi) with 5 treatments replicated 4 times : i).100% recommended dose of Fertiliser(RD), ii) 100% RD+Flyash @ 40 t ha⁻¹, iii) 100% RD + Flyash @ 40 t ha⁻¹ + Liming material(PMS) @ 1 t ha⁻¹; iv). 50% RD+Flyash @ 40 t ha⁻¹ and v). 50% RD + Flyash @ 40 t ha⁻¹ + PMS @ 1 t ha⁻¹. Highest yield of 1.03 t ha⁻¹ was obtained with application of 100% RD + Flyash and PMS. But this was at par with the yield (0.94 t ha⁻¹) obtained with 100% RD + Fly ash. Application of Fly ash @ 40 t ha⁻¹ significantly increased the sesamum yield in the 1st season demonstrates a direct effect on rain fed sesamum grown on a well drained acidic upland in an area that receives more than 1400 mm annual rainfall. With 50% RD the yields in both the treatments that received Fly ash alone and that received both fly ash and PMS were relatively low. Application of fly ash did not bring down the soil pH. Fly ash application also did not have any significant effect on the concentration of Cadmium (Cd), Chromium (Cr) and Lead (Pb) in soil. The seeds in different treatments were also at par in terms of the concentration of these three heavy metals. Another study was also conducted in three numbers of farmers' fields in three acidic medium lands with *kharif* rice grown in all the fields followed by *rabi* moong in two farmers fields with residual moisture. The experiment consisted of 4 treatments; i) Farmers' Practice (FP), ii) FP + Fly-ash applied @) 40 t ha⁻¹, iii) Recommended dose of fertiliser (RD) and iv) RD + Fly ash applied @ 40 t ha⁻¹. Fly ash application @ 40 t ha⁻¹ did not have any significant effect on rice yields. But the *rabi* moong crop grown in fly ash applied plot was much better than the plots that received no fly ash in terms of both growth and yield. There was yield enhancement by 9.10 to 31.33% in *rabi* moong due to fly ash applied to the rice crop. Highest yields were obtained in treatment that received 100% RD + Fly ash @ 40 t ha⁻¹. Thus response to application varied with crops and seasons. Residual effect of such huge quantity of fly ash applied to acid soil proves better than the direct effect. Conjunctive use of fly ash and lime in acid soil proves better in terms of yield and soil health.



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Effect of Sewage Sludge Urban Compost and FYM on Yield Uptake of Heavymetals and Enzyme Activities of Soil in Tomato (*Lycopersicon esculentum Mill*)

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The recycling of organic wastes for increasing soil fertility has gained importance in recent years due to high cost of fertilizers and reduced availability of organic manures. Sewage sludge and urban composts are rich in macro and micronutrients as well as heavy metals, which causes toxic symptoms in plants and pollute the soil. Hence, present studies were conducted to know the effect sewage sludge, urban compost and FYM on yield parameters, quality parameters, uptake of heavy metals and enzyme activities of soil in tomato crop.

The field experiment was conducted on sandy loam soil at College Farm, College of Agriculture, Rajendranagar, Hyderabad. The initial characteristics of experimental soil were 196.3, 21.16 and 305.3 for available N, P₂O₅ and K₂O respectively, while 2.98, 2.76, 0.902, 0.301, 0.153 mg kg⁻¹ and traces for DTPA extractable Zn, Cu, Pb, Ni, Cr and Cd, respectively. The four main treatments viz., 0, 50, 75 and 100 per cent recommended dose of fertilizer (RDF) and seven sub treatments viz., two levels (20 and 40 t ha⁻¹) of each sewage sludge (SS), urban compost (UC), FYM and control (without manure) and combinations of fertilizer levels along with organic manurial levels, thus, total of 28 treatments, each replicated thrice were laid out in split plot design. The recommended dose of fertilizer applied to crop was 150 N, 60 P₂O₅ and 60 K₂O ha⁻¹, respectively.

Results of investigation indicated that the addition of sewage sludge and urban compost as high as 40 t ha⁻¹ did not show any detrimental effect for increasing yield, quality parameters viz., TSS, ascorbic acid and protein content and enzyme activities of soil viz., urease, dehydrogenase, acid phosphatase and alkaline phosphatase, although increased the heavy metal content in tomato plant and soil. However, the concentrations were below the threshold values were proposed by earlier works. It was further concluded that combined application of manures and fertilizers significantly increased the mean yield parameters, quality parameters, uptake of heavy metals and enzyme activities of soil than when applied alone. Among all the combinations, sewage sludge @ 40 t ha⁻¹ along with 100% RDF recorded the significantly highest above mentioned parameters, which was on par with 75 and 50% RDF at the same level of sludge application. However, the highest benefit : cost ratio obtained in treatment with sewage sludge applied @ 40 t ha⁻¹ along with 50 per cent RDF (2.77). Hence, the application of sewage sludge @ 40 t ha⁻¹ along with 50% RDF for tomato may be recommended. However results will have to be confirmed by conducting extensive field trails in farmer's field on long-term basis.



Effect of Beverage Industry Effluent Irrigation on Growth, Yield and Quality of Barley and Sunflower Crops

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Field experiments were conducted in the premises of Pepsico Pvt. Ltd., near Bengaluru during 2012 and 2013 to study the effect of beverage industry effluent on growth, yield and quality of barley and sunflower crops grown in a sequence with ten treatments replicated thrice using RCB design. The quantity of gypsum was calculated on equivalent basis of the sodium content (10.3 m.eq L⁻¹) of beverage industry effluent. In both the experiments 50 per cent of the calculated quantity of gypsum was applied. The beverage industry effluent was neutral in reaction (7.55), medium in electrical conductivity (1.59 dS m⁻¹), BOD (42.2 mg L⁻¹) and COD (143 mg L⁻¹) but low in plant nutrients content. Among the treatments, cycle of 1 irrigation with fresh water + 2 irrigations with beverage industry effluent + RDF + gypsum recorded significantly higher plant height (85.2 cm), number of leaves (7.9), number of tillers per m² (295.6), dry matter accumulation (118.3 g), number of effective tillers m⁻² (253), length of ear head (8.3 cm), number of grains head⁻¹ (20.1), test weight (48.5 g), grain (4.70 t ha⁻¹) and straw yield (5.99 t ha⁻¹) of barley and higher plant height (227.9 cm), number of leaves (13.1), head diameter (31.6 cm), dry matter accumulation (180.2 g) head weight per head (1.73 kg), kernel weight per head (72.3 g), number of grains per head (1320), grain filling percent (95.3%), test weight (6.75 g), volume weight (66.4 g), grain yield (3.43 t ha⁻¹), straw yield (4.99 t ha⁻¹), oil content (42.2%) and oil yield (1377.3 kg ha⁻¹) of sunflower compared to other treatments. However, fatty acids such as palmitic, stearic, oleic and linoleic acid did not differ significantly due to beverage industry effluent irrigation. Significantly lower growth parameters, yield parameters, quality parameters, grain (3.05 and 1.83 t ha⁻¹) and straw yield (4.35 and 2.67 t ha⁻¹) of barley and sunflower crops were recorded in the treatment receiving beverage industry effluent + RDF without gypsum.



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Effect of Continuous Irrigation with Paper Mill Effluent on Chemical Properties of Soil

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The South India Paper Mill located near Mysore has been providing secondary treated effluent to farmers to irrigate their field for growing crops. Farmer's fields which are being irrigated with paper mill effluent (PME) from past few years were identified. These fields were grouped as those irrigated with paper mill effluent since <5, 5-10 and >10 years. From these fields, soil samples were collected at two depths (0-15 and 15-30 cm). Similarly, soil samples at both depths were collected from the surrounding farmer's fields which did not receive paper mill effluent. All these samples were analyzed for various soil properties using standard procedures. The mean pH, EC and OC values in surface soils of the field which received irrigation with paper mill effluent for < 5 years were lower (7.0, 0.52 dS m⁻¹ and 0.69%, respectively) than 5-10 years (7.80, 0.66 dS m⁻¹, 0.83 %, respectively) and > 10 years (8.03, 0.87 dS m⁻¹ and 1.20 %, respectively). Whereas, the mean surface soil pH, EC and OC values for control plots was 6.13, 0.20 dS m⁻¹ and 0.60%, respectively. Available nitrogen, phosphorus and potassium content of soil were lower in control samples (192.9, 18.6, 82.4 and 163.1, 13.2, 72.9 kg ha⁻¹) as compared to fields which received paper mill effluent irrigation for < 5 years (272.5, 19.8 and 255.6, 15.7 kg ha⁻¹), 5-10 years (414.4, 22.0, 409.7 and 333.0, 15.5, 367.2 kg ha⁻¹) and > 10 years (609.1, 27.4 and 461.8, 17.5 kg ha⁻¹) of paper mill effluent irrigated fields at both the depths. Exchangeable calcium, magnesium and sodium contents were higher at both surface and subsurface soil which received paper mill effluent irrigation for > 10 years (12.4, 6.3, 0.84 and 10.4, 4.92, 0.79 cmol(p⁺)kg⁻¹, respectively) at both depths compared to 5-10 years (10.9, 5.9, 0.78 and 9.1, 5.0, 0.71 cmol(p⁺)kg⁻¹, respectively), < 5 years effluent irrigated field soils (6.80, 4.95, 0.58 and 4.90, 3.10, 0.45 cmol(p⁺)kg⁻¹) and control samples (3.48, 1.68, 0.13 and 2.55, 1.33, 0.12 cmol(p⁺)kg⁻¹). Further, available sulphur content of soil was high in > 10 (36.3 and 27.6 mg kg⁻¹), 5-10 years (30.6 and 22.7 mg kg⁻¹) and < 5 years (26.9 and 21.8 mg kg⁻¹) paper mill effluent irrigated fields at both the depths. Similarly, control samples also recorded higher sulphur content at both depths (22.4 and 20.7 mg kg⁻¹). DTPA extractable zinc, copper, manganese and iron (1.86, 1.37, 1.70 and 6.80 mg kg⁻¹) contents were lower in control samples when compared with soils which received paper mill effluent irrigation for < 5 years (2.90, 3.65, 2.65 and 7.5 mg kg⁻¹), 5- 10 years (3.13, 4.27, 3.13 and 8.61 mg kg⁻¹) and > 10 years (4.70, 4.94, 5.40 and 10.1 mg kg⁻¹). Similarly DTPA extractable zinc, copper, manganese and iron contents were decreased with depth.



Response of Gypsum as Fertilizer Sulphur Nutrition on Yield, Yield Attributes and Economics of Gram at Farmers Field of Vindhya Plateau of Madhya Pradesh

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Front line demonstrations were conducted on six farmers fields of adopted villages Ghatwar, Bisanpur and Nandupura Vidisha district of Madhya Pradesh during *rabi* season of 2012-13 in irrigated condition, on medium black soil with low to medium fertility status (pH-7.72, EC-0.66, Available N-342, Available P-19.2, Available K-440 and Available S 9.6 kg ha⁻¹) under soybean –wheat/soybean-chickpea cropping system. Each demonstration was conducted on an area of 0.4 ha and the same area adjacent to the demonstration plot was kept as farmers practices. Gypsum application along with recommended dose of fertilizer positively affected (significantly increased) each and every attributes of yield, grain and straw yields of gram as compared to farmers practice, RDF and RDF+ sulphur through SSP. Plant height was 15% more (43.49 cm) with RDF along with gypsum than the plant height of general farmers practice (37.89 cm). Maximum branches/plant, pods/plant, test weight and straw yield (kg ha⁻¹) were found maximum when gypsum was applied with RDF as compared to other treatments under study. The maximum grain yield (2295 kg ha⁻¹) was recorded with RDF with gypsum as per treatment which was 28, 18 and 9 percent more as compared farmers practice (T₁), RDF(T₂) and RDF+SSP(T₃), respectively. The maximum net returns Rs 68062 /ha and Benefit: Cost ratio (3.58) was also recorded with RDF (NPK) and S through gypsum. These results may possibly be due to the region that gypsum is not only supply sulphur but also other nutrients along with improving physical properties of soil which was congenial for plant growth, like soil structure, soil reaction, nutrient and water holding capacity, etc.



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Effect of Spacing and Nitrogen Level on Cotton Variety GAM-141 under Drip Irrigation Condition

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Cotton is a very important crop in Middle Gujarat. Bt. Cotton hybrid has a changed the production scenario in Gujarat; however, Bt. Cotton is a heavy feeder and needs supplementation of nutrients in soil to sustain yields. A field experiment was conducted at the Tribal Research cum Training Center, Anand Agricultural University, Devgadhi Baria (Gujarat) during the *kharif* season of the year 2011. The soil of experimental plot was loamy sand in texture. It was low in organic carbon and nitrogen, medium in available phosphorus and while high in available potassium with pH 7.6 and EC value 0.23 dS m⁻¹. Six treatments comprising of three spacing (S₁ – 120 × 45 cm, S₂ – 90 × 30 cm and S₃ – 60 × 30 cm) and two levels of nitrogen (N₁ -100% and N₂ -75% RDN) were tried under split plot design with four replications.

The experiment result revealed that the effect of spacing and nitrogen level on seed cotton yield were significant. The highest seed cotton yield (1527 kg/ha) was recorded under treatment S₂ (90 cm × 30 cm) and under nitrogen level treatment N₁ (100% RDN) recorded significantly highest seed cotton yield. (1571 kg ha⁻¹). Treatment S₂ × N₁ combination found significantly higher seed cotton yield (1740 kg ha⁻¹) which was statistically at par with treatment S₃ × N₁.



Precise Crop Production and Yield Enhancement by Nutriseed Pack Technique

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Normally fertilizers are broadcasted in crop fields and straight fertilizers are mostly used as the source of nutrients. Under surface application the fertilizer use efficiency is low. In this situation Nutriseed pack technique has been evolved in Department of Soil Science and Agricultural Chemistry, TNAU, Coimbatore to improve the fertilizer use efficiency in crops. Each Nutriseed pack contains seed at top, enriched manure in the middle and encapsulated fertilizer at the bottom. By placing a Nutriseed pack vertically or horizontally in soil each plant can be established. Nutriseed pack gives support for each plant in the root zone in terms of optimum nutrient supply, biological activity, release of pesticide etc. and consequently enables fullest utilization of nutrients by plants. There is no wastage of fertilizer nutrients with Nutriseed packs. Nowadays labour scarcity in villages prevails particularly at start of crop season. This delays timely sowing of seeds, fertilizer application, etc. In crop production, fertilizers are costly input. Improper, delayed and broadcast applications of fertilizers are major reasons for the reduction in yield of crops. Since Nutriseed pack technique ensures saving fertilizers and labours, it can be welcomed by farmers for adoption. This technique was tested in research trials and demonstration plots in crops like maize, rice, cotton, carnation, cauliflower and marigold, and found to record more yield and profit over the conventional broadcast method of fertilizer application. Hybrid maize recorded grain yield of 6779 kg ha⁻¹ on an average in four different locations under Nutriseed pack over 5345 kg ha⁻¹ yield under farmers' practice showing 27 per cent increase in yield. Similarly, hybrid Cotton recorded 21 per cent increase in yield, rice recorded 18 per cent yield increase, marigold recorded a remarkable increase of 50 per cent yield, Carnation recorded 37 per cent and cauliflower showed a yield increase of 40 per cent under Nutriseed pack over surface broadcast of fertilizer application. Nutriseed Packs can be fabricated in village industries. It can be produced and stored well before the crop season.



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Development of Computer based Information System for Assessing Suitability of Low Quality Water for Irrigation-based on FAO Guidelines

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Globally both natural variability and anthropogenic interventions pose immense pressure on fresh water resources. The driving forces affecting water resources are unbound population growth, demographic changes as people move from rural to urban environments, increased demands for food security and socio-economic well-being and pollution from industrial, municipal and agricultural sources. Freshwater has a global volume of 35.2 million cubic kilometres (km³) which is only 2.5% of the total volume of water present. In India the share of freshwater towards irrigation has been predicted to reduce from 84.6% in 2010 to 74.1% in 2050 due to the competitive demand from domestic, industry and energy sector. With deficiency in irrigation water and uneven distribution of rainfall owing to climatic variability agriculture experiences frequent drought and water scarce conditions. This enables the farmers to use low quality water for irrigation extensively that affects the soil – crop environment adversely. As low quality water generation is increasing vehemently it is becoming an important source for irrigation by the farmers in the peri-urban areas. To avoid emerging problems due to inadequate quality of water there is a need to assess the quality of the water for irrigation based on FAO guidelines to meet the water requirement of crops for sustainable agriculture. An attempt has been made under the Indo-Bulgaria project to develop a Decision Support System for assessing the suitability of water for irrigation depending on its quality. The purpose is to develop an information system, providing recommendations and suggestions how to use the irrigation water for different crops considering the water quality in the best way. The aims of the development are directed towards the protection of water resources, soil fertility, crop production and consumers' health. Based on the laboratory analysis of water for irrigation and on the information of cultivated crops, soil and agro-climatic characteristics of the region and irrigation technology, recommendations will be generated for safe use of available water. The degree of restriction on the usage of irrigation water has been presented as a remark for all analyzed parameters in conformity with FAO methodology on water quality for agriculture as described by Ayers and Westcot. They are salinity, infiltration, specific ion toxicity and miscellaneous effects as per the guidelines of FAO. The guidelines are practical and have been used successfully in general irrigated agriculture for evaluation of the common constituents in surface water, groundwater, drainage water, sewage effluent and wastewater. The recommendation on how to use the irrigation water focuses on irrigation water considering qualitative parameters of the available water.



Increasing Productivity of Rainfed Direct Seeded Rice – Fertilization with *Comlizer* under Different Plant Density and Weed Management

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In Asia, rice is commonly grown by transplanting one month-old seedlings into puddled and continuously flooded soil. But, the area under direct seeded rice (DSR) is increasing and the focus is expected to gain momentum in near future, mainly for two reasons. First, increasing area under DSR is due to growing shortage of water and agricultural labour. Second, aberration in rainfall pattern is affecting the productivity of transplanted rice in rainfed areas. However, dry-tillage practices followed by alternate wetting and drying conditions favour the growth of highly competitive weeds and affect nutrient and water use efficiency by the crop, which cause significant losses in grain yield. Optimum plant density with minimum competition from weed during early and late vegetative stages of the crop would increase the nutrient use efficiency and ultimately grain yield. The present experiment was accordingly conducted during autumn season of 2012 and 2013 to evaluate *comlizer* (compost-fertilizer mixture) on growth and yield of rainfed DSR (variety – *Inglongkiri*) in upland situation under different plant density and weed management. Reduced plant density (20 × 15 cm) and traditional line sowing at 20 cm apart were fertilized with recommended dose of fertilizer (RDF) or vermicompost 1000 kg ha⁻¹-50% RDF *comlizer* applied either in single or two splits, or kept unfertilized. The weed was managed by applying pretilachlor 750 g ha⁻¹ followed by grubber, or by grubber alone, along with control without weed management. The crop suffered severe weed competition from grasses *Panicum repens* and *Cynodon dactylon*; broadleaved species *Borreria articularis*, *Mimosa diplotricha* var. *innermis*, *Ageratum houstonianum*, *Cyrtococcum palens*, *Melochia corchorifolia* and *Spilathes paniculata*; and sedges *Cyperus rotundus* and, *C. halpan* at different stages of crop growth. Pretilachlor 750 g ha⁻¹ followed by grubber significantly reduced weed density and dry weight compared to grubber alone or control plot. Application of *comlizer* in two splits at 20 and 40 days after sowing (DAS) increased effective tillers/m² and filled grains/panicle, and resulted in highest grain yield of rice. The positive effect of *comlizer* application on growth and yield parameters of rice was explained by a corresponding improvement in root growth and soil fertility, resulting in higher nutrient uptake by the crop. The root growth in terms of dry weight and volume was better due to *comlizer* application at 20 and 40 DAS that utilized a consistent pool of available nutrients from soil.



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Leaf Nutrient Status of the Rubber Plantations of South India and the Relationship between the Leaf Nutrient Concentration and Yield in Rubber

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The traditional, rubber (*Hevea brasiliensis*) growing tract in India lies between 75°10' E and 77°30' E Longitudes and 8°15' and 12°35' N Latitudes confining to a narrow tract in the western side of the Western Ghats extending from Kanyakumari district in Tamil Nadu in the south to South Kanara district of Karnataka in the north and lying in general west of Western Ghats and parallel to them for approximately 400 km. The average annual rainfall in this traditional belt ranges from 2000 to nearly 5000 mm and the dry period range from three to five months. The soils in this region are highly weathered and are mostly laterite and lateritic type and majority of the soils (51 out of the 62 series) belong to Ultisols. pH of the surface soil range from 4.5 to 5.5 and are deficient in phosphorus and potassium. Soils of the high rainfall areas were showing very low base saturation with extremely low status of potassium, calcium and magnesium. Owing to the general characteristics of the rubber growing soils and the complexities of the nutrient dynamics in the perennial crop system like rubber, it was felt that an assessment of the nutritional status of the rubber plantations will be useful in formulating the fertilizer recommendations. Hence, through the present study the nutritional status of the mature rubber plantations of South India in the estate sector was assessed and attempted to relate the same with yield. A data bank of 1500 recordings on leaf nutrient concentration for nitrogen, phosphorus, potassium, calcium and magnesium and corresponding yield were generated from 12 large estates representing the traditional rubber growing tract of South India. Further, these 1500 observations were regrouped and 301 recordings having uniform age and system of tapping were selected. The yield data received from the estates were processed and the latex yield and total yield were calculated and expressed as kg/tree/year. The range and mean value of the individual nutrients as well as the frequency distribution of the low, medium and high status for individual nutrients were calculated. Correlations between individual nutrients and yield were calculated. Similarly, correlation among the nutrients was also calculated. Major share of the mature rubber plantations were found to be maintaining its nutritional status in the sufficiency level for the nutrients nitrogen, phosphorus, potassium, and magnesium. However, higher share of the plantations were showing calcium deficiency indicating the need for calcium supplementation in the deficient soils. Relationship between leaf nutrient concentration and yield indicated that the high yielding group of the population in general is having nutrient values in the sufficiency range. Correlation between individual nutrients and yield indicated significant negative relation between phosphorus and calcium concentration and yield.



Agronomic Potentials of Fly Ashes from Biomass Fired Power Plants

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Biomass energy production is steadily increasing worldwide specially in the industrialized countries. In developing countries like India it is expected to rise more as the non-renewable coal reserves would deplete sooner or later. An investigation was carried out on fly ashes obtained from eleven biomass power plants fired with coconut, chicken, sorghum, maize, *P. juliflora* and wood waste, municipal waste, rice and bajra husks, sugarcane bagasse, etc. The high alkalinity (pH 8.50 to 12.7) of the biomass ashes may create problems for soil amendment. However, these alkaline ashes can be used to ameliorate acid soils. The biomass ashes contain considerable amount of plant nutrients: P (0.491 to 3.84%), K (0.584 to 10.7%), Ca (2.23 to 22.6%), Mg (0.587 to 3.48%), Fe (0.413 to 4.13%), Mn (424 to 1323 mg kg⁻¹), Zn (124 to 997 mg kg⁻¹), Cu (68.0 to 445 mg kg⁻¹), B (15.2 to 205 mg kg⁻¹) and Ni (49.9 to 195 mg kg⁻¹). The ashes were also subjected to bio-available element extraction with a universal Mehlich III extractant. Most of the nutrients are present in available form and the percentage of bioavailability of each element is: P (4.19 to 49.7 %), K (61.0 to 100%), Ca (6.81 to 81.2%), Mg (1.09 to 37.5%), Fe (0.385 to 7.13%), Mn (0.35 to 32.7%), Zn (0.14 to 17.8%), Cu (1.48 to 26.8%), B (26.5 to 91.7%) and Ni (0.343 to 8.74%). The sequential extraction of potentially toxic elements showed that most of these elements are present in the non-available residual fractions. The total poly cyclic aromatic hydro carbons (PAHs) content was comparatively lower (0.2-12.3 mg kg⁻¹), except for two sample (193-2077 mg kg⁻¹). Overall, the biomass ashes contain significant amount of all the plant nutrients, except N. These ashes can be sustainably utilized for reclamation of nutrient depleted waste degraded lands; however, the stock of potentially toxic elements and PAHs in these ashes has to be studied before its application for soil amelioration.



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Improved Composting Technique for Composting of High Cellulose Sugar Cane Byproducts/Waste

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Organic residues from sugarcane crop *i.e.* cane trash, press mud and biogasses are rich source of carbon and plant nutrients, two important inputs essentially required for sustainable productivity of soils. However the materials like bagasse and sugarcane trash take a long time for decomposition under normal conditions. Even under vermicomposting also cane trash possess higher CN ratio over other organic residues due to high cellulose and lignin contents. Hence, present study was formulated for integrated composting of sugarcane by products through treatment with microorganisms and subsequent vermicomposting. The present investigation was carried out at Regional Agricultural Research Station, Anakapalle, Visakhapatnam district of Andhra Pradesh, India during 2012. The basic raw materials used for vermicomposting and integrated composting are bagasse, pressmud cake, cane trash and dead canes. Earthworm species used for vermicomposting was *Eisenia foetida*. Whereas in integrated composting both compost culture and earthworms were used for composting of sugarcane byproducts/wastes. The organic residues used in the study contained 0.51% (cane trash) to 0.71% (pressmud cake) of total N, 0.11% (cane trash) to 0.68% (pressmud cake) of total P and 0.41% (bagasse) to 1.10% (cane trash) of total K. The total organic carbon and C:N ratio decreased and total nitrogen increased significantly during maturation of the compost irrespective of the sources and methods of composting. The use of earthworms narrowed the C:N ratio in vermicomposting and it was further reduced in integrated composting by action of both microbes and earthworms. Per cent increase of total nitrogen and decrease of C:N ratio was more in integrated composting over vermicomposting. Reduction in pH was observed in all matured composts compared to their initial values might be due to production of organic acids during decomposition. Among different byproducts the total NPK content in both the composting methods was highest in pressmud cake with narrow C/N ratio and the reverse trend was followed in cane trash. Integrated compost obtained from decomposition of organic residues possessed significantly narrow CN ratio than that of vermicompost obtained from the decomposition of sugarcane byproducts. Which was probably due to the coupled effect of microbes and earthworms.

Commission 3.5: Soil Degradation Control, Remediation, and Reclamation



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Effect of Sugar Mill Spent-wash Application on Soil and Water Qualities and its Prospect of Utilization in Crop Production

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Fresh water scarcity often limits crop growth during post and pre-monsoon periods in India. To find out a suitable and supplementary source of irrigation for crop production, sugar mill spent-wash (E) as different volumes with water (W) @ 20/80, 40/60 and 60/40 and 60/40 was applied for leaching soils of four different types, dominated in sub-humid Odisha. A comparison of salinity of leaching solutions both with spent-wash, and normal water use for washing after equilibrium reached with spent-wash, and normal water used for washing after equilibrium reached with spent-wash, showed that leachate collected from red and lateritic soil was relatively less saline at 40/60 and 60/40 over the leachate collected from alluvial, and red and yellow soil. The pattern of salinity development and reduction varied distinctly with soil type and concentration of spent-wash used for leaching purpose. Irrespective of spent-wash concentrations, the release of salt was relatively stagnant over time in red and lateritic, and red and yellow soil types. Overall the salinity developed due to leaching of soil column with spent-wash varied from 4.3 to as high as 9.8 dS m⁻¹ that subsequently went down to 0.6 to 3.2 dS m⁻¹ during washing with normal water. The study indicates that up to 50% dilution of sugar mill spent-wash with normal water, has found suitable for use in neutral, sandy loam alluvial soil type; and up to 40% dilution has proved useful for moderately acidic, iron rich red and laterite, and red and yellow soil type. No persistent salinity build up either in soil or in groundwater available at shallow depth was observed.



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Effect of Organic and Inorganic Amendments on Seed Yield and Micronutrient Composition of Indian Mustard (*Brassica juncea* L. Czern) Grown in Pb Spiked Soil

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Lead pollution has a long history going back to at least two millennia and is regarded as a serious threat to environment and human health. Apart from the natural weathering processes, Pb contamination of the environment has resulted from mining and smelting activities, Pb containing paints, gasoline and explosives as well as from the disposal of municipal sewage sludges enriched in Pb. Availability of metals in soil to plants is governed by a number of factors and the soil properties often correlated with metal availability include soil pH, organic matter and clay content of soil. To prevent Pb movement to deeper soil layers and ground water aquifers identification of some viable remedial measures is necessary in developing cost effective and community acceptable technologies for chemical and biological immobilization of Pb in soil. The uptake of Pb by plants growing in contaminated soils can be restricted by the addition of amendments to the soil. We selected farm yard manure (FYM) and press mud (PM) (a waste product of sugar industry) as organic amendments and lime (CaCO_3) and fine fraction of the soil (silt + clay) as inorganic amendments, which are very economical and easily available to investigate their influence on i) Seed yield of Indian mustard and ii) micronutrient composition of Indian mustard in relation to addition of amendments. Indian mustard was grown till maturity in a screen house using a loamy sand soil spiked with five levels of Pb varying from 0-400 mg kg⁻¹ soil. Amendments used were lime (CaCO_3), farm yard manure (FYM) and press mud (PM) applied at 2.5 and 5.0 per cent (w/w) and silt+clay applied at 20 and 40 per cent (w/w). Adequate application of nitrogen, phosphorus and potassium was made to Indian mustard. The results showed that there was a linear decrease in the seed yield of Indian mustard with increase in levels of added Pb but addition of amendments increased the seed yield of Indian mustard as compared to unamended soil. All amendments significantly reduced Pb accumulation by Indian mustard and the reduction increased with increasing the rate of amendment application. The ameliorative efficiency of amendments in terms of reducing Pb content in plants followed the order silt+clay > lime > FYM > PM. The addition of amendments also increased the concentration of micronutrients in Indian mustard as compared to unamended soils. There was also a decrease in extraction of Pb with amendments in post harvest soil which followed the decreasing order of silt+clay > CaCO_3 > FYM > press mud.



Enhancing the Productivity of Textile and Dye Industry Polluted Soils using Soil Amendments and Sulphur Oxidizing Bacteria

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A column experiment was conducted to study the effect of soil amendments and sulphur oxidizing bacteria (SOB) on soil properties and leachate quality with gypsum and elemental sulphur in different ratios (0, 50, 75 and 100%) along with three SOB cultures to know the effect of different treatments on soil properties. Based on the effectiveness of the pH reduction of the different cultures isolated from the native sources and existing TNAU cultures, three effective cultures were identified and used for the column experiment. PVC columns with 50 cm height and 6 cm dia was taken and 2.39 kg of soil was filled to maintain the bulk density. Gypsum requirement was estimated and based on the gypsum requirement, the treatments with gypsum and sulphur and its combinations were imposed. The volume of leachate collected were recorded at every 15 days interval. The experiment was continued upto 60 days and after 60 days the setup was dismantled and soil columns of 0-25 cm and 25-50 cm were separated and analysed for pH, EC, exchangeable cations and sulphate. The data on leachate indicated that the treatments *viz.*, 75% gypsum + 25% S + Native Noyyal culture (T16) followed by 50% gypsum + 50% S + Native Noyyal culture (T15) recorded the lowest pH (8.18 and 8.19, respectively) among the different treatments. The highest Sodium Adsorption Ratio (SAR) (1.51) was observed in 50% gypsum + 50% S + Native Noyyal culture (T15) followed by 50% gypsum + 50% S + match factory culture (T9). The results from soil analysis indicated that, in surface soil, the lowest pH value (7.93) was observed in 50% gypsum + 50% S + Untreated tannery effluent culture (T12) followed by 50% gypsum + 50% S + Native Noyyal culture (T15) with a pH value of 7.95. value of 73.95 HH Exchangeable sodium percent was the lowest (5.87%) in 50% gypsum + 50% S + Native Noyyal culture (T15) followed by 50% gypsum + 50% S + Untreated tannery effluent culture (T12) (6.01%) where as the highest was recorded in control (11.87%). In sub surface soil, the lowest pH value varied from 8.45 to 8.88. Reduction pH was observed in sulphur oxidising bacterial treatments along with sulphur when compared to gypsum application alone. The lowest sodium content (231 milli grams) and ESP (6.9) were recorded in 50% gypsum + 50% S + Native Noyyal culture (T15) whereas the highest in control.



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Ameliorative Impact of Organic Amendments and Gypsum in Alleviating Carbon Stress in Sodic Vertisols of Purna Valley in Vidarbha

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The field experiments on cotton (2011) followed by green gram in *kharif* and chickpea in *rabi* season (2012) were conducted on farmers fields in Purna valley of Vidarbha region of Maharashtra representing semi arid ecoregions of central India. The treatments comprised of five different green manures (sunhemp, dhaincha, cowpea, green gram and leucaena loppings), two crop residues (cotton stalk and farm waste as biomulch), gypsum and control. There were nine treatments replicated on three farmers fields on Vertisols treating each farmer as a replication. The application of organic amendments significantly enhanced the organic carbon (6.41 g kg^{-1}), permanganate oxidizable carbon (240.0 mg kg^{-1}), soil microbial biomass carbon ($167.6 \mu\text{g g}^{-1}$ soil) and SOC stock (15.47 Mg ha^{-1}) over the application of gypsum (5.83 g kg^{-1} , 194.2 mg kg^{-1} , $119.1 \mu\text{g g}^{-1}$ soil and 14.04 Mg ha^{-1}) and control (5.64 g kg^{-1} , $174.75 \text{ mg kg}^{-1}$, $92.04 \mu\text{g g}^{-1}$ soil and 14.04 Mg ha^{-1}). The application dhaincha and sunhemp *in-situ* green manuring showed highest potential to sequester carbon in soils. The different treatments of organic amendments followed the sequence dhaincha > cowpea > sunhemp > leucaena loppings > green gram cotton stalk > biomulch for carbon sequestration potential. The results suggest the potential of different organic amendments in alleviating the carbon and nutrient stress in sodic Vertisols under high pH and ESP stress situation besides reclamation.



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Impact of Groundwater Quality on Soil Fertility Parameters of Bhilwara District of Rajasthan

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A survey was conducted during pre monsoon season of the year 2013 in Bhilwara district of Rajasthan to assess the impact of groundwater quality on soil fertility parameters and it was found the soil pH is significantly and positively correlated with all the water quality parameters *viz.*, pH, TDS, EC, Ca, Mg, Na, K, CO₃, HCO₃, SO₄, Cl, B, SAR and RSC. The soil salinity (EC) is considerably correlated with the groundwater quality parameters except pH and RSC of water but the soil organic carbon of the study area is statistically not affected by most of the groundwater quality parameters except bicarbonate and boron contents of water, which have negative and significant correlation with soil organic carbon. The higher contents of bicarbonate and boron in irrigation water adversely affected the soil organic carbon content. The available nitrogen and phosphorus of soil were not much affected by the quality of groundwater. The available nitrogen is negatively correlated with the water quality parameters but the extent of correlation was statistically non significant. The available potassium of the soil was found to have positive and significant correlation with most of the groundwater quality parameters except pH. The DTPA- Fe, Mn, Zn and Cu of soil significantly and negatively correlated with the pH of the groundwater used for irrigation. Further, the DTPA-Mn, Zn and Cu also affected adversely by the higher TDS, EC, cations, anions, SAR and RSC of groundwater. Hence, it can be inferred that the soil pH, electrical conductivity (salinity) and availability of cationic micronutrients adversely affected with the deteriorated quality of the groundwater used for irrigation.



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Influence of Municipal Sewage Sludge on Uptake of Heavy Metals by Golden Rod (*Solidago* sp.)

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Golden rod (*Solidago* sp.) is considered as one of very desirable wildflowers. Most of its species are used in making medicines, for carotene extraction and decorations. Land application of sewage sludge is one of the important disposal alternatives. Being rich in organic and inorganic plant nutrients, sewage sludge may substitute for fertilizers, but presence of heavy metals may warrant its use. Hence, pot culture experiment was conducted on alfisols (red soil) at greenhouse farm of the Department of Horticulture, College of Agriculture, Rajendranagar, Hyderabad during *khariif* 2013 to study the effect of municipal sewage sludge on uptake of heavy metals by golden rod (*Var.* Early Bird). The experiment was laid out in completely randomized design with three replications. There were seven treatments consisting of T₁ (20% sewage sludge), T₂ (40% sewage sludge), T₃ (60% sewage sludge), T₄ (80% sewage sludge), T₅ (100% sewage sludge), T₆ (RDF - Inorganic N, P and K @ 100, 100 and 100 kg ha⁻¹, respectively) and T₇ (control). The volume of each pot was made up to 6 kg on weight basis with sewage sludge + soil as per treatment schedule. The uptake of Pb and Co by golden rod plants was beyond the maximum permissible limits in 80% sewage sludge and 100% sewage sludge treatments. But, cadmium uptake was beyond the maximum permissible limits only in 100% sewage sludge. In contrast, the uptake of heavy metals *viz.*, Pb, Ni, Co and Cd in spikes of golden rod was within the maximum permissible limits in all treatments as per the WHO standards. Significantly higher plant height, number of branches, number of leaves per plant of golden rod and dry matter production was recorded in 100% sewage sludge treatment at all stages of observation. Though, maximum number of spikes was obtained in 100% sewage sludge treatment (T₅), carotene content was more in 80% sewage sludge treatment (T₄) as compared with rest of the treatments. The uptake of major nutrients *viz.*, N, P, K and minor nutrient (Zn) by plants of golden rod was linearly increased with increase in municipal sewage sludge application rates.



Evaluation of Suitable Tree Species for Sodic Soil Restoration

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The study envisaged elucidating information on cataloguing native tree species, screening the tree species and assessing growth performance in sodic soil besides investigating the ameliorating capacity and impact of tree species on soil fertility. The results of the survey in the sodic soil belt of Tamil Nadu viz., Manikandam Block of Trichy District revealed that among the six predominant tree species, *Prosopis juliflora* and *Acacia nilotica* overtopped in almost all the twenty-two panchayat villages forming the sodic soil environment. The results of the nursery experiment to screen the suitable tree species under different soil pH levels (9.0, 9.5 and 10.0) revealed that among 13 tree species, two species viz., *Prosopis juliflora* and *Acacia nilotica* proved superior in terms of important biometric attributes. The evaluation study under field conditions for the plantations established in the year 2000 in the erstwhile Soil Salinity Research Centre (Anbil Dharmalingam Agricultural College and Research Institute), Trichy revealed that among seven tree species, *Prosopis juliflora* found superior followed by *Acacia nilotica*. The mean tree volume of 0.175 m³ tree⁻¹ and 0.164 m³ tree⁻¹ were quantified in *P. juliflora* and *A. nilotica* respectively. The analysis of saturated extract of soil of the above plantations in comparison to the barren site revealed that there was a significant reduction in the soil pH, EC and ESP and considerable increase in the Ca²⁺ and Mg²⁺ under *A. nilotica* and *P. juliflora* plantation after ten years, confirming their ability to ameliorate the sodicity. The impact of plantation on soil fertility also revealed that the tree species *A. nilotica* and *P. juliflora* had significantly increased the soil OC, available N, P and K and the impacts was more pronounced at the surface soil (0-15 cm) compared to lower depths (15-30 and 30-45 cm).

From the above study it was concluded that the soil became less sodic and more congenial for tree growth with increased soil fertility with the plantation of trees in the order of: *Acacia nilotica* > *Prosopis juliflora* > *Tamarindus indica* > *Albizia lebbek* > *Leucaena leucocephala* > *Azadirachta indica* after ten years of planting.



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Degradation and Persistence of Clomazone in a Clay Loam Soil

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Field experiment was conducted with soybean to study degradation and persistence of clomazone in soil. The treatments included two doses of clomazone – pendimethalin 2 and 4 l ha⁻¹ (600 g + 600 g and 1200 g+1200 g a.i.) ready mix at recommended and double the recommended level. In the field, periodical collection of soil (0-15 cm depth) at 0 day (1 h after herbicide application) 1, 3, 5, 7, 10, 15, 30, 45, 60 DAA and at harvest stage was done. The analytical methodology adopted by the Environmental Protection Agency (EPA) - Environment Chemistry Laboratory (ECL) was optimized for estimating clomazone in soil sample with slight modifications and determined using Chemito model 2865 gas chromatograph equipped with flame thermoionic detector (TID). In the soil receiving clomazone-pendimethalin RM at 2.0 l ha⁻¹ and clomazone at 0.5 k g ha⁻¹, clomazone degraded to below detectable level (BDL) at 60 days after application (DAA), while persisted up to 60 DAA (0.005 mg g⁻¹) and degraded to BDL at harvest stage in case of the soil sprayed with clomazone-pendimethalin RM at 4.0 l ha⁻¹. The residue data pertaining to clomazone degradation, when represented by different functions gave significant correlation between residues and time. In this case, the selection of the best fit function was obtained by comparing the deviations between measured values and model values and comparing the modified regression coefficient of determination as per Timme *et al.* (1980). The modified regression coefficient of determination revealed that clomazone-pendimethalin RM at 2.0 l ha⁻¹ and clomazone at 0.5 kg ha⁻¹ fitted in the one fifth order function except for clomazone-pendimethalin RM at 4.0 l ha⁻¹ that fitted in the root function first order. The half-life of clomazone in soil ranged from 7.15 to 9.65 days, irrespective of the treatments.



Long-term Effect of Conjunctive Use of Canal and Alkali Water on the Yield of Rice and Changes in Post Harvest Soil

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Field experiments were conducted during 2008-2013 (five years) at ADAC&RI farm in alkali soil (pH: 8.7, EC: 0.21 dS m⁻¹, ESP: 25.0%) to study the effect of conjunctive use of canal as well as alkali water on the yield of rice cultivar Trichy 1. The quality of canal water used in the present study has EC, SAR and RSC of 0.6 dS m⁻¹, 1.3 and 1.4 m.e l⁻¹ where as quality of alkali water has EC, SAR and RSC of 1.8 dS m⁻¹, 8.2 and 6.9 m.e l⁻¹, respectively. The treatments include main plot with different irrigation M₁ - Irrigating rice with alkali water M₂ - Irrigating rice with canal water M₃ - Irrigating rice with canal water and alkali water in 1:1 ratio (cyclic) and sub-plots with different methods of planting *viz.*, S₁ - Conventional planting (Random), S₂ - Line planting, S₃ - Square planting (SRI) and S₄ -Machine planting. The experiment was laid out in Strip plot design with three replications.

The results revealed that rice grain yield was influenced by the irrigation treatments and method of planting significantly. Regarding the irrigation treatments, canal water irrigation for rice recorded the maximum yield of 5.77, 6.21, 6.5, 5.9 and 6.3 t ha⁻¹ during 2008-2009, 2009-2010, 2010-2011, 2011-2012 and 2012-2013, respectively, followed by cyclic irrigation of canal water and alkali water in 1:1 ratio. Lowest yield was recorded in alkali water irrigation. In respect of method of planting, adopting square planting registered the maximum rice grain yield of 5.82, 6.03, 6.15, 5.48 and 5.85 t ha⁻¹, during 2008-2009, 2009-2010, 2010-2011, 2011-2012 and 2012-2013, respectively, followed by line planting. The highest yield of rice was recorded with canal water irrigation adopted with square planting followed by canal water irrigation with line planting. Mixing mode of canal water and alkali water (1:1) with square planting recorded 23.0% and 34.9% more yield than the alkali water irrigation with conventional planting. Post-harvest analysis of soil samples revealed that the highest mean soil pH of 9.0 and EC of 0.25 dS m⁻¹ and soil ESP build-up of 33.6% were in continuous use of alkali water for rice at end of fifth year (2012-2013). The use of canal + alkali water was observed to be better than use of alkali water alone.



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Physico-Chemical Properties of Surface and Ground Water in Selected Areas of Muraul and Sakara Blocks of Muzaffarpur District, Bihar

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Keeping in view the importance of quality of water for drinking and other purposes, the surface and ground water quality of five villages in Muraul and Sakara blocks of Muzaffarpur district (Bihar) were assessed during rainy season, 2014. The water samples collected from randomly selected ponds and hand pumps situated at different places were analyzed for their various physicochemical properties by following prescribed standard procedure and were also chemically characterized as per guidelines of Indian Standard and WHO. It was observed that the pH of pond water was slightly alkaline (7.7 to 8.8) in nature, whereas, pH of hand pump water was neutral (7.1 to 7.4). Electrical conductivity of pond and hand pump water ranged from 282 to 19739 and 575 to 913 mmhos cm⁻¹, respectively. Alkalinity (61.5 to 312.5), total dissolve solids (190 to 1510) and total hardness (195 to 314 mg l⁻¹) were detected more frequently at higher levels in ponds water. The highest concentration of HCO₃⁻ was found in Sakara village (658.0 mg l⁻¹) and Muraul village (488.0 mg l⁻¹) in pond and hand pump water, respectively. The total dissolve solids ranged from 450 to 660 mg l⁻¹ and Cl⁻ content 11.3 to 53.9 mg l⁻¹ was noticed in hand pump water. Total dissolved solids and Cl⁻ concentration in hand pump water were found more as per the limit mentioned in guidelines of Indian standard and WHO for drinking water in both the blocks. In view of the studies, most of the pond samples crossed total hardness of desirable limit except sample obtained from Bajitpur Sakara village. The maximum concentration of SO₄⁼ (658 mg l⁻¹) and PO₄⁼³ (36.7 mg l⁻¹) were observed in surface water taken from Sakara village. However, CO₃⁼ was not detected either in surface water or in ground water in any samples. The higher chemicals pollution was observed particularly in surface water of Sakara village and it was noticed due to regular cloth washing practices by the local washer man apart from agricultural drainage in surface water.



GIS Mapping of Groundwater Quality of Baragudha Block of Sirsa District, Haryana

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Proper planning and management of groundwater requires spatial assessment and mapping of groundwater quality. The present study was aimed to characterise the groundwater quality and delineate its spatial variations in Baragudha block of Sirsa district, Haryana. 76 water samples were collected from existing tubewells and analysed for different chemical composition (Na^+ , Ca^{2+} , Mg^{2+} , K^+ , CO_3^{2-} , HCO_3^- , Cl^- , SO_4^{2-}) and parameters (pH, EC, SAR and RSC). To study the spatial distribution of different parameters (EC, pH, SAR, RSC and water quality according to AICRP criteria), maps were prepared. The results of analysis were interpreted according to four different classification criteria *i.e.* AICRP, Manchanda, USSL and Piper to check its suitability for irrigation purpose. According to AICRP criteria, out of seven categories, maximum 27.6 per cent of samples were found in marginally saline and minimum 1.3 per cent were found in alkali, whereas, no sample was in marginally alkali and high alkali categories. According to Manchanda criteria, out of five categories, maximum 27.6 per cent of samples were found in normal and minimum 1.3 per cent were found in sodic. According to USSL, groundwater quality of the district was observed under C1S1, C2S1, C3S1, C3S2, C4S2, C3S3, C4S3 and C4S4 categories. According to Piper criteria, in the block, 11.8 per cent samples were under good category (Ca^{2+} - Mg^{2+} - Cl^- and Ca^{2+} - Na^+ - HCO_3^- type) and remaining 88.2 per cent was under poor category (Na-Cl type).



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Groundwater Quality Assessment of Fatehabad Block of Fatehabad District

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Spatial variation of groundwater quality for a region is very important to the developmental workers and policy makers for site specific management of this important natural resource. Thus, a study was carried out to assess the spatial variation of the groundwater quality for Fatehabad block (586.6 sq km) of Fatehabad district, Haryana. One hundred twelve groundwater samples from running tubewells in the area have been analyzed for pH, EC, CO₃²⁻, HCO₃⁻, Cl⁻, SO₄²⁻, Ca²⁺, Mg²⁺, Na⁺ and K⁺. According to AICRP (Gupta *et al.* 1994) classification, it was found that 42.8 per cent waters were of good quality, 25.9 per cent was saline and 31.3 per cent alkali in nature. In saline category, 12.5, 0 and 13.4 per cent were marginally saline, saline and high SAR saline, respectively. In alkali group, 8.0, 6.3 and 17.0 per cent were marginally alkali, alkali and high alkali, respectively. The study revealed that 85.7 per cent of the samples had EC values less than 4 dS m⁻¹ and the maximum value of EC was found as 15.47 dS m⁻¹ at village Dhangar. Residual sodium carbonate (RSC) and sodium adsorption ration (SAR) varied from nil to 9.10 me l⁻¹ and 4.72 to 53.02 (m mol/l)^{1/2}, respectively. Contour maps of EC, pH, SAR, RSC and water quality of groundwater in the block were plotted to study spatial variability of these parameters.



Evaluation of Forage Crops Raised through Sewage Water in Musi, Hyderabad

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Growing of various crops under sewage waters in urban and peri-urban situations is a common scenario in many cities. The crops mostly include forage crops, leafy vegetables, vegetables and some times food grains. These sewage waters are known to contain undesirable constituents like heavy metals, pesticide residues besides, harmful pathogens. These undesirable components can make way possibly from sewage to soils, plant parts, there by to even milk, thus entering into food chain. Musi, a tributary of Krishna on whose banks Hyderabad lays is the main fodder bank of the city. Para grass (*Bracharia mutica*) is the dominant forage crop grown in and around Musi along with several other crops. The path of heavy metals and pesticide residues into forage crops and thereby food chain through milk studied.

The residues of aldrin, endosulphan (α and β isomer), PPDDE, PPDDD and HCH isomers were detected in water samples. The magnitude of these pesticides was however very low and fall within the safe limits. It was also observed that forty per cent of samples did not record any residues. The highest concentration was observed with respect to α - HCH (23.435 ppb) at Amberpet bridge. These pesticides obviously paved their way into soil as observed from the soil analyses. The magnitude however increased in soils owing to their accumulation over time. The lowest and highest levels of residues were found with respect to β HCH (0.0054 ppm) and α HCH (0.2821 ppm), respectively. Channelization of these OC compounds into the fodder (predominantly para grass) was remarkable only regarding PPDDD (para para dichloro diphenyl dichloro ethane). However, residues of α and β HCH and α endosulphan also entered the crop component though the magnitude was found to be very meager. The residues of PPDDD were found in most of the plant samples (0.0307 to 0.5933 ppm).

Most commonly found residues in forage samples were found to be those of dichlorvas and quinolphos. In exceptional cases residues of dimethoate and chlorpyriphos were also recorded. However path of these residues into soil and plant component was very less. The residues of dichlorvas (0.0496 to 0.0565 ppm) were recorded in three samples while those of dimethoate, and profenophos were observed in only one sample each. However, neither water/ soil nor fodder crop recorded any trace of synthetic pyrethroid pesticides which could be attributed to their quick degradability.

Concentration of heavy metals like Cu, Ni, Co and Pb was highest at Imlibun. In fifty per cent of samples, Cu is in unsafe levels while in thirty three per cent of samples Cd and Pb in unsafe limits. With respect to waters in all samples Co is in unsafe levels, on the other hand Cd is more than unsafe levels in 83% of samples. In fodder samples, the magnitude of Pb and Zn is toxic in all samples. Cadmium is more than unsafe level in 79% of samples. Chromium is in very high magnitude in Peerzadiguda and Parvatpura areas. In milk of cattle fed with Musi forages Cu, CO, Ni, Cd and Pd are in very high concentration (above the safe levels in all samples).

Commission 4.1: Soils and the Environment



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Effect of Biochar on Soil Health and Groundnut Yield in Rainfed Alfisol

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The declining trend of organic matter content in rainfed soil, which is already hungry and thirsty, eventually affects the soil quality and crop productivity. In this context to enhancement of soil carbon, nutrient status in soil and crop productivity under rainfed condition to meet the food grains demand of ever growing population is need of the hour. The newer approach of research recently used to dispose the agricultural crop wastes is biochar production and in-turn facilitating carbon sequestration, nutrient use, and crop productivity. The field experiments were conducted for 3 years during 2011 to 2013 to investigate the effect of biochar on soil health, carbon sequestration and yield of groundnut in acidic red sandy loam soils under rainfed condition at Dryland Agricultural Research Station, TNAU, Chettinad, Tamil Nadu. Biochar was prepared from different agricultural wastes viz., redgram, cotton and maize stalk using Tamil Nadu Agricultural University made biochar pyrolysis unit. The different sources of biochar were applied as basal at the rates of 0, 2.5 and 5 t ha⁻¹ with recommended NPK (10:10:45 Kg ha⁻¹). The research results revealed that application of biochar in acidic red soil improved the soil physical environment mainly by reducing bulk density from 1.41 to 1.36 Mg m⁻³ and increasing average soil moisture retention by 2.5 per cent. With respect to soil chemical changes, application of biochar @ 5 t ha⁻¹ raised soil pH from 5.4 to 6.3; increased the cation exchange capacity with a value of 1.4 cmol(p⁺) kg⁻¹ and carbon stock build-up of 1361 kg ha⁻¹ were observed. The maximum pod yield of 1796 kg ha⁻¹ and energy productivity of 0.149 kg per mega joule was also recorded in biochar @ 5 t ha⁻¹ applied soil. These positive changes favoured good soil health and enhanced groundnut productivity in rainfed alfisol.



Assessment of Chromium and Nickel Status in Cultivated Areas Surrounding Coal Opencast Mining of Telangana State

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The present investigation was undertaken to estimate the impact of opencast coal mining on soil available heavy metals *viz.*, Cr and Ni in Telangana state. Soil samples were collected from Srirampur (Adilabad), Medipalli (Karimnagar), Bhupalapally (Warangal) and Yellandu (Khammam) opencast areas of Telangana. At each opencast mining place, surface samples (0-15 cm) were collected, 10 surface samples from cultivated soils at a distance of 1.5 km (approximately) from opencast coal mining area and another 10 surface soil samples from 3.5 km from coalmines in all directions. These samples are designated as samples within 2 km from coal mining and beyond 2 km, respectively with an assumption that accumulation of coal dust will be within 2 km from mining site. Thus a total of 80 samples were collected i.e., 40 within 2 km and another 40 beyond 2 km from mining area, from four places of opencast i.e., Srirampur, Medipalli, Bhupalpally and Yellandu. Twenty grams of 2 mm sieved soil sample was shaken with 40 mL of DTPA extractant of pH 7.3 for 2 hours. The contents were filtered and in the filtrate different heavy metals were determined by using Atomic Absorption Spectrophotometer (AAS) as per the specifications suggested by Lindsay and Norvell (1978). The data was analysed statistically by two sample "t" test to compare Cr and Ni contents in samples. Significantly higher amounts of Chromium and Nickel were observed within 2 km area than beyond 2 km samples. In some of the places nickel and chromium content was above toxic limits also. As heavy metals are important constituent of coal and existing parent rock mining operation may lead to substantial increase in the amount of toxic substance in the environment.



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Micronutrient Cation Status of Paddy and Sugarcane Growing Areas of West Godavari District, Andhra Pradesh

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A survey was conducted in paddy-sugarcane growing areas of west Godavari district. One hundred representative soil samples were collected from sixteen mandals in paddy-sugarcane growing areas of West Godavari district by following the random sampling technique. The soils were found to be mildly alkaline, medium salinity and high in organic carbon. Further the soil were non-calcareous with high cation exchange capacity, clay to clay loams. The soils were medium in available nitrogen, phosphorus and high in available potassium. Exchangeable calcium, magnesium, available sulphur, DTPA extractable copper ranges from (0.26 to 7.55 mg kg⁻¹), manganese (0.02 to 39.42 mg kg⁻¹), iron (0.05 to 47.08 mg kg⁻¹), and zinc (0.42 to 3.86 mg kg⁻¹). DTPA extractable copper and manganese were above critical limits, whereas iron (21%) and zinc (22%) were deficient.



Assessment of Soil and Water Quality in Paddy-Sugarcane Growing Area of West Godavari District, Andhra Pradesh

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An investigation was carried out during months of May, December and March, 2006-07 to study the assessment of soil and water in paddy-sugarcane growing areas of West Godavari district. One hundred representative soil samples (50 surface and 50 sub-surface) were collected from sixteen mandals of paddy-sugarcane growing areas of West Godavari district by following the random sampling technique. At the same time 300 ground water samples were collected from pre-selected sites during pre-monsoon season (150) and post-monsoon season (150) from different sources like tube wells, open wells, hand pumps etc. The soil and water samples were analysed for various physical, chemical and biological properties. The soils were found to be mildly alkaline, medium saline, high in organic carbon, medium in available nitrogen, phosphorus and high in available potassium. The soil were non-calcareous with high cation exchange capacity, clay and clay loams. Exchangeable calcium, magnesium, available sulphur, DTPA extractable copper, manganese were above critical limit, where as iron (21%) and zinc (22%) deficiency was observed. The most dominant exchangeable cation was calcium followed by magnesium, sodium and potassium. In pre-monsoon season majority of water samples (55%) were rated as marginally saline and 16.33 per cent were good for irrigation, 8.66, 4.66, 9.33, 4.00, 2.66 per cent of samples were categorized under saline, high SAR, marginally alkali, alkali and high alkali waters, respectively. The nitrate-nitrogen status of these waters was moderately safe (55%). In post-monsoon season 57.5 per cent samples were good, 42.5 per cent were marginally saline for irrigation. The nitrate-nitrogen status of waters was moderately safe (41.8%), unsafe (53.7%) and safe (4.3%) for irrigation. Soil pH had significant and negative correlation with iron, manganese and copper. Soil EC had a significant and positive correlation with exchangeable calcium and cation exchange capacity. Soil organic carbon had a significant and positive correlation with dehydrogenase activity, CEC, clay content, exchangeable calcium, copper, manganese. EC of water had a positive and significant correlation with nitrate-nitrogen of water. The pH of water had a negative correlation with available zinc of soil. Based on soil quality paddy growing soils were found to be moderate to very good soil quality, while sugarcane growing soils were of moderate soil quality.



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Optimum Conditions for Removal of Heavy Metals from Wastewater by Agrowastes along with Microbial Consortium

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Wastewaters from industries contains high concentration of metals like Pb, Cd, Cr, Cu, Ni, which are toxic to living organisms even at low concentration. Biomass of microbes acts as adsorbent to remove heavy metals from wastewater at low cost and in eco-friendly way. The ability to remove heavy metals from wastewater varies greatly among microbes. This needs to be exploited for removal of heavy metals from wastewater through efficient microbes. Laboratory experiments were conducted to find out optimum conditions like pH, dose of agrowastes (algae, pressmud and rice straw individually and in combination with rice husk) and concentration of heavy metals along with microbial consortium of six fungi and one bacterium for maximum removal of heavy metals from aqueous solution. Data indicated pH 5-7, agrowaste dose of 0.4 to 1% and concentration from 50 to 200 ppm of heavy metal as optimum conditions for maximum removal of heavy metals (Cu, Zn, Pb, Ni, Cd) from aqueous solution containing heavy metals at 25 ppm individually and 10 ppm of multi metals. Maximum removal of heavy metals from wastewater was observed by algae and pressmud agrowaste at optimum conditions. These optimum conditions can be used for removal of heavy metals from industrial wastewater by agro wastes along with microbial consortium at low cost and in eco-friendly way.



Arsenic and Iron Contamination in Groundwater of Narayanpur Development Block of North Bank Plain Zone of Assam

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Arsenic contamination in groundwater and its impact on human health has been reported as one of the world's biggest natural groundwater calamities to the mankind. In Assam, Arsenic concentrations in groundwater above the permissible level have been reported from 20 districts, of which, maximum level of Arsenic concentration was found in Jorhat, Lakhimpur, Nalbari and Nagaon districts. To identify the suitability of groundwater quality for drinking purposes, a survey has been conducted on arsenic and iron contamination of groundwater in Narayanpur development block of North Bank Plain Zone of Assam. Eighty seven numbers of groundwater samples were collected from tube wells at different locations of the block covering each village belonging to the Narayanpur Block during March, 2014. Samples were collected in rinsed 500 mL plastic bottles containing 5 mL of 1.58 M nitric acid for stabilizing the samples. Arsenic and iron were analyzed by using an atomic absorption spectrophotometer (AAS, model Analyst 200, Thermo ICE3000 series, USA). The Arsenic content of analyzed samples varied from 0 (zero) ppb to 102 ppb, of which, 48 (55.1%) samples were found below the WHO guideline value for drinking (<10 ppb) while 39 (44.8%) samples contained arsenic above the guideline value (> 10 ppb, WHO, 2011). Iron concentration of the samples having Arsenic concentration above the critical limit of 10 ppb was analyzed with a view of ameliorating arsenic toxicity through removal of Iron. The iron concentration of the samples ranged from 10 ppm to 58.4 ppm. However, no significant correlation between Iron and Arsenic concentration was observed ($r^2 = 0.0403$).



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Soil Quality under Organic and Inorganic Farming Systems in *Malwa* Region of Western Madhya Pradesh

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To study the effect of organic and conventional farming systems on soil quality changes over time in real farm conditions, an experiment was conducted in the farmers' fields during 2008-09 and 2009-10. The study was carried out in five villages of Indore district. These villages were adopted by the Department of Agriculture, Government of MP as bio-villages and farmers were practicing organic farming for last 2-7 years. The experiment was conducted under soybean – wheat cropping sequence using randomized block design with five replications. Each farmer was taken as one replication. Four treatments comprised of organic farming (≥ 3 years), organic farming (< 3 years), inorganic farming with recommended dose of fertilizers and farmers' practice of nutrient application. Based on the change in relative soil quality index (RSQ), soil quality changes were evaluated. The soil quality changes were evaluated quantitatively for all the four treatments using the data of selected soil indicators analysed during this study like soil pH, electrical conductivity (EC), organic carbon, cation exchange capacity (CEC), soil texture, soil available nitrogen, phosphorus and potassium and soil slope. The results indicated that the quality of soil had improved as compared to farmer's practice of cultivation where the value of Relative Soil Quality Index (RSQI) was above zero. The relative soil quality index under organic farming ≥ 3 years treatment was increased by 14.5 units as compared to 9.5 units in inorganic farming with RDF and 8.75 units under organic farming < 3 years. Under all the treatments soil belongs to class III having minimum value 65.00 under farmer's practice of nutrient management. The maximum improvement was observed due to organic farming ≥ 3 years treatment. This indicates that organic farming improved soil quality due to adoption of improved nutrient management practices as compared to farmer's practice. This study concludes that there was a great increase in soil quality due to adoption of organic farming since ≥ 3 years. In case of inorganic farming with RDF and organic farming < 3 years the increase in soil quality was moderate to slight.



Influence of Amendments on Heavy Metals Accumulation in Rice Grown on Sludge-treated Soils

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Sewage sludge is found to be an effective organic fertilizer causing increments in the biomass of many crops. However, its long-term use can cause heavy metal accumulation in the soil and resulting transfer of these metals to the food chain, causing threat to human health. Thus, it is crucial to reduce the uptake of heavy metals in the above ground plant biomass due to increased sewage sludge application. In a greenhouse experiment, the effect of amendments *viz.* lime (@ 2.5 t ha⁻¹) and FYM (@ 5.0 t ha⁻¹) on the accumulation of heavy metals (Zn, Cu, Pb and Ni) was studied in the different plant parts of rice (*viz.*, grains, straws and roots) grown at different soils (*viz.*, acid, alluvial, red & lateritic and saline) treated with sludge. Both grain and straw yield of rice showed significant positive response under sewage sludge application from 10 t ha⁻¹ to 80 t ha⁻¹ as compared to untreated control. The concentrations of Zn, Cu, Pb and Ni were significantly higher in different parts of rice plants at different sludge application rates than those grown in unamended soil with the highest concentrations at 80 t ha⁻¹ and its concentration was highest in roots followed by straws and lowest with grains. Irrespective of soils there were significant ($P < 0.05$) effects of amendments (*i.e.* lime and FYM) on heavy metal concentrations in roots, straws and grains of rice. The effectiveness of different amendments on the reduction of Pb and Ni concentrations in grains of rice in different soils follows the order as Lime + FYM (Pb: 12.9-13.3%, 12.4-12.7%, 13.7-14.0% and 10.0-10.8%; Ni: 13.2-14.4%, 9.3-10.5%, 11.2-12.5% and 10.0-12.2%) > Lime (Pb: 10.8-10.9%, 9.9-10.5%, 10.8-11.7% and 8.4-9.7%; Ni: 10.3-11.4%, 7.2-8.9%, 9.0-10.2% and 8.5-10.2%) > FYM (Pb: 8.5-8.8%, 9.4-9.9%, 9.7-10.1% and 6.5-6.9%; Ni: 11.5-12.1%, 8.2-9.2%, 9.0-9.2% and 8.0-8.6%) in acid, alluvial, red and lateritic and saline soils, respectively. While maximum accumulation of Pb and Ni obtained when no amendment was applied in soil *i.e.* with only sludge treated soil. Among the different types of soils, at identical sludge application rate the increments in heavy metal concentrations in grains were lowest in red and lateritic soils and highest in acidic soils. Sewage sludge application (SSA) rates above 40 t ha⁻¹ though increased the yield of rice, but caused risk of food chain contamination as concentration of Pb in rice grains were found to be above the Indian safe limits (2.5 mg kg⁻¹) of human consumption and of Ni (1.5 mg kg⁻¹) above 20 t ha⁻¹ SSA in all soils. However, using CaCO₃ and/or FYM as an amendment, the toxic concentration of Ni in rice grains reduced to non-toxic level at 40 t ha⁻¹ sludge applications in all soils. The study suggests that SSA at a rate 40 t ha⁻¹ may be recommended due to better fertilizing value for soil and promoting grain and straw yield of rice. Higher rate of sewage sludge application leads to elevated accumulation of toxic heavy metals in grains, which limits the suitability for human consumption.



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Soil Quality Assessment towards Maximizing Sugarcane Productivity in Theni District, Tamil Nadu

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Concern has recently been raised by many authors regarding the degree of soil quality degradation that can occur under sugarcane production where the percentage loss in productivity is estimated to be 4.5 to 7.9, equivalent to a worth of 200 million US dollars. Sugarcane crop cultivated in 4427 hectares at Theni district of Tamilnadu for more than 15 - 20 years is recently facing problem of declining cane yields. The impaired soil health or deterioration in soil quality is often cited as one of the reasons for stagnation in cane productivity. Hence during 2012-13, a systematic soil quality assessment survey was taken up in Theni district. The cane yielding zones of the district was classified into three categories viz., low yielding (less than 75 t ha⁻¹), medium (75 to 100 t ha⁻¹) and high yielding (more than 100 t ha⁻¹) and the yields were recorded. The key physical, chemical and biological indicators of soil quality were assessed in the surface (0-15 cm) and subsurface (15-30 cm) samples and weightages were assigned to each soil quality attribute through Principal Component Analysis (PCA). Correlations were also worked between different soil quality parameters for interpreting the relationship among themselves and also their effects on sugarcane yield. The yield range of sugarcane in low, medium and high soil quality categories were 50 to 75, 80 to 100 and 97.5 to 140 t ha⁻¹, respectively. The soil quality indicators assessed in the low soil quality zone reflected slightly higher mean bulk density (1.33 Mg m⁻³), lesser percentage of water stable aggregates (41 per cent), lower CEC (11.9 cmol(p⁺)kg⁻¹) and low organic carbon content (0.14 per cent) which created a relatively poor physico-chemical environment that constrained the availability of nutrients in terms of low N status (235 kg ha⁻¹) moderate P and K status (20.5 and 138 kg ha⁻¹ respectively), deficient sulphur (13.9 kg ha⁻¹) and zinc status (2.25 mg kg⁻¹). Almost 93 per cent of the farms surveyed for soil quality assessment in the high yielding zone registered an average cane yield of 120 t ha⁻¹. This may be attributed to the more favourable soil environment in terms of soil texture (sandy clay), higher mean percentage of water stable aggregates (53 per cent), a neutral pH of 7.21 and maximum organic carbon status (0.59 per cent) resulting in better availability of macro, secondary and micro nutrients in these soils. The maximum weightage of 13 was equally assigned for soil organic carbon and available nitrogen. A weightage of 9 was shared by two soil attributes viz., available S and water stable aggregates followed by mechanical composition of soil (texture) and cation exchange capacity with a weightage of 8. The soilavailable P, available K, soil respiration rate, available iron and zinc were assigned with weights of 7, 6, 6, 5 and 5, respectively. The analytical data generated for various physical, chemical and biological indicators of soil quality through this research can be integrated into soil quality index (SQI) and test verified for assessing the soil quality degradation or improvement in similar sugarcane dominant zones regionally and nationally.



Micronutrient Status of Soils and Crops Irrigated with Mixed Industrial Effluent Water in Industrial area of Vadodara District

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The indiscriminate disposal of industrial effluents on agricultural lands during the last few decade in India and especially in Gujarat is expected to carry a part of the micronutrient load in mixed industrial effluent irrigated soil and ultimate in ground water. Therefore, survey work was carried out in effluent irrigated soils of *periurban* area along the effluent channel in Vadodara district in order to find out the micronutrient accumulation in mixed industrial effluent irrigated soils, agricultural crops as well as naturally growing plant species in the area. The study was carried out to assess the level of accumulation of micronutrients in soil-water-plant system as well as naturally growing plant species/tree. The Effluent water, soil and plant samples were collected from the contaminated area irrigated with mixed industrial effluent water as well as non-contaminated sites of the adjoining field irrigated with tube well water. The samples were analyzed for different micronutrient viz; Fe, Mn, Zn and Cu by standard methods. The result revealed that the effluent water and soil-plant system were found accumulated with micronutrients (Fe, Mn, Zn and Cu). The general quality of the effluent as well as tube well water was poor with respect to its suitability for irrigated. The BOD and COD values of the effluents were above the permissible limit for field application. The effluent irrigated soil showed higher content of micronutrients besides higher available nutrients viz., P, K, S. The soil contained more soluble salts up to 45 cm depth in the profile compared to non-contaminated tube well irrigated soil. The content of micronutrients in all groups (cereals, oilseeds, vegetables, fruits, trees and other) of crops was higher in effluent irrigated soil than tube well irrigated soil. Among the oilseeds, cereals and vegetables crops wheat, cotton and drumstick showed higher content of micronutrients compared to other crops in the respective area. The naturally growing tree viz; neem (*Azadiracta indica*), drumstick (*Moringaolifera*) and Mango (*Mangiferaindica*) leaves also contained more or less similar average content of micronutrients. The level of Zn and Cu in neem (*Azadiracta indica*) tree leaves as well as the level of Cu in cereals, oilseeds, vegetables, tree and others natural growing plant leaves was alarming due to their content above the permissible limits. The results indicated the variable behavior accumulation capacity is governed by contents and biomass of different crops and naturally growing trees.



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Effect of Raw and Post Bio-methanated Spent Wash Bio-compost on the Physico-Chemical and Biological Properties of Normal Soil under Seasonal Sugarcane (*Saccharum officinarum*)

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A field experiment was conducted at Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist- Ahmednagar (M.S.). Raw and post bio-methanated spent wash used for preparation of different twelve types of bio-compost. Different organic sources like press mud cake, baggasse, sugarcane trash, pearl millet straw, chick pea straw and wheat cut straw were used for preparation of bio-compost after decomposition. Seasonal sugarcane crop (*Saccharum officinarum*) variety- Co 86032 was a crop taken for study to see the effect of different biocompost on its quality, yield and uptake of nutrients under normal soil condition. Sixteen treatments including absolute control, farmyard manure and vermicompost treatments were taken for comparison in triplicate on normal soil were formulated for this study. The growth parameters like height of the plant, girth of the stem, no. of tillers *etc.* as well as yield and quality of sugarcane was found significantly higher in the post bio-methanated bio-compost treatment as compared to the raw spent wash bio-compost treatment.

Sand, silt and clay did not influence significantly due to application of spent wash bio-compost and manures. The application of bio-composts significantly decreased the bulk density of soil as compared with control and RDF. The use of spent wash bio-compost significantly increased the hydraulic conductivity but significant decrease in dispersion index and significant improvement in MWD over control and RDF, respectively. The soil pH was higher but lower EC values where post bio-methanated spent wash was used as compared to application of raw spent wash. The application of spent wash composts significantly increased the organic carbon, available nitrogen, phosphorus and potassium, exchangeable cations. CEC and ESP over control and RDF and vermicompost. The use of PBSW increased the pHs, ECe as compared to use of raw spent wash. The application of different spent wash bio-compost significantly increased the Ca^{2+} , K^+ , Na^+ , Cl^- and SO_4^{2-} content of saturation paste extract over control and RDF. Microbial population was significantly increased due to application of spent wash bio-compost as compared to control, and RDF.



Mitigation of Cadmium Toxicity through Silicon Application in Maize (*Zea mays* L.)

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A pot experiment was conducted on maize to study the interaction between Cd and Si levels. The experimental soil was treated with four levels of Si *viz.*, 0, 100, 200 and 300 mg Si kg⁻¹ soil and six levels of Cd (5, 10, 20, 40 and 80 mg kg⁻¹). The experiment was planned in a factorial completely randomized design with three replications. Amongst yield attributes, the leaf area of maize was significantly increased (19.2%) at Si₃₀₀ level over control, whereas root length and chlorophyll content at 30 DAS were significantly influenced at Si₂₀₀ and Si₃₀₀ level over Si₀. The highest chlorophyll content at 60 DAS (15.23 cci) was recorded at Cd₀Si₃₀₀ treatment combinations. The decrease in dry shoot weight due to Cd₈₀ level was to the tune of 19.7 per cent over control (Cd₀). The dry shoot weight (35.98 g pot⁻¹) was increased to the tune of 19.5 per cent over control (Si₀) under Si₃₀₀ level. The highest mean dry root weight (4.69 g pot⁻¹) was observed at Si₃₀₀ level, which was on par with Si₂₀₀ level. The highest Cd content was observed under Si₀Cd₈₀ (47.3 ppm) combination which was reduced to 21.13 ppm under Si₃₀₀Cd₈₀ combination in root of maize. The highest Si content (2.26%) was found under Cd₂₀Si₃₀₀ treatment combination in root. The highest dry shoot yield was obtained when Si : P ratio was 7.05 at Si₃₀₀ level, which indicates that Si availability was enhanced due to Si application in soil. The DTPA Cd and total Cd were significantly enriched in soil at different levels of Cd application, which was ranged from 0.08 to 20.0 and 0.95 to 37.9 ppm, respectively. Available P₂O₅, S and Si contents in soil increased at Si₃₀₀ level. The decreased in DTPA extractable Cd and total Cd at Si₃₀₀ level was 26.5 and 18.8 per cent than the control. The highest value of DTPA Cd (22.5 mg kg⁻¹) and total Cd (42.01 mg kg⁻¹) was observed at Si₀Cd₈₀ among the different treatment combinations. The dry shoot yield was positively correlated with Si content in shoot ($r = 0.712^{**}$) and soils, ($r = 0.715^{**}$). While it was negatively correlated with shoot Cd ($r = -0.588^{**}$), DTPA Cd ($r = -0.601^{**}$) and total Cd ($r = -0.595^{**}$). The overall result pointed out an antagonistic effect of Si on Cd which can be favorably exploited in mitigating the ill effects of Cd contaminated soils through application of silicon @ 200 to 300 mg kg⁻¹ soil through calcium silicate. Application of Si helped to maintain nutrient balance in soil and plant.



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Resource Conservation Technology for Wheat Sowing at Farmers Fields in Punjab

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Rice-wheat is major crop rotation of Punjab with an area of 26 lakh ha under this rotation. Most common method is to burn rice straw and stubbles and then sow the wheat with drill after intensive tillage operations. Burning of rice straw leads to environmental pollution, health problems and most importantly loss of significant amount of nutrients. Lack of suitable machinery is a major constraint to direct seed drilling into the heavy stubbles in intensively cultivated irrigated rice-wheat cropping systems of north-west India, mainly due to blockage in many parts of the seeding mechanism and failure to obtain good soil-seed contact. In order to prepare fields for timely sowing of wheat, about 20 Mt of rice stubbles are burnt every year within a span of 20 days in Punjab, (India) alone. Field demonstrations on happy seeder sowing technology (RCT) for wheat were conducted at Farmers fields in irrigated subtropical zone of district Ropar of Punjab during *rabi* 2012-13 and 2013-14 to investigate the feasibility of happy seeder sowing and study its effect on grain yield, weed density and economics of Wheat crop. The demonstrations were conducted under NICRA project in adopted village Rasidpur, Block Chamkour Sahib, District Ropar at 14 locations in 2012-13 and 8 locations in 2013-14. Conventional sowing of wheat was kept as check. The results indicated that grain yields of wheat with happy seeder sowing (Avg. yield 5.12 t ha⁻¹) were marginally less than conventional sowing (Avg. yield 5.26 t ha⁻¹). Weed density per m² was lower in happy seeder plots than conventional sowing plots of wheat. This is due to more favorable environment for weed seeds to germinate under tilled soil conditions as compared to compact soil, moreover paddy straw in happy seeder sown plots act as natural mulch which inhibits weed emergence. Net returns and B: C ratio was more under happy seeder sown plots which were due to less input costs and comparable grain yields.



Partitioning of Micronutrients Uptake in Different Plant Parts of Crops Grown on Contaminated Soil of Peri Urban Area in Gujarat

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The indiscriminate disposal of industrial effluents on agricultural lands is expected to carry a part of load of micronutrient accumulation in industrial effluent irrigated soil and ultimately in ground water. The crops grown on such soil provide way for micronutrients to enter in to food chain. However the absorption and translocation of micronutrients varies with crops and varieties. Keeping this in view the experiment was carried out to study the heavy metals/micronutrients removal/uptake and their partitioning in various components/parts *i.e.* roots, leaf, stem and seed of various crops and their contribution towards total uptake. The soil in bulk having sandy loam texture was collected from mixed industrial effluent irrigated fields as well from the adjoining tube well irrigated fields nearby Ahmedabad industrial zone. The soil was utilized in micro-plots (Size 1.5 × 1.0 × 0.5 m³) at AAU, Anand. Three levels of irrigation water *viz.*, 100% mixed industrial effluent (I₁), 1:1 diluted effluent (I₂) and tube well water (I₃) were kept to study their effect on growth and yield of different crops [Sunflower (SF) (*Helianthus annuus*), Cotton (CT) (*Gossypium hirsutum*), Tobacco (TB) (*Nicotina tabacum*) and Castor (CS) (*Ricinus communis*)]. The experiment was conducted under FCRD design keeping three repeats.

Among the crops, the biomass yield of castor was maximum followed by cotton while minimum yield was recorded in tobacco. The translocation of Fe was restricted in stem while it was increased in seed parts of sunflower, followed by stem; and about 50 per cent of total Fe uptake was found to be retained in roots of sunflower under contaminated soil condition. Zn and Cu were more concentrated in seed of castor, in leaf of tobacco and in stem of sunflower. Cotton and tobacco contributed more than 90 per cent of Fe uptake through parts other than seed and stem towards total Fe removal. Sunflower depicted higher contribution of Zn uptake through seed. Effect of different irrigation depressed Cu translocation towards seeds in cotton and castor by about 5 to 9 per cent over tube well water. The sunflower enhanced contribution of Cu removal through seed by about 3 per cent towards total Cu uptake due to effluent irrigation over tube well water (13.3%). In general, the partitioning of micronutrients removal in different components of various crops and their contribution towards total removal indicated that the micronutrients removal through seed was higher in case of castor followed by cotton which was depressed under contaminated soil condition as well as effluent irrigation. Although the total removal of micronutrient was less in sunflower, contaminated soil condition and effluent irrigation enhanced the uptake over non-contaminated as well as tube well water irrigation. Thus, the sunflower crop was found least sensitive towards contamination of heavy metals in soil and irrigation with effluent water so far as micronutrients uptake was concerned.



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Lead Speciation as Influenced by Sewage Irrigation in Soils and its Accumulation in Crops

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The public concern over the effects of environmental pollution has increased substantially in the last century with the industrial revolution and as a consequence of an enhanced understanding of the risk to human health. In recent decades, urbanization and industrialization in Punjab have led to a considerable increase in heavy metal levels including lead (Pb) in different environmental compartments, especially in soils. There are some reports which indicate that heavy metals pollution including Pb in soils arises as a result of various anthropogenic activities such as combustion of petrol in motor vehicles, smelting processes, continuous use of sewage water, sewage sludge, fertilizers and insecticides. These metals due to their high residence time, remain in the soils in dangerous proportion and thus have implications on human and animal health.

Accumulation of lead in soils and crops influenced by sewage irrigation of mixed industrial effluents was investigated in relation to their uptake by plants. Soil samples from the sites receiving waste water largely contaminated with mixed industrial effluents around Amritsar were taken to determine the distribution of Pb in various chemical pools. The sequential procedure was used to partition Pb into exchangeable + water soluble, carbonate bound, Mn oxide bound, organic bound, amorphous Fe oxide bound, crystalline Fe oxide and residual. The mean DTPA extractable Pb and its total in sewage irrigated was 1.2 and 1.96 times their respective amount in tube-well irrigated soils. Each extracted fraction in sewage irrigated soils exhibited an increase in Pb except carbonate fractions as compared to tube-well irrigated soils with the most significant increases occurring in organic, residual and oxide bound fractions. The mean Pb concentration in exchangeable and water-soluble forms in sewage irrigated soils was extremely low (0.24% of total) compared to other forms. The higher amount of lead in residual fraction confirm residual that plants grown on these soils may not have any toxicity problem of lead. The present distribution among different pools of lead was due to readjustment of metal to the changing conditions as a result of long term waste water irrigation in these soils. The crops growing on sewage irrigated soils invariably contained higher amounts of lead in their roots and shoots as compared to the tube-well irrigated soils yet *raya (Brassica juncea)* and *toria (Brassica campestris)* accumulated higher content of heavy metals as compared to other crops, with higher content in roots than shoots. A fairly large amount of Pb can accumulate in plants without showing stress, this increases the risk for potential intake in diet. This is topical issue particularly in crops used for direct consumption. The result suggest that effluents are potential source of heavy metals including lead which should be monitored periodically. It is enviable that sewage water may be treated for removal of heavy metals or be used for non food crops.



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Biochar from Crop Residues/ Weeds and its Impact on Soil Quality and Carbon Sequestration

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Studies were carried out to sequester carbon in soil through an indirect route. Waste biomass like crop residue, tree litter, weeds, *etc.*, were converted to biochar. The process involves carbonization, wherein ligno cellulose in the biomass was converted into stable aromatic compounds. The pyrolysis conditions were optimized for stable organic matter yield index (SOMYI), which is based on biochar yield and stability. Maximum SOMYI was obtained at low pyrolysis temperature (300-350 °C). Elemental analysis, TGA, and FTIR, indicated the aromaticity and stability of biochar carbon. The scanning electron microscope (SEM) images for biochar revealed the micro porous structure of the biochar. This is of immense use for soil application, especially for enhancing soil water holding capacity and nutrient retention, harbouring micro organisms, and increasing the fertilizer use efficiency, *etc.* Laboratory and field experiments showed the stability of biochar carbon in soil. Besides carbon sink, biochar application significantly enhanced soil quality and crop yield (rice, wheat, maize, spinach, *etc.*). No adverse effect on soil microbial activity was observed even at the highest dose of biochar amendment (20 g kg⁻¹). This biomass carbonization to biochar is a novel approach to establish a significant, long-term, stable sink for atmospheric carbon dioxide in terrestrial ecosystems. Life cycle assessment of biochar system showed the net carbon conservation to the tune of 7.0 t ha⁻¹ y⁻¹. Notorious weeds like *Parthenium*, *Lantana*, *Eichornia*, *etc.* could be effectively managed by their conversion to biochar. In India there exists a vast potential for production of biochar from agricultural wastes and crop residues, otherwise left unutilized or burnt. Large scale application of biochar would result in the net removal of CO₂ from atmosphere and help mitigate global climate change. Biochar systems will have tremendous societal benefits, especially employment generation for rural livelihood.



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Studies on the Effect of Constructed Wetland Treatment on Sewage Water Quality

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An experiment was carried-out at Main Agricultural Research Station, Dharwad, Karnataka to study the effect of constructed wetland treatment on sewage water quality. The sewage water of the University Campus was passed through the constructed wetlands. The constructed wetland was a closed brick walled tank with the filter bed of 85 cm depth. The filter bed consisted of 50 a cm depth of gravel layer (~ 20 mm) at the bottom, a 25 cm depth of sand layer over the gravel, a 5 cm depth of charcoal layer over the sand layer and a 5 cm depth of red soil layer over charcoal. Both para and typha grasses were planted in the constructed wetland to act as a biological filter. The inlet (untreated) and outlet (treated) sewage water samples were collected periodically at 7 days interval and analyzed for various quality parameters.

The analytical results revealed that there was significant improvement in the quality of sewage water due to its passing through the constructed wetland. The mean value of BOD of the untreated sewage was 256 mg L⁻¹ which reduced to 118 mg L⁻¹ due to treatment. Similarly, the mean COD also reduced from 416 mg L⁻¹ to 250 mg L⁻¹ due to passing of sewage water through constructed wetland. The other quality parameters like SAR and RSC reduced drastically due to the treatment. The mean SAR reduced from 4.47 to 2.97 and mean RSC from 10.16 to 3.48 due to the treatment. The treated water showed higher values of NH₄-N (17 mg L⁻¹) and NO₃-N (4 mg L⁻¹) compared to untreated sewage water which were 12.3 and 1.33 mg L⁻¹, respectively.



Soil Quality Assessment of Cotton Growing Environs of Two Agroecological Subregions of Vidarbha, Maharashtra

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Soil quality (SQ) is a measure of soil's fitness to support crop growth without becoming degraded or otherwise harming the environment and hence assumes much significance. The study was conducted to assess SQ in cotton growing environs of two agroecological subregions of Vidarbha, Maharashtra, India, namely, AESR 6.3 and AESR 10.2. These two together cover major cotton growing areas of Vidarbha. Twelve profiles, representative of these areas were identified for the present study. A minimum dataset (MDS) of soil properties was developed using expert knowledge for assessing SQ. For the MDS, the various properties identified were depth, saturated hydraulic conductivity and clay percent (physical properties), exchangeable sodium percent (chemical property) and soil microbial biomass carbon (biological property). A number of methods are used for assessing SQ. A conventional method using the concept of relative soil quality index (RSQI) has been applied in the present study. The RSQI was computed for each pedon based on the five soil attributes, which are known to exert influence on crop productivity.

The RSQI was found to be highest in pedon 3 from AESR 6.3 and pedon 12 from AESR 10.2 and was found to be good quality soil. The RSQI values of both the AESR *viz.*, AESR 6.3 and AESR 10.2 were significantly correlated with average yield ($r=0.81$ and $r= 0.89$, respectively). The successful application of this method provides us to suggest that whenever we have such datasets (as used in the present investigation), we could use this method for reliably assessing and monitoring soil quality for similar agroecological setups.



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Carbon Balance Study using Ex-ACT Model developed by FAO in Nineteen Climatically Vulnerable Villages of South India

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A nation-wide project 'National Initiative on Climate Resilient Agriculture (NICRA) was implemented in 130 vulnerable districts (100 KVKs in eight zones; 23 AICRP on dryland agriculture centres and 7 technology transfer divisions of ICAR core institutes) involving one lakh farm families across the country with an aim to demonstrate integrated package of proven technologies for adaptation of crop and live stock production systems to climatic variability which includes maintenance and improvement of soil health for ensuring national food security as well as to ensure sustained livelihoods of farmers even in the extreme weather events with reduced GHG emissions. The selection of districts was done based on the climatic vulnerability data of past 30 years. The C balance was calculated using Ex-ACT tool developed by FAO as it uses thorough methodology to calculate C balance at village level. Three FAO divisions (TCA, TCI and ESA) jointly developed EX-ACT (EX-ante Appraisal Carbon-balance) tool aimed at providing ex-ante measurements of the impact of agriculture and forestry development projects on GHG emissions and Carbon (C) sequestration, indicating its effects on the C balance. EX-ACT consists of a set of linked Microsoft Excel sheets in which basic data on land use and management practices is to be inserted and EX-ACT adopts a modular approach – each “module” describing a specific land use and follows a three-step logical framework by which it calculates the final C balance. The overall C balance studied in seven climatically vulnerable villages (Nirmalpimri, Amaravathi, Aurangabad, Gondia, Nandurbar, Jalgaon KP and Haral) in seven districts (Ahmednagar, Takali, Shekta, Katangtola & Chandinitola, Umarani, Pune and Ratnagiri respectively) of Maharashtra ranged from -4848 to -25166 t CO₂e; the overall C balance was found to be negative suggesting a sink due to mitigation technologies. Similarly, the C balance in eight climatically vulnerable villages (Nandyalagudem & Boringthanda, Nacharam, Yagantipalli, Chamaluru & Chakrayapet, Matsyapuri and Sirusuwada) present in six districts (Nalgonda, Khammam, Kurnool, Anantapur, West Godavari and Srikakulam respectively) of Andhra Pradesh ranged from -3284 to -19238 t CO₂e and the overall C balance shown a sink due to mitigation technologies. When studied the C balance in four climatically vulnerable villages (Bilakundi, Siddanaru, S. Raghutthahalli and D. Nagenahalli) present in four different (Belgaum, Davanagere, Kolar and Tumkur) districts of Karnataka, it was found that C balance was positive in Belgaum suggesting a source for atmospheric CO₂ emissions with 1204 t CO₂e and the rest three has shown a sink with C balance of -10875, -11156 and -8648 t CO₂e respectively. All the villages studied shown a difference in their mitigation potential which in turn depends on adoption of number of mitigation technologies, crops taken up, land use change and the percentage of feeding and breeding practices followed in livestock and skeptical nature of farmers to fully accept and adopt the technologies. Thus, this model was successful in accounting ex ante measurements of green house gas (GHG) emissions in climatically vulnerable villages in India and also helps in quantifying the impacts of various agriculture management interventions in terms of carbon balance and potential.



Effect of Conservation Agriculture Practices and Balanced Fertilization on Yield, Nutrient Use Efficiency and Soil Properties in Maize (*Zea mays* L.)- Horsegram (*Macrotyloma uniflorum* L.) Cropping Sequence in Rainfed Alfisols

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Improving nutrient use efficiency (NUE) in rainfed condition is a major challenge for agricultural scientists. Conservation agriculture (CA) can play a major role in stabilizing production in rainfed regions by mitigating water and nutrient stress through adoption of reduced tillage, crop rotations and residue retention and also improve NUE. A field experiment was conducted during 2010-2012 in sandy loam soil of Gunegal Research Farm at Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad to study the effect of CA practices and balanced fertilization on performance of maize (DHM 117)-horsegram (CRIDA 18R) cropping sequence, the impact of CA on system productivity, nutrient use efficiency and profitability. Experiment was laid out in split plot design consisting tillage treatments (conservation and conventional) as main plot and nutrient management (control, NPKSZnB, individual N, P, K, S, Zn and B omission) as sub plot. Pooled data showed that seed (3.8 t ha⁻¹) and stover (5.6 t ha⁻¹) yields in maize in CA was on par with conventional system (CT). Significantly higher grain (5.3 t ha⁻¹), stover (6.5 t ha⁻¹) yields and harvest index (0.44) were realized with balanced fertilization with NPKSZnB. In case of horsegram, significantly higher yields (t ha⁻¹) were obtained in CA (0.36) compared to CT (0.24). Maize equivalent yield (4.37 t ha⁻¹) was higher in CA. Significantly higher nutrient uptake was observed in balanced fertilization treatment. Agronomic efficiency of N, P, K and S to the extent of 17.1, 25.0, 18.9 and 18.7% through adoption of CA practices. Available N, P, K status of soil was improved in CA. Soil organic carbon (SOC) and microbial biomass carbon (MBC) varied from 3.1-4.5 g kg⁻¹ and 31-89 µg g⁻¹, respectively in CA and it was slightly higher than CT (0.29-0.42 g kg⁻¹ and 28-78 µg g⁻¹, respectively). Higher MBC was found in case of balanced fertilization of NPKSZnB. KMO₄ oxidizable-C varied from 267-314 mg kg⁻¹ in CA. Very labile, labile and less labile C was in the range of 0.35-0.67, 0.11-0.23 and 0.12-0.4 mg kg⁻¹. Higher net returns (Rs. 26571 ha⁻¹) and B:C ratio (2.1) was obtained in CA compared to Rs. 22529 ha⁻¹ and 1.9, respectively in CT. Maize yields increased with adoption of CA and balanced fertilization in deficit rainfall year. Thus, CA with improved nutrient management can increase net primary productivity in rainfed condition besides improving soil health.



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Impact of Elevated CO₂ and Enhanced Rate of Fertilization on Crop Growth, Nutrient Content of Maize (*Zea mays L.*) and Sunflower (*Helianthus annus L.*) under Semi Arid Alfisols

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The rise in atmospheric CO₂ in the environment is the primary driver of global warming. There was an approximately 280 ppm of CO₂ concentration in preindustrial times which has been increased up to 384 ppm at present and may reach to 550 ppm and 700 ppm by 2050 and 2100, respectively. It is expected that elevated CO₂ concentration enhances the crop yields and correspondingly nutrient uptake in the rainfed crops. A pot experiment was conducted at Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad to study the effect of elevated CO₂ concentrations, on biomass and nutrient content of maize (*Zea mays L.*) and sunflower (*Helianthus annus L.*) in semi arid alfisols with different rate of NPK fertilization *i.e.* T₁=No fertilizer, T₂=120, 60, 40 and T₃=240, 80, 60 (N, P, K kg ha⁻¹), grown in Open top chambers under three CO₂ concentration viz., ambient control, 550 ppm and 700 ppm. The results showed that root: shoot ratio and leaf area in maize increased to 0.79% and 23.61%, 2.34% and 18.78% with 550 ppm and 700 ppm respectively with respect to control. Similarly, in sunflower root: shoot ratio and leaf area increased to 7.39% and 19.14%, 18.20% and 42.50%. The total biomass in maize and sunflower was increased by 12% and 15%, respectively in 500ppm CO₂ level and 26% and 18% in 700 ppm CO₂ level respectively with respect to ambient control. N, P and K content in maize increased as the CO₂ concentration increased. Whereas, in sunflower only N content was increased with elevated level of CO₂. Uptake of N, P, and K in maize was increased with elevated level of CO₂, where as in sunflower the increase was up to 550 ppm and thereafter decreased in 700 ppm. As CO₂ enrichment increased the yield and nutrient content of the crop, enhanced rate of fertilization is required to arrest the further depletion of nutrients in the soil.



Characterization of Tank Silt Sediments and Farmyard Manure as a Source of Nutrient in 100 Climatically Vulnerable Districts of India

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Soil is an important natural resource on which flora and fauna depend. Research priorities should find the best measures to conserve the soils for higher productivity and maintaining a healthy ecosystem. Indian Council of Agricultural Research (ICAR) in 2011 launched a network project “National Initiative on Climate Resilient Agriculture (NICRA)” for enhancing resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. India has various types of climate, landforms and soils. Therefore, selected villages in 100 districts were targeted based on their climatic vulnerability *viz*; drought, floods, heat wave, frost, cyclone and the available technology options. Increasing rainfall intensity is one of the climate vulnerability observed in recent times. Due to that silt sediments suspended as particulate matter through runoff water and settles at the bottom of water bodies as fine sediment. Soil fertility is declining due to top soil erosion in these areas. On the other hand, it is essential to remove sediments from water tanks to increase the rainwater storage capacity. Maintaining soil organic matter in tropical condition is a challenge due to high soil temperatures and long fallow period. Farmyard manure (FYM) is also one of the important sources of organic carbon (OC). An alternate use of FYM limits its application in agricultural field day by day. The study was conducted for characterization of removable tank silt sediments and FYM to develop a resource inventory as a possible source of soil carbon and nutrients and, to increase the awareness about the importance of organic resources for improving soil quality in these areas. The silt and FYM samples varied with their composition indicating variability across regions or catchments. Results showed that texture of tank silt was mostly clay loam. The pH (1:2.5 soil:water) was slightly acidic to alkaline. Due to fine particles, significant amount of total carbon and nitrogen was present with C:N ratio ranges between 1.71-136.18. The available potassium was higher in sediments compared to nitrogen (11-510 mg kg⁻¹) and phosphorus (1-67 mg kg⁻¹). FYM contained 0.047-0.95% of N, 0.018-1.42% of P and 0.12-1.89% of K. The study suggests feasibility of the application of tank silt to the agricultural fields for saving the crop nutrient, in addition to increased hydrological properties of soils. Application of 30 t ha⁻¹ tank silt to the field adds equivalent of (kg) N, P, K, 351, 42, 729, respectively. Linking up of Govt. developmental programme such as Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), Integrated Watershed Management Programmes (IWMP), Agricultural Technology and Management Agency (ATMA) for desilting, transportation and for application of tank silt sediments can upscale its use.



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EDTA Assisted Phytoremediation of Chromium Contaminated Soil using Maize (*Zea mays* L.)

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Phytoextraction is an efficient, cost-effective method for *in-situ* treatment of contaminated soils. Addition of chelating agents (EDTA) increases heavy metal (chromium) bioavailability and solubility in soil and subsequently enhances heavy metal uptake by a plant. Present investigation was conducted to study the effect of EDTA assisted phytoremediation of chromium contaminated soil using maize. The growth parameters like plant height, fresh weight of plant were recorded. The harvested maize crop was analyzed for the macronutrients (N, P and K), micronutrients (Fe, Cu, Mn and Zn) and heavy metal (Cr) following the standard procedures. Biomass of maize compound was positively increased with the application of EDTA. The maximum values for EDTA extractable Cr in soil were 3.24, 3.51, 4.06 and 4.50 mg kg⁻¹, respectively, which have shown an increase of 7.7, 8.35, 9.6 and 10.71 times respectively, over control. The nitrogen, phosphorus and potassium content in maize increased significantly due to application of EDTA compound. Application of EDTA compound had significantly increased the Fe, Cu, Mn and Zn content in maize. Maximum value recorded for Fe, Cu, Mn and Zn content in maize were 727.42, 42.39, 71.43 and 64.79 mg kg⁻¹, respectively which showed about 4.3, 4.5, 6.8 and 7.1 times increase over their respective controls. Maximum content of Fe, Cu, Mn and Zn in maize was recorded in treatment where EDTA was applied. Application of EDTA compound had significant effect on Cr content in maize. The uptake of Fe, Cu, Mn and Zn in maize also increased with the application of EDTA compound. The maximum values reported were 8.2, 0.50, 0.5 and 0.53 mg pot⁻¹ for Fe, Cu, Mn and Zn, respectively which increased by 9.2, 2, 2.9 and 2.3 times over the control. The uptake of Cr in maize also increased with the application of EDTA compound. The maximum values recorded in maize were 0.17 mg pot⁻¹ for Cr which was increased by 3.4 times over the control. This study points out that EDTA compound provided feasible conditions for plants to take metals from soil. EDTA increased uptakes of Cr 3-4 times as compared to control. EDTA was found a good chelating compound. Hence, supplementing soil with a synthetic chelating agent such as ethylene diaminetetraacetic acid (EDTA) is an efficient method to enhance heavy metal uptake by plants for facilitating phytoremediation. However, a careful assessment of the characterization of soil as well as plant species to be grown is required prior to application of EDTA compound.

Commission 4.2: Soils, Food Security, and Human Health



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Evaluation of Different Forage Crops under Silviculture System for Fodder Production, Quality and Effect on Soil Properties

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A field experiment was conducted in sandy loam soils at AICRP on Forage Crops, ARI, Rajendranagar, Hyderabad for four years i.e. during 2010-11 to 2013-2014 to explore the fodder potential of various crops and their influence on soil fertility and intercrops under subabul based rainfed silvipastoral system. Subabul was the main crop and a combination of crops including annuals, perennials, cereals and legumes were studied to aim at highest green fodder production in whole year through resource conservation under rain fed conditions. Crops *viz.*, sorghum, bajra along with intercrop of horse gram in 3:1 ratio, while perennial crops *viz.*, *Cenchrus ciliaris* (anjan grass), *Stylo* and *Desmanthes* were grown in solo as well as intercropped with either of the perennial crops. Among different silvipasture systems studied growing of Subabul + BN hybrid + *Desmanthus virgatus*, intensive silvipasture system being at par with Subabul + BN hybrid + *Stylosanthes* system recorded significantly higher GFY (33.9 t ha⁻¹), DMY (7.27 t ha⁻¹) and fetched highest net monetary return (Rs 44074/ha/yr) and BC ratio (3.75) over rest of the silvipasture systems. However, subabul + *Desmanthus virgatus* fodder production system treatment recorded significantly higher crude protein yield (1.13 t ha⁻¹) over rest of the treatments. The intensive silvipasture system also caused remarkable changes in soil fertility after fourth year of cropping cycle. The growing of subabul + BN hybrid + *Desmanthus virgatus*, silvipasture system resulted in higher available N (260.7 kg N ha⁻¹), and K (586.8 kg K ha⁻¹) over rest of the treatments while organic carbon (0.32%) was highest in Subabul + Bajra napier hybrid + *Stylosanthes* system. The higher level of available N and P in soil was recorded over its initial level under all the intensive forage production systems

Commission 4.3: Soils and Land Use Change



79th Annual Convention: November 24-27, 2014
National Seminar on Developments in Soil Science: 2014

Physicochemical and Micronutrient Status of Soils from *Lasiurus sindicus* Grassland of Chandan in Western Rajasthan

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Forty eight soil samples were collected from 12 selected sites at four different depths (0-15, 15-30, 30-45 and 45-60 cm) from grassland predominantly consisting of *Lasiurus sindicus* (*Sewan*) at Central Arid Zone Research institute experimental area, Chandan (26°50'41" N, 71°20'10" E and 195m above mean sea level), Jaisalmer for physicochemical and micronutrient characterization. The results indicate that the soils are non-sodic and have the texture varied from sandy loam to sandy clay loam texture with mildly to moderately alkaline pH (7.6 to 8.5). The soil organic carbon (SOC) content varied from 0.12 to 0.19 per cent up to a depth of 30 cm. These soils have DTPA extractable zinc and iron content below critical limit, *i.e.* <0.6 and <4.5 mgk g⁻¹ respectively, but showed marked variations with depth whereas copper and manganese contents are in sufficient range (Cu: 0.2 < and Mn: >2 mg kg⁻¹) with perceptible increase in their content with depth. The zinc and iron deficiency in soils are attributed alkaline pH, calcareousness, and low clay content and soil organic matter in the region where evaporation far exceeds precipitation. It is important to protect top soil from wind erosion to minimize the loss of nutrients and SOC by growing denser root crops such as cluster bean, pearl millet and grasses like *Lasiurus sindicus*.



Carbon sequestration through IPNS and it's Effect on Soil Properties under Soybean-Chickpea Cropping System on Inceptisols of Rainfed Agriculture

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Carbon sequestration through IPNS and it's effect on soil properties under soybean-chickpea cropping system on Inceptisols of rainfed agriculture was undertaken during 2013-14 at Dr. PDKV, Akola. The experiment was laid out in randomized block design with eight treatments and three replications. The objectives were to evaluate the effect of IPNS on carbon sequestration and its effect on soil properties. The treatments comprised of unfertilized control, chemical fertilizers alone and their combinations with organics *viz.* FYM, phosphocompost and cotton stalk. The soil of experimental site was medium black belongs to Inceptisol particularly Vertic Haplustepts.

Based on the observations it was observed that comparatively higher organic carbon (6.58 g kg^{-1}) was recorded with conjoint use of chemical fertilizers and FYM followed by integration of chemical fertilizers with phosphocompost (6.37 g kg^{-1}) and cotton stalk (6.27 g kg^{-1}) under soybean-chickpea sequence. Similarly, use of only organics (FYM, phosphocompost and crop residues) recorded higher microbial biomass carbon ($246.18 \mu\text{g g}^{-1}$ soil) and microbial biomass nitrogen ($41.77 \mu\text{g g}^{-1}$ soil) as compared to sole use of chemical fertilizers ($30.48 \mu\text{g g}^{-1}$) indicating the importance of organics for enriching soil quality. The use of organics *viz.* FYM, phosphocompost and cotton stalk in conjunction with chemical fertilizers improved physical, chemical and biological properties. The results revealed that integrated nutrient management system in soybean-chickpea cropping system enhanced carbon sequestration due to improved crop productivity and greater below ground carbon transport to the soil through root, nodule and rhizodeposition biomass. The highest amount of biomass and carbon sequestration in terms of CO_2 was found in the treatment 100% RDF through inorganic fertilizer with FYM @ 5 t ha^{-1} . Hence, amalgamation of organic sources along with inorganic fertilizers is the most vital way to maintain sustenance of soil productivity as well as fertility in the changing climate scenario of rainfed agriculture.

Commission 4.5: History, Philosophy, and Sociology of Soil Science



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Economic Evaluation of Recommended Fertilizer Applications under Farmers' Field Conditions

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Judicious use of fertilizers is must for obtaining optimum crop yields. Maximum use efficiencies of applied fertilizers can be obtained if these are applied in optimum amount, at optimum time and by optimum method. State Agricultural Universities and central research institutes have recommended various improved practices of fertilizer application based on location specific crop rotations and soil conditions. These recommendations are demonstrated to the farmers for enhancing their adoption. Benefits of these practices needs to be demonstrated in terms of economic output. Demonstration were conducted at farmers' fields during the period of 2009 to 2012 in Hoshiarpur district of Punjab at 52 locations and their economic evaluation was done.

Soil test based fertilizer application resulted in saving of 10 to 15 kg ha⁻¹ phosphorous under medium to high available phosphorous soil conditions and saving of 60 kg P ha⁻¹ under very high available soil phosphorous conditions in case of wheat crop without any yield loss as compared to farmers' practice. This saving in phosphorous resulted in saving of Rs. 440 to Rs. 660 per ha under medium to high P soils and Rs. 1200 per ha in case of very high P soils. There is a significant build-up of phosphorous in soils because of non-judicious use of phosphatic fertilizers. It is recommended that skip phosphorous fertilizer application in *kharif* season for maize and paddy crops, if its recommended dose has been applied in preceding *rabi* crop. This practice helps in saving 30 kg P ha⁻¹ without any yield loss in case of paddy and maize crops as compared to farmers' practice, thus economic benefit of Rs. 660 per ha was obtained. Application of 30 kg potassium ha⁻¹ in potassium deficient soils resulted in five per cent higher grain yield both in case of wheat and paddy crops. The additional income of Rs. 3400 per ha was obtained with additional expenditure of Rs. 480 per ha. Thus B:C ratio comes out to be 7.1. For site specific nutrient management, leaf colour chart (LCC) has been recommended for nitrogen application in case of paddy, wheat and maize crops. Use of LCC in paddy resulted in saving of about 30 kg nitrogen ha⁻¹ as compared to farmers' practice and about 15 kg ha⁻¹ as compared to soil test recommended dose without any yield loss, thus saving of Rs. 100 to Rs. 200 per ha without any additional cost. In case of wheat crop this saving was about 35 kg ha⁻¹ as compared to farmers' practice and 15 kg ha⁻¹ as compared to soil test recommended dose of fertilizer nitrogen.

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