NATIONAL SEMINAR

ON

DEVELOPMENTS IN SOIL SCIENCE – 2015

ABSTRACTS

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Indian Society of Soil Science
5-8 December 2015

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held at the
University of Agricultural Sciences, Bangalore

Abstracts

Indian Society of Soil Science

National Agricultural Science Centre Complex
Dev Prakash Sastri Marg, Pusa, New Delhi -110 012
Phone : 0091-11-25841991; 25841529
Email: isss1934@gmail.com; isss.secretary@gmail.com
Web page : www.isss-india.org

ABSTRACTS: NATIONAL SEMINAR ON DEVELOPMENTS IN SOIL SCIENCE – 2015

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Phone : 0091-11-25841991; 25841529
Email: isss1934@gmail.com; isss.secretary@gmail.com
Web page : www.isss-india.org

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Dinesh*, K.S. Grewal and R.S. Antil
Department of Soil Science, CCS HAU, Hisar, 125004, Haryana
**Email: dineshtomar@hau.ernet.in*

A detailed soil survey of Krishi Vigyan Kendra farm Damla (Yamunanagar) which is situated at about 7 km from Yamunanagar, Haryana and lies between 30° 04.806' N latitude and 77°12.893" E longitude was carried out. It extends over an area of 59 acres and which is accessible by road and railways. Geologically, the area constitutes part of Indo-Gangetic alluvial plain and belongs to the Pleistocene age. The physiographic units found in the study area are old and recent flood plains of Yamuna River. The area has a plain topography and gentle slopes with existence of micro-relief variation. The climate of the area is sub-tropical, continental, dry sub-humid and monsoonal type. The average annual rainfall is around 800 to 900 mm, about seventy per cent of which is received during July to September.

The objective of the study was to characterize the soils of research farm and classify them as per Soil Taxonomy and group them according to their capability classes for optimum micro level planning. For this, entire area of the farm was traversed on foot and with the help of post-hole auger, the soils were examined at an interval of 100-150 m depending upon the variation in the soils. Two profiles were exposed, one in each physiographic unit having similar soil, to study detailed morphological characteristics. Soil samples from different horizons of the profiles and surface samples from fields were also collected for their physico-chemical analysis in the laboratory as per the standard procedures. The pH and EC ranged from 7.50 - 7.85 and 0.15 - 0.22 dS m^{-1}. The organic carbon in the farm soil was found low to medium (0.15% - 0.72%) The available phosphorus was found medium to high and available potassium high in the study area. Among the micronutrients except Zn which was found most deficient, none of the samples falls under deficient category for Fe, Mn and Cu micronutrients. The soils were classified as: fine loamy, mixed, hyperthermic, Typic Haplustepts. The soils of the farm were very good cultivable land and hence they were placed in land capability classification as class I. These soils have less limitation for sustained use under irrigation thus are placed in class A. The soil suitability classification is determined by matching the soil characteristics and land use requirements of different crops. It was found that these soils were moderately suitable for wheat, mustard, rice berseem, sugarcane and horticultural and forestry plantation and marginally suitable for bajra and sorghum.

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Survey and Characterization of Underground Water Quality of Fatehpur Sikri and Akola Blocks in District Agra of Uttar Pradesh

P.K. Shishodia*, R.S. Chauhan and R.B. Singh

AICRP on Management of Salt-affected Soils and Use of Saline Water in Agriculture, R.B.S. College, Bichpuri, Agra, 283105, Uttar Pradesh

**Email: pkshishodia1969@gmail.com*

Water is essential natural resource for sustaining all kinds of living beings and their environment. Irrigation water is one of the most critical but scare resource for agricultural production in India. Indiscriminate use of poor quality water leads to development of salinity, sodicity and toxicity in the soil. To assess quality of underground irrigation water samples of Fatehpur sikri and Akola blocks of Agra district in state of Uttar Pradesh were collected and analyzed for electrical conductivity (EC), residual sodium carbonate (RSC) and sodium adsorption ratio (SAR) and presence of toxic acids.

The EC, SAR and RSC ranges from 2.1 to 26.3 dS m^{-1}, 8.4 to 55.1 $(mmol/L)^{1/2}$ and 0 to 13.8 $cmol(p^+)kg^{-1}$ in Fatehpur sikri block and 2.0 to 19.5 dS m^{-1}, 7.5 to 38.6 $(mmol/L)^{1/2}$ and 0 to 28.2 $cmol(p^+)kg^{-1}$ in Akola block, respectively. After analysis no sample was found in good category (A) class in both the blocks, whereas, 90 per cent as saline (B) and rest 10 per cent samples comes under Alkali (C) class in Fatehpur sikri block. In Akola block 85 per cent samples in alkali (B) and rest 15 per cent saline water (C) are found. Saline waters are further categorized under marginally saline (B_1-6.7%), saline (B_2-3.4%) and high SAR saline (B_3-80%) classes in Fatehpur sikri block, whereas in Akola block the waters are categorized as marginally saline (B_1-5%), saline (B_2-Nil) and high SAR saline (B_3-80%). The alkali waters are again sub grouped under marginally alkali (C_1-Nil), alkali (C_2-Nil) and high alkali (C_3-10%) in Fatehpur sikri whereas, in Akola block the quantum of such classes are as, marginally alkali (C_1-Nil), alkali (C_2-2.5) and high alkali (C_3-12.5%). The waters are of Na>Mg>Ca>K types with the dominance of chlorides. In both the blocks, the poor quality water was found.

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Morphological and Physicochemical Characteristics and Classification of Vertisols Developed in Different Agro-ecological Regions of India

Priya P. Gurav, S.K. Ray and Pushpajeet L. Choudhari
National Bureau of Soil Survey and Land Use Planning, ICAR, Nagpur, 440033, Maharashtra

Vertisols have the capacity to swell and shrink, inducing cracks and distinctive soil structure throughout the soil profile. The formation of these specific features is caused by a heavy texture, a dominance of swelling clay and marked changes in moisture content. In India they occur in various agro-ecological regions such as humid tropical (HT), sub-humid moist (SHM), sub-humid dry (SHD), semi-arid moist (SAM), semi-arid dry (SAD) and arid dry (AD) climatic environments and thus indicates an array of soils in a climosequence. In this study benchmark Vertisols, Panjari and Kheri are from sub-humid (moist) region, Teligi and Akola soils are from semi-arid (dry) and Nimone is from arid agro-ecological region. All the Vertisols are characterized by dark colour in surface soil, angular to sub-angular blocky structure, clayey texture, and slight to strong effervescence from upper to lower horizon of the soil profiles. These soils have high bulk density and high water retention capacity. The particle size distribution indicates all the soils are clayey with less amount of sand. In addition, they have deep wide-opened desiccation cracks at the surface which extend deep into the profiles and the depth of cracks increase with increase in aridity. The slickensides are found beginning at a shallower depth in arid climate, whereas they are observed at lower depths in wetter climates. Soils of all climates are dominated by Ca^{2+} ion in their exchange complex throughout the depth. However, in the sub-humid climate Mg^{2+} ions tends to dominate in the lower horizon. The semi-arid dry (Akola) soils have high Na^{+} ions in soil solution. This facilitated the translocation of Na-clay in the soil profile and is responsible for the increase in pH. Chemically the studied soils are slightly alkaline to alkaline in nature and poor in organic matter. The CEC varied from 40.8 to 50.18 cmol(p^{+})kg^{-1} in Panjari series profile which is highest followed by Teligi series profile. The calcium carbonate ($CaCO_3$) shows gradual increase with depth in all the soil profiles, though it is preferentially accumulated in the sub-surface horizons of lower rainfall region soils.In climosequence the soils of the sub-humid region are generally Typic Haplusterts, soils of semi-arid region are Typic/ Sodic/Calcic Haplusterts and soils of arid region are Sodic/ Calcic/ Aridic Haplusterts. The available potassium content (1 *N* NH_4OAc extractable) of these soils is very high and available nitrogen is low. The potassium content in sub-humid moist (kheri) soil is high in surface horizon followed by semi-arid dry (Akola) soil. The ratio of exchangeable to non-exchangeable K varied from about 1:4 to 1:7. The variation is mainly due to mixing of different parent materials during the process of their formation.

Commission 1.2: Soil Geography

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Study of Soil Salinity in relation to Land Use in Coastal West Bengal using Remote Sensing and GIS

Shishir Raut, B. Maji, S.K. Sarangi, S. Mukhopadhyay[1] and T.D. Lama
ICAR-Central Soil Salinity Research Institute, Regional Research Station, Canning Town, S24PGS, 743329, West Bengal
[1]NBSS & LUP, Regional Centre, Kolkata, West Bengal

The coastal areas of West Bengal mostly suffer from high soil salinity. The principal crop cultivated in the area is rice. Assessment of soil salinity is a need to improve crop yield for the area. IRSP6 L3 satellite data for 12th April, 2013 were collected from NRSA. SOI maps and soil salinity maps were also collected from related organizations and were the inputs in GIS. Land use map for 2013 *rabi* season was prepared for the study area in ARC-GIS v.10. From the satellite data a normalized difference vegetation index (NDVI) map was prepared. Soil samples in replicates were collected from cultivated and fallow lands for determining EC and pH. Results showed that out of 1327 sq km study area cultivated area was around 534 sq km and fallow land was around 99 sq km. The study area mainly comprised of four soil series namely, Sonakhali series, Gosaba series, Nikarighata series and Tangrakali series. Salinity varies from 2-5 dS m^{-1}, 5-10 dS m^{-1} and >10 dS m^{-1} from west to east direction. From last five years of study it was found that rice yield was low in the area mainly due to soil salinity and there was no significant change in the area of *rabi* rice cultivation as practised by the farmers. In general, with an increase in EC (1:2) value of soil, there was a decrease in NDVI values for agricultural lands. EC (1:2) of soil was better correlated with NDVI in uncultivated fields than cultivated ones.

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Generation of Fertility Maps using Interpolation Techniques in GIS Platform for Honnenahalli Micro-watershed, Davanagere District, Karnataka

V.R. Ramakrishna Parama, A. Sathish, G.S. Praveen, G.P. Geetha, L. Rajashekar and Y. Shruthi

Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, GKVK, Bangalore, 560065, Karnataka

A study was conducted in Honnenahalli micro-watershed which is situated between 75°54′54.21′′ to 75°54′17.7′′ E longitude and 14°35′96.6′′ to 14°37′17.54′′ North Latitude, Davanagere district, Karnataka to prepare soil fertility maps using geospatial techniques. The cadastral map showing parcel boundaries served as the base map. A grid of 250 m^2 spacing was overlaid on the cadastral map for the study. There were 129 grids in the micro-watershed covering an area of 963 ha from which soil samples were collected. The soil samples were processed and analyzed for major, secondary and micronutrients using standard procedures. The status of N, P and K was medium in majority of the area, sufficient in Ca, Mg and S and Fe, Mn, Zn, Cu. In some patches the nutrients were low resulting in deficiency symptoms. The fertility maps indicating soil reaction, salinity, organic carbon and the major, secondary and micronutrient content were prepared using Krigging technique in Arc GIS, which is one of the most widely used interpolation technique. The maps prepared would indicate the actual fertility status of microwatershed. Based on the nutrient status, fertilizer can be recommended based on crops grown for enhancing crop productivity. The fertilizer consumption can be regulated so cost of cultivation is minimized and also balanced nutrition to crop is made provided.

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Mapping and Characterization of Salt-affected Soils in Fatehabad District of Central Haryana for Reclamation and Management

A.K. Mandal, Ranbir Singh, P.K. Joshi and D.K. Sharma
Central Soil Salinity Research Institute, Zarifa Farm, Kachhwa Road, Karnal, 132001, Haryana

Salt affected soils in Fatehabad district of central Haryana were characterized and mapped based on the image interpretaion (IRS LISS III 2009-10), soil profile studies and laboratory characterization of soil samples. Image interpretation revealed considerable areas of salt affected soils along the Ghaggar plain. In the canal irrigated areas, waterlogging and secondary soil salinization appeared along in the sandy tract with no or imperfect internal soil drainage. In absence of fresh water for irrigation, the use of poor quality ground water for irrigation is a common practice. The continuous use of such water caused salt enrichment in soil profiles causing the low productivity. At places, physical properties of soils deteriorated and movement of water and nutrient were restricted causing temporary waterlogging. The satellite imageries also corroborate such incidences showing high water absorption at surface. In the irrigated areas it showed localized patches of water stagnation along the canal and the incidences of salt efflorescence were identified by higher spectral reflectance from salty surfaces.

The physicochemical properties of pedon 1 (P1) indicated moderately alkaline soil (pHs 8.9 to 9.2), the dominance of carbonates and bicarbonates of sodium, high to very high (49 to 70) ESP and sandy loam to loam soil texture. P2 is a severely saline soils (ECe 10.5 to 46.5 dS m^{-1}) located in the irrigated areas, showing the dominance of sodium (69.7 to 472.0 cmol(p^+)kg^{-1}), calcium + magnesium (80 to 200 cmol(p^+)kg^{-1}), chloride(268 to 1210 cmol(p^+)kg^{-1}) and sulfate (121 to 739 cmol(p^+)kg^{-1}). The depth wise $CaCO_3$ content (1.1 to 4.9%) showed the increasing trend of stratification. The soils were alkaline (pHs 9.0 to 9.5) in areas irrigated by sodic ground water (P3). Sodium and carbonates were dominant ions and the ranges of ESP values (21 to 37%), indicating slight to moderately sodic soil. Higher clay content at surface soil indicated impermeable strata that resulted in temporary waterlogging. P4 is slightly alkaline soil (pHs 8.7 to 8.8) located along the Ghaggar plain and salt composition is dominated by sodium (13.3 to 22.2 cmol(p^+)kg^{-1}), carbonates and bicarbonates (2 to 10 cmol(p^+)kg^{-1}) and soil texture ranges from sandy loam to sandy clay loam for reclamation and management, P1 needs treatment with gypsum, P2 requires interventions with sub-surface drainage, P3 and P4 should be irrigated with ground water following treatment by gypsum. The chemical properties of water samples showed slight to moderately sodic (pH_{iw} 8.4 to 9.7) nature, the dominance of sodium (7 to 36 cmol(p^+)kg^{-1}), carbonates and bicarbonates (3 to 12 me L^{-1}) and the presence of calcium, magnesium (8 to 14 cmol(p^+)kg^{-1}) and chlorides (10 to 18 cmol(p^+)kg^{-1}). The SAR values showed> 10 in Tohana block, while RSC (4 cmol(p^+)kg^{-1}) was also reported at selected place.

The salt affected soils occupied 11614 ha (4.6%) in Fatehabad district. These were distributed in four blocks *viz.*, Fatehabad (1.1%). Tohana (1.1%) and Bhuna (1.3%) blocks. Sodic and saline soils occupied 7200 ha (62%) and 4414 ha (38%), respectively. Sodic soils covered 2689 ha (23%) in Tohana, 2460 ha (21%) in Fatehabad and 1216 ha (11%) in Bhuna blocks, respectively. Saline soils were located prominently in Bhattu Kalan (1976 ha, 17%) block.

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Socio Economic and Biophysical Determinants of Fallow Lands in Tamil Nadu- A Case Study in Nanguneri Block

S. Dharumarajan*, M. Lalitha, Rajendra Hegde and S.K. Singh[1]

ICAR- National Bureau of Soil Survey and Land Use Planning, Hebbal, Bangaluru, 560024, Karnataka
[1] ICAR- National Bureau of Soil Survey and Land Use Planning, Amaravati Road, Nagpur, Maharashtra
**Email: sdharmag@gmail.com*

Recognising the socio-economic and biophysical determinants of fallow lands is important for designing the policies to arrest the increasing trend of fallow lands. The present study was carried out to assess the extent of fallow lands in Nanguneri block of Thirunelveli using Resourcesat-2 LISS IV merged with Cartosat-1 data complemented by field checks. The land resources were characterised and the biophysical and socio-economic factors responsible for the increasing fallow lands were identified. The survey revealed that 41.3 per cent of total geographical area (TGA) in Nanguneri block is identified as other fallow lands. The biophysical survey revealed that 66.4, 83.3 and 12.5% of fallow lands are suffering from depth, calcareousness and erosion constraints, respectively and about 51.3% of fallow lands are affected by slight to strong alkaline problems. The results of micronutrients analysis shows that 39.9, 95 and 100% of fallow land soils are deficient in available Fe, available Cu and available Zn content, respectively. To identify the causative factors for fallowing of lands, the constraints faced by the farmers were collected from farm survey and analyzed. The results revealed that inadequate capital, low profitability in agriculture and labour scarcity are identified as major socio-economic factors for increasing fallow lands. Size of farm holding, non-agricultural income, distance to road and depth of water table had positive correlation on increasing fallow lands. Based on biophysical and socio-economic constraints, the land resources of fallows were evaluated for other alternate land use options and policy measures were suggested.

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Delineation and Mapping of Soil Available Calcium and Magnesium Status in Selected District of Tamil Nadu using GPS and GIS Techniques

T. Anusuya[1] and V.P. Duraisami[2]

[1]Department of Soil Science and Agricultural Chemistry, TNAU, Coimbatore, Tamil Nadu
[2]DNRM, TNAU, Coimbatore, Tamil Nadu

The significance of secondary nutrients in agriculture production has been increasingly recognized in recent years. Calcium (Ca) is a constituent of cell wall and essential for stability of cell membranes in the plants. It makes up about 3.6 per cent of the earth's crust. Magnesium (Mg) is a structural component of chlorophyll thus is indispensable for photosynthesis by plants. The earth's crust contains about 2.0 per cent Mg. The magnitude of Ca and Mg deficiency will vary according to the degree of soil acidity and base saturation.

A study was carried out in selected districts *viz.*, Tirunelveli, Thoothukudi, Pudukottai, Ramanathapuram, Virudhunagar, Theni and Kanyakumari of Tamil Nadu to assess the available Ca and Mg status in the soils to prepare thematic maps based on the nutrient availability and fertility rating class and depicts the severity of Ca and Mg deficiency status at block level.

Totally 9815 geo-referenced surface soil samples covering the selected districts of Tamil Nadu were collected randomly at 0-15 cm depth by adopting the standard procedures of soil sample collection. The global positioning system (GPS) data (Latitude ºN and Longitude ºE) were collected from each sampling sites distributed over the entire districts by using Garmin GPS (76CS model). Locations of soil sampling sites of selected district were marked on base map on 1:50,000 scales prepared from State Revenue Maps and digitized using Arc-info GIS 9.3. The surface soil samples were analyzed for available Ca and Mg content following standard analytical procedure.

The results showed that among the seven districts, Ca appears to be deficient in soils of Thoothukudi (54.9 per cent), Pudukottai (46.3 per cent) and Kanyakumari (55.4 per cent) districts. On the other hand, the available Mg was found to be deficient to the extent of 64.5 per cent and 56.7 per cent in Pudukottai and Kanyakumari districts, respectively.

Regarding the remaining districts, Tirunelveli found to have adequate available Ca. While, Tirunelveli, Thoothukudi, Theni and Ramanathapuram districts observed to be adequate in soil available Mg status. However, in the districts of Ramanathapuram, Virudhunagar and Theni the availability of Ca was found to be higher and Virudhunagar was also noticed with higher magnesium status.

Therefore, to overcome the deficiencies of Ca and Mg, there is a need for supplementation of Ca and Mg containing inorganic fertilizers in the fertilizer scheduling in Thoothukudi, Pudukottai and Kanyakumari districts. For the locations having high available Ca or Mg status, the existing fertilizer practices can be followed.

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Status of Available Boron in Tomato Growing Soils of Thoothukudi district, Tamil Nadu

P.P. Mahendran*, C. Sundarapandian, C. Udayasoorian and P. Balasubramaniam
Agricultural College and Research Institute, TNAU, Killikulam, 628 252, Tamil Nadu
**Email: ppmahendran2002@yahoo.co.in*

Boron (B) deficiency has been realized as the second most important micronutrient constraint in crops after that of zinc (Zn) on global scale. In recent times, the yield potential of many crops could not be realized owing to the widespread micronutrient deficiencies noticed in different parts of Tamil Nadu. Though tremendous research works were carried out on the cationic micronutrients in soil, relatively little attention was given to anionic micronutrients particularly B in soils of Tamil Nadu. Realising the gravity of the emerging problems of micronutrient deficiencies and the immediate need to manage these efficiently, the present investigation was carried out with the main objective of delineating the B deficient areas in the tomato growing blocks of Thoothukudi district, Tamil Nadu. In order to delineate the B-deficient areas, a systematic survey was undertaken and two hundred and fifty surface soil samples representing eight tomato growing blocks of Thoothukudi district (50 villages @5 samples/village) were collected randomly using Garmin GPS 76CS model and analyzed for various soil properties and available B using hot water extractable method (Azomethine-H).

There was a wide variation among soils of tomato growing blocks in physical and chemical properties in terms of texture, soil reaction, EC, organic matter, $CaCO_3$ and iron and aluminium oxides. The texture of soils ranged from coarse to fine textured with the varying textural classes of sand, loamy sand, sandy loam, sandy clay loam, sandy clay and clay. The soils were mildly acidic to alkaline reaction, non-saline and low to high in organic carbon content. The sesquioxides were generally high in some of red soils. The wide variation in CEC of soils was mainly due to quantity and quality of clays.

The hot water soluble B was significantly and positively correlated with clay, silt, pH and organic carbon whilesand and $CaCO_3$ contents were negatively correlated with available B. Stepwise regression analyses showed that clay, pH and EC together accounted for 53 per cent of the variation in the water soluble B.

The available B (hot water soluble B) content ranged from 0.03 to 1.91 mg kg^{-1} in soils of the study area. Based on the existing classification, available B less than 0.5 mg kg^{-1} shall be considered as low, 0.5 to 1.0 mg kg^{-1} as medium and more than 1.0 mg kg^{-1} as high in B availability. Based on this classification, the plant available B in tomato growing blocks of Thoothukudi district was grouped into deficiency and sufficiency status indicating that the availability of B was low in 62.4 per cent of soils cautioning seriousness of B deficiency, medium in 10 per cent of the samples and high in 27.6 per cent of the soils. Hence, the soils analyzing available B of less than 0.5 mg kg^{-1} need balanced fertilization including B to avoid its deficiency.

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Testing the Accuracy of Spatial Interpolation Methods for Mapping Soil Properties

Nisha Sahu*, G.P. Obireddy, Nirmal Kumar, M.S.S. Nagaraju, Rajeev Srivastava and S.K. Singh

ICAR-National Bureau of Soil Survey and Land Use Planning, Amravati Road, Nagpur, 440 033, Maharashtra

**Email: nishasahu5@gmail.com*

A study was conducted to interpolate and to explore the analysis of spatial variability of major soil nutrients in Basaltic Terrain of Nagpur district, Maharashtra. A total of 235 soil samples (0-25 cm) were collected grid wise at an interval of 250 m using GPS. Soil chemical properties *i.e.* available nutrients (N, P and K) were measured in laboratory. After normalization, data were interpolated by Ordinary Kriging (spherical, exponential and gaussian) and inverse distance weighted (IDW) with power 2. The performance of methods was evaluated using mean absolute error (MAE), root mean square error (RMSE) and goodness of prediction (G) obtained from a cross-validation procedure. The results showed that geostatistical method had a higher accuracy compared to IDW. Ordinary Kriging (spherical model) was the best method to estimate available N and K whereas Gaussian Model fits well with highest precision for estimation of available P in this area. Available P and K have displayed moderate spatial dependence whereas Available N showed strong spatial dependence. Cross validation of kriged map showed that spatial prediction of soil nutrients using semi variogram parameters is better than assuming mean of observed value for any unsample location. Therefore, it is a suitable alternative method for accurate estimation of soil properties in unsampled positions as compared to direct measurement which has time and costs concerned.

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Suitability Classification of the Soils of Buraka Micro-watershed in Mewat District of Haryana

S.K. Mahapatra, Jaya N. Surya, Ram Gopal, Tarsem Lal and R.P. Yadav
ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, IARI Campus. New Delhi, 110012

Land and water are the basic natural resources and form essential inputs to agricultural productivity. These resources have to be used carefully and conserved for sustainable development. Keeping this view in mind, a study has been undertaken in Buraka micro-watershed in Mewat district of Haryana for sustainable land use. The area of the watershed is 635 ha comprising Buraka, Panchgaon and part of Chila and Gwarka villages. The elevation ranges from 266 to 335 m above MSL and slope varies from nearly level to moderately steep slopes. The geology is sandstone, quartzite and alluvium. Major crops grown are bajra, wheat, jowar, mustard and pigeon pea.

The detailed soil survey had been conducted using satellite image data (IRSP6 LISS IV) and Survey of India toposheet and by studying mini pits and master pedons. Eleven soils have been identified and mapped into 21 soil mapping units as phases of soil series. Soils of hill slopes are shallow, gravelly sandy loam, brown in colour and classified as loamy skeletal Lithic Ustorthents. Soils of inter hill basin are deep, calcareous, loamy sand, yellowish brown colour and classified as calcareous, Typic Ustipsamments. Soils of piedmont plains are deep to very deep, loamy sand to sandy loam in texture, both calcareous and non calcareous, brown to dark yellowish brown in colour and classified as Typic Ustipsamments and coarse loamy Typic Haplustepts. On the basis of their characteristics and limitations soils have been classified into land capability units. Major soils belong to land capability unit Iles1 (18.71%), followed by 11s1 (16.76°/0), Illes1 (15.50%), I Iles2 (9.18%), VIles2 (8.15%), Vies1 (7.36%), IVes1 (6.88%), VI les1 (5.97%), IVes2 (3.34%) and Iles2 (2.64%), respectively. Soils were also classified into land irriaability units on the basis of limitations and potentials for irrigation. Major soils belong to land irrigability unit 6st (24.82%), followed by 2st (18.71%), 3st (18.14%), 2s (16.76%) and 4st (16.06%), respectively.

Soils of the watershed have been assessed for their suitability for growing various important crops on the basis of their physico-chemical and site characteristics. The study reveals that about 35.47% area is moderately suitable for wheat and 34.25 area is marginally suitable whereas for pearl millet, 35.47% suitable, 18.14% moderately suitable and 16.06% marginally suitable, for sorghum, 35.47% moderately suitable and 27.32% marginally suitable, for pigeon pea, 35.47% moderately suitable and 27.32% marginally suitable, for mustard, 35.47% suitable and 34.20% moderately suitable and for potato, 38.11% moderately suitable and 31.56% marginally suitable, respectively. Based on land capability, land irrigability and soil suitability, suggested land use has been evaluated. The data reveals that about 23% area of the watershed is recommended for dense cropping system (Agri-horticulture-floriculture), 12.5% area for rice-wheat / mustard, 15.5% area for agro-forestry, 14.9% area for single rain fed crops / agri-pastural / horticultural plantations, 7.1% area for social forestry and 21.5% area for permanent pastures / silvi-pastures.

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Characterization and Classification of Soils in Semi-arid Region of Chillakur Mandal in SPSR Nellore District of Andhra Pradesh

M.V.S. Naidu and U. Vedadri

Department of Soil Science and Agricultural chemistry, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati, 517502, Andhra Pradesh

Seven typical pedons representing major land forms in semi-arid ecosystem of Chillakur mandal *viz.* nearly plain (0-1%) to gently sloping (1-3%) topography, developed from granite-gneiss and alluvium under varying land use were studied for their morphological characters, physical, physicochemical properties and nutrient status. Soils were moderately deep to very deep in depth, pale brown to dark reddish brown in colour and soil texture varied from sand to clay loam. However, the soils were slightly acidic to moderately alkaline (6.10 to 8.50) in reaction, low to medium in organic carbon (0.12 to 0.61%) and CEC (4.70 to 25.52 cmol $(p^+)kg^{-1}$ soil), and crumb to angular blocky in structure. All the pedons registered low $CaCO_3$ status. The soils were low to medium in available nitrogen and phosphorus, low to high in available potassium and high in available sulphur. However, soils were deficient in DTPA extractable zinc and sufficient in DTPA extractable copper, iron (except pedon 7) and manganese. As per Soil Taaxonomy, pedons 1, 3, 4 and 7 were grouped under Entisol due to absence of sub-surface diagnostic horizon and classified as Typic Ustorthents (Pedons 1, 3 and 4) and Typic Ustipsamment (pedon 7). Pedons 2, 5 and 6 were placed under Inceptisol due to presence of cambic (Bw) sub-surface diagnostic horizon and classified as Typic Haplustepts. All the soils of the study are fall under agricultural land with land capability sub-classes, namely IIIs (Pedons 5 and 6), IIIws (Pedon 2), IVs (Pedon 7) and IVse (Pedons 1, 3 and 4).

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Mapping of Salt-affected Soils in Seven Districts of Andhra Pradesh

G.V. Lakshmi, K. Hema, M. Latha, P. Venkata Rao and M. Raghu Babu
ANGRAU- AICRP-Saline Water Scheme, Bapatla, Andhra Pradesh

The area under cultivation in the state is 36% and there is no scope for expansion of area required for increasing agricultural production. Even this arable land area is shrinking because of diversion of prime agricultural land to non-agricultural purposes. About 1.5-20.0% of irrigated lands in various districts have adversely been affected due to water logging and soil salinization. Degree of the problem of salinity/ alkalinity determines the amount of efforts and investments that are needed to reclaim the land.

Most of the salt affected soils in Andhra Pradesh are occurring in the districts Guntur, Prakasam, Chittoor, Anantapur, Krishna and Nellore. The coastal salt affected soils are mainly deltaic alluvium, while the inland salinity problems occur in medium and deep black soils. The salt affected soils of Andhra Pradesh were digitized and ground truth was verified with the help of FCC obtained from NRSC using Remote Sensing Data. The profile soil samples (up to 100 cms depth) were collected, analysed and salt affected soil maps of seven districts Andhra Pradesh were prepared.

Mapping and digitisation of surveyed area is done based on satellite imageries of 2010 acquired from NRSC. Classification of salt affected soils based on CSSRI, Karnal is completed in seven districts viz., Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Nellore and Chittoor districts. Digital map of salt affected soils profile were prepared on 1:50000 scale taking in to consideration the ground truth data and digital data.

Salt affected soils identified will be advised to the farmers to grow suitable crops and tolerant varieties within the crops on particular soils and the amendments for reclaiming the salt affected soils were suggested.

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Spatial Distribution of Micro and Secondary Nutrients in North Central Plateau Agroclimatic zone of Odisha and their Effect on Crop Productivity

R.K. Nayak, S. Shivhare, B. Jena, J. Das and M. Maheshwar
AICRP on Micronutrient, Department of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar, Odisha
**Email: :rabisoilorissa@gmail.com*

Micro and Secondary nutrients play a vital role in increasing agricultural productivity. Study of their distribution in soil helps immensely for crop planning and fertilized management. To know the status of these nutrients and common soil properties in North Central Plateau Agro-climatic zone of Odisha, there were 650 GPS based surface soil samples were collected from 26 blocks of Mayurbhanj district and analyzed following standard methods. Analysis results revealed that 96% soils were acidic and medium to low in soil organic carbon (SOC) status. The mean available S content of different blocks ranged from 2.86 to 43.76 mg kg^{-1} and 34% samples were found deficient. The exchangeable Ca and Mg value ranged from 0.2 to 14.1 and 0.1 to 9.2 cmol(p^+)kg^{-1}, respectively and most of the samples for Ca and Mg were found sufficient. Soils were found to be marginal to low in available B and Zn to a tune of 61.2% and 34%, respectively whereas DTPA-Fe, Mn, Cu were adequate in most of the surface soils. Popular field crop like maize and potato were well responded to the application of S and B. By application of S @ 40 kg ha^{-1} maize grain yield was increased by 17.2% over control (3.02 t ha^{-1}) and tuber yield of potato increased by 43.0% with addition of 60 kg S ha^{-1}. Similarly, addition 1 kg B ha^{-1} enhanced potato tuber yield by 13.7% over control (12.7 t ha^{-1}). Proper supplementation of deficient nutrients like S, B and Zn along with lime was helped for boosting the productivity of different crops in a tribal district like Mayurbhanj under North Central agro-climatic Zone of Odisha.

Commission 2.1: Soil Physics

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Influence of Soil Moisture and Temperature on Carbon Dioxide Production in an Inceptisol under Rice-Rice Cropping System

D. Srinivas[1*] and T.V. Sridhar

A.P. Rice Research Institute, Maruteru, 534122, Andhra Pradesh
[1]Department of Soil Science and Agricultural Chemistry, Agricultural College, Rajahmundry, 533 103, East Godavari District, Andhra Pradesh
**Email: drd_srinivas@yahoo.com*

The effect of fertilization and its interaction with varying temperature and moisture regimes on carbon dioxide (CO_2) production in an Inceptisol in a laboratory incubation study under rice-rice cropping system was investigated. The experiment consisted of intensive rice cropping for 20 years with the treatments *viz*., unfertilized (control), inorganic N (90 kg ha^{-1}), inorganic fertilizer (NPK @ 90-60-60 kg ha^{-1}), FYM (@ 10 t ha^{-1}) and inorganic fertilizer (NPK @ 90-60-60 kg ha^{-1}) + farmyard manure (FYM) (@ 5 t ha^{-1}). At a soil depth of 0-15 cm, highest total organic carbon (TOC) was found under FYM + NPK (1.39%), followed in descending order by FYM (1.25%), inorganic NPK (1.04%), inorganic N (0.81%) and control (0.74%). The cumulative CO_2 production (mg CO_2-C g^{-1} dry soil) was closely related to level of fertilization, temperature and soil organic carbon (SOC) pools. Cumulative CO_2 production increased up to 90 days of incubation and best fitted in power functions irrespective of fertilization treatments, moisture and temperature. A general decreasing trend of CO_2 production corresponding with decrease in TOC under different fertilization treatment was noted for all moisture and temperature treatments. Significantly higher CO_2 productions were observed under FYM + NPK followed by FYM, NPK, inorganic N and control treatments. Higher cumulative CO_2 production (2.25 mg CO_2-C g^{-1} dry soil) at 90 days of incubation in FYM + NPK treatments was presumably due to high TOC (1.39%) and permanganate oxidizable carbon (POC) (888.6 mg kg^{-1}) content and higher biological activity. Higher microbial biomass carbon (MBC) (250.7 mg g^{-1}) and acid hydrolysable carbohydrates (AHC) in FYM treated soil caused considerable amount of cumulative CO_2 production at 90 days (1.90 mg CO_2-C g^{-1} dry soil) and possibly acted as a source of bio-energy for higher amount of exogenous micro organisms. Carbon dioxide production was lowest in unfertilized control soil due to lower labile and active pools (MBC, RMC, AHC, POC and WSC) of C responsible for lower biological activity in soil. Temperature is a prime factor regulating microbial activity, soil respiration and hence CO_2 evolution regardless of fertilizer treatments. Productions of CO_2 per unit of dry soil in all fertilization treatments were significantly higher at 35 ^oC than at 25 ^oC, both at 60% WHC and submergence because of higher biological activity at higher temperature. Mean cumulative CO_2 production increased by 24% at 45 ^oC (from 2.80 mg to 3.48 mg CO_2-C g^{-1} dry soil) than at 25 ^oC at 60% water holding capacity compared to submergence and was influenced by different fertilizer treatments. From this study it is concluded that among the various treatments, integration of inorganic fertilizer (90-60-60 kg NPK) and organic (FYM @ 5 t ha^{-1}) treatment caused more production of carbon dioxide in the long-term trial under rice-rice cropping system.

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Long-term Fertilization Impacts on Temperature Sensitivity of Soil Organic Carbon Decomposition under a Wheat-based Cropping System in an Alfisol

Avijit Ghosh, Ranjan Bhattacharyya*[1], B.S. Dwivedi, M.C. Meena and B.K. Aggarwal[2]
Division of Soil Science and Agricultural Chemistry, ICAR-Indian Agricultural Research Institute, New Delhi, 110 012
[1]Centre for Environment Science and Climate Resilient Agriculture, ICAR-Indian Agricultural Research Institute, New Delhi, 110 012
[2]Birsa Agricultural University, Ranchi, Jharkhand
**Email: ranjan_vpkas@yahoo.com*

Understanding temperature sensitivity of soil organic carbon (SOC) decomposition from bulk soils and aggregates of long-term fertilized plots is very imperative to forecast soil C dynamics under climate change. Hence, we evaluated the impacts of 44-years of fertilization under a wheat (*Triticum aestivum* L.) based cropping system on temperature sensitivity SOC decomposition (Q_{10}) and activation energy (Ea) required for SOC degradation in an Alfisol. Bulk soils as well as macro- and micro-aggregates were incubated for 24 days at 25 °C and 35 °C. Results revealed that in the 0-15 cm soil layer, cumulative SOC mineralization (Ct) at both temperatures and Q_{10} values of bulk soils with NPK + FYM and NPK treated plots were similar, but these values were significantly higher than unfertilized control plots. However, both Ct and Q_{10} values under NPK + FYM plots were higher in the 15-30 cm soil layer. Interestingly, despite Ct values from both macro- and microaggregates in the plots under NPK + FYM and NPK were similar at 25 °C in the surface layer, NPK + FYM treated plots had about 9 and 25% higher Ct from macro- and microaggregates than NPK at 35 °C. Thus, NPK + FYM treated plots had about 10 and 26% greater Q_{10} values than NPK plots. In the deeper depth, bulk soils and soil macro- and microaggregates of NPK + FYM treated plots were more temperature sensitive than NPK. Despite similar values in the soil surface, higher Ea was required for SOC decomposition from bulk soils of NPK + FYM than NPK plots in the sub-surface soil layer. Contrarily, although higher Ea values were required for decomposition of macro- and microaggregate associated-C of NPK + FYM treated plots than NPK in the soil surface, similar Ea were required for macro- and microaggregate-associated C decomposition in the sub-surface. Again, dehydrogenase activities within bulk soils of NPK + FYM treated plots were ~21 and 18% higher than NPK + lime plots in the surface layer at 25 and 35 °C, respectively, and similar trend was obtained for both macroaggregates and microaggregates. This indicates complex role of aggregation and matrix stabilization on temperature sensitivity of SOC in both layers under these plots. Thus, this study highlights consideration of the role of microbial diversity and matrix stabilization within bulk soils and aggregates to understand temperature sensitivity of SOC decomposition, in addition to physicochemically derived substrate-temperature sensitivity relationship. Overall, long-term NPK + FYM application has great potential in reducing SOC decomposition under a temperature rise in these sub-tropical acidic soils.

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Water and Nutrient Use Efficiency as Influenced by Drip Fertigation in Chilli (*Capsicum annuum* L.)

Ajeet Singh, S.K. Sharma, S.C. Meena, Rahul Chopra and Priyanka
Department of Agricultural Chemistry and Soil Science, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture & Technology, Udaipur, 313 001, Rajasthan

A field experiment was conducted to study the influence of drip fertigation on efficiency of water and nutrient in chilli at Department of Horticulture, Rajasthan College of Agriculture, MPUAT, Udaipur during *rabi* 2013-14. The experimental soil was clay loam in texture containing 268.8, 21.5 and 368.50 kg ha^{-1} available nitrogen, phosphorus and potassium, respectively with pH 8.10, EC 0.62 dS m^{-1} and organic carbon 0.62 per cent and 1.85, 2.65, 8.09, and 1.88 mg kg^{-1} DTPA-extractable zinc, iron, manganese and copper, respectively. The experiment was laid out in split plot design with three replications, assigning fifteen treatments combination consisting of three irrigation levels (drip at 80% PE (I_1), at 60% PE (I_2) and at 40% PE (I_3)) and five levels of fertigation (i) 100% RDF (F_1), 75% RDF (F_2), 75% RDF + two foliar spray of urea phosphate (17:44) @ 1% (F_3), 50% RDF (F_4) and 50 per cent RDF + two foliar spray of urea phosphate (17:44) @ 1% (F_5). Irrigation schedules were planned to provide the estimated water requirement of the crop. A perusal of data indicated that the average fruit weight, yield per plot and fruit yield of chilli increased significantly with the application of 80% PE (I_1) over 40% PE (I_3). Treatment I_1 and I_2 registered an increase in fruit yield of chilli in order of 10.6 and 5.71 per cent, respectively over I_3 treatment. Fertilizer application at different levels *i.e.* 50% RDF, 50% RDF + 1% two foliar spray of urea phosphate, 75% RDF, 100% RDF and 75% RDF + 1% two foliar spray urea phosphates resulted in significant increase in the fruit yield of chilli. In terms of per cent increase, F_3, F_1, F_2 and F_5 levels of fertilizer application recorded an increase of 16.1, 10.3, 6.9 and 2.6 per cent over F_4 treatment, respectively. The combined effect of irrigation and fertilizer levels application through drip irrigation resulted in a significant increase in the yield of chilli. The maximum yield of 17.2 t ha^{-1} was recorded in treatment of drip irrigation at 80% of PE with fertigation of 75% RDF + two foliar spray of urea phosphate compared to other treatments.

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Effect of Relay Planting of Wheat in Cotton on Yield and Water Productivity of Wheat

V.K. Phogat* and A.S. Dhindwal
CCS Haryana Agricultural University, Hisar, 125004, Haryana
**Email: vkphogat@gmail.com*

Cotton-wheat is the second most important cropping system after rice-wheat in Haryana. Sowing of wheat after cotton in usually delayed due to late picking and time required for seedbed preparation, resulting in low wheat yield. An experiment was conducted to evaluate the relay planting of wheat (WH 1105) in standing cotton (Bio-6588 at row spacing of 100 cm) with a manual drill without prior tillage, on yield and water productivity of wheat. The treatments comprised of conventional and relay sequences of cotton-wheat, three sowing dates (2nd & 4th week of November and 2nd week of December) and three moisture regimes (CRI + CPE of 50, 100 and 150 mm). Relay planting resulted in significantly higher seed cotton yield and lower wheat grain yield as compared to conventional. Showing dates did not influence seed cotton yield but wheat yield decreased significantly when sown in 2nd week of December as compared to November sowing. Interaction effect among various treatments revealed that the conventional planting of cotton-wheat produced significantly higher wheat grain yield with irrigation at CRI+100 and CRI+150 mm CPE but at par with CRI+50 mm CPE over cotton-wheat relay planting. The effect of moisture regimes on wheat yield was significantly higher in December sowing. The water productivity (WP) of wheat was higher under conventional than relay system of cropping. The highest WP was observed for sowing of wheat in 4th week of November. Irrigation at CRI+150 mm CPE resulted in highest WP of wheat.

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Soil Organic Carbon, Aggregation and Microbial Response to Conservation Agriculture Production System (CAPS) in a Rainfed Agro-ecosystem of Odisha

K.N. Mishra, Pratibha Pradhan, P.K. Roul, S.N. Dash, Aliza Pradhan and Tad Mashuda[1]

Orissa University of Agriculture and Technology, Bhubaneswar, 751003, Odisha
[1]Kinki University, Japan
Email: khiturajprav@yahoo.co.uk

Conservation agriculture production system (CAPS) with the components of minimum tillage, legume based intercrops and follow up cover crop has been established in a Fluventic Haplustepts at Regional Research and Technology Transfer Station, OUAT at Kendujhar district of Odisha during 2011 in split plot design for sustainable management of natural resources in the degraded hilly agro-ecosystem of the tract. The impact of CAPS on BD, WSA, SOC, WSA-C, STN, soil moisture and microbial attributes across the profile (0-5, 5-10 and 10-20 cm) was assessed at the end of the 4th cropping cycle. The treatment combinations are conventional tillage (CT) and minimum tillage (MT) with sole maize (M) and inter crop maize + cowpea (M+C) in main-plots during wet season and horse gram (H), toria (T) and no cover crop (NCC) in sub-plots during dry season. Build-up of SOM and their retention in the soil surface under MT decreased the BD (-3.0%, -2.2%), increased SOC (+31.8%, +16.8%), STN (+19.4%, +11.1%), water stable macro-aggregates (+18.4%, +15.2%), macro-aggregate associated C (+12.7%, 7.6%) with concomitant decrease in micro-aggregates (-11.1%, -12.7%) in 0-5 and 5-10 cm layers. Loss of SOM induced by soil inversion under CT in the top layers increased the BD (+2.3%, +1.5%) and micro-aggregates (+21%, +22.1%), decreased the SOC (-6.8%, -13.2%), macro-aggregates (-5.3%, -5.7%) and macro-aggregate associated C (-6.5%, 7.1%). The elevated population of bacteria (+37.7%, +29.6%), fungi (+22%, +19.7%), actinomycetes (+19.9%, +18.4%), MBC (+85.5%, +51.4%), MBN (+70.1%, +57.3%) in the top layers in MT over CT is due to higher restoration of SOM. Dramatic changes in soil quality under cover crops were reflected with elevated status of SOC (+11.4%), Macro-aggregates (+7.9%), population of bacteria (+22.4%), fungi (+12.2%), actinomycetes (+12.4%), MBC (+20.6%) and MBN (+28.1%) in the surface layer of 0-5 cm. Soils under MT exhibited higher MBC/SOC ratio (2.04%, 1.8%), MBN/STN ratio (3.87%, 3.81%) and C/N ratio (10.4, 10.9) in the top two layers and C-stratification ratio of 1.82. SOC was identified as the most dominant soil parameter influencing soil BD ($r = -0.85^{**}, -0.89^{**}$), water stable macro-aggregates ($r = 0.90^{**}, 0.76^{**}$), MBC ($r = 0.98^{**}, 0.99^{**}$), population of bacteria ($r = 0.91^{**}, 0.77^{**}$), fungi ($r = 0.86^{**}, 0.88^{**}$) and actinomycetes ($r = 0.87^{**}, 0.86^{**}$) in the top two layers. Though the MEY of MT and CT with M+C intercrop are at par (10.9 and 10.7 t ha^{-1}), the restoration and enrichment of soil attributes reflected at the end of the 4th cropping year will enhance the productivity of soils in the long run.

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Impacts of Conservation Agriculture on Soil Aggregation and Aggregate-associated N in a Rice-Wheat Cropping System in the Indo-Gangetic Plains

Ranjan Bhattacharyya*, T.K. Das and S. Das
ICAR-Indian Agricultural Research Institute, New Delhi, 110 012
**Email: ranjan_vpkas@yahoo.com*

The effects of conservation agriculture (CA) on total soil nitrogen (N) and N retention potential in the 0-30 cm layer under a sub-tropical rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) cropping system have rarely been evaluated. Hence, we appraised the 3-year old impacts of different CA practices on the estimated N input, total soil N (TSN) retention, soil aggregation and aggregate-associated N in the western Indo-Gangetic Plains. In this experiment, plots under mungbean residue+ direct seeded rice – zero tilled wheat – zero tilled summer mungbean (DSR+MBR-ZTW-ZTMB) had higher macroaggregates, macroaggreate-associated C and N and glomalin content than TPR-CTW plots in the topsoil. Plots under DSR+MBR-ZTW-ZTMB had about 9 t ha^{-1} yr^{-1} estimated C addition in the 0-30 cm layer, and mean (of all CA practices) C and N retention rates of in that layer were nearly 6.7 and 7.3%, respectively after 3 years of cropping. That said DSR+MBR-ZTW-ZTMB management option had higher system productivity (in terms of wheat equivalent yield) compared with farmers' practice, and hence can be adopted.

All plots under CA had significantly higher gain (over initial value) in total SOC than the gains in TPR-CTW and TPR-ZTW 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) and all CA had no significant impact on total SOC concentration or stock in the 5-15 and 15-30 cm layers. Plots under MBR+DSR-ZTW+RR-ZTMB had 13.5 per cent larger total SOC concentration than TPR-CTW plots (7.4 g kg^{-1}) in the topsoil, yielding 12.5 per cent higher total SOC stock (on equivalent depth basis) in the former treatment. Again, plots under MBR+DSR-ZTW+RR-ZTMB had 24 per cent larger labile C pools (sum of very labile and labile C pools) than TPR-CTW plots (3.1 g kg^{-1}) in the topsoil. In the 5-15 cm layer, that difference was reduced to 11 per cent and short-term CA had no impact on recalcitrant SOC pools in all layers. As soil bulk density under all CA plots significantly reduced in the 15-30 cm layer, and had a decreasing trend in the upper two layers, C gains on an equivalent mass basis were calculated. 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. Thus, future research on C stock estimation should aim at measuring it on an equivalent mass basis and the suggested method must be adopted for all CA trials, as CA has great potential to alter soil bulk density due to residue load. In inference, CA, especially the MBR+DSR-ZTW+RR-ZTMB management practice, has a good potential to retain C and sustain productivity of the rice-wheat cropping system in this region and may be adopted.

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Analysis of Soil Water Balance for Cotton Grown under Conservation Agriculture in the Indo-Gangetic Plains using Hydrus-2D Model

Pramila Aggarwal*, Ranjan Bhattacharyya, A.K. Mishra, T.K. Das, P. Pramanik, D. Chakraborty and P. Krishnan

ICAR-Indian Agricultural Research Institute, New Delhi, 110 012

**Email: pramila.iari@gmail.com*

The root water uptake (RWU) patterns of cotton and water balance of soil profile in a cotton-wheat cropping system grown under conservation agriculture were analyzed using the Hydrus-2D model. The following treatments were investigated: conventional tillage (CT), zero tillage (ZT), permanent narrow beds (PNB), permanent broad beds (PBB), ZT with residue (ZT+R), PNB with residue (PNB + R) and PBB with residue (PBB + R). Results in the third and fourth years of the cotton (*Gossypium hirsutum* L.) crop indicated that surface (0-15 cm layer) field saturated hydraulic conductivity in both PNB and PBB plots were similar and were significantly higher than ZT plots. Plots with conventional tillage had more root proliferation due to more applied irrigation water than PNB and PBB plots. Computed potential transpiration rates (Tp) under CT was lower than other treatments mainly because of less radiation interception and lower leaf area index (LAI). Both PNB/PBB plots had higher Tp and crop yields, which were further improved by residue retention. Predicted soil water content (SWC) patterns during the simulation periods (25 to 122 DAS) showed good correlations (r = 0.81) with the actual field measured SWCs. Also cumulative drainage and evaporation significantly reduced and cumulative transpiration increased under PNB+R and PBB+R plots. Thus, PBB+R and PNB+R practices could be adopted for cotton cultivation in this region, as these treatments enhanced root growth and modified micro-climate by improving radiation interception and LAI and ultimately the crop productivity. Hydrus-2D model may be extensively adopted for efficient water use under CA as it can simulate the temporal changes in SWC in the profile and actual transpiration rates of a crop/cropping system.

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Changes in Soil Organic Carbon Status and Hydro-physical Properties of Typic Haplustepts

A. Thangasamy[1], Dhyan Singh[2], B.S. Dwivedi[2] and Mahesh Chand Meena[2]
[1]ICAR-Directorate of Onion and Garlic Research, Rajgurunagar, Pune, 410 505, Maharashtra
[2]ICAR-Indian Agricultural Research Institute, New Delhi, 110 012

Continuous application of inorganic fertilizer and organic manure greatly influence the accumulation of soil organic matter and soil physical environment which affect the nutrient availability to plants and crop yield. The long-term effect of fertilizer and manure application were studied in maize–wheat sequence on soil organic carbon status and hydro-physical properties of Typic Haplustept in Delhi during 34th crop cycles. The results revealed that combined application of inorganic fertilizers with farmyard manure increased soil organic carbon by 75.6 per cent followed NPK application (31%) over control (without fertilizer application). Soil bulk density decreased by 6.38 per cent over control and the difference is significantly different. Integrated use of farmyard manure and inorganic fertilizers increased available water content (35%), saturated hydraulic conductivity (64.6%), and infiltration rate (133.6%) significantly over control at 0-15 cm depth. However, no significant difference was observed between fertilizer treatments at 15-30 cm. Inorganic fertilizer application (N, NP and NPK) maintained initial bulk density, porosity and mean weight diameter. Stepwise regression analysis showed that among the parameters analysed, infiltration rate contributed to 65.1 and 49.3 per cent wheat yield and nutrient uptake, respectively, while, 70.5 and 59.7 per cent maize yield and nutrient uptake, respectively. From this, we conclude that application of 100% NPK and farmyard manure sequestered soil organic carbon in the surface layer and improved the soil physical environment and contribute to increase the crop yield and nutrient uptake. Although, inorganic fertilizer application maintained initial bulk density, porosity and mean weight diameter, application of inorganic fertilizers along with organic manures improved yield by supplementing secondary and micronutrients and indirectly by altering soil physical environment.

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Effect of Puddling and Direct Sowing Methods of Rice Cultivation on Soil Structure and Water Productivity of Rice-Wheat Cropping System

K.K. Bandyopadhyay*[1], A. Sarangi[2], Dinesh Kumar[3], D.K. Singh[4], Ashok Kumar[5], Nain Singh[6] and Lalit Kumar[7]

[1]Division of Agricultural Physics, [2,4,5,7]Water Technology Centre, [3,6]Division of Agronomy
ICAR-Indian Agricultural Research Institute, New Delhi, 110 012
**Email: kk.bandyopadhyay@gmail.com*

Rice-wheat cropping system, the major cropping system in the country, faces steep competition for water from domestic and industrial sectors, which can be tackled by increasing water productivity in rice-wheat cropping system. Further, excessive tillage during traditional puddle method of rice cultivation leads to deterioration of soil structure and decline in soil health. In this context, field experiments were undertaken during 2012 to 2014 at the research farm of Indian Agricultural Research Institute, New Delhi to study the effect of three rice cultivation methods *viz.*, (i) Direct seeded rice (DSR), (ii) System of rice intensification (SRI) and (iii) conventional puddle transplanted rice (PTR), two irrigation methods *viz.*, (i) Adequate irrigation and (ii) Deficit irrigation and two cultivars each of rice (PRH 10 and Pusa 1460) and wheat (DBW 17 and HD 2967) on soil structure and the water productivity of rice-wheat cropping system. Results showed that there was decrease in mean weight diameter and percentage of macro-aggregate stability under PTR (1.47 mm and 71.8%) and SRI (1.62 mm and 74.2%) method than DSR (1.82 mm and 79.5%) method of rice cultivation. SRI method of rice cultivation resulted in significantly higher yields of rice cultivars than PTR and DSR method by 15.7 and 42.5 per cent, respectively. However, the water productivity of rice under SRI and DSR method was significantly higher than PTR method by 34.6 and 41.2 per cent, respectively. The grain yield of succeeding wheat under RWCS was significantly influenced by the residual effect of the rice cultivation method. The grain yield of wheat was higher in plots under DSR cultivation than that under PTR and SRI method of rice cultivation by 21.2 and 10 per cent, respectively. The water productivity of succeeding wheat under RWCS was significantly higher in plots under DSR cultivation by 12 per cent than that under PTR but was statistically at par with that under SRI. It was also observed that deficit irrigation reduced grain yield of rice (9.3%) and wheat (8.6%), but increased the water productivity in both rice (6.6%) and wheat (14.7%). Among the rice genotypes, PRH10 registered higher grain yield and water productivity whereas, among the wheat genotypes, DBW 17 registered higher yield and water productivity. Considering the rice-wheat cropping system, the DSR method of rice establishment resulted in significantly higher system water productivity (7.78 kg ha-mm^{-1}) and significantly lower water use (1294 mm) than the PTR and SRI methods leading to saving of irrigation water. However, the system productivity of RWCS under DSR method (9.99 t ha^{-1}) was higher than PTR (9.07 t ha^{-1}) but less than SRI method (10.64 t ha^{-1}). So in sandyloam soil of Delhi NCR region, DSR method of rice cultivation in rice-wheat cropping system can yield higher yield and water productivity, improve soil health and save water. Thus, there is a trade-off between grain yield, water productivity and soil health, which needs site specific optimization under different cultivation methods and genotypes to obtain higher water productivity without significant deterioration in soil health and reduction in grain yield leading to sustainability of rice-wheat cropping system.

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Impact of Long-term Application of Fertilizers and Organic Manure on Physical Properties and Organic Carbon Content under Finger millet-Maize Cropping System in an Alfisol

G.V. Gangamrutha* and R.C. Gowda[1]
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka
**Email: gangamrutha@gmail.com*

The physical quality of the soil, which creates suitable environment for the availability of the plant nutrients, is generally ignored. Though the effect of organic manures on soil physical quality has been widely appreciated but that of inorganic fertilizers is studied to a lesser extent. The present study carried out during 2013–2014 aims to characterize the soil physical quality in relation to the long-term application of inorganic fertilizers, FYM and lime in finger millet-maize cropping system. Soil samples were collected after 27th cycle from ongoing field experiment of AICRP on Long-Term Fertilizer Experiment, Bangalore during 2014 after harvest of maize crop at different depths and treatments consisted of T_1: 50% NPK, T_2: 100% NPK, T_3: 150% NPK, T_4: 100% NPK + hand weeding, T_5: 100% NPK + lime, T_6: 100% NP, T_7: 100% N, T_8: 100% NPK + FYM, T_9: 100% NPK (S-free), T_{10}: 100% NPK + FYM + lime and T_{11}: control. Organic carbon content, bulk density and stability of soil aggregates were measured up to 0–60 cm soil layer. The soil of the experimental site varied from sandy loam to sandy clay loam and the initial pH, EC and OC of soil was 6.17, 0.06 dS m^{-1} and 0.46%, respectively. At 0-15 cm depth, soil organic carbon (SOC) content was significantly highest in NPK+FYM+lime treated plots (0.75%) followed by NPK+FYM (0.73%) as compared to inorganic fertilizers alone. Treatments receiving imbalanced fertilization (100% N and 100% NP) recorded significantly lower soil organic carbon (0.5 and 0.48% respectively) as compared to 100%NPK treated plots (0.62%). After 27 years of intensive cropping soil organic carbon was significantly influenced up to 45 cm depth with application NPK fertilizer and FYM. However at 45-60 cm depth effect of balanced NPK fertilization with or without FYM were not significant. Further at 0-15 cm depth application of NPK+FYM+lime significantly improved soil aggregation (86.62%), porosity (48.2%) and water holding capacity (39.2%) and reduced bulk density (1.39 g cm^{-3}) of the soil over control. In contrast, soil aggregate stability, porosity and water holding capacity were significantly lower in the imbalanced fertilizer treated plots and control. The organic carbon content, stability of aggregates, porosity and water holding capacity also improved with the balanced application of fertilizers. The SOC content at 0–60 cm soil depth showed a significant and positive linear relationship with mean weight diameter and total porosity and a significant negative linear relationship with bulk density of soil. The study thus suggests that soil management practices in acidic Alfisols should include integrated use of mineral fertilizer and organic manure or lime to maintain the organic carbon status and physical environment of soil.

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Characterization of Nano-porous (Zeolite) Materials through Various Adsorption Models

K. Ramesh*, K. Sammi Reddy, I. Rashmi, A.K. Biswas and A.K. Patra
ICAR-Indian Institute of Soil Science, Nabibagh, Bhopal 462038, Madhya Pradesh
**Email: ramechek@gmail.com*

Nano-porous zeolites are one of the greatest cationic interchangers and their cationic interchange capacity is two to three times greater than other types of minerals found in soils. The zeolitic channels (or pores) are microscopically small, and in fact, have molecular size dimensions such that they are often termed as "molecular sieves". Molecules can be separated via shape and size effects related to their possible orientation in the pore, or by differences in strength of adsorption. Zeolites are becoming the subject of interesting investigation in dozens of agricultural issues of which increasing the input use efficiency assumes greater significance in the soil science sector. Four natural zeolites and two synthetic nanoporous (zeolite) materials available in the Indian market were characterized through various adsorption models and analysis of meso-porosity and textural characteristics was done experimentally using a N_2 adsorption isotherm. The SEM morphology was determined using FE-SEM. The detailed surface area, pore volume and pore size were determined from the adsorption–desorption isotherms of nitrogen measured volumetrically at 77^0 K. The pattern of the isotherms suggested that the materials were mesoporous in nature. To study the reliable pore-size distribution (PSD) both adsorption and desorption curves were used by fitting the data to several well-known adsorption models, *i.e.*, Bruaner-Emmett-Teller (BET) model, Barret, Joyner and Halenda (BJH) model, Dollimore and Heal (D-H) model, Horvath-Kawazoe model and the density functional theory (DFT) model. Only minor difference was observed for pore volume distribution between BJH and DH models while perceptible differences were observed in other models due to their inherent assumptions. A comparative analysis of the models is discussed from the natural and synthetic zeolite samples.

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Characterization of Biochar Prepared from Different Types of Feedstock and its Impact on Microbial Activity in an Acidic Soil

Awtar Singh*, A.P. Singh, S.K. Singh and Sumit Rai
Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences
Banaras Hindu University, Varanasi, 221005, Uttar Pradesh
**Email: singhawtar91@gmail.com*

Application of biochar in soil has increased tremendously in recent years, because it acts as a soil amendment and manages soil health; but the effects were varied, and depend upon types of soil; feedstocks and pyrolysis condition used for biochar preparation. Therefore, characterization of biochar is more important, prior to its application to soil. In the present study, biochar was prepared from rice husk, sugarcane bagasse, *parthenium* and *lantana* in a pyrolysis kiln at the temperature of around 400 °C. The biochars were characterised for various physico-chemical and structural properties. The sugarcane bagasse had the highest charring yield while *lantana* had the lowest. The pH values of all the biochars were alkaline in nature and *lantana* biochar showed the highest pH (10.4) followed by *parthenium* biochar (10.2), sugarcane bagasse biochar (9.4) and rice husk biochar (8.5). The highest value of EC was recorded in *lantana* biochar, followed by that in *parthenium* biochar, sugarcane bagasse biochar, and rice husk biochar. The bulk density of sugarcane bagasse and *parthenium* biochar was comparatively lower than that of rice husk and *lantana* biochar. The water holding capacity was observed to be highest in sugarcane bagasse biochar, followed by that of *parthenium* biochar, rice husk biochar and *lantana* biochar. Total C content was highest in *lantana* biochar (50.9) followed by that in *parthenium* biochar (40.4%), sugarcane bagasse biochar (39.3%) and rice husk biochar (36.1%). The EDS analysis of all the biochar samples indicated that oxygen content was highest in rice husk biochar (34.5%), followed by *parthenium* biochar (26.7%), *lantana* biochar (23.9%) and sugarcane bagasse biochar (18.5%). *Lantana* and *parthenium* biochars were superior in K content than sugarcane bagasse biochar and rice husk biochar.

To assess the impact of biochar on microbial activity, acid soil was collected from Naugarh, Chandauli, U.P., and treated with different types of biochar at different doses. The soil was sandy clay loam in texture with pH (1:2.5) 5.5, electrical conductivity (1:2.5) 0.030 dS m^{-1}, cation exchange capacity 8.83 cmol(p^+)kg^{-1}, soil organic carbon 0.50%, and mineralizable nitrogen 147.2 kg ha^{-1}. The processed soil sample was treated with all the four types of biochar at different doses *viz.* 0, 2.25, and 4.50 g kg^{-1} of soil in pots of 10 kg capacity. The mustard and green gram were grown in these pots with recommended agronomic practices. After the harvest of both the crops, (mustard taken as direct and green gram taken as residual), soil samples were collected from all the pots and analyzed for dehydrogenase, acid phosphatase and microbial biomass carbon. All the biochar treated soil samples were found to exhibit higher soil microbial biomass carbon (MBC); dehydrogenase activity (DHA) and acid phosphatase activity (APA). Among the biochars, *lantana* biochar showed the highest DHA; while it was the lowest in sugarcane bagasse biochar treated soil. The DHA in soils amended with *parthenium* and rice husk biochar were in between that obtained with *lantana* and sugarcane bagasse biochar. The MBC and APA also followed the same trend as of DHA.

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Persistence of Bispyribac-Sodium in Soil, Plant and Grain of Aerobic and Transplanted Rice in Vertic Inceptisols

T. Ram Prakash*, M. Yakadri and P. Leela Rani
AICRP on Weed Management, PJTSAU, Rajendranagar, Hyderabad, Telangana
**Email: trapkash@gmail.com*

A field experiment was carried out during *kharif*, 2014 to study the field-persistence of bispyribac-sodium, a new selective rice herbicide, in aerobic and transplanted rice, in soil, plant and rice grain at College farm, PJTSAU, Rajendranagar, Hyderabad. Rice variety MTU-1010 was planted at a row spacing of 20 cm × 15 cm. Bispyribac sodium was applied as post-emergence herbicide at 20 g *a.i.* ha^{-1} at 20 days after transplanting. Initial soil samples were collected and analyzed. The texture of the soil was a clay loam with pH 7.8, EC 0.51 dS m^{-1} and organic carbon 0.60%. The soils were classified as Vertic Haplustepts.

Soil samples were collected on 1, 5, 10, 15, 30 and 60 days after application (DAA) of the herbicide and at harvest. For residue analysis, rice plants and grain, were collected randomly from each plot at harvest time. Residues of bispyribac sodium were determined in soil, grain and plant using HPLC. In soil, the averaged recoveries of the method ranged 87.1-93.2%, at the fortified levels of 0.02-1.0 mg kg^{-1}. The minimum detectable limits in soil were found to be 0.02 mg kg^{-1}. In plant and grain samples the recoveries varied between 92.6-98.7% and 90.1-94.3%, respectively. Minimum detectable limit for the method adopted was 0.02 μg g^{-1}.

In transplanted rice, initial residues (1 DAA) of bispyribac-sodium in the soil were 0.047 mg kg^{-1} and the residues persisted upto 15 DAA (0.020 mg kg^{-1}) in soil. The percent dissipation was 34.0, 51.1 and 61.7% at 5, 10 and 15 DAA at recommended level of application. In aerobic rice, initial residues bispyribac sodium in the soil was 0.039 mg kg^{-1}. Residues persisted upto 15 DAA beyond which they were below detection (0.020 mg kg^{-1}) in soil. In aerobic rice soil, the percent dissipation was 28.2, 56.4 and 69.2% at 5, 10 and 15 DAA. Residues of bispyribac-sodium in soil, rice grain and straw collected at harvest time were below the detectable limit of 0.02 mg kg^{-1} in both transplanted and aerobic rice.

Different curves of fit were tested to predict the dissipation behavior of the herbicide. Among the models tested (linear, polynomial, logarithmic and exponential) the exponential model was found to give better fit for field dissipation bispyribac-sodium 20 g ha^{-1} dose. Bispyribac-sodium dissipation in followed a first-order (or more correctly for field dissipation, pseudo first-order) decay process in both methods of rice establishment.

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Quantity Intensity Relationship of Potassium in Vegetable Growing Soils of Ranga Reddy district, Telangana

T. Chaitanya[1], G. Padmaja[2] and P. Chandrasekhar Rao[3]
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, 500030, Telangana

In recent years, various attempts were made to find a suitable method for determining the availability of soil K in order to evaluate the amount of K fertilizers needed by a particular crop. For a greater understanding of the fertility status of agricultural soils, the quantity-intensity (Q/I) relationship has been used as a measure to know the availability of potassium in soils. In general, Q/I relations of K may serve as an index for the strength and quantity of effective K supply to plants in soils. Some parameters such as equilibrium activity ratio (AR^k_e) and potential buffering capacity (PBC^K) may provide important information for the K behaviour in soils. AR^k_e indicates the amount of K that can be provided by solution instantly in the soil. Higher PBC^K shows higher K buffering capacity of the soil. Therefore, this information may be based as reference for K fertilization. These relationships were studied in sixteen selected vegetable growing soils from different villages of Rangareddy district. The AR_e^K values ranged from 1.10 to 18.75 $(ML^{-1})^{1/2} \times 10^{-3}$ with a mean value of 3.25. The lowest and highest values being recorded in Kathagadi and Ravirala, respectively from the Ranga reddy district. The PBC^K values were low in all the soils falling in the range of 0.018 to 0.818 $(cmol(p^+)kg^{-1})/ (ML^{-1})^{1/2} \times 10^{-3}$ with an average of 0.210 $(cmol(p^+)kg^{-1})/ (ML^{-1})^{1/2} \times 10^{-3}$. Clay was negatively correlated with AR_e^K (r = -0.111). The PBC^K was positively and significantly correlated with pH (r = *0.496), EC (r = *0.436), CEC (r = **0.853), OC (r = *0.410), silt (r = *0.793), and clay+silt (r= 0.658**) and negatively correlated with sand (r= -0.658**). On the other hand, easy absorption of K from soils by plants (that is, high AR_e^K) does not mean that the soils are not K deficient. If PBC^K is small then activity ratio for K will drop rapidly following K absorption by plants. This means that, K effectiveness will decrease rapidly. From the view point of long term availability of K to plants, the K buffering capacity in soils is an important factor to consider. In general, if PBC^K is high, then K fertilization may be done once with a higher amount. When PBC^K is low, then K fertilization may be accomplished with a small amount but multiple times so that AR_e^K may be maintained at a higher and more stable value.

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Development of P Saturation Indices for Black, Red and Alluvial Soils of India

I. Rashmi and A.K. Biswas
ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

Phosphorus (P) 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 P 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.*, Black soil (Nagpur), Alluvial soil (Kanpur) and Red soil (Ranchi) using different extractants.

The P sorption maxima (P smax) as determined by Langmuir equation followed the order black (469.5 mg kg^{-1}) > red (247.0 mg kg^{-1}) > alluvial soil (236.4 mg kg^{-1}). Soils were incubated with 0, 10, 25, 50, 75, 100 and 200 per cent Psmax. The incubated soils were analyzed for labile P content with different extractants namely Olsen, Bray1, Mehlich 3 and Ammonium Oxalate. In black soil the DPS was calculated with DPS Ol, DPS A.O. and DPS M3 ranged 0.4 to 58.5, 0.2 to 44.7 and 0.12 to 51.3 per cent respectively for P1 to P7 treatments. Similarly in alluvial soil DPS Ol, DPSA.O. and DPS M3 ranged from 2.06 to 68.9, 0.2 to 28.1 and 1.6 to 106.3 per cent for P1 to P7 treatments. In red soil DPS By 1, DPS M3 and DPSA.O. ranged from 1.7 to 64.3, 0.04 to 61.8 and 0.51 to 22.1 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 Mehlich3 and ammonium oxalate can be used for determining DPS in all the three soils.

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Assessment of Plant Available N from Legume Residues

D.S. Jakhar, R.S. Antil[1] and B. Singh
Krishi Vigyan Kendra, Sirsa, Haryana
[1]Director of Extension Education, CCS HAU, Hisar, Haryana

For using crop residues effectively, there is a need for reliable and rapid method to assess the amount of plant available N in legume residues. Keeping in view the above, a screen house and laboratory experiment was conducted with six legume residues. Four levels of N *viz.*, 40, 80,120 and 160 mg N Kg^{-1} soil were applied through urea and legume residues. Relative effectiveness (RE) was studied to compare the availability of nitrogen from legume residues and that from chemical fertilizer (Urea). The factors determining nigrogen availability from legume residues *i.e.* KCL extracted inorganic nitrogen, lignin+polyphenol: N ratio, carbon and nitrogen mineralization from legume residues were compared with plant nitrogen uptake by wheat plants from legume residues. The relative effectiveness of total nitrogen ranged from 0.11 to 0.56 from cowpea to pigeonpea. The relationship between RE of total nitrogen and nitrogen extracted from KCL extraction was non significant. A negative relationship between RE of organic nitrogen and lignin: N ratio, polyphenol : N ratio and lignin+polyphenol :N ratio was observed causing 77, 58 and 90 per cent variation in RE of organic nitrogen respectively. Among various indices, lignin + polyphenol: N ratio of legume residues provided a good index of plant available N in legume residues.

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Long-term Effect of Organic Manure Application on Nutrient Uptake and Yield of Wheat in Pearl millet and Wheat Cropping System

Sanjay K. Kashyap, Kiran K. Khokhar*[1], Dev Raj[2] and R.S. Antil[2]
[1]Regional Research Station, Karnal, Haryana
[2]Department of Soil Science, CCs HAU, Hisar, Haryana
**Email: kirankhokhar123@gmail.com*

A field experiment was conducted during the year 2014-15 at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar. The pearl millet and wheat cropping system was adopted for this field trail. The experiment consisted of seven treatments, laid out in randomized block design with three replications and the plot size was 10 m × 8 m. The seven treatments were control (T1), 50% RDF through NPK (T2), 100% RDF through NPK (N 50, P_2O_5 60, K_2O 60 kg ha^{-1}), 50% RDF through NPK+ 50% N through farmyard manure (FYM) (T4), 50% RDF through NPK + 50% N through wheat straw (T5), 50% RDF through NPK+ 50% N through green manure (T6) and farmer's practice (T7). Well decomposed FYM was incorporated in the soil about 35-45 days before the sowing of pearl millet in 2013. The wheat straw obtained after harvest was cut into small pieces and then incorporated into the soil. *Dhaincha* as green manuring crop was grown on a separate field and it was harvested after 40-45 DAS and chopped into small pieces and incorporated into the soil. Amount of organic materials added to the soil to substitute 50% of N was calculated on the basis of their N content and it was calculated to be *i.e.* 5, 12 and 2.5 t ha^{-1} FYM, wheat straw and green manure, respectively. The results revealed that the maximum grain (5.81 t ha^{-1}) and the straw (5.98 t ha^{-1}) of yield was obtained on application of 50% RDF through NPK+ 50% N through farm yard manure (T4) Likewise, maximum accumulation of nutrient content in grain (N: 2.22%; P: 0.373% and K: 0.283%) and in straw (N: 0.45%; P: 0.09% and K: 0.06%) was also observed in T4. Substitution of 50% N through FYM considerably increased the total N (158.3 kg ha^{-1}), P (28.6 kg ha^{-1}) and K (79.84 kg ha^{-1}) uptake by the wheat crop over 100% RDF application.

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Impact of Long-Term Intensive Cropping and Fertilization on Potassium Fractions and Balance in an Inceptisol of Indo-Gangetic Plain

D.K. Kundu*, D. Ghosh, S.P. Mazumdar, A.R. Saha, B. Majumdar, A.K. Ghorai and M.S. Behera

Division of Crop Production, ICAR-Central Research Institute for Jute and Allied Fibres Barrackpore, Kolkata, 700120, West Bengal

** Email: kundu_crijaf@yahoo.com*

Impact of forty-two years of intensive cropping (three crops, *viz*. jute, rice and wheat grown every year) and fertilization on different fractions of soil potassium (K) and their balance was studied in a Typic Ustochrept of Indo-Gangetic Plain. Seven fertilization and manuring treatments, *viz*. 50% NPK fertilizers, 100% NPK fertilizers, 150% NPK fertilizers, 100% NP fertilizers, 100% N fertilizer, 100% NPK fertilizers plus FYM, and no-fertilizer and no manure control were included in this study conducted at Barrackpore of North 24-Parganas district, West Bengal. It was observed that water soluble K, exchangeable K as well as non-exchangeable K in the soil were higher with K fertilizer treatments compared to no fertilizer control treatment. The K fractions significantly decreased with increasing depth of the soil, with exception of non-exchangeable K. The concentration of water-soluble K ranged from 7.6 to 12.8 mg kg^{-1} in the surface soil and from 3.8 to 6.5 mg kg^{-1} in the sub-surface soil. The exchangeable K content ranged from 49.5 to 92.7 mg kg^{-1} in surface and from 38.6 to 69.7 mg kg^{-1} in sub-surface soil. The highest concentrations of water-soluble K and exchangeable K at both the soil depths were observed with 100% NPK fertilizers plus FYM treatment which was at par with 150% NPK fertilizers treatment. The non-exchangeable K content in the soil, however, was lower under 100% NPK fertilizers plus FYM than under 150% NPK fertilizers treatment. All the K fractions at 0-15 cm soil depth showed significant positive correlations with yields and K uptake of crops. Inclusion of K in the fertilization treatments helped in maintaining higher step K and constant rate K (CRK) in both surface and surface soils. The highest step K and CRK in the soil were measured under the 150% NPK fertilizers treatment. Application of N or NP fertilizers alone resulted in the lowest step K and CRK at both the soil depths. The cumulative release of non-exchangeable K from the NPK fertilizers treated soil was higher than that from the unfertilized soil. Application of FYM together with NPK fertilizers increased the cumulative release of non-exchangeable K from soil, but the release was lesser than that from the 150% NPK fertilizers treated soil. Mean annual K removal by the crops surpassed the amount of total K applied to the soil, thereby resulting in a negative apparent K balance in the soil under all the treatments. Among the K fertilization treatments, NPK fertilizers plus FYM resulted in a greater negative K balance in soil due to larger K removal by the crops under this treatment. And the lowest negative K balance was observed with the 150% NPK fertilizer treatment. Observed mining of the soil K, despite application of recommended dose of NPK fertilizers (100% NPK fertilizers) alone or together with organic manure, calls for revision of the K fertilizer recommendation to a higher level for jute-rice-wheat cropping system in the gangetic alluvium of West Bengal. The higher doses of K fertilizer may bring the negative K balance to an admissible limit and check the soil degradation.

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Establishment of Critical Limit of Boron in Soil and Plant for Predicting Response of Mustard (*Brassica juncea* L.) to Boron Application in Inceptisols of Varanasi

S.K. Singh, S.N. Yadav and Omkar Kumar

Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanas, 221005, Uttar Pradesh

Boron is one of the most important micronutrient essential for plant growth and is involved in several metabolic functions of plants. It is a crucial element because of its vital role in fertilization and flowering processes of crops. One of the first adverse effects of B deficiency is on flowering and fruiting, therefore, it reduces the yield and quality of the seeds and fruits. Application of B either through soil or foliar spray has been found beneficial for increasing the yield of crops.

India is the third largest rapeseed-mustard producer in the world after China and Canada with 12% of world's total production. This crop accounts for nearly one-third of the oil produced in India, making it the country's key edible oilseed crop contributes 28.6% in the total production of oilseeds. Out of the total cropped area in India, the share of oilseeds is 14.1% and the rapeseed-mustard accounts for 3% of it. The critical limit of B in plant refers to a level at or below which plant either develops deficiency symptoms or causes significant reduction in crop yield as compared to optimum. Since meagre information is available on the critical limits of boron in mustard coupled with wide spread deficiency of boron in Varanasi regions, the present investigation was undertaken.

Twenty one bulk soil samples were collected from different locations of Varanasi. The air dry soil samples passed through 2 mm sieve and filled with polythene lined pots (5 kg capacity) during *rabi* season of 2012-2013 in net house of the Department of Soil Science and Agricultural Chemistry, taking mustard (*Brassica juncea* L.) var. Varuna as a test crop. The bulk soil had sandy loam to loam texture, pH 7.4-8.1, EC-0.24-0.98 dS m^{-1}, organic C 3.5-7.1 g kg^{-1}, $CaCO_3$ 1.2-2.8%, CEC 8.9-15.5 [cmol(p^+)kg^{-1}], available N, P, K and S ranged from 100-188, 9-28, 132-290, 10-39 kg ha^{-1}, respectively. Hot water extractable B ranged from 0.24-1.13 mg kg^{-1} with a mean of 0.69 mg kg^{-1}. The experiment was laid out in factorial complete randomized design having three treatments (0, 1.0, 2.0 mg kg^{-1}) and replicated thrice. Five extractants were used for the extraction of boron in soil to assess the critical limit of B in soil. The critical limits of boron in soil and plant of mustard were established using graphical and statistical procedure. The respective values of critical levels of B obtained using graphical and statistical methods with hot 0.01 *M* $CaCl_2$ (0.60 /0.60 mg kg^{-1} followed by hot water (0.54/0.54 mg kg^{-1}), 0.05 *M* HCl (0.45 / 0.48 mg kg^{-1}), 1.0 *M* NH_4OAC (0.45 / 0.46 mg kg^{-1}) and 0.01 *M* $CaCl_2$ + 0.05 *M* manitol, pH 8.5 (0.36 / 0.38 mg kg^{-1}) in soil. The critical limit of B in mustard plant was found 27.8 and 27.6 mg kg^{-1} using graphical and statistical methods, respectively.

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Effect of Diatomite Application as Silicon Source on Leaf Relative Water Content, Electrolyte Leakage, Proline and Chlorophyll Content of Aerobic Rice under Moisture Stress

M.S. Anitha and N.B. Prakash*
Department of Soil Science and Agricultural chemistry, UAS, GKVK, 560065, Bengaluru
**Email: nagabovanalliprakash@rediffmail.com*

The term diatomite or diatomaceous earth (DE) refers to a sedimentary rock that results from the deposition of silica-rich unicellular life forms known as 'diatoms'. Diatom frustules are composed mainly of amorphous silica with high plant available silicon, highly porous in structure, helps in alleviating drought stress and nutrient imbalance when added to soil. The information regarding the effect of DE on aerobic rice under moisture stress is very limited and such study is of great importance to understand its efficacy and behaviour under moisture stress condition. Hence, a pot culture study was conducted to know the effect of diatomite in alleviating the deteriorative effect of moisture stress and on growth of aerobic rice. The treatments of the study were (1) 100% FC (field capacity), (2) 100% FC + DE @ 150 kg ha^{-1}, (3) 100% FC + DE @ 300 kg ha^{-1}, (4) 50% FC, (5) 50% FC + DE @ 150 kg ha^{-1} and (6) 50% FC + DE @ 300 kg ha^{-1}. The water-deficit treatments were maintained for a period of 45 days (45 to 90 DAS) with a moisture level equivalent to 50 per cent of FC, whereas the well watered pots were maintained at 100 per cent field capacity. The fresh leaves were sampled on 90 DAS at the end of moisture stress period and analysed for chlorophyll content, leaf relative water content (LRWC, %), electrolyte leakage (EL) and proline content by adopting standard procedures.

There was a significant increase in plant growth parameters with application of DE @ 300 kg ha^{-1} along with RDF at 100 per cent FC in both acidic and alkaline soil. Application of DE @ 300 kg ha^{-1} at 50 per cent FC along with RDF recorded higher LRWC in both acidic (67.1%) and alkaline (60.9%) soil compared to 50 per cent FC alone but less compared to 100 per cent FC along with DE. Significant reduction in proline content was observed with application of DE @ 300 kg ha^{-1} along with RDF at 50 per cent FC in both acidic and alkaline soil, respectively. Application of DE @ 150 kg ha^{-1} along with RDF significantly reduced the EL in both acidic and alkaline soil, respectively at 50 per cent FC but found to be higher compared to 100 per cent FC. Application of DE @ 300 kg ha^{-1} along with RDF significantly increased content of Silicon in rice straw in both acidic and alkaline soil at 50 per cent FC. Significantly higher uptake of Silicon by rice straw was recorded with application of DE @ 300 kg ha^{-1} and DE @ 150 kg ha^{-1} along with RDF at 100 per cent FC in acidic and alkaline soil, respectively compared to non DE treated plants. Results indicated that application of DE @ 300 kg ha^{-1} has performed better in aerobic rice under moisture stress condition in both acidic and alkaline soil.

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Characterization of Enriched and Unenriched Urban Solid Waste Compost and FYM and its Effect on Yield of Aerobic Rice

B.C. Punitha* and H.C. Prakasha
Department of Soil Science & Agricultural Chemistry, UAS, GKVK, 560 065, Bangalore
**Email: puni529@gmail.com*

Wastes recycling can bring tremendous benefits to agriculture in long run. Towards this end urban solid waste compost (USWC) with micronutrients and microbial enrichment could serve as a valuable organic matter source and soil conditioner for agricultural applications. Enrichment of USWC and farmyard manure (FYM) was done with iron (Fe), zinc (Zn) and boron (B) by thoroughly mixing and curing with water for two weeks. Later enriched composts were mixed with microbial consortia like N fixers and P solubilizers @ rate of 1 kg per tonne of compost at the time of sowing and applied to the soil. The characterization of the representative USWC sample revealed that the compost was neutral in reaction (pH 7.10) and EC of 1.63 dS m^{-1}. The concentration of N, P, K and B were 0.91, 0.17, 0.79 and 0.22 per cent, respectively. The micronutrients like Fe and Zn content was 574.19 and 19.40 mg kg^{-1}. Whereas the enriched USWC showed a marginal increase in pH value of 7.21 and EC 1.70 dS m^{-1} and an improvement in N, P, K and B content which recorded 1.21, 0.25, 1.25 and 0.34 per cent and micro nutrients like Fe and Zn content recorded 619 and 24.8 mg kg^{-1}, respectively. The characterization of FYM where the pH of 7.10 and EC 0.98 dS m^{-1} was recorded. The nutrient concentration of N, P, K and B were 0.49, 0.15, 0.45 and 0.19 per cent and the micronutrients concentration *viz*., Fe and Zn content was 560 and 14.8 mg kg^{-1}, respectively. Whereas enrichment of FYM recorded an increase in pH (7.18) and EC of 1.04 dS m^{-1}. The improved concentration of N, P, K and B content in enriched FYM showed values of 0.89, 0.23, 1.14 and 0.31 per cent and concentration of micro nutrients like Fe and Zn content were increased to 583 and 18.6 mg kg^{-1}, respectively.

Field investigation on effect of enriched and unenriched urban solid waste compost and FYM on grain and straw yield of aerobic rice was carried out during *kharif* -2013 at UAS, GKVK, Bangalore. The treatments were fixed based on their N content in enriched USWC and FYM and unenriched USWC and FYM and were compared with the package of practice (100 :50 :50 NPK kg ha^{-1} + FYM @ 10 t ha^{-1}) and 100% NPK alone. The 100% P and K were given through inorganics was common for all the treatments. The grain (4.57 t ha^{-1}) and straw (5.31 t ha^{-1}) yield and yield parameters of aerobic rice increased significantly in 50% N + 100% PK + 50% N through enriched USWC. Enriched compost treatments in conjunction with inorganic fertilizers has produced higher yield compared to inorganic fertilizers alone due to addition of nutrients to soil pool from enriched organics which enhanced the yield and yield parameters.

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Characterization of Different Biochars and their Effect as a Source of Silicon on Aerobic Rice

M.K. Akshatha and N.B. Prakash*
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, 560065, Bengaluru
**Email: nagabovanalliprakash@rediffmail.com*

Many studies revealed the potential of biochar amendment to sequester C and to increase the crop land productivity. Positive benefits of biochar addition are reported in acidic soil where low pH and Al toxicity hinders the plant growth. Alkaline nature of biochar and presence of high amount of exchangeable bases help in increasing the pH and base status of acidic soil and thereby crop improvement. Although, Si is considered as a nutrient of agronomic essentiality for high Si-accumulating crops such as rice, the effect of biochar application on plant available Si content and its uptake by aerobic rice in acidic soil has not been evaluated. An incubation study with acidic soil was conducted to know the dynamics of soil pH and 0.01 *M* $CaCl_2$ - Si upon addition of wood (WB), bamboo (BB) and rice husk biochar (RHB) at 4 levels (2, 4, 8 and 16 t ha^{-1}) under field capacity moisture regime. This was followed by a pot culture study with the same biochar treatments to know effect of biochar amendment on growth and yield of aerobic rice and tissue Si content and uptake.

Results revealed that all the biochars were alkaline in nature and RHB contained highest total Si content. The highest soil pH was observed with addition of wood biochar at 30 days after incubation (DAI) and thereafter a decreasing trend was observed. Independent of types and levels of biochar an increasing trend in 0.01 *M* $CaCl_2$ - Si content was observed from 30 DAI to 120 DAI. Higher 0.01 *M* $CaCl_2$ - Si was observed with application of rice husk biochar (RHB). Independent of type of biochar, increased rate of biochar application increased the pH and 0.01 *M* $CaCl_2$ – Si at all intervals. The increase in pH was directly related to total content of Ca and C:N ratio and inversely to N content of biochar. Plant available Si content of soil as result of biochar application was dependent on Si content of biochar. Application of RHB recorded higher grain and straw yield and higher tissue Si content than other two biochars. The higher grain yield with RHB addition can be attributed to lower C:N ratio and higher Si content. Increase in yield to an extent of 9.19 to 46.47 per cent in comparison to control was observed with application of different biochars. In conclusion, biochar application can supplement Si in acidic soil besides serving as an amendment.

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Effect of Climatic Conditions and Slopes on Soil Organic Carbon Stock in the Grasslands of Western Ghats, India

K. Rajan, R. Ragupathy, V. Kasthuri Thilagam, O.P.S. Khola and D. Dinesh
ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Udhagamandalam, The Nilgiris, Tamil Nadu

Western Ghats of India encompass rich bio-diversity, varied climatic conditions and different land uses. The Nilgiri district of Tamil Nadu represents the Western Ghats in case of climate and geomorphology where the soil organic carbon (SOC) stock assessment was planned. Climatic conditions and land slopes play major role in organic carbon accumulation in soils. In Nilgiris district, out of 2,54,485 ha land, 2 per cent area is occupied by grasslands. The temperate grassland are found in higher elevation (>2000 m above mean sea level, MSL) and tropical grasslands are found in lower elevation below 2000 m MSL. Being hilly region, all types of slope classes are found in the district and it was grouped under three categories *viz*., <10%, 11-33% and >33% of slopes for this study. Herewith, SOC stock was assessed in the grasslands under two climatic conditions and three slope categories. Representative sites for climate and slope category in the grasslands were identified in the district for soil sample collection. Six profiles were opened and soil sample were collected depth-wise with 15 cm increments up to one meter. Soil core samples collected depth wise for estimating bulk density (BD). Totally 42 soil samples were collected, processed and analyzed for SOC with standard procedure. The SOC stock (kg m^{-3}), was calculated from SOC percentage, BD and depth of soil up to one meter depth. The SOC stock was highest in temperate grasslands (21.4 kg m^{-3}) and the lowest in tropical grasslands (14.2 kg m^{-3}). Among slope categories, the grasslands in <10% slope category recorded highest SOC stock followed by 10-33% and lowest was in >33 per cent slope category irrespective of climate. In temperate grasslands, highest SOC stock was recorded in <10% slope (22.7 kg m^{-3}) category which is 14% higher than >33 per cent slope (19.9 kg m^{-3}) category. Similar trend was recorded tropical grasslands also and the SOC stock in <10% category is 27 per cent (16.8 kg m^{-3}) higher than >33% slope (13.2 kg m^{-3}) category. Low SOC stock in grasslands especially in higher slope conditions mainly due to soil erosion being a high rainfall region. Implementation of necessary soil and water conservation measures in higher slopes will improve SOC stock and soil health for better grassland ecosystem.

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Effect of Tillage and Crop Residue Management Practices on Clay-Humus Complex Stability in Wheat-Maize and Wheat-Pigeonpea Cropping Sequence

R.N. Pandey*[1], Suresh Chandra[1], S.C. Datta[1] and T.K. Das[2]
[1]Division of Soil Science and Agricultural Chemistry,[2]Division of Agronomy,
ICAR-Indian Agricultural Research Institute, New Delhi, 110 012
**Email: rnpandeyssaciari@rediffmail.com*

The study on the stability of clay humus complex under different cropping sequence and tillage and residue management options is important for long term retention of sequestrated carbon in soil. An investigation was carried to know the effect of different tillage and residue management practices on stability of clay-humus complexes under wheat-maize and wheat-pigeonpea cropping sequence started during *kharif* 2009 at IARI, New Delhi. The experiment was laid out in randomized block design in which seven combinations of tillage and crop residue management practices were zero-tillage flat bed no residues (ZTFBNR), zero tillage flat bed with residue (ZTFBWR), permanent broad bed with residue (PBBWR), permanent broad bed no residue (PBBNR), permanent narrow bed no residue (PNBNR), permanent narrow bed with residue (PNBWR) and conventional tillage (CT) in both the cropping sequences. The plot-wise composite surface (0-15 cm) soil samples were collected from both the cropping sequences before sowing of *rabi* 2013-14 wheat. Soil organic matter of the collected samples were sequentially extracted with a mixture of 0.1*M* sodium pyrophosphate and 0.1*M* sodium hydroxide (pH 13) by shaking for 2 h and followed by centrifugation at different time intervals till there was no further extraction. Organic carbon content in the extracts was estimated by 0.4*N* chromic acid and in soil by Walkely and Black 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 constent. Cropping sequences and tillage and residue management practices influenced stability of clay-humus complex. In wheat-maize cropping sequence the highest stability was observed under treatment ZTFBWR and the lowest in the CT which was at par with PBBNR and PNBNR. Irrespective of method of bed preparation the higher clay humus stability was observed under residue treated plots as compared to untreated plots. Probably application of the wide C:N ratio crop residue of wheat and maize increased the stability of clay humus complexes. In the wheat-pigeonpea sequence the highest stability was observed under zero tillage flat bed no residue (ZTFBNR) treatment over all the other treatments whereas PBBNR, PNBNR and CT were at par. Irrespective of type of bed preparation and tillage plots which received residue significant decrease in stability of clay humus complexes was observed which could be due to application of narrow C:N ratio of pigeonpea residue. The findings of this study clearly indicated the effect of quality of crop residue on the stability of clay humus complex.

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Evaluation of Growing Environment on Yield and Anti-nutritional Factors in Bajra Napier Hybrids

M. Shanti, R. Susheela, V. Chandrika, T. Shashikala and M. Anuradha
AICRP on Forage Crops and Utilization, ARI, Rajendranagar, Hyderabad, 500 030

Agriculture is primary occupation of the rural inhabitants in the state of Telangana. Dairying goes hand in hand with agriculture in most of the rural households, though many a time the shift to dairying alone was seen. The livestock population of the state is 50.3 lakh cattle, 41.9 lakh buffaloes, 128.7 lakh sheep and 46.7 lakh goats. The cattle population of Adilabad (10.01 lakhs) is highest among all districts while Mahboobnagar districts dominate in sheep population (38.8 and 37.3 lakhs, respectively) and goat population (7.85 and 6.87 lakhs, respectively). Bajra napier hybrids are the most promising perennial fodders to feed these livestock population.

Being a hybrid between the bajra and napier grass, this hybrid tends to express accumulation of oxalates. However, owing to intensive cultivation of this hybrid especially in shade, besides nitrogen fertilization after every cut could lead to accumulation of anti-nutritional factors *i.e.*, nitrates and oxalates. An experiment was hence conducted in an orchard to study the effect of nitrogen levels and shade on the production of the crop, quality parameters *viz.*, crude protein, crude fibre and anti-nutritional factors *viz.*, oxalates and nitrates on APBN-1 (Andhra Pradesh Bajra Napier Hybrid-1). The nitrogen levels of 0, 25, 50, 100 and 125% of the recommended rate *i.e.*, 40 kg ha^{-1} of N as basal dose and after each cut were imposed. Parameters *viz.*, green fodder yields, crude protein, crude fibre anti-nutritional factors viz., oxalates and nitrates were studied after each cut. The study indicated that physical parameter, plant height did not vary with growing environment but highest plant height was observed in 100% recommended application of N while most of the treatments were at par. The leaf: stem ratio and no. of tillers/clump was significantly highest when crop was grown under direct sun (0.88) rather than under shade (0.81). Green fodder yield (36.8 t ha^{-1}) and dry fodder yield (8.74 t ha^{-1}) was maximum when grown in sun while highest GFY was recorded when N is applied at 125% of recommendation. The crop in shade recorded GFY of 35.4 t ha^{-1} and DFY of 8.06 t ha^{-1}, respectively. The fodder quality parameters viz., Crude protein though high when crop was in shade (9.1%) as compared to crop in sun (8.9%), the difference was not significant. Crude fibre did not vary with growing environment. Invariably in all cuts the nitrate concentration of fodder was highest in 125% N receiving treatment and crop in shade recorded more nitrate values, however these concentrations were much below the toxic levels. Oxalates concentration was significantly highest when grown in sun (1.85%) while oxalate accumulation was at peak at 50% of recommended N and reached a straight line. The three year study did not bring significant changes in soil available N, P or K. The study indicated the crop can be grown even under shade or under orchards as there was no accumulation of nitrates or oxalates in unsafe limits.

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Effect of Nickel Application on Nitrogen Metabolism and its Utilization in Wheat

P.V. Mehta[1], K.P. Patel[2]* and V.P. Ramani[3]

[1]N.M. College of Agriculture, Navsari Agricultural University, Navsari, 396450, Gujarat
[2]B.A. College of Agriculture, Anand Agricultural University, Anand, 388110, Gujarat
[3]Micronutrient Project (ICAR), Anand Agricultural University, Anand, 388110, Gujarat
**Email: kishorbhai_patel@rediffmail.com*

An investigation was undertaken to study the effect of nickel (Ni) application on nitrogen (N) metabolism and its utilization in wheat (*Triticum aestivum* L. var. GW 496) on two different Typic Ustochrepts soils of Anand. Three N levels: 80, 100 and 120 kg ha^{-1} and four levels of Ni: 0, 2-5, 5 and 10 mg kg^{-1} (applied 15 days before sowing) were taken in a microplot experiment with three repetitions under completely randomized block design (factorial) during 2009-10 and 2011-12. The Ni application at 2.5 mg kg^{-1} resulted in significant and maximum improvement in grain yield in both the soils. Further, the combined application of 100 kg ha^{-1} in conjunction with 5 mg Ni kg^{-1} soil was found most effective in increasing wheat yield.

The Ni application at 2.5 mg kg^{-1} enhanced soil urease activity; and beyond this level, it resulted in reduced activity at all the stages of wheat growth. The improvement in NH_4^+-N content of soil after 24 and 48 h of N application was comparatively higher at initial growth stages than at panical initiation stage, however, Ni did not cause any significant change in NH_4^+-N content at any of the growth stages. There was increase in NO_x–N content in soil with increase in N application from 80 to 120 kg N ha^{-1} after 24 h of sampling. The contents of NO_x-N increased to a greater extent after 48 h of N application at all the stages. The combined effect of N and Ni, application of N at 80 kg ha^{-1} in conjunction with 2.5 mg Ni kg^{-1} proved to be the best for highest nitrate reductase activity at sowing stage.

The overall findings suggested the practical significant of Ni application on N transformation, metabolism and utilization in wheat. The wheat responded to higher Ni levels with advancement in crop growth, Ni application at 2.5 mg kg^{-1} was found to enhance growth and yield of plants in combination with N application. Therefore, the results are suggestive for judicious use of Ni with N application (through urea) to increase its efficiency and crop production under intensive cropping. However, detailed research is necessary to investigate the harmful effect of Ni on soil-plant-human/animal health due to entry in food chain, if continuously applied over the years.

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Development of Newly Manufactured Controlled Release Phosphatic Fertilizers: An Attempt to Improve Phosphorus Use Efficiency

Abhijit Sarkar, D.R. Biswas*, S.C. Datta and T. Roy
Division of Soil Science and Agricultural Chemistry, ICAR-Indian Agricultural Research Institute, New Delhi, 110012
**Email: drb_ssac@yahoo.com*

Phosphorus (P) is the irreplaceable primary nutrient element in plant, which plays a key role in virtually all biochemical processes that involve energy transfer. In general, P is found to be deficient in acid and calcareous soils due to presence of higher concentration of aluminium/iron and calcium, respectively. Thus, P use efficiency (PUE) is very low among the major nutrients, and improvement of PUE is also the prime challenge for agricultural production. The alternative means of improving PUE is to develop new modified products by using some coating materials like polymers and/or superabsorbent that form diffusion barrier to initiate controlled or slow release characteristics of coated fertilizers. This could be magnifying the aim to perceive advantages of P release from newly manufactured product that match with crop demands. To accomplish the objective, two different phosphatic fertilizers were synthesized in the laboratory through ammoniation of ortho-phosphoric acid (Product-A) and acidulation of Udaipur rock phosphate (Product-B) with ortho-phosphoric acid. Followed this, products were coated with poly-vinyl alcohol (PVA) and liquid paraffin (LP) at two coating levels (2 and 3%, w/w), based on the affinity of polymers towards water. Chemical analysis of products showed that Product-A had the highest total P (28.8%) followed by Product-B (21.6%). The scanning electron microscopy (SEM) studies showed the corresponding surface morphology of Product-A and Product-B, which were smooth cuboidal and irregular flaky. The X-ray diffraction (XRD) studies revealed the superior crystalline structure of Product-A over the other product. Whereas, the fourier transform infra-red spectroscopy (FTIR) results indicated the presence of N-P groups in Product-A, whereas only P groups in Product-B. To study the release characteristics, the products along with commercial DAP were evaluated through incubation experiment with two different temperature (20 and 30 °C) and moisture (10 and 20%, v/v) regimes the release of Olsen P followed this descending order: DAP > Product-A > Product-B. Moreover, the release rate of P from coated fertilizers are lesser than the DAP. Results emanated from pot culture experiment revealed that overall mean yield of wheat grain and straw as well as P recovery efficiency increased significantly due to application of modified coated phosphatic fertilizers compared to commercial DAP.

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Interrelationship between Forms of Nitrogen with Soil Properties in Selected Soils under Varied Farming Situations

G.N. Manjunatha, S.R. Balanagoudar*, K. Narayana Rao, Mahadevaswamy and R.V. Beladhadi

Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, Raichur, 584104, Karnataka
**Email: srbalanagoudar@gmail.com*

Continuous application of manures and fertilizers are found to influence the various fractions of soil nitrogen (N) besides influencing other soil properties. Hence, the knowledge regarding the forms of soil N and conditions controlling, their availability is of importance in an appraisal of available N status of the soil. The present investigation was undertaken to evaluate the different forms of N and their relationship with some soil characteristics. Ten representative soil profile samples covering Hyderabad and Karnataka region under different farming situation and cropping practices were collected for the study. The results revealed that the total N content in the soil profiles varied between 313 to 1350 mg kg^{-1}. Total hydrolysable N was dominant portion of total N and its content varied between 272 to 1216 mg kg^{-1}. Exchangeable ammonical N and nitrate N along with nitrite N fractions ranged from 8 to 40 mg kg^{-1}, 4 to 26 mg kg^{-1} and 1 to 8 mg kg^{-1}, respectively. The available N in the surface was more and found to decrease with depth. Available N contents were significantly and positively correlated with organic carbon in black and red soils. Among the forms of N all the fractions were positively correlated among themselves, indicating existence of dynamic equilibrium among different forms. The available N and total hydrolysable N was relatively found more in organic farming farmers' field and at the same time was not influenced by heavily fertilized rice fields. The particle size distribution was found to vary from sandy clay to clay, soil reaction was neutral and sodic. The soluble salts of all the profiles were normal except Navalakal village. The organic carbon content in all profiles varies between low to medium and the content followed decreasing trend with depth. The available P was low to medium and followed same trend as that of organic carbon. Among the DTPA extractable micronutrients Zn content found to be deficient compared to Fe, Cu and Mn. The microbial population was more in surface soil sample and was decreasing with increasing soil depth because of more organic carbon and total N.

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Status of Nitrogen Fractions under Different Land Use Systems of a Micro-Watershed in Northern Transition Zone of Karnataka

Sabyasachi Majumdar[1], P.L. Patil[2] and C.R. Patil[3]

[1]Department of Soil Science and Agricultural chemistry, UAS, GKVK, 560065, Bangalore
[2]Department of Soil Science and Agricultural chemistry, UAS, 580005, Dharwad
[3]Department of Agricultural Microbiology, UAS, 580005, Dharwad
**Email: sabyasachiuasd@gmail.com*

An investigation was undertaken during 2013-14 in northern transition zone of Karnataka to study the forms and distribution of sulphur under different land use systems of Singhanhalli-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 analyzed for forms of nitrogen. One representative soil profile was sampled from each land use system for studying the vertical distribution of different nitrogen fractions. The exchangeable ammonical nitrogen values of surface soil samples varied between 8.4 to 36.4, 14.0 to 47.6 and 16.8 to 35.6 mg kg^{-1} under agriculture, horticulture and forest land use systems, respectively. Nitrate nitrogen values of surface samples ranged between 2.8 to 47.6, 3.9 to 25.2 and 8.4 to 24.7 mg kg^{-1} under agriculture, horticulture and forest land use systems, respectively. Total nitrogen content decreased with depth in almost all the profiles and ranged from 270 to 1000 mg kg^{-1}. There was a significant positive correlation recorded between total nitrogen and clay content under all the land uses systems except non-paddy land. The contribution of inorganic nitrogen fractions to total nitrogen was very low.

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Behaviour of Nickel in Soils as Described by Adsorption and Desorption Isotherms

Dhanwinder Singh, Pinaki Mandal and Kuldip Singh
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141 004, Punjab

The bioavailability of nickel (Ni) in soils depends on its concentration in it and ability of soil to release Ni from its various solid phases. Adsorption and desorption behaviour of Ni in two surface soils, one each from Rupnagar and Ludhiana districts, were studied by adding six different levels of Ni (5, 10, 20, 30, 60 and 90 mg L^{-1}) using a batch technique. A known weight of soil samples were equilibrated with these different concentrations of Ni in the presence of a background electrolyte 0.01*M* $Ca(NO_3)_2$. The sequential desorption of Ni from the same samples were carried out using Ni free 0.01*M* $Ca(NO_3)_2$. The amounts of Ni sorbed and desorbed were determined using ICP-AES.

Both the surface soils exhibited high capacity of Ni adsorption at all concentrations. The percent Ni adsorbed was in the range between 96 (for Rupnagar soil at 50 mg kg^{-1} of initial concentration) to 44.3 (for Ludhiana soil at 900 mg kg^{-1} of initial concentration). It was observed that with an increase in initially added Ni concentration, the amount of Ni adsorbed was increased. It was also observed that, within each soil, as added Ni concentration increased from 50 to 900 mg kg^{-1} soil there was a continuous decrease in percent Ni adsorption. The per cent Ni adsorbed decreased from 96 to 77.1 for Rupnagar, and 80.2 to 44.3 for Ludhiana soil. The decrease was less for Rupnagar soil as compared with Ludhiana soil indicating the former has higher adsorption capacity than the later. The adsorption data were well described by Langmuir adsorption isotherm. Langmuir isotherm curves for both soils exhibited two distinct linear regions with separate slopes. Adsorption maxima (b) increased from region I to region II while, bonding energy (k) decreased from region I to region II. This indicates that adsorption rate was faster in case of lower concentrations and Ni was initially adsorbed on specific sites. Subsequently with increase in concentration Ni got adsorbed onto non-specific sites, which results in slower adsorption process. Nickel adsorption data for the present experimental soils were also described using Freundlich isotherm model. High coefficient of determination (0.985-0.998) for Ni adsorption data and Freundlich isotherm, for the two selected soils fit values were observed. Adsorption capacity, K_f (relative affinity of adsorbate for adsorbent) was higher for Rupnagar soil than Ludhiana soil. The patterns and amounts of Ni desorbed varied substantially among the present experimental soils, which indicate their different capacity to continue supplying Ni in solution. Both the soils desorb less at lower levels of Ni addition than at higher levels. Nickel desorption was higher in Ludhiana soil than the Rupnagar soil at all added Ni levels. Desorption data were well explained by Langmuir desorption isotherms (R^2 = 0.82 to 0.98). Langmuir parameters desorption maxima (D_m) was ranged from 625.0 to 1428.6 mg kg^{-1} and distribution coefficient (K_d) was ranged from 0.08 to 0.28 L mg^{-1}. The D_m and K_d value was higher for Rupnagar soil probably because of higher pH, clay and CEC value.

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Effect of Organic and Inorganic Nutrients Sources on Soil Humus Fractions under Soybean-Safflower Cropping Sequence

S.L. Waikar, A.L. Dhamak and F.F. Shaikh
Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra

In the 8th cycle of long-term fertilizer experiment at Departmental Farm, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, the experiment was carried out to study the effect of organic and inorganic nutrient sources on soil humus fractions under Soybean-Safflower cropping sequence. The experiment was laid out in randomized block design (RBD) with twelve treatments were replicated four times. The treatments containing T_1-50% NPK, T_2- 100% NPK, T_3-150% NPK, T_4-100% NPK + Hand weeding, T_5-100% NPK + $ZnSO_4$@ 25 kg ha^{-1}, T_6-100% NP, T_7-100% N, T_8-100%NPK + FYM @ 5 t ha^{-1}, T_9-100% NPK- sulphur, T_{10}-FYM@ 5 t ha^{-1}, T_{11}-Control and T_{12}- fallow.

The experimental observations were recorded during 2013-14. The result indicates that, the treatment T_8 (100% NPK + FYM@ 5 t ha^{-1}) recorded highest grain and straw yield of both soybean and safflower crop, whereas 150% NPK (T_3) and 100% NPK + Zn (T_5) were recorded statistically at par with T_8. Whereas, 3.91% of soil, pH decreased over control after harvest of soybean, 3.54% soil pH decrease over control after harvest of safflower. In case of organic carbon (OC), 20.9 and 21.8% soil increased OC over control after harvest of soybean and safflower, respectively with the application of 100% NPK + FYM @ 5 t ha^{-1}. However, $CaCO_3$ was statistically non-significant, but yield recorded was maximum in treatment (T_{11}).

Moreover, the soil nutrient status indicated maximum available N, P, K and S in 100% NPK+FYM@ 5 t ha^{-1}. However, 100% NPK + $ZnSO_4$ @ 25 kg ha^{-1} treatment (T_5) recorded maximum available Zn content in soil. Also, organic matter fractions like humin content found to be increased by 14.4% and 15.0% over control after harvest of soybean and safflower, respectively. Whereas humic acid content was increased by 13.9% and 20% over control after harvest of soybean and safflower, respectively. Fulvic acid content also increased significantly by 28.9% and 41.6% over control after harvest of soybean and safflower, respectively with application of 100% NPK + FYM@ 5 t ha^{-1}.

It can be concluded that the application of 100% NPK + FYM@ 5 t ha^{-1} was beneficial in respect to build up soil organic matter, soil fertility, higher productivity and sustainability in soybean-safflower cropping sequence grown on Vertisol.

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Carbon Fractions and Nitrogen Mineralization as affected by Long-term Organic and Inorganic Fertilization under Rice-Wheat Cropping System

B.S. Brar*, Gagandeep Kaur, S.P. Saini and G.S. Dheri
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab
**Email: bsbrar1957@yahoo.co.in*

Effect of long-term nutrient management on the carbon fractions and nitrogen mineralization was investigated under rice-wheat cropping system at Soil Science department farm, Punjab Agricultural University, Ludhiana (30°52′N 75°52′ E and 274 m above sea level). The plant and soil samples were collected at 15 days interval from control, 100% N, 100% NP, 100% NPK and 100% NPK+FYM treatments from on-going experiment on rice-wheat sequence (in progress since 1999). Seasonal changes of soil organic carbon (SOC), water soluble carbon, labile carbon, NH_4^+-N and NO_3^-N content from soil samples were determined. Soil organic carbon content was found to be increased after 3 weeks of rice transplanting and it was found maximum at harvesting in all treatments. Application of organic amendment in conjunction with mineral fertilizer increased the soil organic carbon content over control across all the sampling dates. Water soluble carbon and labile carbon content was increased up to 5th week after transplanting and it decreased afterwards in all treatments. The values were higher in plots receiving organic manure along with inorganic fertilizers throughout the growing season. A general decrease in ammonical and nitrate nitrogen was observed in all treatments with progression of rice growth and minimum value was observed at harvesting. Rice dry matter yield at maturity and grain yield correlated significantly with SOC, water soluble carbon, labile carbon, NH_4^+-N and NO_3^-N content. Crop yield of rice and nutrient uptake (N, P and K) increased with the integrated use of inorganic fertilizers and FYM at all growth stages. Simultaneous inclusion of mineral nitrogen determined across the rice growth period explained 88 per cent contribution both in grain and total N uptake. The overall net change in organic carbon pool was maximum in treatment receiving integrated use of FYM and NPK. The carbon sequestration was higher under plot receiving integrated use of FYM and inorganic fertilizer under rice-wheat cropping systems.

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Effect of Long-term Nutrient Management on Carbon Fractions and Nitrogen Mineralization under Maize-Wheat Cropping Sequence

B.S. Brar*, Gagandeep Kaur, S.P. Saini and G.S. Dheri
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab
**Email: bsbrar1957@yahoo.co.in*

An investigation was undertaken to access the effect of long-term nutrient management on the carbon fractions and nitrogen mineralization under maize-wheat. The plant and soil samples were collected at 15 days interval from selected treatments (control, 100% N, 100% NP, 100% NPK and 100% NPK+FYM) during maize growth period from on-going long-term field experiments on maize-wheat sequence, since 1971 at Soil Science department farm, Punjab Agricultural University, Ludhiana (30°52′N 75°52′ E and 274 m above sea level). Seasonal dynamics of different pools of C (soil organic carbon, water soluble carbon and labile carbon) and NH_4^+-N and NO_3^-N content from soil samples were determined. Soil organic carbon and available N improved with continuous application of organic and inorganic fertilizers under maize-wheat sequence. Soil organic carbon content in all treatments was found to increase after 3 weeks of sowing and it was found maximum at harvesting of maize. Application of organic amendment in conjunction with mineral fertilizer increased the soil organic carbon content over control across all the sampling dates. Water soluble carbon and labile carbon content was found to increase up to 5th week after sowing and it decreased afterwards in all treatments in maize. The values were higher in plots receiving organic manure along with inorganic fertilizers throughout the growing season. A general decrease in ammonical and nitrate nitrogen was observed in all treatments with progression of maize growth and minimum value was observed at harvesting. Dry matter yield at maturity and grain yield of maize correlated significantly with SOC, water soluble carbon, labile carbon and NH_4^+-N+NO_3^- N content. Crop yield of maize and nutrient uptake (N, P and K) increased with the integrated use of inorganic fertilizers and FYM at all growth stages. Simultaneous inclusion of mineral nitrogen determined across the growth period of maize explained 85 per cent and 86 per cent contribution in grain yield and N uptake, respectively.

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Impact of Rice Residue Biochar on C and N Mineralization in Soils with Varied Texture

Manpreet S. Mavi*, G.S. Batth, B.S. Sekhon and Jagdeep Singh
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141 004, Punjab
**Email: mavims16@pau.edu*

Maintaining threshold level of organic matter in the soil is critical for the soil to perform its various processes and functions. However, long-term burning of crop residues reduces total mineralizable C and N especially in the upper 0-15 cm soil layer. Production of biochar from surplus crop residues is attracting attention worldwide as a means for sequestering carbon and as a potentially valuable input for agriculture to improve soil fertility. However, despite widespread interest in biochar use for soil amelioration and potential climate change mitigation, some concerns about its use as soil amendment are also reported in the literature. Therefore, an incubation study was conducted to assess the impact of different rates of rice residue biochar (0, 0.5, 1, 2 and 4%) on C and N dynamics in soils with varying texture (sandy loam, sandy clay loam and clay, termed sand, loam and clay respectively) collected from A horizon (0-30 cm). Experimental soils were amended with five rates of rice-residue biochar (ground, sieved to 0.25-2 mm), thoroughly mixed into the soils following which, 50 g of each soil (sand, loam and clay) with rice residue biochar 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. Separate set of samples were harvested at 2, 7, 14, 28, 42 and 60 days of incubation and analyzed for microbial biomass C and mineral N. Evolutions of CO_2 in samples were recorded throughout the incubation period. Irrespective of the soils, the rate of C mineralization (mg CO_2-C g^{-1} SOC day^{-1}) were consistently higher for the biochar amended treatments (B0.5%, > B1% >B2% > B4%) than the non-amended (B0%) soils. A steady increase in MBC content was found upto day 7 in clay, day 28 in sand whereas, MBC values declined on day 7 and then increased on day 14 in loam. Thereafter, MBC declined in all soils during the subsequent sampling times. NO^-_3-N increased with increase in rates of biochar addition at all sampling times whereas NH_4^+-N declined after day 7 until the end of incubation in all soils. The results indicate that there were some highly labile components in biochar which were mineralized by biotic mechanism apart from the larger proportion of recalcitrant compounds. The cumulative amount of total C mineralized (expressed as per unit of initial native SOC basis) ranged between 48.9 and 785.6 mg CO_2-C g^{-1} SOC and followed the sequence clay ≤ loamy ≤ sandy across all biochar treatments. These results clearly reflect the importance of clay content and mineralogy in stabilizing biochar-C mineralization in the soils.

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Leaching Behavior of Oxyfluorfen and Oxadiargyl in Red and Black Soils

T. Ram Prakash*, M. Yakadri and P. Leela Rani
AICRP on Weed Management, PJTSAU, Rajendranagar, Hyderabad, Telangana
**Email: trapkash@gmail.com*

Leaching studies of herbicides in soil columns are simple and reliable methods to assess their environmental fate and contamination potential. Oxyfluorfen and oxadiargyl are popular herbicides used extensively in rice, oil seeds and vegetables crops. A lab experiment was conducted during 2014 in red and black soils to study leaching behavior of oxyfluorfen and oxadiargyl with soil columns (PVC tubes of 10 cm diameter and 65 cm length). Soils were collected horizon wise and were filled into the column and pre-conditioned. Oxyflorfen (23.5% EC) and oxadiargyl (80% WP) were applied to the surface portions of the column at (X dose) recommended (100 g and 125 g a.i. ha^{-1}, respectively) and double the recommended (2X) doses (200g and 250 g a.i./ha respectively). Water was added to the surface of the column equal to the long-term average rainfall of the period. After 7 days, soil samples were collected from each 5 cm blocks and analyzed for herbicide residues on GC-ECD. Recovery of oxyfluorfen in the soil varied from 90.2 to 94.8% and LOQ was 0.025 mg kg^{-1}. Oxadiargyl recovery varied from 86.8 to 90.2% with 0.015 mg kg^{-1} LOQ.

In red soils, oxyfluorfen leached up to 5-10 cm and 10-15 cm respectively in recommended and double doses. In X dose, depth wise distribution showed that 60.6% of the total herbicide was detected in the top 0-5 cm layer and 39.4% in the 5-10 cm layer. At 2X dose, the herbicide detected was 50.4, 30.9 and 18.5% in the 0-5, 5-10 and 10-15 cm soil layers, respectively. In Black soils, oxyfluorfen leached up to 10 cm depth in X and 2X treatments. In both treatments, 72% of the total herbicide was detected in the top 0-5 cm layer of soil and 28% in 5-10 am layer. Oxadiargyl applied to red soils leached up to 5-10 cm and 10-15 cm in X and 2X doses, respectively. In X dose, 62.7% and 37.2% of the total herbicide was detected in the 0-5 and 5-10 cm layer of soil. In 2X dose, the herbicide detected in the top 0-5 cm layer was 50.4% and remaining 49.5% in 5-10 cm layer. In Black soils, oxadiargyl leached up to 10 cm depth in both doses. Depth wise distribution showed that, 71.8 to 74.7% and 28.13 to 25% of the total herbicide was detected in the top 0-5 and 5-10cm layers, respectively. In both soils, at the two rates of application, residues of the oxyfluorfen and oxadiargyl could not be detected beyond 15 cm depth, which indicated limited leaching potential of these herbicides. Higher concentration in the top 5 cm layer of the soil indicated strong affinity of the herbicide molecules with the clay/ organic matter in the soil surface horizon.

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Studies on Integrated Nutrient and Water Management for Banana

V.P. Bhalerao, A.R. Mendhe and N.B. Shaikh
Banana Research Station (Mahatma Phule Krishi Vidyapeeth), Jalgaon, 425 001, Maharashtra

Field experiment was conducted at Banana Research Station, Jalgaon to study the effect of integrated nutrient and water management for banana (Cv. Grand Naine) under drip irrigation. Experiments were laid out in factorial randomized block design (FRBD) comprised of twelve treatment combinations (Nutrient levels- 4, Irrigation water levels- 3) and replicated thrice. Tissue cultured plantlets of banana cv. Grand Naine were planted in pair row system at 0.9×1.5×2.1 m spacing (4,444 plants ha^{-1}). Inline drip irrigation system was used. Fertilizer dose of 200 g N, 40 g P_2O_5 and 200 g K_2O with 10 kg FYM per plant was used. The nutrient levels were 100:100:100% RDF, 75:100:100% RDF, 100:75:100% RDF and 100:100:100% RDF N:P_2O_5:K_2O and the irrigation water levels were 50, 70 and 90% evaporation replenishment (ER). The soil of the experimental field was medium black having pH 8.17, electrical conductivity (EC) 0.39 dS m^{-1}, low in available nitrogen (217 kg ha^{-1}), moderate in available phosphorus (19.6 kg ha^{-1}) and very high in available potassium (623 kg ha^{-1}).

Soil available N was significantly lower (208 kg ha^{-1}) in the nutrient level in which 25 per cent N was reduced. Significantly low soil available P (18.3 kg ha^{-1}) was recorded in the nutrient level in which 25 per cent P was reduced. Highest N, P and K uptake (578, 106 and 1142 kg ha^{-1}, respectively) was recorded in nutrient level in which 100 per cent NPK were applied. All the nutrient levels were statistically at par with each other in respect of soil pH and EC and growth parameters of banana *viz.* pseudostem height, pseudostem girth, days to flower, crop duration. Application of 100 per cent recommended dose of fertilizers (F_1) recorded high water use efficiency of 72.03 kg ha-mm^{-1} and water productivity of 95.79 Rs. ha-mm^{1} water, which was followed by application of 100% NP with 75% K (F_4) which recorded water use efficiency of 70.97 kg ha-mm^{-1} and water productivity of 94.03 Rs. ha-mm^{1} water. As regards nutrient levels, 100% recommended dose of fertilizers (F_1) recorded higher monetary returns of Rs. 2,84,550 /- and net profit of Rs. 1,08,104 /-. It was followed by F_4 level i.e. application of 100% NP with 75% K, which recorded monetary returns of Rs. 2,80,350/- and net profit of Rs. 1,06,129/-. Both the F_1 and F_4 reported similar B:C ratio (1.61).

Application of irrigation water at 90 PER observed significantly superior over rest of the irrigation water levels in respect of pseudostem height (175 cm), pseudostem girth (72.1 cm), no. of hands per bunch (9.1), no. of fingers per bunch(147), bunch weight (20.1 kg $plant^{-1}$), yield (89.4 t ha^{-1}), N uptake (641 kg ha^{-1}), P uptake (116 kg ha^{-1}), K uptake (1273 kg ha^{-1}), monetary returns (Rs. 3,12,900 ha^{-1}), net profit (Rs. 1,36,516 ha^{-1}) and B: C ratio (1.77). Application of irrigation water at 90 PER recorded higher EC (0.39 dS m^{-1}) than rest of the treatments. Among the irrigation levels, I_2 *i.e.* application of irrigation water at 70 PER recorded higher water productivity of 95.50 Rs. ha-mm^{-1} water with 22.2% water saving over I_3 *i.e.* application of irrigation water at 90 PER. The interaction effect between nutrient levels and irrigation water levels were also found to be significant in respect of growth and yield parameters, electrical conductivity, soil available NPK, nutrient uptake by banana and B:C ratio. Thus, application of irrigation water at 90 PER (per cent evaporation replenishment) with 100 per cent RDF found beneficial in terms of yield and monetary returns of banana.

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Impact of Potassium Nutrition on Fingermillet and Maize under Different Fertility Gradients in an Alfisol of Eastern Dry Zone of Karnataka

Atheefa Munawery, V.R. Ramakrishna Parama, C. A. Srinivasamurthy, R.C. Gowda and K.R. Ashoka

Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, GKVK, Bangalore, Karnataka

Potassium (K) an essential element for growth and development of crops, which is being depleted in Indian soils due to very low applications, requires a greater attention in order to ensure enhanced crop production and mitigation of biotic and abiotic stress as well as improvement in produce quality. Hence, the present study was conducted to know the influence of K nutrition on fingermillet and maize under different fertility gradients. Field experiments were taken up in an Alfisol in GKVK campus with creation of five potassium fertility gradients in an individual field viz, very low (K_0), low (K_1), medium (K_2), high (K_3) and very high (K_4) K fertility gradient strips utilizing the organic and inorganic source of nutrients. The grain and straw yield of finger millet and maize increased significantly due to application of super optimal dose of K (200% K followed by 150% K) along with recommended doses of N and P and incorporation of FYM to soil (T_6 and T_4, respectively), which suggests finger millet and maize responded to higher dose of K application than to the recommended dose and significantly lower yields was recorded in T_1 (control) of K_0 (very low K fertility gradient) strip to which no fertilizers were applied resulting in poor growth of crops.

The available nitrogen (N) and phosphorus (P) content of soil increased with increase in levels of K application and with increase in K fertility gradient. Application of 150% recommended K along with recommended NP and FYM (T_4) of K_4 strip recorded higher available nitrogen in finger millet and maize, respectively whereas T_6 (200% K + Rec. NP + FYM) of K_4 strip recorded available phosphorus. The available potassium content of soil reduced to 98.8 kg ha^{-1} in K_0 strip and increased with increase in fertility gradient. The available potassium decreased in soil as the growth of crops attained physiological maturity. Application of 200% recommended K along with recommended NP and FYM (T_6) of K_4 strip recorded significantly higher 525.3 kg ha^{-1} and 491.91 kg ha^{-1} available K in fingermillet and maize respectively, subsequently T_1 (control) of K_0 (very low K fertility gradient) recorded significantly lower 83.78 and 61.0 kg ha^{-1} in fingermillet-maize sequence to which no fertilizer was applied. High major, secondary and micronutrients in soils with increase in potassium fertility gradients (K_0 to K_4). Calcium and magnesium decreased from control (T_1) to treatment T_7 (200% K+Rec.NP). A comparison of K added and taken-up which is referred to as K balance indicated a negative value in-case of (T_1, T_2, T_4 and T_6) in very low K gradient (K_0) whereas (T_1, T_2, T_3 and T_5) recorded negative in low K gradient (K_1) strip respectively, this was in-case of fingermillet whereas in maize T_1 of K_0 gradient recorded negative K balance, all other treatments in other K fertility gradients recorded positive balance. The study clearly indicates that there is a need for application of potassium fertilizer to crops based on soil tests for sustainable yield.

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Carbon Sequestration Potential and Dynamics of Soil Organic Carbon Labile Pool under Tropical Rice-Rice Agro-ecosystem

Prajnyamayee Kamp[1], M. Mandal[1], K.K. Rout[1], P. Majhi[1] and M. Singh[2]
[1]AICRP ON LTFE, Department of Soil Science and Agricultural Chemistry,
Orissa University of Agriculture and technology, Bhubaneswar, 751003, Odisha
[2] AICRP on LTFE, Indian Institute of Soil Science, Bhopal, Madhya Pradesh
**Email: mitalimandal83@gmail.com*

Soil carbon sequestration is a complex process influenced by agricultural practices, climate and soil conditions. Labile organic carbon is sensitive to soil management practices and thus provides the better management of carbon dynamics in short-term to medium- term effect than total carbon alone. Soil organic carbon and its labile fraction are strong determinants of chemical, physical and biological properties and soil quality. Thus, an attempt is made here to investigate the carbon sequestration potential and dynamics of labile pool of SOC in relation to crop productivity. Soil sample of post-kharif 2014 were collected from long term fertilizer experiment started in the year 2005-06 in the central farm of OUAT under AICRP in an acidic sandy soil taking swarna (MTU-7029) as a test crop. The experiment was systematically initiated with quadruplicated 12 treatments in a Randomized Block Design. Out of 12 treatments, six treatments were selected for the present study i.e. no fertilization, 100% N, 100% NP, 100% NPK, 150% NPK and 100% NPK+FYM. A fallow treatment was also included to compare the impact of cultivation vis-a-vis no cultivation. The experimental results revealed that cultivation over the years caused a significant decrease in soil organic carbon content by 14% in unfertilized control as compared to uncultivated soil. The balanced fertilization with NPK, super optimal dose of NPK and integration of balanced fertilization with FYM increased the SOC content as well as SOC stocks over the initial year. The carbon sequestration potential (1.77 t ha^{-1}) was highest in 100%NPK +FYM treatment. The cumulative C mineralized in 36 days of incubation of surface soil ranged between 1.08 to 2.18 g kg^{-1}, being highest in the 100% NPK + FYM treatment. The biological pool such as MBC(C_{mic}) comprised of 3.4% of the soil organic carbon content. The greater magnitude of C_{mic} and readily mineralisable C (RMC) was found in 100% NPK+ FYM. The greater accumulation of water extractable carbon, $KMnO_4$-C was recorded in 100%N PK + FYM treatment. The content of SOC significantly correlated with sustainable yield index (SYI) which support better sustainable productivity. The highest Carbon management index (CMI) was computed in the integrated treatment of 100% NPK with FYM. The microbial quotient (MQ) was highest in 100%NPK+FYM but the respiratory quotient (qCO_2) or metabolic quotient was however, significantly higher under control and only N vis-à-vis other fertilized treatments, the least value being recorded in the NP, NPK, and NPK+FYM treatments. The CMI can be used as a more sensitive indicator of the rate of change of SOC in response to soil management changes. Results suggested that current fertilizer recommendation of 100% NPK+ FYM are adequate for maintaining SOC stock and this practice may help in maintaining the sustainability of rice-rice cropping system.

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Influence of Long-term Use of Fertilizers and Amendments on Different Fractions of Organic Matter in an Acid Alfisol

Raj Paul Sharma, Hari Mohan Meena and Sanjay K. Sharma
Department of Soil Science, CSK HPKV, Palampur, 176062, Himachal Pradesh

The effect of fertilizers and amendments on organic matter dynamics in soil-plant system in an acid Alfisol was studied in a long-term field experiment initiated during 1972 at experimental farm of Department of Soil Science, CSK HPKV, Palampur. Continuous application of NPK fertilizers either alone or in combination with FYM or lime for forty two years significantly influenced the grain, straw/stover yield of wheat and maize and different fractions of soil organic matter *viz.*, water soluble organic carbon, water soluble carbohydrate, soil microbial biomass carbon, soil microbial biomass nitrogen, soil microbial biomass phosphorus, soil microbial biomass sulphur, humic acid and fulvic acid. Application of farmyard manure (FYM) and lime along with NPK fertilizers increased the grain and straw/stover yield of wheat and maize. Use of recommended level of N alone through urea had deleterious effect on crop productivity. Continuous cropping without fertilization resulted in depletion to the order of 17, 21, 24, 23, 22, 26, 12 and 18 per cent in water soluble organic carbon, water soluble carbohydrate, soil microbial biomass carbon, soil microbial biomass nitrogen, soil microbial biomass phosphorus, soil microbial biomass sulphur, humic acid and fulvic acid, respectively.

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Effect of Long-term Integrated Nutrient Management on Profile Distribution of DTPA-Zinc in a Typic Ustochrept Soil of Punjab

Navdeep Singh[1], R.S. Gill[2*], G.S. Dheri[1], S.S. Walia[2] and C.S. Aulakh[2]
[1]Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab
[2]Department of Agronomy, Punjab Agricultural University, Ludhiana, 141004, Punjab
**Email: roopinder79@gmail.com*

Micronutrient deficiencies have become one of the major constraints in sustaining crop production in the present day agriculture. With the introduction of rice cultivation on highly permeable coarse textured alkaline soils of Punjab, the deficiencies of zinc (Zn) has been reported. Among the management options of Zn, integrated nutrient managements (INM) have promising results. The present experiment was conducted to study the long-term effect of INM on the bio-available form of Zn (DTPA-Zn) at 0-15cm, 15-30 cm and 30-60 cm soil depths. The soil samples were collected from an on going long-term INM experiment under rice-wheat cropping system on Typic Ustochrept soil at department of Agronomy, Punjab Agricultural University, Punjab since 1983. The different INM treatments were designated as T_1 (Control), T_2 (50% NPK), T_3 (75% NPK), T_4 (100% NPK), T_5 [50% NPK through mineral fertilizers+50% NPK through FYM), T_6 (75% NPK through mineral fertilizers+25% NPK through FYM), T_7 (50% NPK through mineral fertilizers+50%NPK through wheat cut straw), T_8 [75% NPK through mineral fertilizers+25% NPK through wheat cut straw), T_9 [50% NPK mineral fertilizers+50% NPK through green manure) and T_{10} [75% NPK through mineral fertilizers+25% NPK through green manure). The application of FYM, green manure and wheat cut straw in INM treatments were applied annually before the cultivation of rice crop. The results indicated that different fertilizer treatments had differential effect on bio-available Zn both in surface and sub-surface soil depths. The DTPA-Zn in surface soil (0-15 cm) was minimum in T_1 (1.28 mg kg^{-1} soil) which significantly improved to 1.85 mg kg^{-1} soil in T_5 where 50% of NPK was substituted through FYM. In general, INM treatments had positive and significant effect on DTPA-Zn as compared to the sole application of mineral fertilizers. The DTPA-Zn content under different treatments varied from 1.28 mg kg^{-1} soil to 1.85 mg kg^{-1} soil in the surface soil (0-15 cm), from 0.53 to 0.80 mg kg^{-1} soil and 0.39 to 0.71 mg kg^{-1} soil at 15-30 cm and 30-60 cm soil depth, respectively. Irrespective of the treatments, the DTPA-Zn decreased with increase in depth of soil profile whereas the effect of treatments on DTPA-Zn was prominent only in surface soil. The study suggests that adoption of INM in rice-wheat cropping system may be helpful in maintaining or improving the Zn availability in soil.

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Dynamic of Enzyme Activities during Decomposition of Various Organic Residues in a Sandy Loam Soil: A Laboratory Study

Sandeep Sharma, Jatinder Kaur, H.S. Thind, Yadvinder-Singh and Neha Sharma
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141 004, Punjab
Email: sandyagro@rediffmail.com

Addition of organic residues to soil is an important management strategy to improve organic matter status and providing better soil conditions to below ground soil microbial compositions. Monitoring soil biological quality, particularly enzyme activities, after receiving organic amendments is pre-requist for sustainable management of soils. An incubation study was undertaken to examine the influence of eleven crop and tree residues widely varying in chemical composition on the periodic changes in important enzyme activities. Significant improvement in soil enzymes (dehydrogenase, fluorescein diacetate, acid and alkaline phosphatase and phytase) due to incorporation of different plant residues were observed as compared to control. The enzymatic activities substantially enhanced after addition of different crop residues during first few days of incubation. The maximum enzymatic activities were observed upto 28 days after incorporation. Among plant residues, highest activities were shown by *Azadirachita indica*, *Avena sativa*, and *Lens culinaris*. We observed that decomposition rate of incorporated plant residues with diverse chemical composition can be predicted by periodic changes in soil enzyme activity for long term productivity of the soil.

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Effect of Integrated Nutrient Management on Active Pools of Soil Organic Carbon under Groundnut-Wheat System of *Vertic Haplusteps*

Gaurav U. Karad* and N.B. Babariya
Department of Agricultural Chemistry and Soil Science, College of Agriculture, Junagadh Agricultural University, Junagadh, 362 001, Gujarat
**Email: karadgaurav77@gmail.com*

The effect of organic and inorganic fertilizers treatments on active pools of soil organic carbon *viz*., soil microbial biomass carbon (MBC), microbial biomass nitrogen (MBN), microbial biomass phosphorus (MBP), carbon mineralization and dehydrogenase activity was investigated in long-term fertilizers experiment of Junagadh district in Gujarat state. Under this study the surface soil samples (0-15 cm) were collected from the AICRP-LTFE experiment soils conducted on groundnut-wheat sequence in randomized block design replicated four times at Instructional Farm, JAU, Junagadh, during the year 1999 (Initial), 2002-03 (4th year), 2006-07 (8th year), 2010-2011 (12th year). The treatments were T_1 - 50% NPK of recommended dose to groundnut-wheat sequence; T_2- 100% NPK of recommended dose to groundnut-wheat sequence; T_3- 150% NPK of recommended dose to groundnut-wheat sequence; T_4 - 100% NPK+ $ZnSO_4$ @ 50 kg ha^{-1} once in three year to groundnut only; T_5 - NPK as per soil test; T_6 - 100% NP of recommended dose to groundnut-wheat sequence; T_7 - 100% N of recommended dose to groundnut-wheat sequence; T_8 - 50% NPK + FYM @ 10 t ha^{-1} to groundnut and 100% NPK to wheat; T_9 - FYM @ 25 t ha^{-1} to groundnut only; T_{10} - 50% NPK + *Rhizobium* + PSM to groundnut and 100% NPK to wheat; T_{11} - 100% NPK of recommended dose to groundnut-wheat sequence, T_{12} – Control. The result showed that the application of 50% NPK + FYM @ 10 t ha^{-1} to groundnut and 100% NPK to wheat (T_8) and FYM @ 25 t ha^{-1} to groundnut only (T_9) significantly increased the MBC, MBN, MBP, carbon mineralization and dehydrogenase activity, as compare to control treatment in soil of all the 12 year span. Improvement in active pools of soil organic carbon in the LTFE soils was very slow during 2000; it was highest during 2004 and further also increases during the year 2008 and 2012. The result indicated that application of FYM alone and in combination with chemical fertilizers improves crop yield and active pools of soil organic matter.

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Carbon Sequestration Potential of Some Soils of Vidarbha Region of Maharashtra, India

T.K. Sen, Sarika Patil, Prajakta Kherade, S. Chatterji and S.K. Singh
ICAR-National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), Amravati Road, Nagpur, 440033, Maharashtra

Eight pedons representing dominant soils under different crops were studied to estimate soil organic carbon (SOC) stocks and carbon sequestration (C-sequestration) potential of Vidarbha region of Maharashtra. The soil carbon stocks were estimated by mass, volume and density relationship. Forest soils of the adjoining study areas were considered as control and used as reference (base level) for the comparative study on C-stock and C-sequestration potentials. The soils, mostly developed in basaltic alluvium are, in general, deep, medium to fine textured, well to moderately well drained, slightly acidic to slightly alkaline with low to medium cation exchange capacity and low to medium organic carbon content. The soils were classified as Vertic Haplustalfs, Typic Haplusterts, and Vertic Haplustepts. Bulk density of the surface soils, in general, ranged from 1.18 to 1.73 Mg m^{-3} and that of sub soils were observed to range from 1.19 to 1.95 Mg m^{-3}. Soil organic carbon stock of the soils ranges from 2.51 (under wheat cultivation) to 11.63 t ha^{-1} (under paddy for more than 50 years). The potential to sequester organic carbon in the soils under open forest was estimated to the tune of 34.3 to 37.2 t ha^{-1} by way of good management practices. Recently converted forestland into agriculture resulted in huge loss of SOC stock and these are most affected soils where SOC can be sequestered well to the extent ranging from 6.7 to 40.9 t ha^{-1} following modern methods of cultivation instead of traditional ones. Considerable variation has been observed in SOC stock and C-sequestration potentials of paddy growing soils in the region. The SOC stock estimates revealed that most soils of the area studied are much below their potential level because of huge carbon loss. Therefore, the scope of sequestering organic carbon in these soils is immense.

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Effect of Long Term Soil Fertility Management on Potassium Fixation and Release Pattern of Soils under Rice-Cowpea Cropping System

M. Divya, B.R. Jagadeesh, D.K. Srinivasa and Eresh
Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, GKVK, Bangalore, Karnataka

Long-term fertilizer experiment was initiated at the Zonal Agriculture Research Station, VC Farm, Mandya at "I" Block during 1989-90. The long-term fertilizer experiment consists of permanently laid out plots in randomized block design with sixteen treatments replicated two times. The treatments consists of control (T_1), 100% P and K (T_2), 100% N and K (T_3), STCR approach for targeted yield (T_4), 100% N and P (T_5), 100% NPK + Zn+ S (T_6), 100% NPK+ Zn+ S+ FYM at 5 t ha^{-1} (T_7), 100% NPK-Zn (T_8), 100% NPK-S (T_9), 100% N + 50% P + 50% K (T_{10}), 50% NPK (T_{11}), 50% NPK+ *Azospirillum* (T_{12}), 50% NPK + 50% N-green manure (T_{13}), 50% NPK + 50% N- FYM (T_{14}), 50% NPK + 25% N-GM + 25% N-FYM (T_{15}), FYM at 10 t ha^{-1} (T_{16}). Rice (thanu) and cowpea (KMP-101) crops were taken during *kharif* 2012, to assess the effect of long term soil fertility management on potassium release pattern of soils under rice-cowpea cropping system. The extraction of soil with KCl and neutral normal NH_4OAC, The difference expressed as cmol(p^+)kg^{-1} of soil was considered as the potassium fixing capacity of soil. The K release characteristics of soils were determined by employing successive extraction of soil with boiling 1*N* HNO_3 after removing exchangeable K.

The experimental results revealed that the highest rate of potassium fixation was observed in the treatment 50% NPK+25%N-GM+25%N-FYM (T_{15}) (0.58 meq L^{-1}) and lowest in the control plot T_1 (0.39 meq L^{-1}) in the surface soil. But in sub-surface soil recorded highest fixation capacity compare to surface soil. In sub-surface the highest fixation was recorded in the T_{15} (0.63 meq L^{-1}) and lowest was recorded in the T_1 (0.41 meq L^{-1}). The activity of K^+ ions in the soil solution around mica particle is a factor for determining the K release from the soils. The cumulative K release from different treatments ranged from 253 to 857 meq L^{-1}. The soils with higher contents of NH_4OAC-K recorded relatively higher cumulative release of K than the soils with lower amounts of available K. In general potassium release was faster in the initial stage up to 5th extraction and later it released less amount of K and finally reached constant by 10th or 11th extraction. The total step potassium content in soils of different treatments ranged from 198 to 791 meq L^{-1}. The highest amount was total K was recorded in the T_{15} (791 meq L^{-1}) which received 50% NPK+25% NGM+ 25% N-FYM and lowest was recorded in the control plot which was not supplied with any organic and inorganic fertilizers. The constant rate potassium (CR-K) content of soils as influenced by long term soil fertility management were ranged from 2 to 7 meq L^{-1} in the surface layer of soils.

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Distribution of Different Forms of Potassium in Rice Growing Soils of Kurnool District, Andhra Pradesh

P.N. Siva Prasad*, P. Kavitha, M. Sreenivasa Chari and M. Srinivasa Reddy
Department of Soil Science and Agricultural Chemistry, Agricultural college, Mahanandi, ANGRAU, Hyderabad, 500030, Andhra Pradesh
**Email: matli.chari@rediffmail.com*

Surface soils (15 cm) were collected from eleven mandals of rice growing soils of canal ayacut of Kurnool district. The Nutrient status of these soils was evaluated for pH, EC, Organic carbon, texture, CEC, $CaCO_3$, Available N, P, K status and different forms of K such as water soluble K, available K, exchangeable K, non-exchangeable K and fixed K and their relationship between different forms of potassium were also studied. The soils are found moderately coarse to fine with a texture of sandy loam to clay. The pH of the soils are neutral to slightly alkaline in nature and EC of the soils are non saline. The soils under study are medium in organic carbon and non calcareous in nature. The investigated soils were low to medium in available N, where as available P and available K were having medium to high status. The cation exchange capacity (CEC) of the soils varied between 14.4 to 31.6 cmol(p^+)kg^{-1} soil. The mean values of water soluble K, available K, exchangeable K, non-exchangeable K and fixed K were in the ranges of 33.9, 274.3, 240.4, 253.9 and 528.2 mg kg^{-1} respectively. The order of dominance of different forms of K was fixed K > non-exchangeable K > available K > exchangeable K > water soluble K. Water soluble K had negative correlation with pH, clay, silt and organic carbon where as available K had positive correlation with pH, organic carbon, CEC. Non-exchangeable K had negative correlation with organic carbon. Exchangeable K showed positive relationship with clay, organic carbon but negative with sand fractions. Fixed K shows positive correlation with silt, pH and organic carbon. Different forms of potassium had positive correlation among themselves. Non-exchangeable K had significant positive relationship with other K fractions indicating the existence of an equilibrium between different forms of potassium in the soil. The maximum positive correlation of plant growth parameters was found with non exchangeable K and fixed K in Neubauer's seedling technique. The correlation coefficient with water soluble K and plant growth parameters was estimated and found lowest. Hence, for intensive cultivation non exchangeable K and fixed K fractions also be taken into consideration for fertilizer recommendation in order to increase potassium use efficiency in the soils of canal ayacut of Kurnool district for sustainable crop productivity.

Commission 2.3: Soil Biology

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Integrated Nutrient Management: An Approach to Enhance Soil Biodiversity and Apple Production in North Western Himalayan Region

Sarvendra-Kumar[1,2]*, A. Sharma, N. Ahmed[2] and Kapil A. Chobe[1]
[1]Division of Soil Science and Agricultural Chemistry, ICAR- Indian Agricultural Research Institute, New Delhi, 110012
[2]ICAR-Central Institute of Temperate Horticulture, Srinagar, J&K
**E-mail: sarv.grandee@gmail.com*

One current proposition towards solving agro-environmental problem is integrated nutrient management (INM), which promotes low chemical input but improved nutrient-use efficiency by combining natural and manmade sources of plant nutrients in an efficient and environmently prudent manner. A field experiment was conducted to study the effect of inorganic fertilizers supplemented with biofertilizers on growth parameters of apple (*Malus domestica*) with variety Oregon spur for two seasons (2012 and 2013) in Srinagar, Jammu and Kashmir. The experiment consisted of different treatment combinations comprising recommended dose of inorganic fertilizers (RDF) and in combination with different bio-fertilizer *viz*., *Azotobacter*, *Microphos* and *Azospirllium*. In addition, density of plant maintained at 4 m × 4 m distance or 625 plant ha^{-1} in orchard with three replications under randomized block design. Experimental findings revealed that inorganic fertilizer in combination with biofertilizers have significant impact on plant growth parameters. Data also revealed that biofertilizer had a significant impact on the soil enzymes activity especially oxidative capacity of soil (dehydrogenase activity) and urease activity compared with only mineral fertilizers. Microbial biomass carbon significantly ($P<0.05$) improved under treatment of 75% of RDF+Zn+B with biofertilizers than only inorganic fertilizer treatments. The average fruit number per plant recorded in treatment T_1 (control) was around 186 $plant^{-1}$ but in RDF+ biofertilizer treated plants, the same was varied between 225-272 $plant^{-1}$ with high quality (TSS of fruit), which resulted higher yield than control plant. Among the INM treatments, treatment comprising 75% of RDF and biofertilizers (either *Azotobacter* 50 g or *microphos* 50 g or *Azospirllium* 30 g) was found significantly superior over other treatments with respect to growth parameters such as per cent increase in plant height, root stock girth, scion girth, plant spread. Overall, study reveals that, through INM practice, apple production can gain the momentum in north western Himalayan region of India.

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Metagenomic Survey Revealed the Altered Relationship of Biota Community and Nutrient Cycling Processes in Soils under Shifting Cultivation

Dwipendra Thakuria[1]*, Henry Saplalrinliana[1], Juri Deka[1], Alarisa Khyllep[1], Prathana Hazarika[1], Samarendra Hazarika[2], Manoj-Kumar[2] and Bibhash C. Verma[2]

[1]School of Natural Resource Management, College of Post Graduate Studies, Central Agricultural University, Umiam, 793103, Meghalaya

[2]Division of Natural Resource Management, ICAR Research Complex for North Eastern Hill Region, Umiam, 793103, Meghlaya

**Email: thakuria.dwipendra@yahoo.co.in*

Soil biota communities are key drivers of biogeochemical cycles. To what extent the biological inputs of the above-ground biota community can alter the below-ground communities and their functional attributes in soils is not fully understood. We used whole metagenomic approach to study the impact of the fallow lengths (5 and 20 year *jhum* cycles) on the composition and functional attributes of the soil biota communities and the associated soil processes. Surface soils (0 to 10 cm depth) from 5 and 20 years *jhum* cycles located in Changki village of Nagaland were collected in two time points *viz.*, 48 h before and after burning operation. Soil dehydrogenase (DHA), acid-phosphomonoesterase (PHA) and β-glucosidase (GSA) as indicator of microbial activity, organic-P mineralization and C-mineralization, respectively were analyzed in soils from burnt and unburnt fields. Soil genomic DNA from 5 and 20-years-old fallows (unburnt) were used for the pair-end sequencing library preparation and the libraries were sequenced on MiSeq using 2×300 bp chemistry kit. High quality metagenome reads of 5 and 20 years fallows were assembled and analyzed using MGRAST. Soils of 5 years fallow housed approximate 2 times (108 nos.) more bacterial orders than that (51 nos.) in 20 years fallow. The higher rank abundance of taxa in 5 yrs fallow community were *Proteobacteria*, *Acidobacteria*, *Actinobacteria*, *Firmicutes*, *Chloroflexi*, *Verrucomicrobiota*, *etc.* and in 20 years fallow community were *Streptophyta*, *Chordata*, *Cyanobacteria*, *Ascomycota*, etc. The enzyme classes such as oxidoreductases, transferases, lyases, *etc.* were abundant in 5 years fallow and tranferases, ligases, hydrolases, *etc.* were abundant in 20 years fallow. Of the predicted proteins, 60.2% and 38.1% were metabolism related in 5 and 20 years fallows, respectively. Besides, the activity of DHA, PHA and GSA significantly (P<0.05) reduced in burnt soils as compared to unburnt soils, irrespective of fallow lengths. The activity of DHA, PHA and GSA were significantly (P<0.05) higher in 20 years fallow soils than that in 5 years fallow soils under both burnt and unburnt conditions. The relative abundances of genes associated with Fe acquisition and P metabolism were lower, while photosynthesis, K and secondary metabolisms were higher in 5 years fallow communities compared to 20 years fallow communities. Overall, it can be concluded that ecological traits of the plant community in the fallow phase are the driving force in shaping the microbial communities in soils of *jhum* fields and allowing longer fallow length in rejuvenating the biological interactions over time. Detection of greater microbial taxonomic diversity during the shorter fallow length (5 years *jhum* cycle) does not necessarily indicate the stability of the ecosystem. In fact, the results of our work based on metagenomic analyses clearly demonstrated that greater microbial taxonomic diversity might be an indication of the state of an ecosystem under environmental stresses. As the most comprehensive metagenomic survey on shifting cultivation cycles, this study demonstrates clearly the role of the regenerated above-ground vegetation in shaping the soil biodiversity and thereby regulation on ecosystem processes and stability.

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Synergistic Effect of Different Bio-inoculants on Nodulation and Yield of Chickpea (*Cicer Arietinum* L.) under Rainfed Conditions

Vivek Sharma*, Sandeep Sharma, Sapana Sharma, Vijay Kumar, Anil Kumar Khokhar, Manmohanjit Singh and Yogesh Khokhar

Regional Research Station (Punjab Agricultural University), Ballowal Saunkhri Distt SBS Nagar, 144521, Punjab

**Email: sharmavivek@pau.edu*

Chickpea is one of the most suitable crops for cultivation under arid and dry farming regions of developing countries. It tolerates biotic stresses and is grown mostly on marginal lands. India is the largest producer of chickpea in the world. In Punjab, chickpea is the important winter legume crop but the area is declining due to lower productivity than other crops. The low productivity of chickpea is mainly due to imbalanced use of fertilizers and traditional varieties. Also least importance is given to use of biofertilizers such as *Rhizobium*, phosphate solubilizing bacteria (PSB) and arbuscular mycorrhizae fungi (AM fungi). The increasing demand for production of pulse crops has led to an interest and necessity for the use of bio-fertilizers for the betterment of these crops.

To study the synergistic effect of different bio-inoculants on nodulation and yield of chickpea under rainfed conditions, pot and field experiment was conducted at Regional Research Station (Punjab Agricultural University), Ballowal Saunkhri during the *rabi* 2014-15 with four levels of bio-inoculants (*Rhizobium, Rhizobium* + PSB, *Rhizobium*+ PSB + AM fungi and *Rhizobium*+ PSB + AM fungi + *Azotobactor*) and two levels of phosphorus (15 and 20 kg P_2O_5 ha^{-1}). Results revealed that inoculation of bio-inoculants significantly improved growth parameters like plant height, yield parameters like number of pods, grain yield, stalk yield and harvest index over the un-inoculated treatment. Among the different bio-inoculant combinations, treatment of *Rhizobium* + PSB + AM fungi + *Azotobactor* along with 15 kg P_2O_5 ha^{-1} produced highest grain yield which was 30, 15, 24 and 6 per cent higher yield over *Rhizobium*, *Rhizobium* + AM fungi, *Rhizobium* + PSB, *Rhizobium* + PSB + AM fungi, respectively. The nodule count, nodule weight, per cent root colonization of AM fungi and different enzymes activities were also highest in different bio-inoculant combination treatment.

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Quality Fibre Production from Repeated Retting of Jute in Stagnant Water with Microbial Formulation

B. Majumdar*, A.R. Saha, S. Sarkar, S.K. Jha and S.K. Sarkar
Division of Crop Production, Central Research Institute for Jute & Allied Fibres, Barrackpore, 700 120, Kolkata
**Email: bijju5@rediffmail.com*

Production of quality fibre is very much essential for manufacturing of high valued diversified products like carpet, yarn for textile use, handicrafts, ornaments, *etc*. besides the manufacture of hessian and sacking. The repeated retting of jute and mesta in the stagnant water of same natural retting tank following conventional retting method lead to the production of inferior quality fibre unless the tank is recharged with fresh water after each retting. Thus, development of suitable retting technology for quality fibre production in stagnant water is of prime challenge to the CRIJAF. With the introduction of microbial formulation "CRIJAF SONA", the quality fibre production in the same stagnant water from repeated retting has become a reality. CRIJAF SONA consists of three different strains of *Bacillus pumilus* isolated from retting water having very high pectinolytic and xylanolytic activity without any cellulase activity. Two large scale retting experiments in stagnant water with and without CRIJAF SONA under same environmental condition was carried out at Goaldah, Swarup Nagar, North 24 Parganas district of West Bengal during the month of July and August, 2014. The same set of experiment was carried out for consecutive 3 times in the same retting tank.

The result of the large scale retting trial with harvest of 0.13 ha (1 bigha) indicates that repeated retting in the same stagnant water can be carried out without degradation in fibre quality by using microbial formulation CRIJAF SONA. The retting duration for consecutive three retting ranged between 13 to 14 days with CRIJAF SONA which was 6 to 7 days less than the conventional retting. The fibre colour was golden to golden yellowish in case of improved retting with CRIJAF SONA compared to greyish to black coloured fibre in conventional retting. Besides the lustrous fibre with CRIJAF SONA, the fibre recovery was 10 to 12 per cent higher over conventional retting. The Fibre strength reduced slightly under both the system, but was higher by 3.4 to 4.6 g tex^{-1} with CRIJAF SONA over conventional retting.

Retting water samples analysed for total microbial, pectin, xylan and lignin degraders indicates higher colony forming unit (CFU) with CRIJAF SONA than the conventional retting and the CFU increased gradually after each retting. Besides quality fibre production with higher fibre recovery in stagnant water with CRIJAF SONA, the repeated retting in the same retting site decreases drastically the water requirement as the same water was utilized for repeated retting.

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Alleviation of Salt Stress in Tomato var. Arka Rakshak by Intervention of Halotolerant Bacteria

D. Kalaivanan, P. Panneerselvam, A.N. Ganeshamurthy and V. Revathi

Division of Soil Science and Agricultural Chemistry, ICAR-Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bengaluru, 560 089, Karnataka

Twenty five halotolerant bacteria were isolated from the saline habitats and screened for growth at different NaCl concentrations. All the isolates showed good growth at 5% NaCl, but only the following five isolates *viz*., *Lycinibacillus* spp., *Bacillus circulans, Pseudomonas plecoglossicida, Pseudomonas* spp. and *Pseudomonas stutzeri* could grow at 15% NaCl concentrations and were further characterized for their growth promoting attributes. Out of the five isolates, *Pseudomonas* spp. recorded higher enzymatic activity, IAA and GA_3, ACC deaminase activity and siderophore production. A pot culture experiment was conducted to study the effect of different salinity levels (EC: 1.0, 2.0, 3.0, 4.0, 5.0 dS m^{-1} and control) on soil respiration, enzymatic activities, growth and leaf nutrient content of tomato var. Arka Rakshak with and without inoculation of *Pseudomonas* spp. Twenty days old tomato seedlings were transplanted in the plastic pots containing 8 kg of soil. Plants were allowed to grow for 10 weeks at a soil water potential near field capacity. During this period plants were watered as per the treatment with 200 mL of saline water per day with different EC levels. The growth parameters of the tomato was recorded at 20, 40 and 60th days after transplanting. No significant difference on growth parameters was observed with respect to different salinity levels and *Pseudomonas* spp inoculation. In general, the tomato plant growth was retarded under different saline treatment as compared to the control plants without saline treatment. Inoculation of *Pseudomonas* spp found to enhance plant height and number of leaves of tomato under 4.0 dS m^{-1} salinity levels. Similarly, higher number of branches and girth was recorded in 5.0 dS m^{-1} with bacterial inoculation. Due to salinity stress, flowering and fruiting of the plants were also delayed compared to control plants. The macro- and micro-nutrients in soil and leaf were also determined. The macro- and micro-nutrients contents in both soil and plant were found to decrease under lower saline conditions with bacterial inoculation, whereas it was observed to be increased under higher saline condition. The treatments with higher salinity inoculated with *Pseudomonas* spp enhanced the soil respiration and enzymatic activities in rhizosphere of tomato plants. This finding clearly indicated that the halotolerant bacteria *i.e. Pseudomonas* spp has potential to improve tomato plant growth under salt stress and it can be used as one of the bio-inoculants for crop production under salt affected regions.

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Effect of Mycorrhiza, Lime, Inorganics and Organic Sources on Soil Quality and Yield Performance of Yam Bean in Acid Alfisols

K. Laxminarayana

Regional Centre, ICAR - Central Tuber Crops Research Institute, Bhubaneswar, 751 019, Odisha
Email: klnarayana69@rediffmail.com; klnarayana69@yahoo.co.in

A field experiment was conducted for two consecutive *kharif* seasons during 2013 - 2015 to study the effect of integrated use of mycorrhiza, lime, inorganics and organic manures on soil quality and yield performance of yam bean (*Pachyrhizus erosus* L.) in an acid Alfisol of Odisha. The experimental soil is fine-loamy, mixed, isohyperthermic, typic Haplustalf; sandy loam in texture, acidic (pH 4.67), non saline (0.24 dS m^{-1}), and having 2.56 g kg^{-1} organic C, 0.012% total N, 226, 24.6 and 189 kg ha^{-1} of available N, P and K, respectively. The soil also contains 33.4, 1.42, 112.8 and 0.52 mg kg^{-1} of available Fe, Cu, Mn and Zn, respectively. Significantly highest mean tuber yield (29.61 t ha^{-1}) was recorded due to integrated application of lime + FYM + NPK + $ZnSO_4$ followed by lime + FYM + NPK + $MgSO_4$ (27.54 t ha^{-1}). The response between limed and un-limed treatments along with FYM, recommended doses of NPK and micronutrients was highest in respect of Zn (10.8 %) followed by Mg (8.0 %) and B (4.2 %). Graded doses of NPK showed a mean yield response of 65, 134 and 191 per cent due to addition of 50, 100 and 150% of NPK over control, respectively. Among the organic sources, in situ incorporation of green manure has recorded highest mean tuber yield (21.81 t ha^{-1}) followed by vermicompost (21.68 t ha^{-1}) and FYM (19.94 t ha^{-1}). Inoculation of arbuscular mycorrhiza (AM) combined with NPK and FYM recorded a mean tuber yield of 25.14 t ha^{-1} with an increase of 9.8 per cent over that of NPK, however, liming further enhanced the tuber yield by 6.4 per cent over that of VAM + FYM + NPK.

Highest mean dry matter (18.85%) was recorded due to application of 150% NPK at par with lime + FYM + NPK + B (18.65%), whereas highest starch content on fresh weight basis (11.11%) was recorded due to integrated use of lime + FYM + NPK + $MgSO_4$. Total sugars ranged from 3.09-4.04 % with highest due to integrated application of lime + FYM + NPK + B. Application of soil test based fertilizers (100% NPK) has recorded highest efficiency of N, P and K (140, 1012 and 196 kg tubers kg^{-1} of N, P, and K, respectively). Integrated application of 100% NPK combined with lime, FYM and $ZnSO_4$ has shown highest dehydrogenase (1.87 µg TPF h^{-1} g^{-1}) and fluorescein diacetate activities (1.80 µg g^{-1} h^{-1}). Inoculation of AM in combination with lime + FYM + NPK recorded highest acid and alkaline phosphatase activities (82.48 and 60.25 µg PNP g^{-1} h^{-1}, respectively). All the soil properties showed significant relationship with dehydrogenase activity of the soil and the 'r' values were found to be 0.67^{**}, 0.69^{**}, 0.49^{*}, 0.68^{**}, 0.66^{**}, and 0.77^{**} in respect of pH, organic C, total N, available N, P, and K. Available P content of the soil had highly significant relationship with alkaline phosphates activity ($r = 0.75^{**}$) rather than acid phosphatase activity ($r = 0.73^{**}$). Dehydrogenase activity showed highly significant relationship with tuber yield, starch, sugars and dry matter of yam bean and the 'r' values were found to be 0.73^{**}, 0.65^{**}, 0.69^{**} and 0.68^{**}, respectively. Dehydrogenase, FDA and phosphatase activities had highly significant relationship with tuber yield and biochemical constituents of yam bean. The study emphasized the conjunctive use of soil test based inorganic fertilizers, micronutrients and organic manures to enhance the enzymatic activities and to realize higher crop yields of yam bean in acid Alfisols.

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Zinc Solubilization Potential of Some Promising Microbial Strains and their Effect on *Bt* Cotton Grown on Vertisol

Syed Ismail*, Anuradha Pawar, Vilas Patil and S.R. Harkal

All India Network Project on Soil Biodiversity-Biofertilizers, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani 431 402, Maharashtra
**Email: syed_ismail123@rediffmail.com*

The capabilities of soil microorganisms to solubilize zinc have been known for many years, but their isolation and use as crop inoculants have been met with little success. Seven microbial isolates were tested for their ability of *in vitro* zinc solubilization using the TSM culture broth containing zinc oxide, zinc carbonate and zinc phosphate as insoluble zinc. All the isolates were found to solubilize insoluble zinc sources, these strains were also screened as bioinoculants for plant growth promotion in field condition. Field experiment was conducted during *kharif* seasons of 2013-14 and 2014-15 at Research farm, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani on Vertisol. *Burkholderia cepacia, Burkholderia cenocepacia, Pseudomonas fluorescens, Pseudomonas striata, Trichoderma viride, Trichoderma harzianum* and *Bacillus megaterium* were used as bioinoculants along with recommended dose of fertilizers in *Bt* cotton. 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 @ 2.5 L ha^{-1} diluted in required quantity of water was applied through drenching. Five plants from each plot were tagged for plant growth observations such as number of bolls, chlorophyll and carotenoids content, root characteristics, NPK and Zn content and yield of cotton. Further, NPK and periodical Zn availability were determined as per standard procedures. Results indicated that *in vivo* condition all the isolates were found to solubilize zinc with a maximum effect for the isolate *Trichoderma viride* in zinc carbonate containing medium (273.5 mg L^{-1}) after 10th day of incubation and *in vitro*, the zinc carbonate amended media produced greater halozone diameter (3.76 cm) with 2.60 cm clearing zone having 325 per cent solubilization efficiency and 4.27 solubilization index. Results of field experiments indicated that effective zinc solubilizing microorganisms such as *Trichoderma viride* and *Pseudomonas striata* were found to enhance the plant growth characters such as plant height, number of branches, number of bolls, chlorophyll and carotenoids content in leaves, improved root characters such as root and shoot weight. Nutrient content in seed and stalk of cotton such as nitrogen, potassium and zinc was noted maximum with *Trichoderma viride* and *Pseudomonas striata*. Whereas, phosphorus content in seed and stalk of cotton was increased with strain *Bacillus megaterium* and *Pseudomonas striata* as these are good P solubilizers. These zinc solubilizing microbial isolates increased seed cotton and dry matter yield.

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The Seasonal Variability of Biological Pools of Carbon, Nitrogen and Phosphorus in Acidic Rainfed Hill Rice Ecosystems

Christy B.K. Sangma*, D. Eladdaka Biam and D. Thakuria
School of Natural Resources Management, College of Post Graduate Studies, CAU, Umiam, 793103, Meghalaya
**Email: christysangma@gmail.com*

Soil ecosystems are complex and biogeochemistry of soils is governed largely by the functioning of soil biota community through their control over the biological pool of every elemental cycle. Biological pools of carbon (C), nitrogen (N) and phosphorus (P) in soils of hill rice ecosystems in North East India are not yet characterized. Soil samples (0-15 cm depth) were collected from six different sites located in two villages (Saiden and Kyrdemkulai) of Ri-Bhoi district of Meghalaya in post-monsoon and in post-winter seasons. The elevation of two villages is 533 m and 808 m above mean sea level, respectively. These sites were: Saiden slope land (SSL, direct seeded), Saiden upland terrace-1 (SUT-1, 1 yr old terrace), Saiden upland terrace-2 (SUT-2, stabilized terrace, 20 yrs), Saiden lowland (SL), Kyrdemkulai lowland (KL) and upland terrace (KUT, stabilized terrace). Factors like frequent slash and burn practices and higher slope aspect in slope land rice fields and less time since removal of soil top layer in terrace rice fields had significant negative impacts on soil moisture (MC), soil organic carbon (SOC) and pH in hill rice ecosystems. Rice ecosystems exhibited a strong soil moisture gradient in the order of SSL and SUT-1 (27-31%)<SUT-2 & KUT (55 to 57%)<SL and KL (>69.5% to water-logged). Soils of lowland contained 33, 55 and 60 per cent more SOC over that in soils of stable-terrace, slope land and new terrace, respectively. Dissolved organic carbon (DOC), microbial biomass C, N and P (MBC, MBN and MBP), extractable organic N (EON) and potentially mineralizable N (PMN) also showed a trend similar to SOC. The C:N:P ratio within microbial biomass ranged from 41:5:1 to 59:6:1 with the indication of narrow ratio in lowlands and stable terraces and wider ratio in slope land and new terraces. Pair-wise correlation matrix analysis revealed that biological parameters of C, N and P were strongly influenced by each other. Principal component analysis (PCA) performed season-wise considering the biological parameters as defined variables indicated that rice fields were grouped according to ecosystem type and soil moisture status, and such effects override the impacts of site differences in biological pools of C, N and P. Overall, it can be concluded that moisture content in soils controls the size and dynamics of biological pools of C, N and P and the interrelationships among these parameters. C and N components of soils in lowland and stabilized upland terrace rice ecosystems seem to be self-sustained, but the major limiting factor was availability of P.

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Arbuscular Mycorrhizal Association of Crops in Cold Desert Ladakh Region of Jammu and Kashmir

Z.A. Baba[1], Burhan Hamid[1], Basharat Hamid[1] and Mudasir Nazir[1]
Biofertilizer Research Laboratory, Wadura Campus, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Sopore, 193201, J&K

Ladak is the extreme frontier division of Jammu and Kashmir state. The region is popularly known as cold desert with sandy soil texture, located at an altitude of 2400 to 8500 metres above mean sea level receiving a scanty annual rainfall of about 83 mm with an average annual temperature of -4.0 to 17.4 ^{0}C. The study was aimed at assessing the diversity of arbuscular mycorrhizal fungi and development of improved inoculum for cropping patterns of ladakh region. In this study rhizosphere soil samples and root cuttings were collected from barley, oats, wheat, maize, seabuck thorn and wild grasses fields in 20 different villages across the Kargil. Mycorrhizal spores were isolated by wet sieving and decanting method. Soil sample (100 g) was mixed with 1000 mL water, vigorously stirred and the heavier particles were allowed to settle down for few seconds. The suspension was passed through a set of sieves with size from 38 to 250 μm. The contents retained on the sieves were washed repeatedly till the suspension became colourless. The sieving retained on the finest sieve was transferred into a beaker and then the spores were counted under trinocular microscope. For determining the root colonization, the collected roots after washing free of soil were cut in 1 cm segments. The root cuttings were cleared of the cell contents by boiling in 10% KOH for 1 h. The cleared roots were bleached with alkaline hydrogen peroxide which effectively removed the remaining pigment in the roots. After clearing and bleaching, the roots were thoroughly washed with distilled water and then acidified with 5 N HCl. Acidification is necessary to make the stains bind to the fungal structure. The cleared roots were stained with trypan blue (0.05%; w/v) in lacto glycerol (lactic acid: glycerol: water: @ 2: 2: 1, v/v) over night. The excess stains of the roots were destained with lactophenol. The assessment of mycorrhizal infection was done by the slide method wherein the root segments were selected randomly from the stained samples and observed for the presence or absence of mycorrhizal colonization by using the following formulla:

$$\text{Percent root colonization} = \frac{\text{No. of root bits having colonization}}{\text{Total number of root bits observed}} \times 100$$

Soil organic carbon was also determined by standard technique. Identification of mycorrhiza was performed on morphological basis. Significantly higher organic carbon (0.57%) and spore population (0.88 spores g^{-1} soil) was found in soils of Gumri village. Similarly the AM fungal root colonization (34.0%) observed in the root cuttings of the grasses at the same location (Gumri) was also significantly higher in comparison to the other locations. Morphologically four different genera like *Glomus, Acaulospora, Scutellospora and Gigaspora* were identified from all the studied sites. Additionally there were present some unidentified spores also. Pure culture of improved inoculum was developed on the root stock of oats plants under controlled conditions in polybags. The study concludes that the overall status of mycorrhizae in the agricultural crop fields in this cold desert area is very low. The mycorrhizal population diversity and their extent of root colonization are known to be greatly influenced by the environmental conditions. Since soils in this region are sandy in texture and nutritionally poor with low moisture retention capacity so may not be fully supportive for the proliferation of arbuscular mycorrhizal fungi.

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Long-Term Effect of Soil fertility Management on Enzyme Activity and Carbon Fractions in Rice-Rice Cropping System, Godavari Zone of Andhra Pradesh

G. Padmaja, P.V. Geetha Sireesha, P.C. Rao and Ch. Sreenivas Rao
Department of Soil Science and Agricultural Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, 500030, Telangana

Enrichment of soil organic carbon (SOC) stocks through sequestration of atmospheric CO_2 in agricultural soils is important because of its impact on soil quality, yield, and adaptation to mitigate climate change. A long-term experiment of rice-rice (*Oryza sativa* L.) cropping sequence was initiated in the year 1989 at APRI, Maruteru, Andhra Pradesh to study the changes in soil fertility status and carbon sequestrated over 26 years in different treatment combinations of organic and inorganic fertilizers. The treatments consisted of T_1 - Control (no fertilizer and manure) T_2 -100% NPK+Zn+S, T_3 -50% NPK+ 50% N through green manure, T_4- 50% NPK + 50% N through FYM, T_5 -50% NPK +25% N through FYM + 25% N through green manure, T_6 - FYM, T_6 - FYM @ 10 t ha^{-1}, T_7 -100% NPK + FYM @ 5 t ha^{-1} and T_8 -50% NPK+ *Azospirillum* @ 2.5 kg ha^{-1}. The different forms of soil organic carbon *viz*., SOC, SIC, $KMnO_4$-C, mineralizable-C and MBC were analyzed in all the soil samples collected after harvest of each crop following standard procedures. Soil enzyme activity of urease, phosphatase and dehydrogenase were analyzed following standard procedures. The results indicated that application of mineral fertilizers showed higher SOC and SIC concentrations. While higher contents of mineralizable-C (2470 µg CO_2 – C g^{-1} soil) and $KMnO_4$-C (507 mg kg^{-1}) were recorded in treatment receiving FYM @ 10 t ha^{-1} . This might be due to application of FYM favours to increase in both C and N, stimulating the activities of microorganisms, sustaining the microbial biomass and mineralization of organic C. The organic C remaining in long-term cultivation and fertilization (>20 years) might be expected to enrich the resistant and decomposable fractions of carbon. The accumulation of unoxidizable C and total organic C was slower than oxidizable C, microbial biomass C, and mineralizable C and increases with addition of large amounts of FYM. With regard to enzyme activities higher activity of urease (µg of NH_4^+ - N g^{-1} 2h^{-1}), acid and alkaline phosphatase (ug p-nitrophenol g^{-1} soil h^{-1}) and dehydrogenase (µg of TPF g^{-1} soil +day^{-1}) enzymes were noticed in the treatment receving 100% NPK through inorganic fertilizers + FYM @ 5 t ha^{-1} (16.5, 109.3, 144.8 and 29.6, respectively). An increase in the enzymatic activity with the application of either organic manures alone or in combination with 50% recommended dose of N 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. The carbon input along with mineral fertilizers is essential for improving soil health, and to curtail the depletion of SOC stocks under continuous cropping. Thus, application of FYM (or other organics) in conjunction with mineral fertilizers is essential for maintaining and enhancing the SOC stock in the rice-rice cropping systems.

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Effect of Crop Cover and Stage of Crop Growth on Soil L-glutaminase, Acid and Alkaline Phosphatase Activity in an Alfisol

G. Pavani*, P. Chandrasekhar Rao, G. Padmaja and R. Subhash Reddy
Department of Soil Science and Agriculture Chemistry, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, 500030, Telangana
**Email: pawanigolla@gmail.com*

A pot culture experiment was conducted on an Alfisol in the vegetable production unit of Horticulture Department, College of Agriculture, Rajendranagar, Hyderabad, to study the influence of crop cover and stage of crop growth on soil enzyme activity. The experiment was undertaken with three cereals – rice, sorghum and maize, two oilseeds – groundnut and sesame, two vegetables – bhendi and spinach and two pulses - greengram and blackgram. The experiment was conducted using crops as treatments in a completely randomized block design with three replications along with the uncropped control. L-glutaminase activity was assayed by the standard procedure with slight modifications and expressed as μg of NH_4^+ released g^{-1} soil $2h^{-1}$. The amount of ammonia released was estimated by using steam distillation method. The acid and alkaline phosphatase activity was assayed by standard procedures. The results obtained with regard to the effect of these crops on soil enzyme activity showed that there was an increase in enzyme activity with age of the crop and exhibited maximum activity at 60 days of plant growth stage and there after decreased to original levels at harvest. The increase in L-glutaminase activity (expressed as μg of NH_4^+ released g^{-1} soil $2h^{-1}$) varied in groundnut (*Arachis hypogea*) from 5.7 to 13.4, blackgram (*Vigna mungo*) from 5.7 to 12.9, greengram (*Vigna radiata*) from 5.6 to 12.7, sesame (*Sesamum indicum*) from 4.8 to 11.8, rice (*Oryza sativa*) from 4.7 to 11.3, maize (*Zea mays*) from 4.3 to 10.2, sorghum (*Sorghum vulgare*) from 3.1 to 10.7, spinach (*Spinacea oleracea*) from 3.8 to 9.5 and bhendi (*Abelmoschus esculentus*) from 2.4 to 8.4. The activity of L-glutaminase, acid and alkaline phosphatase under different crop coverages followed the order groundnut > blackgram > greengram > sesame > maize > sorghum > spinach > bhendi. Here legume crops showed maximum enzyme activity and later followed by oilseeds, cereals and vegetables. The presence of plants and the type of plants grown on a soil have shown a marked effect on enzyme activities. This may be due to presence of organic carbon which increase proliferation of microorganisms which inturn increase the enzyme activity. The decrease in enzyme activity levels at harvest was due to the completion of life cycle, senecence and death of the crop.

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β-D-Glucosidase Activity as Influenced by Application of Organic and Inorganic Fertilizers in a Long-term Trial under Rice-Rice Cropping System

D. Srinivas[1]* and T.V. Sridhar

Andhra Pradesh Rice Research Institute and RARS, Maruteru, Andhra Pradesh
[1]Department of Soil Science and Agricultural Chemistry, Agricultural College, Rajahmundry, 533 103, East Godavari District, Andhra Pradesh
**Email: drd_srinivas@yahoo.com*

Intensification of rice cultivation to feed the increasing human population is imperative, especially in India where rice occupies the pivotal position in food security. Flooded rice soil ecosystems are predominantly anaerobic and are different from upland soils in several physicochemical and biological properties. A field experiment is being continued for the past 20 years in an tropical inceptisol consisted of unfertilized (control), inorganic N fertilizer (90 kg ha^{-1}), inorganic fertilizer (NPK @ 90-60-60 kg ha^{-1}), FYM (@ 10 t ha^{-1}) and inorganic fertilizer (NPK @ 90-60-60 kg ha^{-1}) + FYM @ 5 t ha^{-1}) as treatments in rice-rice cropping system at Andhra Pradesh Rice Research Institute, Maruteru, West Godavari District, Andhra Pradesh. β-D-Glucosidase (EC 3.2.1.21) activity was assayed from the rhizopshere soils of the field experiment at critical stages of crop growth. Results showed that β-D-glucosidase activity was significantly influenced by the application of organic manures and chemical fertilizers and stages of crop growth. The activity ranged from 5.20 µg p-nitrophenol g^{-1} soil h^{-1} in the control plots to 20.20 µg p-nitrophenol g^{-1} soil h^{-1} in the plots received FYM + inorganic fertilizer NPK. A seven-fold increased activity of β-D-glucosidase was recorded at panicle initiation stage of crop growth and thereafter the activity decreased. β-D-glucosidase activity was significantly and positively correlated with total organic carbon content of soil. The study reveals that long-term application of FYM and inorganic fertilizer NPK causes a significant build-up of soil enzyme activity.

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Role of Zinc Solubilizing Microorganisms in Enhancing Zn Availability and Enzyme Activity in Cotton

Anuradha Pawar*, Syed Ismail and S.R. Harkal
Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, 431 402, Maharashtra
**Email: radhapawar.236@rediffmail.com*

Plant growth promoting rhizobacteria (PGPR) mediate the soil processes such as decomposition, nutrient mobilization, mineralization, solubilization, nitrogen fixation and growth hormone production. Microorganisms having the zinc solubilizing capacity can convert the insoluble zinc into soluble forms through the production of organic acids. Inoculation of cotton seedlings with zinc solubilizing microorganisms is a promising technique which may alleviate the deficiency of zinc. A pot culture experiment was conducted on zinc deficient soil at Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani to assess the ability of zinc solubilizing microorganisms to enhance the zinc availability and enzyme activity in soil. The soil was air dried, sieved and sterilized at 121° C for 1 h for 3 consecutive days and filled in the pots of 8 kg soil capacity. Hoagland solution was only used as a nutrient solution. Bioinoculants evaluated were *Burkholderia cepacia, Burkholderia cenocepacia, Pseudomonas fluorescens, Pseudomonas striata, Trichoderma viride, Trichoderma harzianum* and *Bacillus megaterium*. Tenth day after sowing 24 h-old-fresh culture of microbial isolates was inoculated at the rate 10 mL per pot as per the treatment. Results revealed that *Trichoderma viride* noticed significantly highest periodical Zn content in soil followed by *Pseudomonas striata* and *Bacillus megaterium*, respectively. Activity of alkaline and acid phosphatase was high in the rhizosphere at early vegetative and flowering stage thereafter it decreased till harvest. As seen among different microbial inoculants, *Bacillus megaterium*, *Pseudomonas striata* and *Pseudomonas fluorescens* noted significantly greater values of alkaline and acid phosphatase activity along with RDF at different sampling intervals and these were found atpar with each other and superior over remaining treatments.

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Effect of Rhizosphere Hybridization and Nutrient Dynamics in Sweet Orange

A.S. Cheke*, V.D. Patil and A.K. Srivastava[1]

Department of Soil Science and Agricultural Chemistry, College of Agriculture Parbhani, Vasantarao Naik Marathwada Krishi Vidyapeeth, Parbhani, 431 402, Maharashtra
[1]National Research Centre for Citrus, Nagpur, Maharashtra
**Email: ashwincheke387@gmail.com*

A field study on the effect of rhizosphere hybridization and nutrient dynamics in sweet orange was carried out during 2013-14 on farmers' field, Village- Zari, Parbhani district. The rhizosphere soil sample was collected from three different tree species *viz.*, Pipal (*Ficus religiosa* L.), Banyan tree/wad (*Ficus benghalensis* L.) and Umber tree /Indian fig (*Ficus racemosa* L.). The rhizosphere soil samples were collected from 0-30 cm depth of root zone and used for hybridization with field soil. The field experiment was carried out with 7 treatments and 4 replications. The treatments were T_1 (NPK + control (no microorganism), T_2 (NPK + Rhizosphere soil of pipal tree (*Ficus religiosa* L.), T_3 (NPK + Rhizosphere soil of banyan tree /wad (*Ficus benghalensis* L.), T_4 (NPK+ Rhizosphere soil of umber/Indian fig tree (*Ficus recemosa* L.), T_5 (NPK+ mix of 3 *Ficus* species rhizosphere soil*)*, T_6 (without NPK mix of 3 *Ficus* species rhizosphere soil), T_7 (NPK + dose of *Azotobacter* + PSB *(Phosphorus solublising bacteria*) + *Trichoderma*). Results showed that microbial consortium of hybridized soil improved the weight of fruit, diameter of fruit, No. of fruits per tree, vitamin-C, TSS and yield/tree and microbial population and nutrient uptake over control treatment. However, among available N, P and K content in soil the treatment T_5 was found to be at par with T_6, T_7, T_4 and superior over the control treatment. The micronutrient were also high in treatment T_5,T_6, T_7,T_4,T_3,T_2 and T_1 over control, increase in the enzymatic activity such as acid phosphatase, alkaline phosphatase, dehydrogenase, MBC, and MBN, microbial population was very high in treatment (T_5), fungi in (T_7) and actinomycetes in (T_5) except control treatment. These results also demonstrated that the microbial consortium reduces the sweet orange dieback disease in citrus orchards.

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Response of Soybean to Liquid *Rhyzobium* and Phosphate Solubilizing Bacteria Culture

R.J. Tiwari, Ankita Pandey and R.P. Sharma
RVSKVV-Krishi Vgyan Kendra, Dewas, 455 001, Madhya Pradesh

Biofertilizer is a natural organic fertilizer that helps to provide all the nutrients required by the plants and helps to increase the quality of the soil with a natural micro organism environment. Application of *Rhizobium* culture is an established fact to increase the pulse production. *Rhizobium* culture increases the nodulation in soybean and phosphate solubilizing bacteria increase the availability of phosphorus (P) from soil.

Trials on farmers' field were conducted during 2014 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 $KMnO_4$ extractable N 180 kg ha^{-1} and 1*N* ammonium acetate extractable K 395 kg ha^{-1}. There are three practices adopted [Farmers practices (18 kg N and 46 kg P_2O_5 ha^{-1}), RDF practices (20, 60 and 20 kg N, P_2O_5 and K_2O ha^{-1}) and improved practices (20, 60 and 20 kg N, P_2O_5 and K_2O ha^{-1} + seed treatment with *Rhizobium* + soil application of PSB). All the doses were applied at the time of sowing. Thirteen farmers' fields were selected for the experiment. A common package of practices and pest management practices were adopted for the experiment.

The growth and yield parameters were significantly influenced by the treatments. Highest pods/plant (67.9), branches/plant (8.42) and seed yield (1.81 t ha^{-1}) were recorded under improved practices against the farmers and recommended practices *i.e.* pods/plant (55.7 and 66.3), branches/plant (5.17 and 6.96) and seed yield (15.0 and 1.66 t ha^{-1}), respectively. Highest cost of cultivation (Rs. 33565 ha^{-1}) gross return (Rs. 56472 ha^{-1}), net return (Rs. 22907 ha^{-1} and B:C ratio (1.68) were recorded under improved practices. However, lowest cost of cultivation (Rs. 32995 ha^{-1}) gross return (Rs. 46800 ha^{-1}), net return (Rs 13805 ha^{-1}) and B:C ratio (1.42) were recorded under farmers practices.

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Evaluation of Cellulose Degrading Microbe and *Yoghurt* with Glyphosate for *In-situ* Rice Stubble Decomposition under Rainfed Upland Ecosystem

Nilay Borah*, Rajen Barua, I.C. Barua[1] and Amrita Phukon
Department of Soil Science, Assam agricultural University, Jorhat, Assam
[1]DWR Centre, Department of Agronomy, Assam agricultural University, Jorhat, Assam
**Email: nilayborah@rediffmail.com*

Rainfed upland rice constitutes about little less than one tenth of the total rice growing areas of India. Rice-based cropping system under rainfed upland situation is an important contributor to the livelihood of the farming community with small to medium holding of marginal land in Asia and many parts of Africa. Pulses are the most common crops that succeed harvest of rice crop with a brief fallow period of about two months, coinciding with the monsoon rains. Rationing ability of many rice cultivars coupled with intense weed growth pose serious problem for effective establishment of the succeeding crop. Incorporation of the residues and weed biomass is not a suitable option owing to many reasons and undesirable effects. Thus, enhanced decomposition aiming at reducing the C:N ratio of the biomass may be a good proposition towards efficient management of the residues facilitating tillage and decomposition. Accordingly, the present work was carried out to isolate, characterize and evaluate cellulose degrading microbe (CDM) for their cellulose degrading ability or *yoghurt*, with glyphosate for *in-situ* decomposition of rice stubbles after harvest. A field experiment was conducted by spraying glyphosate, and CDM or *yoghurt* with or without sugar on rice stubbles after harvest of the crop. Altogether twelve treatments were tested in a randomized block design with individual plot size of 4 m × 5 m and three replications in upland rice (variety Inglongkiri). A one metre square quadrate was placed randomly in each plot and the stubbles were collected at monthly interval. The stubbles were cleared of soil particles, allowed to dry in a hot air oven at 55±1 ^{0}C till constant weight, and the dry weight was expressed as g m^2. After recording the dry weight of rice stubbles, grinding was done using an electrical grinding machine, the sample was homogenized by mixing several times and three sub samples of 500 mg each were drawn for estimation of carbon, nitrogen and cellulose content. The number of species under each category of grasses, broadleaved and sedges was counted for the whole plot at monthly interval after imposing the treatments. Glyphosate, and CDM or *yoghurt* significantly reduced the dry weight, carbon and nitrogen content of stubbles both at two and three months after spray compared to glyphosate alone or untreated plot. The effect of adding sugar with the spray solution was not significant. The cellulose content of stubbles was not affected at one month after treatment, but differed significantly at two months after spray. The species diversity of the weeds was unaffected by the treatments.

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Study of Microbial Role in the Crops on Alfisols and Inceptisols Soils of Rajasthan

S.C. Meena*, H.S. Purohit, R.H. Meena and D.P. Singh
Department of Agricultural Chemistry and Soil Science, Rajasthan College of Agriculture, Udaipur, 313 001, Rajasthan
**Email: subhmeena@yahoo.com*

Field and pot study was carried out to assess the microbial role in the crops wheat, maize, sorghum and mustard in rhizosphere and non-rhizosphere of plants under Alfisols and Inceptisols. A significant difference in dehydrogenase activity: acid phosphates, biomass carbon, biomass P and phytase activity by different plant species were observed between the soils under study.

The microbial effect (*i.e.*, treatment B_3 and B_5) with and without fertilizer P was greatly altered the organic P content of both the soils (8.62 – 20.17%) particularly up to 60 DAS of crop growth. The enzymatic activities (dehydrogenase and acid phosphatase) as well as microbial biomass carbon and phosphorus were also higher in Inceptisols than Alfisols and significantly increased with plant growth particularly up to 30-45 DAS under all the plant species under study. Further, the effect of rhizosphere was higher on all the parameters than non-rhizosphere soils.

Higher content of biomass carbon at 45 DAS and harvest than initial status is an indication of good microbial soil health for better P-mobilization in both the soil types. Crops having more root length density and surface area favour the improvement of biomass carbon. More dehydrogenase activity was observed under rhizosphere than non-rhizosphere which would be attributable to root effects of crops. The changes in soil enzymatic activities (*i.e.,* dehydrogenase and acid phosphatases), soil microbial biomass carbon, and phosphorus were highest under microbial effect (*i.e.,* treatment B_3 and B_5).

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Effect of Biofertilizers and Fertility Levels on Productivity and Net Returns of Blackgram (*Vigna mungo* L.)

D.P. Singh, Chetan Kumar Jangir, R.H. Meena and J. Choudhary[1]
Department of Agricultural Chemistry and Soil Science, [1]Department of Agronomy, Rajasthan College of Agriculture, Udaipur, 313001, Rajasthan

A field experiment was conducted at Institutional Farm, Rajasthan College of Agriculture, Udaipur, (Rajasthan) during *kharif,* 2014 on clay loam soil to study the effect of biofertilizers and fertility levels on productivity and net returns of black gram (*Vigna mungo* L.). The experiment was laid out according to factorial randomized block design with three replications. The experiment comprised of four fertility levels of (control, 50% RDF, 75% RDF, and 100% RDF) and four biofertilizers levels (control, PSB, Rhizobium and Rhizobium+PSB) were applied to the black gram var.T-9. The soil of the experimental site was clay loam in texture, slightly alkaline in reaction (pH 8.1), medium in available nitrogen (276 kg ha^{-1}) and phosphorus (20.6 kg ha^{-1}), while high in potassium (427 kg ha^{-1}) and DTPA extractable micronutrients (Zn, Cu, Mn) above the critical limits but Fe below the critical level.

The application of fertilizer significantly increased the number of pods $plant^{-1}$, number of seeds pod^{-1}, seed, straw, biological yield and net returns with the application of 100% RDF. The increase in test weight and harvest index were found non-significant. The Seed inoculation with *Rhizobium* + PSB significantly increased the number of pods $plant^{-1}$, number of seeds pod^{-1}, seed, straw, biological yield and net returns. The interaction effect of fertility levels and biofertilizers significantly influenced the seed and straw yield and net returns and maximum being with 100% RDF and *Rhizobium* +PSB combination.

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Soil Biological Activity and Seed Cotton Yield under Different Nutrient Management Practices in *Bt* Cotton

M. Ranjith*, S. Sridevi, M. Venkata Ramana and P. Chandrasekhar Rao
Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad
**Email: ranjithagrico34@gmail.com*

The effect of different nutrient management practices on the soil enzyme activity, microbial communities and microbial biomass carbon content and yield of *Bt* cotton was studied at research farm of Krishi Vigyana Kendra (KVK), Malyal, Warangal district during *kharif* 2013 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 a 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} randomised block design with 3 replications. The activity of dehydrogenase was high at flowering stage when compared to harvest. Higher dehydrogenase activity was recorded in soi test based fertilizer treatment and was on par with the DHA recorded in 100% RDF with and without S treatments. Excessively high doses of fertilizers showed a negative impact on activity of dehydrogenase as evidenced by the significantly lower DHA in farmer's practice and 150% RDF. Urease activity was significantly higher in 100% RDF followed by 100% RDF +S @ 30 kg ha^{-1} and soil test based fertilizer application. Increasing recommended doses of fertilizers from 100 to 150% with and without S @ 30 kg ha^{-1} resulted in significant decrease in urease by 22 to 24 per cent with 150% RDF and by 24 to 27 per cent with 150% RDF + S @ 30 kg ha^{-1}. Owing to very low status of available P of the experimental soil, the activity of acid and alkaline phosphatases was highest in control. Addition of fertilizers in increased doses from 100 to 150% significantly reduced the activity of these enzymes. Application of S also showed inhibitory effect on acid phosphatase activity. Soil microbial population and microbial biomass carbon did not show significant variations with treatments. Increasing fertilizer dose from 100 to 150% increased the kapas yield bus was on par with the yield realized in 100% NPK (3.62 t ha^{-1}) and soil test based fertilizer application treatments (3.69 t ha^{-1}). Very high fertilizer application as in farmer's practice the yield (3.58 t ha^{-1}) was even less and on par with that of 100% NPK.

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Effect of Moisture and Temperature on Soil Enzyme L-Asparaginase Activity in Selected Soils

J. Aruna Kumari, P.C. Rao and G. Padmaja

Department of Soil Science and Agricultural Chemistry, College of Agriculture, Professor Jayashanker Telangana State Agricultural University, Rajendranagar, Hyderabad, 500 030, Andhra Pradesh

The present experiment was conducted to study the effect of moisture and temperature on L-asparaginase activity in soil, for these study four soil samples (two Vertisols and two Alfisols) were collected from college farm and student farm of College of Agriculture, Rajendranagar. L-asparaginase converts the amide asparagine to L-asparatic acid and release (NH_4^+) in soil, factors such as, moisture and temperature have influence on enzyme activities. Asparaginase activity was assayed by the procedure Nesseler's method. Asparaginase activity varied from 0.49 to 3.4 μg g^{-1} soil h^{-1} in vertisols and 0.89 to 4.32 μg g^{-1} soil h^{-1} in alfisols. The activity of the enzyme steeply increased from 40% to 80 % and stabilized at 100 % moisture levels. The L-asparaginase activity increased from 10 to 60°C temperature and then decreased sharply . The temperature coefficient in alfisols 0.3 to 1.9 μg g^{-1} soil h^{-1} and vertisols 0.2 to 2.6 μg g^{-1} soil h^{-1}.

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Effectiveness of *Frankia*, *Pseudomonas fluorescens* and *Bacillus subtilis* as PGPR to Control Wilting and Enhancing Plant Growth of Tomato (*Solanum lycopersicum* L.)

Janardan Yadav, Sanjeet Kumar Verma and Jay Shankar Yadav
Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, 221005, Uttar Pradesh

Five isolates of *Frankia* (symbiotic N_2-fixer), isolated from the root nodules of non-leguminous Seabuckthorn (*Hippophae* spp.) shrubs wildly grow in Leh and ladakh (J&K) and in Chamoli district of Uttarakhand, were characterized for their plant growth promoting properties. During the interaction studies, a *Frankia* isolate (FL-1) of Leh showed synergistic relationship with well characterized effective PGPR strains of *Pseudomonas aeruginosa* (BHUPSB-02), *P.fluorescens* (BHUPSB-06) and *Bacillus subtilis* (BHUPSB-13). Root and stem wilt causing bacteria and fungi isolated from tomato plants from the farmer's field of village- Namapur, Baragaon, Varanasi were morphologically identified as *Ralstonia solanacearum* and *Fusarium oxysporum lycopersici.* However, molecular characterization and identification of these pathogens are under the study. During the interaction study, *Frankia* isolate (FL-1) and *B. subtilis* (BHUPSB-13) showed inhibitory effect on both *Ralstonia solanacearum* and *Fusarium oxysporum lycopersici* in *in-vitro* condition.

Therefore, a pot experiment was further conducted on tomato Var. *Kashiamrit* with 12 treatments in triplicate at Banaras Hindu University, Varanasi to see the effect of *P. fluorescens*, *B. subtilis* and *Frankia,* separately and together, in controlling the infestation of wilt causing bacterial and fungal pathogen *in-vivo* conditions. Seedlings of tomato were inoculated with PGPR strains in respective treatments at the time of transplanting. After 20 days of transplanting when seedlings were well established, broth inoculants of *Ralstonia solanacearum* and *Fusarium oxysporum* spread over the stem and roots for their artificial infestation. Observation after 10 days of infestation showed that the plants without pretreated with PGPR were showing much more infestation and few of plants died completely in separate or combined treatments of bacterial and fungal pathogens. Though, *B. subtilis, P. fluorescens* and *Frankia* (FL-1) were effective, separately or in combination, to control the infestation of both pathogens but comparative observations showed that *B. subtilis* (BHUPSB-13) was more effective to control bacterial pathogen while, *Frankia* isolate (FL-1) was effective not only to control wilting caused by both pathogens but also for higher plant growth and early flowering in the tomato plant. *P. fluorescens* was lesser effective compare to *B. subtilis* and *Frankia* but their combined application gave better performance than individual inoculants in all respect.

Though, there is need of further study at laboratory and field levels but this initial finding gives hope to develop a quality biopesticide of multiple properties using consortium of *Bacillus subtilis* strain BHUPSB-13 and *Frankia* isolate FL-1 for improved plant growth and to control wilting of tomato, a serious disease caused by *Ralstonia solanacearum* and / or *Fusarium oxysporum lycopersici.*

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Effect of PGPR and Zn-blended FYM on Growth and Yield of Rice at Different Levels of Phosphorus in Inceptisols of Eastern Uttar Pradesh

Kanhaiya Lal Regar and Janardan Yadav
Department of Soil Science and Agricultural Chemistry, BHU, Varanasi, 221005, Uttar Pradesh

Field experiments were carried out with 20 treatments of two factors vide five levels of PGPR + Zn blended FYM (M_0= No FYM, M_1= normal FYM, M_2= PGPR blended FYM, M_3 = PGPR + Zn @ 2.5 kg ha^{-1} blended FYM, and M_4 = PGPR + Zn @ 5.0 kg ha^{-1} FYM) and four levels of P (0, 20, 40 and 60 kg P_2O_5 ha^{-1}) on rice var. HUR-105 during *kharif* seasons of 2013-14 and 2014-15 at the Agricultural Research Farm, Banaras Hindu University, Varanasi (U.P.). The experiment was replicated thrice under factorial randomized block design. Blended FYM was applied @ 5 t ha^{-1} along with doses of N 60 kg and K_2O 60 kg ha^{-1} before transplanting of rice seedlings and remaining N @ 60 kg ha^{-1} was top dressed in two equal doses after 40 and 80 days of transplanting. The PGPR consortium was consisting of *Azospirillum brasiliense*, *Pseudomonas fluorescens* (BHUPSB-06), *P. aeruginosa* (BHUPSB-10), *Basillus subtilis* (BHUPSB-13), *Paenibacillus polymyxa* (BHUPSB-17) and *Trichoderma harzianum*.

Results pertaining to pooled data of average plant height and tillers $hill^{-1}$, grains $penicle^{-1}$, test wt., grain, straw and biological yields of rice were significantly increased with application of PGPR + Zn blended FYM and at increasing levels of P application over the control treatment. Though the blended FYM with PGPR + Zn @ 5.0 kg ha^{-1} (M_4) gave the higher values of above parameters but results obtained by the treatment of PGPR + Zn @ 2.5 kg ha^{-1} (M_3) was at par to the treatment of M_4 except plant height. Among the levels of P, an application of 60 kg P_2O_5 ha^{-1} was found significantly effective to increase all the growth and yield parameters over the control and 20 kg P_2O_5 ha^{-1}. The harvest index was remained unaffected due to blended FYM and P levels. The interaction effect of blended FYM and P levels was significant on increasing plant growth and yield of rice. Application of PGPR + Zn @ 5.0 kg ha^{-1} blended FYM with 60 kg P_2O_5 ha^{-1} resulted highest plant height, grain, straw and biological yields but it was remained at par with the treatment of PGPR + Zn @ 2.5 kg ha^{-1} blended FYM in conjunction to application of 40 kg P_2O_5 ha^{-1}. Therefore, it was conferred that 20 kg P_2O_5 and 2.5 kg Zn could be saved and optimum grain and straw yield of rice could be obtained with application of 5 t ha FYM blended with PGPR consortium + Zn @ 2.5 kg ha^{-1}, 120 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1} in the soils of eastern Uttar Pradesh.

Commission 3.1: Soil Evaluation and Land Use Planning

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Land Suitability Studies for Honnenahalli Micro-watershed, Davanagere District, Karnataka using Geospatial Techniques

V.R. Ramakrishna Parama, A. Sathish, G.S. Praveen, G.P. Geetha and Y. Shruthi
Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, GKVK, Bangalore, 560065, Karnataka

Land resource inventory of Honnenahalli micro-watershed which is situated between 75°54′54.21″ to 75°54′17.7″ E longitude and 14°35′96.6″ to 14°37′17.54″ North Latittude, Davanagere district, Karnataka was made using geospatial techniques. Cadastral map at 1:7,920 scale was used as base map for the study. The satellite image (Cartosat 2) along with survey of India toposheet was used for delineation of land forms and physiographic units. The transects were identified in the field representing different landforms and soil profiles were opened and studied in 29 locations. The horizon wise soil samples were collected and analyzed for various physical and chemical parameters. The soil map showing 29 phases was prepared. The land suitability for major crops like maize, paddy, sugarcane, cotton, mango, lime, amla, custard apple *etc* was worked out and the database was used for suggesting appropriate cropping system for the location, thereby utilizing land resource for the best suited crop.

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Detailed Land Resources Inventory for Micro-planning of Watershed Program- A Case Study of Hosahalli, Chamarajanagar, Karnataka

Rajendra Hegde, K.V. Niranjana, S. Srinivas, B.A. Danorkar, A. Natrajan and S.K. Singh

ICAR-NBSS&LUP, Hebbal, Bangalore, Karnataka

As a pilot study under World Bank Funded Sujala project was carried out for the generation of detailed LRI(1:10,000 scale) for the Hosahalli micro-watershed(513.47 ha) spread across four villages. Database was generated by using cadastral map of the village as a base along with high resolution satellite imagery (IRS LISS IV and Cartosat-1). The objectives of the project was to develop a micro-plan for science based watershed interventions and it was carried out during March 2015. Land capability classification indicated that nearly 479 ha comes under arable land category (Class II to IV) and only 7 ha of land belonged to non arable land category. Major limitations identified in the arable land class were depth, erosion, gravellyness, alkalinity and wetness. Alkali soils in the micro-watershed was found in around 48 ha (9.43% total area). On the basis of soil reaction the major area (224 ha, 43.57% of total area) is moderately alkaline (pH 7.8-8.4) followed by slightly alkaline (pH 7.3-7.8), 79 ha, 15.34% area), strongly alkaline (pH 8.4-9.0) 117ha, 22.72% area). Thus, nearly soils of 423 ha was alkaline in reaction. However, the soils with neutral reactions occur to the extent of 14.87 per cent of total area (76 ha). Action plan was suggested to improve current land husbandry practices and provide a sound basis for the successful adoption of sustainable crop production intensification. For, strongly alkaline soils interventions like compartment bunding, surface drainage with proper outlet, tied ridges and furrows, de-silting of tanks and nala, application of elemental sulphur (1/3 of GR for 3 seasons, based on ESP), application of press mud, organic manure, green leaf manure, in-situ green manuring (*Dhiancha*), growing of *Casuarina* at the starting point on bunds to intercept the seepage, growing of tolerant crops such as bajra, cotton, sorghum, ber, sapota, amla, application of 125% of RDF for the crop, use of biofertilizers, application of $ZnSO_4$ – 12.5 kg ha^{-1} (once in three years) and application of boron – 5 kg ha^{-1} (once in three years) were suggested in the micro-plan. Soil and water conservation plan, productivity enhancement measures and crop diversification possibilities for the entire watershed were planned and approximate cost estimate was provided in the micro-plan to the Karnataka Watershed development department for taking up the treatments.

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Studies on Integrated Nutrient and Water Management for Banana

V.P. Bhalerao, A.R. Mendhe and N.B. Shaikh
Banana Research Station (Mahatma Phule Krishi Vidyapeeth), Jalgaon, 425 001, Maharashtra

Field experiment was conducted at Banana Research Station, Jalgaon to study the effect of integrated nutrient and water management for banana (Cv. Grand Naine) under drip irrigation. Experiments were laid out in factorial randomized block design (FRBD) comprised of twelve treatment combinations (Nutrient levels- 4, Irrigation water levels- 3) and replicated thrice. Tissue cultured plantlets of banana cv. Grand Naine were planted in pair row system at 0.9 m × 1.5 m × 2.1 m spacing (4,444 plants ha^{-1}). Inline drip irrigation system was used. Fertilizer dose of 200 g N, 40 g P_2O_5 and 200 g K_2O with 10 kg FYM per plant was used. The nutrient levels were 100:100:100% RDF, 75:100:100% RDF, 100:75:100% RDF and 100:100:100% RDF N:P_2O_5:K_2O and the irrigation water levels were 50, 70 and 90% evaporation replenishment (ER). The soil of the experimental field was medium black having pH 8.17, electrical conductivity (EC) 0.39 dS m^{-1}, low in available nitrogen (217 kg ha^{-1}), moderate in available phosphorus (19.6 kg ha^{-1}) and very high in available potassium (623 kg ha^{-1}). Soil available N was significantly lower (208 kg ha^{-1}) in the nutrient level in which 25 per cent N was reduced. Significantly low soil available P (18.3 kg ha^{-1}) was recorded in the nutrient level in which 25 per cent P was reduced. Highest N, P and K uptake (578, 106 and 1142 kg ha^{-1}, respectively) was recorded in nutrient level in which 100 per cent NPK were applied. All the nutrient levels were statistically at par with each other in respect of soil pH and EC and growth parameters of banana *viz.,* pseudostem height, pseudostem girth, days to flower, crop duration. Application of 100 per cent recommended dose of fertilizers (F_1) recorded high water use efficiency of 72.03 kg ha-mm^{-1} and water productivity of 95.79 Rs. ha-mm ^{1} water, which was followed by application of 100% NP with 75% K (F_4) which recorded water use efficiency of 70.97 kg ha-mm^{-1} and water productivity of 94.03 Rs. ha-mm^{-1} water. As regards nutrient levels, 100% recommended dose of fertilizers (F_1) recorded higher monetary returns of Rs. 2,84,550/- and net profit of Rs. 1,08,104/-. It was followed by F_4 level *i.e.* application of 100% NP with 75% K, which recorded monetary returns of Rs. 2,80,350/- and net profit of Rs. 1,06,129/-. Both the F_1 and F_4 reported similar B:C ratio (1.61).

Application of irrigation water at 90 PER observed significantly superior over rest of the irrigation water levels in respect of pseudostem height (175 cm), pseudostem girth (72.1 cm), no. of hands per bunch (9.1), no. of fingers per bunch (147), bunch weight (20.1 kg $plant^{-1}$), yield (89.4 t ha^{-1}), N uptake (641 kg ha^{-1}), P uptake (116 kg ha^{-1}), K uptake (1273 kg ha^{-1}), monetary returns (Rs. 3,12,900 ha^{-1}), net profit (Rs. 1,36,516 ha^{-1}) and B: C ratio (1.77). Application of irrigation water at 90 PER recorded higher EC (0.39 dS m^{-1}) than rest of the treatments. Among the irrigation levels, I_2 *i.e.* application of irrigation water at 70 PER recorded higher water productivity of 95.50 Rs. ha-mm^{-1} water with 22.22% water saving over I_3 *i.e.* application of irrigation water at 90 PER. The interaction effect between nutrient levels and irrigation water levels were also found to be significant in respect of growth and yield parameters, electrical conductivity, soil available NPK, nutrient uptake by banana and B:C ratio. Thus, application of irrigation water at 90 PER (per cent evaporation replenishment) with 100 per cent RDF found beneficial in terms of yield and monetary returns of banana.

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Effect of Different Irrigation Methods and Wheat Straw Mulching on Soil Physical Properties and Seed Cotton Yield

Kamla K. Choudhary, Rita Dahiya* and V.K. Phogat
Department of Soil Science, CCS Haryana Agricultural University, Hisar, 125004, Haryana
**Email: ritajbd@yahoo.com*

Cotton (*Gossypium spp*.) is one of the most important commercial fiber cash crops (White Gold) and India is among largest cotton producing countries. The genetically modified *Bt* (*Bacillus thuringiensis*) cotton is getting popularity among the growers due to higher yield potential over the conventional varieties of cotton. Therefore, a field experiment was carried out at Research Farm of Department of Soil Science of CCS Haryana Agricultural University, Hisar during 2014 to evaluate the effects of different irrigation methods and mulching on soil physical properties and seed cotton yield. The experiment consisted of three irrigation methods as main treatments: i) drip, ii) furrow and iii) flood irrigation; four wheat straw mulching rate (0, 2, 4, 6 t ha^{-1}) as sub-treatments. The experiment was carried out with four cotton cultivars *viz*., MRC-7017, RCH-134, American H-1236 and *Desi* HD-123 in three replicates. The seed cotton yield, yield attributes including yield per plant, number of bolls per plant and boll weight, soil organic carbon (OC) content and soil moisture were measured using standard methods. The soil temperature was measured at 2 and 15 cm depths using YSI tele thermometer sensors. The application of wheat straw mulching at 4 and 6 t ha^{-1}, significantly increased soil (0-15 cm) OC by 17 per cent and 23.8 per cent, moisture content by 25.7 per cent and 34.5 per cent, respectively, under *Bt* cotton (MRC-7017) in drip irrigation. Similar trend in soil OC was observed in furrow and flood irrigation methods and *Desi* cotton. The mulching also conserved the soil moisture in *Desi*, American and RCH-134 in furrow and flood irrigation. The mulching at 6 t ha^{-1} significantly decreased the mean soil temperature at 2 and 15 cm depths by 4.8 ^{0}C and 3.6 ^{0}C, respectively, compared to control in drip irrigated plots under the *Bt* cotton (MRC-7017) in the month of June 2014. The mulching (6 t ha^{-1}) and drip irrigation both increased significantly seed cotton yield of *Bt* cotton (MRC-7017) by 21.4 per cent compared to control and 29.0 per cent over flood irrigation method. The seed cotton yield of *Desi* cotton also followed the similar trend under irrigation methods. Similarly, the yield attributes i.e., yield per plant, number of bolls per plant and boll weight of the *Bt* cotton and *Desi* cotton were highest in drip irrigation followed by furrow and flood methods. The results implies that drip irrigation has potential to increase the seed cotton yield and improve soil properties under wheat straw mulching in arid and semi arid climatic conditions.

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Impact of Maize-based Conservation Agriculture Production System (CAPS) on Soil Organic Carbon and Microbial Attributes in North Central Plateau Zone of Odisha

A. Mohanty* and K.N. Mishra
Department of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar, Odisha
**Email: ayeshamohanty89@gmail.com*

The major categories of land degradation in the undulating hilly terrains of Kendujhar district under north central plateau zone of Odisha are degraded forest cover, accelerated soil erosion, mining activities and shifting cultivation coupled with practice of growing mono culture of maize in intense tillage without any scientific agro-techniques. With these facts in the backdrop, a field experiment on conservation agriculture production system (CAPS) with the components of minimum tillage, erosion resistant legume intercrop and a succeeding cover crop in triplicate split-plot design was initiated during 2011- 12 at regional research and technology transfer station, Kendujhar of Orissa University of Agriculture and Technology located in these zone. The impact of CAPS involving tillage practices and cropping system on soil organic carbon status and microbial attributes including MBC and microbial quotient have been assessed at the end of the 2nd cropping cycle (2012-13).

The treatment combinations are conventional tillage (CT) and minimum tillage (MT) with sole maize (M) and maize + cowpea (M+C) as intercrop in the main-plots during the wet season and horse gram (H), mustard (T) and no cover crop (NCC) in the sub-plots during the dry season. The accumulation and physical protection of SOM due to less soil disturbances in MT elevated the status of soil organic matter (+17%), which enhanced the population of bacteria (+10.8%), actinomycetes (+14.6%) and MBC (+13.6%) over initial. The inclusion of cover crops in CAPS significantly enhanced the SOC (+6.8%), actinomyctes (+6.4%) and MBC (+5.8%) over the soils with NCC. The microbial quotient (MBC/SOC) which is a measure of carbon availability to microorganisms was higher in the practice of MT (2.1%) as compared to CT systems (1.9%). The higher MBC/SOC ratio in MT suggests higher substrate availability through the accumulation of crop residues in the surface soils. Considerable build-up of SOM due to residue incorporation and its protection under MT contributed significantly in improving the status of macro-aggregates (R=0.92**), bacteria (R=0.93**), actinomycetes (R=0.92**) and MBC (r=0.87**). Though the system of MT- M+C- CC was marginally lower than CT at the end of the 2nd cropping cycle, the positive influence on soil health will be reflected in yield in the long run.

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Innovative Soil and Water Conservation Strategies for Chambal Ravines

S.K. Verma, Akhilesh Singh and P.S.Tomar
Rajmata Vijyaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, 474 002, Madhya Pradesh

The technologies developed during last hundred years by various researchers are not found effective for Chambal ravines due to its different nature of formation and posing a serious challenge to check its further advancement and gobbling some other new villages. Some new approaches have been started under niche area project for various developing stages.

A. Indigenous technology

After consultation with thousands of villagers the fact emerged that peoples are trying since hundreds of years to check the advancement and save their village but it never worked permanent solution only delayed the situation for some years. Among many methods the shaping of advancing gullies and planting of shelterbelts of trees are quite impressive. Shaping was done manually and on individual basis by making the edge in slanting condition (say $120^{R"}$ rather than $90^{R"}$angle) and planting of *Sachrum munja* as vegetative barriers on the slopes. These two methods can be very effective if made on community basis and with the help of modern machineries.

B. Innovative techniques

Two methods *i.e.* terracing in advancing area and slopping the vertical fall has been introduced under this project and it may give a permanent solution to the problem. A strong vegetative barrier at suitable intervals is provided on slopes of terrace and diagonal surface of slanting face of the slopes. Many options has been introduced by the project to manage the gullies and conserve the natural resources, it includes masonry structures, gabions, submersible dams, earthen dams, plugging of gullies and temporary bunds (bori bandhan). All the measures normally got failed due to leakage from side or gushing of water under the structures. The submersible dam has some edges over others structures provided it has been built at least at a depth of 1.00 to 1.25 m. A modified form of submersible dam plus gabion was introduced to check runoff, reduce the cost and it is working satisfactorily.

C. Multi-step Leveling System or Zero Loss Technology

A very innovative, simple and practical methodology for reclamation of deep Chambal ravine has been developed by the centre. This technology involves use of heavy earth machine (Hitachi 110 or 220) only for cutting of top edge and uses this soil for chocking of drainage gullies at specified distance with appropriate strength. Construction of peripheral bunds and partial modification of slope at every leveled piece of land is mandatory. The reclaimed flat land is usable for crop cultivation (35 to 50%), modified slopes can be used for medicinal/ fruit trees/grasses/ silvi-pastoral system (30 to 45%) and plugged deep gullies are good for water storage. This is most cheapest and practical methodology to make ravines usable. The reclamation cost varies only Rs.35,000 to 40,000 depending on depth of ravine. The system is eco-friendly, remunerative and takes care of all aspects sustainability to human being.

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Groundwater Quality Assessment of Palwal Block of Palwal District

Gagandeep, Ram Prakash*, Sanjay Kumar[1], Rajpaul, Satyavan and S.K. Sharma
Department of Soil Science, [1]Department of Soil and Water Engineering,
CCS Haryana Agricultural University, Hisar, 125004, Haryana
**Email: ramsansanwal@gmail.com*

The present study examined the quality of groundwater in a 49785 ha region comprising Palwal block of Palwal district of Haryana state, lies adjoining to Faridabad district and at a distance of 45 km from the northern border of New Delhi. 132 groundwater samples from running tubewells in the block have been analyzed for ionic concentrations of CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+ and K^+. Parameters such as electrical conductivity (EC), sodium absorption ratio (SAR) and residual sodium carbonate (RSC) have been evaluated. According to AICRP classification, it was found that 34.8% water samples were of good quality, 49.2% saline and 16.0% alkali in nature. Out of the saline water, 24.2, 1.5 and 23.5% were marginally saline, saline and high SAR saline, respectively. In alkali group, 2.3, 2.3 and 11.4% were maginally alkali, alkali and high alkali, respectively. The study revealed that out of 133 samples 101 of the samples showed EC upto 4 dS m^{-1} and the maximum value of EC (11.0 dS m^{-1}) was found in village Rakhuta. Residual sodium carbonate (RSC) and sodium adsorption ratio (SAR) varied from nil to 5.50 me L^{-1} and 2.50 to 23.40 (mmol $L^{-1})^{½}$, respectively. Spatial variable maps of EC, SAR, RSC and water quality of groundwater used for irrigation in the block were prepared through GIS to study spatial variability.

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Effect of Pulse-based Cropping System and Fertilizer Management on System Productivity in Vertisol of Dharwad, Karnataka

M.S. Venkatesh
IIPR-Regional Centre cum Off-season Nursery, UAS Campus, Dharwad, 580 005, Karnataka

Crop diversification by inclusion of pulses in cropping system has gained much attention in view of soil degradation and ill-effects of mono-culture. In Karnataka, pulses are gaining importance in terms of area as well as production even though much scope exists to attain maximum productivity when compared to neighboring states like Andhra Pradesh, Maharashtra, *etc*. The major pulse based cropping system in Karnataka include maize-chickpea, groundnut-chickpea, soybean-chickpea and mungbean-*rabi* sorghum. Among the above cropping system, management of natural resources is important to attain highest productivity. In view of the above, a field experiment was conducted under rainfed conditions at the research farm of IIPR-Regional Research Centre cum Off-Season Nursery, Dharwad, Karnataka. There were 16 treatment combinations comprising of four cropping systems (mungbean-sorghum, maize-chickpea, soybean-chickpea and groundnut-chickpea), two conservation practices (Mulching and No mulching), and 2 fertilizer management practices (Recommended and Farmer practice). The mean grain yield of *kharif* crops *viz.*, mungbean (cv. IPM 2-14), maize (cv. Arjun Hybrid), groundnut (cv. GPBD-4) and soybean (cv. DSB-21) ranged from 400-550, 5500-6400, 2800-3300 and 2200-2600 kg ha^{-1}, respectively. The mean grain yields of chickpea and sorghum ranged from 1530-2730 and 2620-3800 kg ha^{-1}, respectively. Highest system productivity (6500 kg ha^{-1}) was recorded in groundnut-chickpea system followed by maize-chickpea system (5400 kg ha^{-1}). There was about 17% increase in system productivity due to conservation practice as compared with normal practice.

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Effect of Silicon Fertilizer on Growth, Nutrient Uptake and Yield of *Rabi* Onion

A.G. Durgude* and S.R. Kadam
Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, 413 722, Maharashtra
**Email durgudeagarediffmail.com*

A field experiment was conducted on effect of silicon containing fertilizer (Biosil de) on growth, nutrient uptake and yield of *rabi* onion (cv N-2-4-1) during 2014. The experimental soil type was Typic Haplustept with clayey texture. The initial soil pH was 8.22, EC 0.41 dS m^{-1}, organic carbon content 0.6% and available Si ($CaC1_2$) content in soil was 116 mg kg^{-1}. The product of Biosil de contain 70% Si. The design of experiment was RBD with three replication and eight treatments, which comprises: T_1 only FYM, T_2 GRDF (100:50:50 N:P_2O_5: K_2O + 20 t ha^{-1} FYM), T_3, T_4 and T_5 were full GRDF with Biosil de @ 200, 300 and 400 kg ha^{-1}, respectively, however T_6, T_7 and T_8 were half GRDF with Biosil de @ 200, 300 and 400 kg ha^{-1}.

The results revealed that polar diameter of onion bulb was significantly increased (5.91 cm) in treatments of T_4 and T_5 of full GRDF + Biosil de @ 300 and 400 kg ha^{-1}. The bulb yield of onion was significantly increased (45.6 t ha^{-1}) in treatment of T_4 (full GRDF + Biosil de @ 300 kg ha^{-1}) over T_1, T_2, T_6 and T_7. However, stover yield of onion was significantly increased (10.8 t ha^{-1}) in treatment of T_6. The total of uptake of N, P and K (120.7, 36.7 and 70.7 kg ha^{-1}) significantly increased in treatment of T_4 which was at par with treatment T_3. Same trend was also observed in case of total uptake of Fe, Mn, Zn, Cu and Si (2523, 258, 264, 90 and 27.7 kg ha^{-1}), respectively. Hence, it is concluded that soil application of Biosil de @ 300 kg ha^{-1} with full GRDF to onion found beneficial for increasing plant available silicon in soil, polar diameter of bulb, uptake of macro and micronutrients and bulb yield of *rabi* onion.

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Effect of Application of Different Nutrient Sources on Yield and Nutrient Uptake of Soybean in Vertisol

H.K. Kausadikar, S.T. Shirale and V.D. Patil

AICRP on Long Term Fertilizer Experiment, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, 431 402, Maharashtra

The long-term fertilizer experiment was conducted at experimental farm, Department of Soil Science and Agricultural Chemistry, VNMKV, Parbhani during *kharif* season 2013-14 to study the changes in soil quality, crop productivity and sustainability. The soil of experimental field was medium black and dominated by montmorillonite clay. The experiment was laid down in randomized block design (RBD) with twelve treatments replicated four times. The treatments were T_1 - 50% NPK, T_2 - 100% NPK, T_3 - 150% NPK, T_4 - 100% NPK + hand weeding, T_5 - 100% NPK + 25 kg $ZnSO_4$, T_6 - 100% NP, T_7 - N, T_8 - 100% NPK + FYM @ 5 t ha^{-1}, T_9 - 100% NPK - sulphur (S-free), T_{10} - Only FYM @ 10 t ha^{-1}, T_{11} - absolute control and T_{12} - fallow. Out of twelve treatments, the chemical weed control was practiced in all other treatments except T_4. The FYM @ 10 t ha^{-1} was incorporated in soil 15 days before sowing of *kharif* crop and zinc was applied through $ZnSO_4$ @ 25 kg ha^{-1} to the plots where FYM and zinc treatments were applicable during *kharif* season only. Recommended dose for soybean was 30 kg N, 60 kg P_2O_5 and 30 kg K_2O ha^{-1} was applied at the time of sowing. For T_9 (100% NPK - sulphur) treatment nitrogen and phosphorus were applied through urea, diammonium phosphate to avoid sulphur addition. In rest of the treatments urea and single superphosphate were used as a source of N and P_2O_5. In T_{11} treatments neither manure nor chemical fertilizers were applied. The results indicated that the treatment received 100% NPK + FYM @ 5 t ha^{-1} proved its superiority over all other treatments and recorded significantly higher soybean grain yield (2.27 t ha^{-1}) and straw yield (2.34 t ha^{-1}) while 150% NPK recorded grain yield (2.24 t ha^{-1}) and straw yield (2.33 t ha^{-1}) and 100% NPK + $ZnSO_4$ recorded grain yield (2.10 t ha^{-1}) and straw yield (2.29 t ha^{-1}) and these treatments were statistically at par with each other and found significantly superior over 100% NPK treatment as well as all other treatments. Drastic reduction in yield was recorded only 100% N and absolute control treatment. 100% NPK + FYM treatment recorded 16 per cent more grain yield over 100% NPK treatment. Highest N, P, K and S uptake (161.6, 24.6, 59.6, 13.8 kg ha^{-1}, respectively) was recorded by the treatment 100% NPK + FYM @ 5 t ha^{-1} followed by 150% NPK and 100% NPK + $ZnSO_4$ treatment as compared to all other treatments.

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Effect of Different Sowing Times and Potassium Levels on Nutrient Availability, Uptake, Insect, Pest Populations, Yield and Economics of Soybean

B.M. Kamble, R.G. Jadhav and D.K. Kathmale
Agricultural Research Station, K. Digraj, Dist-Sangli, Maharashtra

The field experiments were conducted during *kharif* season from 20012-13 to 2014-15 at Agricultural Research Station, K. Digraj, Dist-Sangli to study the effect of different sowing times and potassium (K) levels on nutrient availability, uptake, yield and economics of soybean. The experiment was laid out in a split plot design and replicated three times. The treatments consisted three sowing times (first fortnight of June, second fortnight of June and first fortnight of July) as a main treatments and four levels of K (0, 15, 30 and 45 kg ha^{-1}) as a sub treatments. The significantly highest pooled grain yield (2.0 t ha^{-1}) of soybean was registered in plot sown during first fortnight of June over all those sown thereafter. Similarly, it also remained highest in receiving K @ 45 kg ha^{-1}. The effect of different sowing times was found non significant on soil properties except electrical conductivity (EC). The effect of different levels of K given to soybean exerted significant influence on electrical conductivity of soil, available N, P, and also K in soil after crop harvest. The highest pooled EC of soil and available K were recorded in treatment with K applied @ 45 kg ha^{-1} as compared to rest of the levels of this nutrient tried and at par with application of K @ 30 kg ha^{-1} in respect of EC, available N, P and K content in soil. The significantly highest pooled total uptake of N, P and K by soybean was observed in first fortnight of June as compared to first fortnight of July. The highest pooled total uptakes of N, P and K by soybean were recorded in treatment with K applied @ 45 kg ha^{-1} as compared to rest of the levels of K. The population of aphids and *Spodoptera* reduced significantly with late sowing. The stem length tunneling % significantly increased with late sowing and ranged between 12.84-14.12 among sowing times adopted. The reduction in population of aphids, *Spodoptera* and stem tunneling was recorded in 45 K_20 kg ha^{-1} applied to soybean as compared to control. The sowing of the soybean crop during first fortnight of June gave significantly higher gross monetary returns (Rs.50459) over other sowing dates resulting in to highest net monetary returns of Rs. 15493 with significantly highest B: C ratio of 1.58. The B: C ratio of K applied @ 30 and 45 kg ha^{-1} remained at par, however gross monetary returns of 45 kg ha^{-1} exceeded significantly over 30 kg ha^{-1}. Application of 5 t FYM ha^{-1} with 50: 75:45 N: P_2 O_5:K_2O kg ha^{-1} to soybean sown in first fortnight of June is recommended as a revised fertilizer nutrient dose for medium deep black soils for minimizing insect, pest populations, getting higher yield, monetary returns and maintaining soil fertility.

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Effect of Fe, Zn and S with FYM on Yield and Nutritional Quality of Forage Sorghum var. SSG-59-3

K.H. Patel, N. Singh, N.H. Garaniya and N.K. Kalyanasundaram
College of Agriculture, Navsari Agricultural University, Bharuch, Gujarat

A field experiment was conducted in factorial randomized block design (FRBD) with three replication to study the effect of soil application of Fe, Zn and S in combination with FYM on yield and nutritional quality of multicut forage sorghum var. SSG-59-3. There were eighteen treatments comprising of combination of three level of FYM [0(F_0), 10(F_1) and 20(F_2) t ha^{-1}] and six nutrient treatments [control(M_0), Fe(M_1), Zn(M_2), S(M_3), Fe+Zn (M_4) and Fe+ Zn+S(M_5)]. Iron, Zn and S were applied @ 10, 5 and 40 kg ha^{-1} as $FeSO_4$, $ZnSO_4$ and gypsum respectively. There were three cuts in each year. Initial available S, Fe and Zn contents in soil were low. Green forage yield (GFY) and crude protein (CPY) were significantly increased by the treatments. The per cent increase in GFY due to F_2 and F_1 over F_0 (74.2 t ha^{-1}) was 8.5 and 5.3, respectively. The treatment M_1, M_2, M_3, M_4 and M_5 increased GFY by 4.2, 5.3, 5.7, 8.5 and 13.0 per cent, respectively over that of M_0 (73.1 t ha^{-1}). A significant interaction effect of F × M on GFY, DFY and CPY showed that nutrient use efficiency of Fe-Zn-S treatments was higher when they were applied along with FYM @ 10 and 20 t ha^{-1}. Application of FYM at F_1 and F_2, as well as Fe-Zn-S treatments favourably influenced quality parameters like N content, S content, Fe content and Zn content in comparison to their respective controls. A synergistic interaction of F × M on S content and Zn content were noted. N:S ratio was reduced due to F_2 and M_5 treatment, which were in acceptable range (10.91 to 10.05) indicates improvement in nutritional quality of forage sorghum.

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Response of Foxtail Millet (*Setaria italica*) to the Application of Varied NPK Levels in Alfisol under Rainfed Condition

R. Vigneshwaran[1] and R. Shanmugasundaram[2]
Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, 641 003, Tamil Nadu

A field experiment was conducted in farmer's field of Panamarathupatty block, Salem District, Tamil Nadu, during *rabi* season of 2014 to study the effect of NPK levels on plant growth characters and yield of foxtail millet (*Setaria italica*) in Alfisol under rainfed condition. The experiment was laid out in a randomized block design with three replications. The experiment was carried out in clay loam soil texture. The treatments consisted of T_1 – Control, T_2 – NPK @ 30:20:10 kg ha^{-1}, T_3 – NPK @ 45:20:10 kg ha^{-1}, T_4 – NPK @ 60:20:10 kg ha^{-1}, T_5 – NPK @ 30:30:20 kg ha^{-1}, T_6 – NPK @ 45:30:20 kg ha^{-1}, T_7 – NPK @ 60:30:20 kg ha^{-1}, T_8 – NPK @ 44:0:0 kg ha^{-1}, T_9 – NPK @ 0:22:0 kg ha^{-1}, T_{10} – NPK @ 44:22:0 kg ha^{-1} (recommended dose of fertilizer). Foxtail millet CO (T) 7 was used as a test variety. The nitrogen was applied as urea in two splits i.e. 50% basally and remaining 50% as top-dressing at tillering stage. The entire dose of phosphorus and potassium were applied basally as single superphosphate and muriate of potash, respectively.

Application of NPK at higher levels had significant effect on number of grains per panicle. The highest number of grains (2806) was recorded for the application of NPK @ 60:30:20 kg ha^{-1} (T_7) which was significantly superior to other treatments. The control treatment (T_1) registered the lowest number of grains per panicle. Application of NPK @ 60: 30: 20 kg ha^{-1} (T_7) recorded significantly more thousand grain weight (1.63 g) than other treatments and was on par with NPK @ 45:30:20 kg ha^{-1} (T_6) (1.62 g) and NPK @ 30:30:20 kg ha^{-1} (T_5) (1.58 g). Among the different nutrient combinations, application of NPK @ 60:30:20 kg ha^{-1} (T_7) gave higher yield (2077 kg ha^{-1}) and it was on par with treatment that received NPK at the rate of 60:20:10 kg ha^{-1} (2044 kg ha^{-1}) (T_4) which were significantly different from other treatments. The lowest yield was recorded in control (1402 kg ha^{-1}). Similarly, application of 60 : 30 : 20 kg N, P_2O_5 and K_2O kg ha^{-1} (T_7) recorded significantly higher straw yield (5886 kg ha^{-1}) than other treatments and it was on par with NPK @ 60:20:10 kg ha^{-1} (T_4) (5723 kg ha^{-1}). The highest net return and B: C ratio was registered with application of NPK @ 60:30:20 kg ha^{-1} which was followed by the treatment involving NPK @ 60:20:10 kg ha^{-1}.

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Standardising the Nutrient Schedule for Maximising the Ratoon Crop Yield of Sugarcane in Theni District

S. Udayakumar, K. Baskar and B. Bakiyathu Saliha
Department of Soils and Environment, Agricultural College and Research Institute, Madurai, Tamil Nadu

An investigation was undergone to standardise the nutrient schedule for maximising the ratoon crop yield of sugarcane. A field experiment was conducted in the farmer field located in the Palani Chettipatti village in Theni district, Tamil Nadu with the test crop of ratoon sugarcane (Var. CO 86032) during 2013-14 with ten treatments replicated thrice with randomized block design with the following set of treatments *viz.,* RSCL- recommended dose of fertilizers T_1 (350:150:150 kg N, P_2O_5 and K_2O ha^{-1}); T_2 (125% N + 100% P_2O_5 and K_2O); T_3(100% N + 75% P_2O_5 and K_2O); T_4 (100% N + 50% P_2O_5 and K_2O); T_5 (125% N + 75% P_2O_5+ 100% K_2O); T_6 (STCR based fertiliser recommendation); T_7 (T_1+ Zn); T_8 (T_7+S); T_9 (RSCL package) and T_{10} (TNAU package). In all the treatments, 10 per cent recommended N and 50 per cent P were applied basally remaining 90 per cent N was applied in three equal splits @ 30 per cent with K @ 20, 40 and 40 per cent at 30, 60 and 90 days after ratoon. The remaining 50 per cent of P was applied in 2 equal splits at 60 and 90 days after ratoon.

Among the treatments, the STCR based fertilizer recommendation (T_6) recorded the highest yield attributes (number of millable cane, single cane weight, number of internodes and girth of millable cane). The STCR based fertilizer recommendation (T_6) recorded higher cane yield of 124.6 t ha^{-1} which was on par with RSCL package of recommendation (T_9) of 122.6 t ha^{-1}. It is concluded that there is no need to apply 25 per cent extra N and there is no response in separate application of either $ZnSO_4$ @ 25 kg ha^{-1} or sulphur @ 25 kg ha^{-1} alone or in combination. Due to the greater influence of RSCL package (T_9), the brix, pol and CCS per cent was greatly enhanced. The STCR based fertilizer recommendation (T_6) influenced the total N and K uptake of ratoon sugarcane. The RSCL package (T_9) recorded the highest total P uptake which was on par with T_6. The same treatment recorded the highest total S uptake of 46.4 kg ha^{-1}. Considering the uptake of total micronutrients, the treatment T_9 recorded the highest uptake of Fe and Zn while T_{10} recorded the highest Mn and Cu uptake. The present investigation indicated that a standard treatment combination of 350 to 375 kg N, 100 to 150 kg P_2O_5, 150 kg K_2O and 50 kg $FeSO_4$ per ha along with other input like bio-compost and biofertilizers for ratoon sugarcane is suggested on the basis of the ratoon sugarcane yield of 124 t ha^{-1} from a farm trial in farmers field.

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Effect of Varied Levels and Frequency of Zinc Application on the Soil Zn Status and Yield of Rice–Rice Cropping System

P. Malathi[1], T. Chitdeshwari[1], P. Stalin[1], D. Jegadeeswari[1] and A.K. Shukla[2]

[1]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, 641 003, Tamil Nadu

[2]ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

Rice is one of the major crops, feeding more than half of the world population. After nitrogen, phosphorus and potassium, widespread zinc (Zn) deficiency has been found responsible for yield reduction in rice. In Tamil Nadu, 65% of soils are low in plant-available Zn. The present study was undertaken to evaluate the long-term effect of various levels and frequency of Zn addition on the soil Zn and yield of rice – rice cropping system. Field experiments were conducted in the wetlands of Tamil Nadu Agricultural University, Coimbatore district in black, clay loam soil (Typic Haplustalf) with various levels of Zn (0, 2.5, 5.0, 7.5 and 10.0 kg Zn ha^{-1}) and frequency of Zn addition (all crops, every year, alternate years and once in three years) for a period of three years (six crops). The soil was marginal in available Zn and sufficient in all other micronutrients. Totally twenty treatment combinations were replicated thrice in split plot design. In all the treatments 100% recommended dose of NPK *viz.*, 150:50:50 kg ha^{-1} for each crop was uniformly applied.

The results revealed that rice grain yield was significantly increased with the application of Zn. In the sixth crop, the treatment receiving 2.5 kg Zn ha^{-1} to every crop recorded significantly highest grain yield of 6.60 t ha^{-1} which was on par with the application of 7.5 kg Zn ha^{-1} every year (6.40 t ha^{-1}). An increase in rice grain yield to the tune of 13.2% was observed with Zn application when compared to NPK check. Among the different frequencies of Zn application, F_1 (Zn application to all the crops) recorded significantly highest grain yield of 6.18 t ha^{-1}. With respect to levels of Zn application, Z_4 (7.5 kg Zn ha^{-1}) recorded the highest grain yield of 5.96 t ha^{-1} which was on par with Z_5 (10.0 kg Zn ha^{-1}), Z_3 (5.0 kg Zn ha^{-1}) and Z_2 (2.5 kg Zn ha^{-1}).

Regarding post-harvest soil available Zn status, significant variation was observed among the frequencies, levels of Zn application as well as their interaction. Among the frequencies of Zn application, F_1 (Zn application to all the crops) recorded significantly highest DTPA-extractable Zn content of 3.49 mg kg^{-1}. With increasing levels of Zn application, available Zn content in the post-harvest soil increased. The treatment Z_5 (10 kg Zn ha^{-1}) recorded significantly highest soil available Zn of 3.37 mg kg^{-1}. Continuous application of $ZnSO_4$ for every rice crop resulted in build-up of Zn in soils. The results obtained so far indicated that Zn application to rice-rice cropping system can be given either 2.5 kg Zn (12.5 kg $ZnSO_4$) ha^{-1} for every rice crop or 7.5 kg Zn (37.5 kg $ZnSO_4$) ha^{-1} for first rice crop alone in a year for obtaining higher grain yields.

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Effect of Manganese Nutrition on Growth, Yield, Manganese Uptake and Oil Content of Sesame

P. Stalin[1], F. Habimana[1], D. Muthumanickam[1], P. Malathi[1] and A.K. Shukla[2]

[1]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, 641 003, Tamil Nadu

[2]ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

Sesame (*Sesamum indicum L.*) is called "Queen" of oilseeds plant and India ranks first in its area and production in world. Its average productivity (437 kg ha) is below than that of the world (489 kg ha^{-1}). In Tamil Nadu, sesame is grown in an area of 43,175 ha with a production of 26,447 tonnes and a productivity of 463 kg ha^{-1}. The rate of growth in sesame production in Tamil Nadu is low and unstable. Manganese (Mn) in plants is a constituent and activator of enzymes involved in protein synthesis, lipid metabolism and photosynthesis.

A field experiment was conducted in RBD with sesame variety CO 1 in 2014-2015 at the farmer's holding in Erode district in red sandy loam soil (Typic Ustropept). The soil was deficient in available N, S and Mn and sufficient in all other major and micronutrients. The various treatments included control (recommended NPKS), graded levels of Mn (0, 1.5, 3.0 and 4.5 kg ha^{-1}) applied to soil as $MnSO_4$ (T_2 - T_4) and $MnCl_2$ (T_5-T_7) and recommended dose of NPK + 5 kg ha^{-1} $MnSO_4$ (T_8). In all the treatments 100% recommended dose NPK *viz.*, 35:23:23 kg ha^{-1} for irrigated sesame was uniformly applied. Sulphur @ 40 kg S ha^{-1} as gypsum was applied uniformly to all treatment plots, except T_8.

The results revealed that the application of 3 kg Mn ha^{-1} as $MnSO_4$ registered the highest dry matter production of 181, 1070, 3090, 3832 kg ha^{-1} at vegetative, flowering, milking and harvesting stages, respectively with a mean increase of 52 per cent over the control. The manganese uptake in sesame showed increasing trend up to physiological maturity of the crop. The level 3 kg ha^{-1} Mn as $MnSO_4$ registered the highest manganese uptake with 14.9, 81.4, 97.4 and 218.1 g ha^{-1} with a mean increase of 93 per cent over the control. The highest seed (740 kg ha^{-1}) and stalk (2973 kg ha^{-1}) yields were obtained in the treatment having 3 kg Mn ha^{-1} as $MnSO_4$ and the yield increase being 32 and 31 per cent, respectively over the control. The highest oil content (49.1%) and oil yield (369 kg ha^{-1}) in seeds were recorded by application of 3 kg Mn as $MnSO_4$ with a contribution of 17 and 56 per cent increase over the control respectively. The highest soil available Mn was recorded by applying 4.5 kg ha^{-1} Mn as $MnCl_2$ after harvest with 2.24 mg kg^{-1}.

Hence, for obtaining high yield and quality in irrigated sesame, the optimum dose was found as 3 kg Mn (10 kg $MnSO_4$) ha^{-1} along with recommended dose of 35:23:23:40 kg N, P_2O_5, K_2O and S kg ha^{-1} which can be followed by the farmers in manganese and sulphur deficient soil.

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Evaluation of Released and Pre-release Finger Millet Varieties for Nitrogen Requirement

B. Vajantha*, M. Subbarao, L. Madhavilatha and N.V. Sarala
Agricultural Research Station (Acharya N.G. Ranga Agricultural University, Andhra Pradesh), Perumallapalle, Tirupathi, 517 507, Andhra Pradesh
**Email: vajantha@gmail.com*

Different finger millet varieties respond differently to different levels of nitrogen (N). The normal recommended dose of N fertilizer is 60 kg ha^{-1}. But all the new varieties developed may not give higher grain yield with the normal recommended dose. Hence, it is essential to find out the optimum requirement of N for released and pre-release finger millet varieties. Keeping this in view, the present study was taken up to know the response of finger millet varieties to different levels of N during *kharif* 2014 and *rabi* 2014-15. The field experiment was laid out with three varieties (PPR 1012, PPR 2885 and Vakula) and six levels of N (50% RDN, 75% RDN, 100% RDN, 125% RDN and 150% RDN) in split plot design. Recommended dose of fertilizer for finger millet is 60:40:30 kg NPK ha^{-1} (100% RDF). Nitrogen was applied in the form of urea in two equal splits as basal and 30 days after transplanting as per treatments. Phosphorus and potassium were applied as basal in the form of single superphosphate and muriate of potash, respectively.

The results revealed that the grain yield was significantly influenced by varieties, N levels as well as their interaction during *kharif* 2014 and *rabi* 2014-15. During both the seasons among the varieties PPR 2885 recorded highest mean grain yield (2.84 and 2.77 t ha^{-1}, respectively) followed by PPR 1012 (2.71 and 2.57 t ha^{-1}, respectively) and vakula (2.42 and 2.77 t ha^{-1}, respectively). During *kharif* 2014, among the N levels application of 150% RDN recorded higher grain yield (3.19 t ha^{-1}) and it is on par with 125% RDN (3.10 t ha^{-1}). During *rabi* 2014-15, application of 125% RDN recorded higher grain yield (3.01 t ha^{-1}) and it is on par with 150% RDN (2.94 t ha^{-1}). During both the seasons application of 125% RDN to PPR 2885 recorded higher grain yield (3.30 and 3.21 t ha^{-1}) and it is on par with other treatments. The N uptake by grain was higher with PPR 2885 followed by vakula. Among the levels 150% RDN recorded higher N uptake by grain and it is on par with 125% RDN. The protein content (%) in grain was higher with PPR 2885 followed by vakula. Application of 150% RDN recorded higher protein content and it is on par with 125% RDN.

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Response of Major Coarse Cereals to Foliar Application of Urea Phosphate

S.K. Sharma, Priyanka, D.P. Singh and Mahendra Sharma

Department of Agricultural Chemistry and Soil Science, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, 313 001, Rajasthan

A field experiment was conducted to evaluate the effect of foliar spray of nutrients in integration with recommended dose of fertilizers on maize, sorghum and pearlmillet during *kharif* 2013 at Agronomy Farm, Rajasthan College of Agriculture, Udaipur. The experiment was laid out in split plot design having four replications with following treatments (a) main plot – maize, sorghum and pearlmillet and (b) sub plot (fertilizer levels) - T_1: 100% NPK, T_2: 75% NP + 100% K, T_3: 75% NP + 100% K + two foliar sprays of 17:44 urea phosphate @ 1% (spray at pre flowering stage and 15 days after 1st spray),T_4 : 50% NP + 100% K and T_5 : 50% NP + 100% K + two foliar sprays of 17:44 urea phosphate @ 1% (spray at pre-flowering stage and 15 days after 1st spray). The soil of the experimental field was fine loamy in texture, slightly alkaline (pH 8.3), medium in organic carbon (6.12 g kg^{-1}) low in available N (218 kg ha^{-1}) and medium in available P_2O_5 (21.1 kg ha^{-1}) and K_2O (344 kg ha^{-1}). The highest grain, stover and biological yield of maize (3.64, 5.69 and 9.33 t ha^{-1}), sorghum (3.23, 6.49 and 9.70 t ha^{-1}) and pearl millet (1.17 and 3.80 t ha^{-1}) was obtained by applying 100 per cent NPK. Foliar application of urea phosphate (1%) significantly increased the grain yield of maize by 7.52 and 8.63%, sorghum by 1.66 and 2.49%, pearlmillet by 7.33 and 3.73%, as compared to 75% NP (T2) and 50% NP (T4), respectively. Application of RDF along with foliar application of urea phosphate (1%) also significantly increased the uptake of N and P in maize, sorghum and pearlmillet over the application of respective dose of fertilizers.

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Nitrogen Use Efficiency of Some Rice Varieties: An Analysis using Multivariate Statistics

D.V.K. Nageswara Rao* and K. Surekha
ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, 500 030
**Email: dvknrao@gmail.com*

Nitrogen (N) is key substrate in many important structural, genetic and metabolic compounds of plant cells drawing attention for last some decades. Increasing N use efficiency, which is the grain yield per unit of N available in the soil, is an important input in reducing the cost of production of N-fertilizers and to reduce environmental impact of N losses. Conventional breeding in past few decades had significantly increased crop yield and also improved N use efficiency (NUE) and is a continuous process to improve existing or release new varieties from time to time. However, there is a necessity to evaluate them for all required traits. Hence, the datasets developed at IIRR over a period of four years evaluating 54 released rice varieties were subjected to statistical analysis for interpretation with the assumption that there were no greater differences in agronomic conditions over these four years, which could drastically influence plant behaviour. In addition, the present effort did not aim at modelling the dependence of rice yield on different variables but to study the latent structure in data. The parameters included were AE (agronomic efficiency), PE (physiological efficiency), RE (recovery efficiency), IE (internal efficiency) at both N_0 and N_{100} levels and PFP (partial factor productivity). The IE at N_0 was also included with the assumption that there would be highly efficient genotypes, which could perform even when there was no applied N.

Correlations indicated that internal efficiency at N_0 and N_{100} positively influenced the yield. Nevertheless, IE-N_0 should indicate much about the genotypic character to perform even with N_0. Yield at N_{100} showed significant and positive relationship with AE, PE, RE and PFP. The PFP was positively contributed to by AE, PE, RE and IE at both N_0 and N_{100}.

Factor analysis extracted three factors, which described a cumulative variability of 95% (sum of 44, 32 and 19%, described by three factors, respectively). The rotated component matrix indicated that AE, RE and PFP had higher loadings on factor 1 while PE and IE at N_{100} showed positive and higher loadings on factor 2 with a negative loading by RE, which needs exploration. The third factor was more attached to internal efficiency at both levels of N application and PFP. A two dimensional scatter plot with scores on factor 1 on X-axis and factor 2 on Y-axis grouped all 54 genotypes into 4 groups with both positive scores, positive and negative scores, both negative scores and negative and positive scores on factor 1 and 2. The group behaviour in terms of these factor scores were interpreted and described in the main text, which could form the basis of further studies. It was imperative that application of multivariate statistics could be extended to agronomic studies also for the same purpose for which the tool was developed *i.e.* to reduce the dimensionality in the data.

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Development of Integrated Nutrient Management (INM) Modules for Improving Crop Productivity and Soil Health in a Deep Black Soil

B.P. Meena, A.K. Biswas, Muneshwar Singh, R.S. Chaudhary and A.B. Singh
ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

A field experiment is in progress since 2012-13 at research farm, Indian Institute of Soil Science, Bhopal on a fixed site to assess the effect of different integrated nutrient management modules on crop yield of maize-chickpea cropping sequence and soil health. The experiment was laid out in a randomized block design with 12 treatment modules consisting of a no-nutrient/control, general recommended dose (GRD) of fertilizer, soil test based fertilizer recommendation for yield targets of 5 t ha^{-1} and 1.5 t ha^{-1} for maize and chickpea, respectively, and other integrated and only organic nutrients replicated thrice. Application of fertilizer based on STCR (soil-test crop response) had highest mean grain yield of maize over the period, which was at par with GRD and farmyard manure (FYM) based INM modules. Grain and biological yield of maize were also increased with application of GRD, 75% NPK of STCR dose along with either 5 t FYM or 1 t poultry manures, or only 20 t FYM (every season). All the INM modules, irrespective of sources of organics, were at par in recording grain, stover and dry matter yield. The residual effect of organic and inorganic sources of nutrients was observed in succeeding chickpea crop. Application of GRD, STCR based recommended dose of fertilizers and its residual effect, in general significantly increased the mean grain yield of chickpea over control. However, application of 5 tonne FYM in every season improved the grain and straw yield of chickpea as compared to residue management (mulching by maize residues). FYM based INM module (75% NPK of STCR dose +5 t FYM) gave significantly higher nutrients (N, P and K) uptake followed by GRD and STCR based recommended dose of fertilizers by maize and chickpea crops. The agronomic efficiency (AE), partial factor productivity (PFP) and recovery efficiency (RE) also improved by the FYM based INM modules all the years. All modules involving fertilizers had negative apparent K balance, but organic modules had positive K balance of the soil after harvest. While, N and P balances were positive in all treatments. Therefore, it can be concluded that soil test based recommended dose of nutrients and FYM based INM module continued to perform better than any other module probably because of larger quantity and efficient utilization of nutrients.

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Effect of Sulphur and Zinc on Yield and Nutrient Uptake by Summer Greengram (*Vigna radiata* L.) under Middle Gujarat Conditions

N.J. Jadav, J.H. Italiya and J.K. Parmar
Department of Agricultural Chemistry and Soil Science, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat

The field experiment was carried out at Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat during summer season of 2013 to study the effect of sulphur (S) and zinc (Zn) on yield and nutrient uptake by summer green gram (*Vigna radiata* L.) under middle Gujarat conditions''. The experiment was laid out in a factorial randomized block design, comprising of four levels of S (0, 10, 20 and 30 kg S ha^{-1}), and three levels of Zn (0, 10 and 20 kg Zn ha^{-1}) in three replications. The experiment was conducted in loamy sand soil having alkaline in reaction ($pH_{2.5}$ 7.9) and normal salt contents ($EC_{2.5}$ 0.20 dS m^{-1}). The soil was low in available N (184.7 kg ha^{-1}) and S (7.27 mg kg^{-1}), medium in available P_2O_5 (41.5 kg ha^{-1}) and Zn (0.61 mg kg^{-1}) and high in available K_2O (310 kg ha^{-1}). The *Meha* variety of green gram was fertilized with 20–40–00:: N-P-K kg ha^{-1}.

Application of S @ 30 kg ha^{-1} registered significantly higher grain (1.04 t ha^{-1}) and straw (1.97 t ha^{-1}) yield as compared to control and 10 kg S ha^{-1}, but it was at par with 20 kg S ha^{-1}. Application of 30 kg S ha^{-1} resulted in higher N, P, K, S and Zn concentration and uptake by grain and straw as well as protein content in grain, but it was at par with 20 kg S ha^{-1}. Significantly the highest grain (1.01 t ha^{-1}) and straw (1.88 t ha^{-1}) yield was registered under the application of 2 kg Zn ha^{-1}. Similarly the S and Zn content in grain and N, P, K, S and Zn content in straw were noticed higher under the application of Zn @ 2 kg Zn ha^{-1}. In general, significantly the highest uptake of N, P, K, S and Zn by grain and straw as well as protein content in grain were registered under application of Zn @ 2 kg ha^{-1} than rest of the levels of Zn. Treatment combination of 30 kg S and 2 kg Zn ha^{-1} (S_3Zn_2) recorded significantly the highest grain (1.23 t ha^{-1}) and straw (2.12 t ha^{-1}) yield. The similar treatment combination also recorded significantly higher S and Zn content in grain and straw, N uptake by straw, P uptake by grain and straw, K uptake by grain, S uptake by grain and straw and Zn uptake by grain. It is concluded that application of 20 kg S ha^{-1} through gypsum (16.5% S) and 2 kg Zn ha^{-1} in form of zinc chloride (48% Zn) on loamy sand soil deficient in available S and medium in Zn increased the yield and nutrient uptake by green gram.

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Soil Fertility and Cotton Yield as Influenced by Integrated Nutrient Management and Tillage in Vertisols of Semi-arid Region of Maharashtra

P.R. Kadu, B.A. Sonune, V.V. Gabhane and Y.D. Pawar
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444 104, Maharashtra
**Email: basonune@gmail.com*

A field experiment was conducted to study the effect of tillage and integrated nutrient management on soil fertility and yield of rainfed cotton in Vertisol during 2010-11 at Research field, Department of Soil Science and Agricultural Chemistry, Dr. PDKV, Akola (M.S.). The experimental soil was clay in texture, moderately alkaline in reaction, low in available N and P and high in available K. The experiment was laid out in a factorial randomized block design with two factors *viz.*, tillage (conventional and conservation) and integrated nutrient management which included incorporation of FYM, crop residues, *in situ* green manuring of sunhemp, glyricidia leaf manuring in combination with 50 per cent inorganic fertilizers and 100 per cent RDF (80:40:40 kg N, P_2O_5 and K_2O ha^{-1}) replicated thrice. The plotwise soil samples were collected and analyzed for available nutrients (N, P and K) as per standard methods and the seed cotton yields were also recorded for making further interpretations.

The results indicated that numerically higher seed cotton yield and improvement in soil fertility were observed in conservation tillage compared to conventional tillage. The integrated use of 50% RDF through chemical fertilizers and 50% N through FYM produced significantly higher seed cotton yield which was on par with 100% RDF through chemical fertilizers. The combined application of 50% nitrogen through green manuring alongwith 50% RDF was also found beneficial in enhancing the seed cotton yield. The highest available N was recorded in treatment 50% N through FYM + 50% RDF which was superior over rest of the treatments. While highest availability of P and K was observed with the integrated use of 50% RDF + 50% N through FYM followed by 50% RDF + 25% N (FYM) + 25% N (GLM) which was found on par with each other. Hence, it can be concluded that integrated use of nitrogen 50% through organics (FYM / sunhemp) and 50% through chemical fertilizers resulted in higher seed cotton yield with higher improvement in fertility status of Vertisol under rainfed conditions of semi arid region of Maharashtra.

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Relative Efficacy of Methods of Iron Application in Alleviating its Deficiency in Aerobically-Grown Rice

B.L. Meena[1]*, R.K. Rattan[2], S.P. Datta[2], M.C. Meena[2] and B.S. Dwivedi[2]
[1]ICAR-Central Soil Salinity Research Institute, Karnal, 132 001, Haryana
[2]ICAR- Indian Agricultural Research Institute, New Delhi, 110 012
**Email: blmeena2008@gmail.com*

Iron (Fe) deficiency is one of the serious nutritional disorders which lead to a decline in productivity in aerobically-grown rice on upland alkaline and calcareous soils. Enhancing the content of Fe in edible portion of rice for improving human health is a global challenge. With a view to resolve the Fe-deficiency syndrome in aerobic rice, a greenhouse experiment was conducted to evaluate the relative effectiveness of soil, foliar and seed treatment of Fe application in alleviating Fe-deficiency using two rice cultivars (IR-64 and Pusa Sugandh-3) grown on alkaline, calcareous, acid and lime-treated acid soils. Results showed that the soil application of Fe improved the available Fe status of soil over control. The foliar application of Fe (3% $FeSO_4.7H_2O$ solution, thrice 40, 60 and 75 days after sowing of rice) was more effective and economical in enhancing the yield as well as increasing Fe content of milled rice (grain) grown under aerobic condition as compared to soil application (67 mg $FeSO_4.7H_2O$ kg^{-1}). Among the soils, acid soil (without lime) produced highest yield of aerobic rice followed by alkaline, calcareous and lime-treated acid soils. Pusa Sugandh-3 performed better under aerobic condition compared to IR-64. Ferrous-iron (Fe^{2+}) content in rice plants proved to be a better index of Fe nutrition status compared to total plant Fe and chemically extractable soil Fe. The Fe^{2+} content of @ 42 mg kg^{-1} in plants (on dry weight basis) appeared to be an adequate level at 45 days after sowing for direct seeded rice grown under upland aerobic condition. Baker soil test was used to evaluate the quantity and intensity parameter of Fe in soils. The plant Fe content and yield of rice were positively associated with intensity parameter of Fe in different soils.

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Phosphorus Use Efficiency of Wheat Cultivars Grown on Low P Soils

A.A.S. Gill[1]* and P.B.S. Bhadoria[2]

[1]Punjab Agricultural University, University Seed Farm, Naraingarh, Fatehgarh Sahib, 147 203, Punjab
[2]Department of Agricultural and Food Engineering, Indian Institute of Technology, Kharagpur, 721 302, West Bengal
[*]Email: arsh@pau.edu

Plant species and even varieties of same species differ in their P efficiency *i.e.* ability to grow at low P supply. To study the phosphorus (P) efficiency of wheat (*Triticum aestivum*), five cultivars named Sonalika, PBW 343, PDW 274, PBW 373 and PDW 233 were tested at three different levels of P (0, 50 and 200 mg P kg^{-1}) in a greenhouse pot experiment at Indian Institute of Technology, Kharagpur. The sandy loam textured experimental soil was acidic in reaction (pH:5.1), normal in electrical conductivity (0.4 dS m^{-1}), medium in soil organic carbon (4.2 g kg^{-1}) and low in available P (2 mg P kg^{-1} soil). The wheat cultivars were harvests two times, first at 10 and second at 30 days after sowing. The plant shoots and roots were collected and dry weight were recorded. The plant samples were digested to determine the P content and uptake. The results reveled that wheat cultivars had varied P use efficiency and differ in utilizing the native soil P. In the absence of external P (0 mg P kg^{-1} soil), the maximum dry matter yield (DMY) was recorded for cv. PDW 274 and PDW 233 (35%) followed by PBW 343 and PBW 373 (17%) and minimum for cv. Sonalika produced (10%). Considering relative yield as a measure of P use efficiency, the durum wheat was superior over bread wheat in utilizing native soil P in the absence of external P supply. The higher P use efficiency of durum cv. may be related to maximum relative root length (44 to 49%) as compared to the cv. Sonalika where relative root length was only 16 per cent. However, at 50 mg P kg^{-1} added, wheat cv. PBW 343 and PBW 373 were most efficient and produced 76 and 81 per cent relative dry matter yield, respectively whereas relative DMY of durum cv. was less than 57 per cent. The results indicated that cultivation of durum wheat in P deficient soils in the absence of external P may help to obtain maximum crop productivity. Although, the performance of bread wheat cvs. were not efficient in the absence of external P supply but may perform better under sufficient P supply.

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Evaluating and Enhancing the Phosphorus Use Efficiency of Different Phosphatic Fertilizers to Maximise Rice Crop Yield

C. Jemila and B. Bakiyathu Saliha
Department of Soils and Environment, Agricultural College and Research Institute, Madurai, Tamil Nadu

Best management practices for P should aim in ensuring P availability in soil solution at appropriate time, at a reasonable cost, thus increasing P use efficiency (PUE) in sustaining crop productivity. This can be achieved by using suitable P source which minimises reaction with soil components and makes P pools available to crop. Hence, an investigation was taken up to evaluate the effect of different sources of P fertilizers and also in combination with phosphate solubilising bacteria on the productivity of wetland rice. A laboratory experiment was taken up to evaluate the effects of P sources *viz.*, Mussoorie rock phosphate (MRP), single superphosphate (SSP) and complex fertilizers (20:20:0 and 15:15:15) on availability for a duration of 60 days in two sets of samples from soils of low and high status of available P from the rice dominant tracts of Vadipatti block of Madurai district. Among the treatments imposed, SSP and FYM incubated soils registered maximum release of Olsen-P of 163.3 and 184.3 mg kg^{-1} in soils of low and high available P status, respectively. A field experiment was taken up in the farmers field at Irumbadi village of Vadipatti block of Madurai district during *rabi* 2013 with rice (*var* ADT 39) as test crop to evaluate the influence of P sources and forms (SSP and complex P with and without PSB) on soil nutrient status, uptake and crop yield. Among the P sources, 20:20:0 and PSB (T_8) followed by 20:20:0 alone (T_6) proved significantly superior to SSP and farmer's fertiliser practice of DAP application. Also the availability of P was higher in treatment T_8. It was noteworthy to observe that 100 per cent and 50 per cent of recommended P as SSP were on par in influencing the available P status indicating the scope for reducing 50 per cent of P in soils of high P availability.

The overall results of the incubation study and field experiment conducted to evaluate the different sources of phosphatic fertilizers on rice crop yield showed that application of recommended dose of fertilizers (RDF) @ 150:50:50 kg N, P_2O_5 and K_2O ha^{-1} through complex fertiliser (20:20:0) along with phosphate solubilising bacteria (PSB) @ 2 kg ha^{-1} recorded the maximum grain and straw yields of 6950 and 8120 kg ha^{-1}, respectively. This treatment also registered the maximum net returns of Rs. 69,195 ha^{-1} compared to the farmer's fertiliser practice that registered the net return of Rs. 44,130 ha^{-1}. Application of 100 per cent recommended P as SSP and 50 per cent recommended P as SSP were on par in influencing the available P status and also the yields of rice crop. Hence, in rice growing soils with high available P status, a maintenance dose of 50 per cent recommended P as SSP is sufficient to sustain the P fertility status of soil until the soil test values report moderate to low available P. It can be thus concluded that the use of complex fertilizer sources (20:20:0 or 15:15:15) along with PSB @ 2 kg ha^{-1} can be recommended for release and mobilization of insoluble and fixed forms of P and subsequently for maximizing the grain and straw yields of rice crop in the rice dominant tract of Madurai district.

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Effect of Phosphorus, Sulphur and PSB on Uptake of Nutrients by Mustard (*Brassica juncea* L.) in Southern Rajasthan

Ratan Lal Solanki[1]*, Mahendra Sharma, S.K. Sharma and R.H. Meena
Maharana Pratap University of Agriculture and Technology, Udaipur, 313 001, Rajasthan
[1]Krishi Vigyan Kendra, Chittorgarh, 312 001, Rajasthan
**Email: solanki_rl@yahoo.com*

Experiments were conducted during winter (*rabi*) seasons 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 (P), sulphur (S) and PSB on uptake of nutrient by mustard cultivar Bio-902 in southern Rajasthan. The experimental soil was sandy loam in texture, slightly alkaline in reaction (pH 8.10), normal with respect to salinity (EC 0.79 dS m^{-1}), low in organic carbon (4.5 g kg^{-1}) , available N (246 kg ha^{-1}) and S (9.52 mg kg^{-1}) and medium in available P (27.6 kg ha^{-1}) and available K (329 kg ha^{-1}). The experiments were conducted in a completely randomized block design with factorial concept of thirty two treatment combinations comprising of four levels of P (0, 30, 40 and 50 kg P_2O_5 ha^{-1}), four levels of S (0, 30, 40, and 50 kg S ha^{-1}) and two levels of PSB seed inoculation with and without and with three replications.

The results showed that application of P up to 50 kg ha^{-1} significantly enhanced seed and straw yield and nutrient uptake. The N and P uptake significantly increased in seed and N, P, K, S and Fe nutrient uptake by straw significantly increased with application of P @ 50 kg ha^{-1}. While K, S, Mn, Fe, Cu and Zn nutrient uptake by seed and Mn, Cu and Zn nutrient uptake by straw significant increased with application of P @ 40 kg ha^{-1}. The maximum nutrients uptake by seed and straw due to better development of yield attributes with P 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.

The uptake of N, P, K, S, Zn, Mn, Cu and Fe by seed and P, S and Cu uptake by straw significantly improved and increased with application of S @ 50 kg ha^{-1}. While application of 40 kg S ha^{-1} significant increased the N, K, Zn, Mn and Fe by straw. However, it statistically at par with treatment 40 and 50 kg ha^{-1}. The increase in these characters might be due to the important role of S in energy transformation, activation of enzymes and in carbohydrate metabolism. The inoculation of seed with PSB application significantly influenced the N, P, K, S, Zn, Mn, Cu, and Fe uptake by seed and straw of mustard as compared to control.

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Phosphorus Fertilizer Requirement and its Use Efficiency in Rice-Maize Cropping System on P-Accumulated Soils

D. Balaguravaiah[1], A. Madhavi[2] and V. Gopala Krishna[2]

[1]Department of Soil Science, S. V. Agricultural College, Tirupathi, Andhra Pradesh
[2]Radiotracer Laboratory, PJTSAU, Agricultural Research Institute, Rajendranagar, Hyderabad, 500030, Telangana

Field experiment was conducted during *kharif* 2014-15 at Maize Research Centre, Agricultural Research Institute, Rajendranagar on P accumulated soil in randomized block design with 5 treatments in rice-maize cropping system (rice-kharif and maize-*rabi*) to study the phosphorus (P) requirement and its use efficiency in P accumulated soils.Treatments comprises of control, 25, 50, 75 and 100% RDP (recommended dose of P) in 5 replications. Radioisotope P-32 was tagged @0.35 mCi per g of P_2O_5 to find out the P use efficiency in P accumulated soils. Experimental soils were neutral in reaction, low in salt content, organic carbon and available N but high in available P_2O_5 and K_2O status. Dry matter yield of rice at maximum tiller stage was significantly higher due to application of P at 100 per cent RDP as compared to 75, 50 and 25% RDP. The dry matter yield was lowest with no P was application. Grain and straw yield increased with increased levels of P application from 0 to 100% RDP. Highest grain and straw yield was observed when P was applied @ 100% RDP (3.99 and 5.32 t ha^{-1}) when compared to other levels of P applied to this crop. P content and uptake by grain and straw of rice not showed regular trend with application of different levels of P application. 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. Maximum P use efficiency (28.3%) was recorded with application of 25% RDP to rice crop when compared to 100% RDP (9.04%) in P accumulated soils. In rice-maize cropping system, rice yield increased from 2.65 to 3.99 t ha^{-1} with 100% RDP in high P soil (Available P_20_5 67 kg ha^{-1}) . In the same field during rabi, zero tilled maize showed similar trend as that of kharif rice in terms of yield and P use efficiency.

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Effect of Trees and Forage Combination on Growth, Yield and Soil Health under Silvi-Pastoral System

R.N. Singh, M.S. Malik, P.R. Oraon and Swati Singh
Department of Silviculture and Agroforestry, Birsa Agricultural University, Ranchi, 834 006, Jharkhand

An experiment was associated in *kharif* 2008 to study the performance of different combination of trees and forage crops under silvi-pastoral systems at Birsa Agricultural University, Kanke, Ranchi, Jharkhand. There were 12 treatments consisted of different combination of trees and forage crops. The treatments details are teak + hybrid napier, teak + sudan grass, gamhar + hybrid napier, gamhar + sudan grass, teak + gamhar + hybrid napier, teak + gamhar + sudan grass, teak (sole), gamhar (sole), teak + gamhar, hybrid napier (sole), sudan grass (sole) and absolute control. The experiment was replicated thrice in randomized block design, plot size area was 12×9 m^2.

The experimental initial soil had pH (5.0), organic carbon (0.42%), available P (3.9 kg ha^{-1}), available K_2O (402 kg ha^{-1}). Results revealed that plant height (m) and collar diameter (cm) of individual tree and in combinations (teak and gamhar) were recorded. After 6 years plantations average maximum plant height (4.63 m and 4.31 m) of gamhar and teak was found more in forage crop (hybrid napier). On the other hand the maximum collar diameter (8.11 cm) of gamhar tree with sudan grass and collar diameter of teak was found with hybrid napier (8.21 cm). It was also observed that the growth of gamhar is faster than teak. Maximum yield of forage were recorded in pure hybrid napier (30.5 t ha^{-1}) which is 75% more than the lowest yield of sudan grass (22.9 t ha^{-1}). After six years tree plantation and forage cultivation in 0-15 cm depth of soil, the maximum available nitrogen content (231 kg ha^{-1}) was found with gamhar + sudan which was significantly superior over control, gamhar (sole) and teak + gamhar (sole) treatments. There was considerable improvement in pH, organic carbon and available P in soil, whereas the available K in soil was reduced from its initial value.

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Impact of Potassium Nutrition on Fingermillet and Maize under Different Fertility Gradients in an Alfisol of Eastern Dry Zone of Karnataka

Atheefa Munawery, V.R. Ramakrishna Parama, C.A. Srinivasamurthy, R.C. Gowda and K.R. Ashoka

Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, GKVK, Bangalore, Karnataka

Potassium (K) an essential element for growth and development of crops, which is being depleted in Indian soils due to very low applications, requires a greater attention in order to ensure enhanced crop production and mitigation of biotic and abiotic stress as well as improvement in produce quality. Hence, the present study was conducted to know the influence of K nutrition on finger millet and maize under different fertility gradients. Field experiments were taken up in an Alfisol in GKVK campus with creation of five K fertility gradients in an individual field *viz*., very low (K_0), low (K_1), medium (K_2), high (K_3) and very high (K_4) K fertility gradient strips utilizing the organic and inorganic source of nutrients. The grain and straw yield of finger millet and maize increased significantly due to application of super optimal dose of K (200% K followed by 150% K) along with recommended doses of N and P and incorporation of FYM to soil (T_6 and T_4, respectively), which suggests finger millet and maize responded to higher dose of K application than to the recommended dose and significantly lower yields was recorded in T_1 (control) of K_0 (very low K fertility gradient) strip to which no fertilizers were applied resulting in poor growth of crops. The available nitrogen (N) and phosphorus (P) content of soil increased with increase in levels of K application and with increase in K fertility gradient. Application of 150% recommended K along with recommended NP and FYM (T_4) of K_4 strip recorded higher available N in finger millet and maize, respectively whereas T_6 (200% K + recommended NP + FYM) of K_4 strip recorded available P. The available K content of soil reduced to 98.8 kg ha^{-1} in K_0 strip and increased with increase in fertility gradient. The available K decreased in soil as the growth of crops attained physiological maturity. Application of 200% recommended K along with recommended NP and FYM (T_6) of K_4 strip recorded significantly higher (525 and 491 kg ha^{-1}) available K in finger millet and maize, respectively, subsequently T_1 (control) of K_0 (very low K fertility gradient) recorded significantly lower 83.7 and 61.0 kg ha^{-1} in finger millet-maize sequence to which no fertilizer was applied. High major, secondary and micronutrients in soils with increase in K fertility gradients (K_0 to K_4). Calcium and magnesium decreased from control (T_1) to treatment T_7 (200% K+ recommended NP). A comparison of K added and taken-up which is referred to as K balance indicated a negative value in case of T_1, T_2, T_4 and T_6 in very low K gradient (K_0) whereas T_1, T_2, T_3 and T_5 recorded negative in low K gradient (K_1) strip, respectively, in case of finger millet, whereas in maize T_1 of K_0 gradient recorded negative K balance, all other treatments in other K fertility gradients recorded positive balance. The study clearly indicates that there is a need for application of potassium fertilizer to crops based on soil tests for sustainable yield.

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Site Specific Nutrient Management in Rice for Bridging the Yield Gap in Farmers' Fields

K. Surekha, Brajendra, S.R. Krishna Murthy and T.J. Ghose
ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, 500 030, Telangana State

Rice is the most important staple food crop of India, grown in about 45 million hectares (Mha) with about 100 million tonnes (Mt) production. Current fertilizer management practices, in general, are not tailored to site specific soil nutrient supply capacities and crop demand. Blanket fertilizer recommendations are still being followed in large domains with less importance being given to management induced site variations of soil nutrient supply capacities, and crop demand especially when high yielding cultures with increasing yield potential are being regularly introduced. This has been the major reason for reported nutrient imbalances and un-sustainability in realizing yields.

Site-specific nutrient management (SSNM), developed by International Rice Research Institute (IRRI) for intensive rice production systems is an approach to feeding rice with nutrients as and when needed. The application and management of nutrients are dynamically adjusted to crop needs of the location and season. Hence, to assess the yield gap in farmers' fields by analyzing the variability in nutrient supply, its relationship with rice yields at current recommended and farmers' fertilizer practices and fine-tune the fertilizer nutrient requirement for specific target yields in a given environment and validation of fertilizer recommendations for targeted yields, a trial was conducted in farmers' fields around two centres *viz.*, Mandya and Titabar during *kharif* 2012 and 2013 under AICRIP of Indian Institute of Rice Research (IIRR). At Mandya and Titabar 12 and 20 farmer sites each were selected for generating information on the field variability in soil fertility and current level of efficiency of farmers' practices. The treatments consisted of nutrient (NPK) omission plots, farmers' fertilizer practice (FFP) and recommended dose of fertilizer (RDF).

Rice productivity with recommended fertilizer practice varied from 4.4-5.6 t ha^{-1} at Titabar and 2.94-6.81 t ha^{-1} at Mandya while the yields were lower with farmers' fertilizer practices in these locations with corresponding variation in nutrient uptake, nutrient utilization and recovery efficiencies. The yield gap between RDF and FFP is narrow (0.2-1.9 t ha^{-1}) at Mandya and wide (3.0-3.2 t ha^{-1}) at Titabar. On an average, each ton of grain accumulated 17.9, 2.72 and 21.3 kg N, P_2O_5 and K_2O at Titabar and 10.3, 3.89 and 12.4 kg N, P_2O_5 and K_2O at Mandya. The target yields were decided as per the maximum yields recorded at the test sites under recommended fertilizer practice (RDF). Fertilizer doses estimated based on the nutrient uptake and its efficiency at each site for yield targets of 6.4 and 6.1 t ha^{-1} at Mandya and Titabar, respectively, varied substantially between the sites from the currently followed blanket dose indicating the importance of site characteristics for recommending fertilizer prescriptions. Validation of these SSNM recommendations in representative farm sites in the succeeding year showed promising results at both centres with increase in the yields over farmers' fertilizer practices (by 62 and 165% at Mandya and Titabar, respectively) and current blanket recommendations (by 40 and 17% at Mandya and Titabar, respectively) indicating the importance of location and site specific input management for sustaining soil and crop productivity.

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Effect of Organic Manures and Zinc Sulphate on Yield and Zinc Content in Spinach (*Beta vulgeris* L.) under Calcareous Soil

K.K. Mourya, S.K. Singhal*, R.D. Singh, V.K. Sharma and N.P.S. Yaduvanshi
Division of Soil Science and Agricultural Chemistry, ICAR-Indian Agricultural Research Institute, New Delhi, 110 012
**E mail: singhalssac@gmail.com*

Micronutrient deficiency in soils not only limits the crop production but it also has negative effects on human nutrition and health. Applications of organic amendments affect the immediate and potential availability of micronutrient cations and increase plant biomass. A greenhouse experiment was conducted with zinc (Zn) deficient (DTPA-Zn 0.48 mg kg^{-1}) calcareous soil (Typic Calciorthents) to evaluate the combined and alone effect of organic manures (FYM, poultry manure and vermicompost) and zinc sulphate on yield and Zn content in spinach. The treatments consisted of Zn @ 5 mg kg^{-1} soil and FYM, poultry manure (PM) and vermicompost (VC) @ 1 and 2% levels. The results revealed that spinach yield responded positively to the applied organic manures, zinc sulphate and integrated use of OM + $ZnSO_4$. The integrated use of organic manure with $ZnSO_4$ was obtained higher yield as compared to organic source alone. Among the organic manures the total biomass of spinach was highest (4.94 g pot^{-1}) in 2% PM treatment. Whereas, the highest dry matter yield (4.81 g pot^{-1}) of spinach was recorded for the treatment 2% VC along with 5 mg Zn kg^{-1} soil as compared to rest of treatments except treatment 2% PM +$ZnSO_4$ which recorded 4.71 g pot^{-1} and statistically at par with 2% VC +$ZnSO_4$. Zinc content in spinach was progressively increased with application of different organic manure along with Zn. The highest Zn content (183 mg kg^{-1}) in spinach was obtained with PM @ 2% + $ZnSO_4$ treatment which was significantly higher than other treatments and almost 1.5 times more than control. Among all the organic manures PM emerged out to be viable option for increment of yield or Zn content in plant. DTPA-Zn in post-harvest soil samples was recorded highest (0.94 mg kg^{-1}) when 2% OM with zinc sulphate was applied. It showed that the deficiency of Zn in calcareous soil could be controlled by the manures along with zinc sulphate during their decomposition.

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Effect of 30 Years of Long-term Integrated Nutrient Management Practices on Soil Fertility and Productivity of Rainfed Groundnut (*Arachis hypogea*) Grown on *Alfisols* of Arid Region of Andhra Pradesh, India

M. Vijay Sankar Babu, A. Srihari, K.C. Nataraj, D. Balaguravaiah and B. Sahadeva Reddy

Agricultural Research Station, Anantapur, 515 001, Andhra Pradesh

Studies on long-term integrated nutrient management for groundnut were initiated during rainy (*kharif*) season 1985 at Agricultural Research Station, Anantapur, A.P, comprising of ten treatments including inorganics with and without recyclable farm wastes *viz.* FYM and groundnut shells replicated thrice in RBD to study the long-term effects of recycling of farm wastes along with or without chemical fertilizers on soil properties and crop yield. As the soil fertility build up was observed over years, depletion studies were initiated since 1993 in half of the treatment plots. Significantly higher soil organic carbon (%) was recorded in treatments applied with organics alone or organics along with inorganics. The initial available P content (44 kg ha^{-1}) increased with only inorganics (106 kg ha^{-1}) applied plots. In the control plot, initial available phosphorous (P_2O_5) levels of 44 kg ha^{-1} was reduced to 23 kg ha^{-1} over 30 years. Mean differential yield (920 kg ha^{-1}) was at par in recommended fertilizer dose (RFD) and recommended fertilizer dose (HRFD) +FYM @ 4 t ha^{-1} (937 kg ha^{-1}). However, control (713 kg ha^{-1}) recorded lowest mean pod yield over 30 years. Pod yield was not significantly varied in treatments of RFD (20-40-40 N, P_2O_5, K_2O kg ha^{-1}); HRFD (10-20-20 N, P_2O_5, K_2O kg ha^{-1} + FYM @ 4 t ha^{-1}); only FYM treatments in depleted plots. So keeping in view of soil inherent nutrient status, the treatment with half recommended dose (10-20-20 N, P_2O_5, K_2O kg ha^{-1}) along with FYM @ 4 t ha^{-1} is giving at par groundnut pod yields compared to full recommended fertilizer dose (20-40-40 N, P_2O_5, K_2O kg ha^{-1}) which not only giving sustainable yields but also enhancing the soil health.

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Effect of Long-term Fertilizer and Manure Application on Sorghum Yield, Nutrient Content and Uptake under Sorghum-Sunflower Cropping System in an Alfisols

G. Venugopal*, S.H.K. Sharma, Abdul Aziz Qureshi, Chandrasekhar Rao Palli and G.E. Ch. Vidya Sagar

Department of Soil Science and Agricultural Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana
**Email: venugopalguttikonda@gmail.com*

The present study was conducted during *kharif* 2013 at research farm of Indian Institute of Oilseeds Research (IIOR), Rajendranagar, Hyderabad. The soil (a red soil) was sandy loam in texture and slightly alkaline (pH 7.20) in reaction, non saline in nature (EC 0.08 dS m^{-1}) and medium in organic carbon content (0.52%). The experiment was laid out in randomized block design with 12 treatment and three replications. The treatments consisted of different combinations of fertilizers, manures and a control. The optimum NPK *i.e.*, 100% NPK (60-30-30 kg N-P_2O_5-K_2O ha^{-1}) was fixed at the initiation of experiment and same layout and treatments are being followed till date. After fifteen years of continuous cropping of sorghum-sunflower in an alfisols, the effect of different mineral fertilizers with or without manures was studied on sorghum yield, nutrient content and uptake by sorghum crop. Integrated nutrient management practice by applying FYM or crop residues along with optimum NPK fertilizers (NPK+FYM and NPK+CR) increased the sorghum grain yield significantly over application of only fertilizers (100% NPK). The sorghum yield increased significantly only up to 100% NPK. Super optimal dose of fertilizers (150% NPK) did not increase the yield. Continuous imbalance application of only nitrogen resulted in reduced yields due to the imbalanced use of fertilizers. Additional application of phosphorus significantly increased the yield 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. Application of FYM or crop residues along with 100% NPK, in general, significantly increased the uptake of all the nutrients.

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Performance of Garlic Crop under Various Fertilizer Regimes

B.S. Sekhon*, M.S. Mavi, J. Singh, and P. Dey
Punjab Agricultural University, Ludhiana-141004
**Email: bsekhon@pau.edu*

A field experiment involving three fertility gradient strips was conducted on garlic-maize cropping system at the PAU Soil Science Research Farm, Ludhiana. The experimental design was latin square with three rates of FYM (0, 25 and 50 t ha^{-1}), three nitrogen (N) rates (90, 120, and 150 kg N ha^{-1} both for garlic and maize), three P rates (45, 60 and 75 kg P_2O_5 ha^{-1} for both the crops) and three K rates (20, 30, and 40 kg K_2O ha^{-1} for both garlic and maize). A control plot was kept with each rate of FYM application. Each fertility strip accommodated all the treatments. After the imposition of FYM and other treatments, garlic (var. PG-17) was raised. Evaluation of garlic yield average response to fertilizer N applied at different FYM levels indicated that with FYM rate of 50t ha^{-1}, the crop did not respond to fertilizer N beyond 90 kg ha^{-1}. In high fertility strip, similar effect was witnessed even at 25 t ha^{-1} FYM level. The FYM application also suggested a P fertilizer saving effect. In general, response to P application beyond 45 kg ha^{-1} was not observed when FYM @ 25 t ha^{-1} or higher rate was used. Likewise across all fertility levels and FYM application rates, response to fertilizer K application higher than 20 kg ha^{-1} did not cause any yield increment. A non-significant correlation between garlic yield and FYM, after adjusting for the effects of fertilizers suggested that fertilizers perform inefficiently when they are used without considering the contribution of FYM. This observation was substantiated by the significant correlation (0.29 at 5%) between N fertilizer and garlic yield after adjusting for the effects of SOC, FYM and other fertilizers. The correlation between P fertilizer application and garlic yield after adjusting for the effects of FYM and other fertilizers was not significant. However, the same correlation after adjusting for SOC and available P was highly significant (0.40 at 1%). Likewise, the correlation between fertilizer K and garlic yield as such was not significant. However, when adjusted for the effect of available K and FYM application, the relation was highly significant (0.42 at 1%). A similar evaluation for fertilizer P suggested that in most cases in the absence of FYM garlic did not respond to fertilizer P beyond 45 kg ha^{-1}. However, it behaved anomalously at 50 t ha^{-1} FYM level. Similarly, for K in most cases the garlic did not respond to fertilizer K more than 20 kg ha^{-1}

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Effect of Inorganic Anions on Pb Uptake by *Toria* (*Brassica compestris* var. Toria) and its Fractions in Pb-contaminated Soil

Davinder Singh, R. Sikka* and B.S. Sekhon
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141 004, Punjab
**Email: sikkar@pau.edu*

Contamination of soil with heavy metals has become a major environmental concern. Among heavy metals lead (Pb) is a widespread contaminant of soil all over the world. 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 organic and inorganic amendments to the soil. We studied the effects of inorganic anions on Pb fractions and absorption by Indian rape (*Brassica compestris* var. Toria) in Pb-contaminated soil. In a greenhouse pot experiment four levels of Pb (0, 50, 100, 200 mg Pb kg^{-1} soil) were added to a sandy loam soil which was further amended with potassium salts of four anions ($H_2PO_4^-$, Cl^-, SO_4^{2-}, CO_3^{2-}) at four rates (0, 60, 120 and 240 mg kg^{-1} soil). The amended soils were equilibrated for 30 days and Indian rape was grown. Results indicated that plant shoot dry biomass and seed yield of Indian rape were significantly reduced by the contamination of increasing amounts of Pb. However, addition of $H_2PO_4^-$ and CO_3^{2-} anions decreased but addition of Cl^- enhanced the magnitude of reduction in shoot dry biomass and seed yield with Pb contamination. The Pb absorption in shoots and seeds also increased linearly and significantly with increase in Pb contamination levels. Correspondingly, Pb uptake by Indian rape decreased with the addition of $H_2PO_4^-$ and CO_3^{2-} and increased with the addition of Cl^-. Addition of $H_2PO_4^-$ and CO_3^{2-} decreased the water soluble and exchangeable Pb and reduced Pb uptake whereas addition of Cl^- and SO_4^{2-} increased these fractions and Pb uptake. Application of $H_2PO_4^-$ @ 240 mg kg^{-1} soil was most effective in reducing Pb bioavailability. The results suggested that addition of $H_2PO_4^-$ and CO_3^{2-} anions lowers the bioavailability and increases the geochemical stability of soil Pb, so these have the potential for *in-situ* remediation of Pb-contaminated soil.

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Effect of Seed Priming, Rhizobium Culture and S Application on the Yield of Summer Moong bean (*Vigna radiata*) under Field Conditions

R.K. Gupta, H.S. Thind and R. Sikka
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab
**Email: rkg1103@yahoo.com*

Unfavourable environmental conditions are major cause of poor stand establishment and low crop yield. However, rapid germination of seedlings could emerge and produce deep roots before the upper layers of the soil are dried and crusted, which may result better crop establishment and higher crop yield. To overcome these problems, seed priming seems to be a viable option. Keeping this in view, a study was carried out in a split plot design for improving yield of summer moong bean priming techniques, inoculation of seeds with *rhizobium* and sulphur (S) nutrition. Seeds invigorated by traditional soaking (hydropriming), osmo-conditioning (soaking of seeds in aerated, low-water potential solutions) with potassium di-hydrogen phosphate (KH_2PO_4), sodium molybdate dihydrate ($Na_2MoO_4.2H_2O$), seeds inoculated with *rhizobium* and untreated seeds as control were kept in the main plots. Three levels of sulphur were kept in the sub plots. All the priming treatments significantly improved the dry matter yield (4.11 to 4.54 t ha^{-1}) and seed yield (1.36 to 1.53 t ha^{-1}) compared to control. The highest dry matter yield (4.54 t ha^{-1}) and seed yield (1.53 t ha^{-1}) was observed in molybdenum primed seeds compared to the control. The dry matter yield (4.07 t ha^{-1}) and seed yield (1.36 t ha^{-1}) obtained with rhizobium treated seeds were significantly higher as compared to control. Application of 30 kg S ha^{-1} significantly improved the dry matter and seed yield over no application of S. In conclusion, overall priming of summer moong bean seed with phosphorus (P at 0.6%), molybdenum (Mo at 0.025%), rhizobium culture and application of 30 kg S ha^{-1}) were found very effective in improving the dry matter and seed yield significantly under field conditions.

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Effect of Copper Sulphate Application on Growth and Yield Parameters of Onion

V. Nagarjuna and D. Muthumanickam
Department of Soil Science and Agricultural Chemistry, T.N.A.U. Coimbatore, 614003, Tamil Nadu

Field experiments were conducted at eight locations in various farmer fields at Vadivellampalayam. Panaiyampalli and Pungampalli villages in Tamil Nadu during *rabi* season 2012. The initial analysis of experimental soil was neutral to slightly alkaline in reaction and with free from salts. The organic carbon content of the soil was low. The available nutrient status of the soil was low in available N and P, medium in available K. The soil was sufficient in DTPA-Zn, Mn, Fe and hot water soluble boron. Based on the available status of Cu, the eight farm holdings (L1 to L8) were selected (on the ascending order of Cu status stating from 0.22 mg kg^{-1} at interval of 0.2 mg kg^{-1}). The experiment was laid out in a randomized block design replicated trice with seven levels of Cu application *viz.*, 0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 kg ha^{-1} along with recommended fertilizer dosage 60:60:30 kg N, P_2O_5 and K_2O kg ha^{-1}. Before sowing of onion bulbs, the required quantity of Cu was applied through $CuSO_4$ as per the schedule. The graded level of Cu application, significantly influenced the plant growth parameters *i.e.* plant height, number leaves per plant and yield parameters *viz.*, fresh and dry weight of total pant, bulb and leaf, number bulbs per plant, bulb diameter, content and uptake of other micronutrients (Fe, Zn and Mn) in varied available Cu status soils. Application of 1.5 kg Cu along 100% RDF of NPK @ 60:60:30 kg ha^{-1} (T_4) was superior in enhancing the yield and yield components. The same treatment proved its superiority by recording 35 to 44.9 per cent and 30.9 to 47.3 per cent increased total fresh plant yield during bulb initiation and harvest stage. Among various locations, location 3 with initial available Cu 0.62 mg kg^{-1} which showed the best response with Cu application. The response of onion plant to Cu application, bulb yield increased with increasing doses of copper up to 1.5 kg Cu ha^{-1} and beyond these limit excess application of Cu decreased the bulb yield.

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Effect of Soluble Fertilizers through Fertigation on Nutrient Uptake, Yield and Quality of Bt Cotton

A.L. Dhamak, S.L. Waikar and J.D. Gawali
Department of Soil Science and Agricultural Chemistry, VNMKV, Parbhani, 431 402, Maharashtra

Field experiment was conducted during *kharif* season of 2013-2014 at Research farm, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidypeeth, Parbhani. The experimental soil was clayey in texture, slightly alkaline in reaction (7.85), medium in organic carbon content (5.50 g kg^{-1}), low in available nitrogen (156 kg ha^{-1}), and available phosphorus content (8.90 kg ha^{-1}) and high in available potassium content (744 kg ha^{-1}). The experiment was carried out in randomized block design with four replication and five treatments comprised of 100%, 80% and 60%. RDF through water soluble fertilizers through drip, 100% RDF of conventional fertilizers through drip (urea, phosphoric acid and sulphate of potash) and 100% RDF of conventional fertilizers through soil application. The Bt cotton (Rashi-2) was sown with the spacing of 180 cm × 30 cm and plot size (7.2×5.4 m^2). The recommended NPK dose (100:50:50 kg ha^{-1}) was given to cotton through fertigation in splits. The nitrogen was applied in six splits at sowing, 20 DAS, 40 DAS, 60 DAS, 80 DAS and 100 DAS. The phosphorus and potassium was applied in five splits at sowing, 20 DAS, 40 DAS, 60 DAS and 80 DAS. The 100 per cent RDF through soluble fertilizers by fertigation showed higher content and uptake of N, P and K in cotton stalk. The lowest N, P and K content and uptake was noticed in treatment receiving 100% RDF through soil application. The seed cotton and stalk yield per hectare were improved significantly with application of 100% RDF through soluble fertilizers by fertigation followed by 80% RDF through soluble fertilizers. The highest lint index (3.38), ginning percentage (33.07) and test weight of seed cotton (8.15 gm) was recorded with 100% RDF through soluble fertilizers followed by 80% RDF through soluble fertilizers.

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Effect of Biomass Ashes on Soil Reaction and Potassium Availability of an Acid Soil

D. Damodar Reddy and J. Poorna Bindu
ICAR-Central Tobacco Research Institute, Rajahmundry, 533105, Andhra Pradesh

Biomass ashes resulting from burning of crop residues and other farm wastes are the oldest mineral fertilizers. Disposal of crop residues (especially tobacco, maize rinds, cotton, *etc.* having little or no economic value) by burning them on or off the field is a common practice in vogue in many areas. Similarly, combustion of wood (such as eucalyptus, mango, cashew nut, acacia *etc*.) in tobacco curing barns also generates large quantities of ash. The recycling of biomass ashes in agriculture is important to supplement nutrient cycles in soils and reduce dependency on chemical fertilizers. An incubation experiment was conducted to study the effects of crop residue and wood ashes on soil acidity and K fertility. An acid Alfisol collected from the CTRI-RS, Jeelugumilli, Andhra Pradesh was amended with crop residue and wood ashes and incubated for 90 days. Four ashes *viz.*, tobacco stem ash (TSA), and maize rind ash (MRA), cotton stem ash (CSA), barn wood ash (BWA) and $CaCO_3$ at three rates of addition (0.05, 0.10 and 0.15%) and a control (no biomass ash) were included in the incubation experiment. Sub-samples of soils were drawn 6 times (7, 15, 30, 45, 60 and 90 days) during the course of incubation and analyzed for pH and available K. Addition of biomass ashes caused a marked increase in soil pH over the no-ash control. The increments in soil pH were larger with the increase in ash application rate. For all the biomass ashes and at all the application rates, soil pH tended to decrease with the progress of incubation time. The magnitude of increase in soil pH also differed between different biomass ashes and followed the order: CSA > BWA > TSA > MRA. The addition of biomass ashes brought out a distinct change in availability of K in the soil. All treatments with biomass ashes enhanced the K availability in soil as compared to the no-ash control throughout the incubation period. Irrespective of ash type, increasing rates of ash addition resulted in greater increase in K availability. The biomass ash induced increase in K availability was consistent with the amount of K added through ashes. Among the biomass ashes, the increase in K availability followed the order: TSA > MRA > CSA > BWA. Present study demonstrates that the biomass ashes resulting from crop residue burning or wood ash from tobacco curing barns can serve as potential liming material to increase pH of acid soils and also as K source to improve K-fertility.

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Sustainability of Basmati-wheat Sequence under Intensive Management of Nutrients and its Effect on Yield and Uptake of Zn, Cu, Fe and Mn

J.K. Dhaliwal*, G.S. Saroa and S.S. Dhaliwal
Department of Soil Science, Punjab Agricultural University, Ludhiana, Punjab
**Email: dhaliwal.jasleen33@gmail.com*

Rice-wheat is a predominant cropping system of Punjab state and this system helps in production of staple food to meet the feeding requirement of burgeoning population of the world. To fulfill the increasing demand of food production intensive agriculture practices involving high yielding varieties and high analysis fertilizers are practiced. With this practice organic matter and micronutrients levels had decreased in intensive cultivation areas showing either decline or stagnation in the productivity of rice and wheat crops. An increase in crop productivity may be achieved with the use of organic sources. Organic sources alone may not enough to meet the nutrient requirements of high yielding varieties but when they are applied along with chemical fertilizers. Wheat grain and straw samples were collected from an ongoing field experiment (since *rabi* 2006-07) on basmati-wheat sequence, at Research Farm, Punjab Agricultural University, Ludhiana in 2013. The experimental soil was sandy loam in texture and tested near neutral in pH (7.5), non-saline (0.2 dS m^{-1}) and low in organic carbon (0.37%) at the time of start of experiment in 2006-07. The grain and straw samples were collected at harvest of wheat crop and the concentrations of Zn, Cu, Fe and Mn were determined using atomic absorption spectrophotometer. The results indicated that grain as well as straw yield was maximum in integrated nutrient management plots while minimum in control plots. Uptake as well as content of Zn and uptake of Mn was more in recommended fertilizer plots as compared to control, integrated nutrient and organic treatments. However, uptake and content of Fe and Cu as well as content of Mn was maximum in integrated nutrient management plots. The results of the study revealed that for sustainability of agricultural systems, addition of organics either alone or in combination with chemical fertilizers is pre-requisite to enhance the yield, concentration and uptake of micronutrients by wheat. Grain yield of wheat increased significantly with the application of chemical fertilizers, organic manures and integrated use of both the sources over control. Concentration of Zn, Fe, Mn and Cu in wheat grain ranged between 20.0 and 25.7, 49.3 and 114.0, 13.6 and 24.3 and 2.7 and 5.7 mg kg^{-1}, respectively under different treatments. The Zn, Fe, Mn and Cu uptake in wheat grain ranged from 41.5 to 104.6, 102.2-390.5, 28.3 to 94.8 and 5.5 to 22.4 g ha^{-1} respectively. Highest removal of Zn and Mn was observed in plot receiving recommended dose of fertilizer and lowest in control plots. Application of recommended fertilizer, integrated nutrient management and application of N through organic manures (FYM, VC & RSC) significantly increased the Zn and Mn uptake over the control. Uptake of iron and copper in wheat straw ranged between 527.4 and1183.1 g ha^{-1} and 3.9 to 27.6 g ha^{-1}, respectively under different treatments. Maximum uptake of Fe and Cu by wheat straw was recorded in treatment where 200 kg N ha^{-1} from FYM was applied along with recommended fertilizer (INM2) and minimum in control plots.

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Differential Response of Wheat Cultivars to Zinc through Ferti-fortification to Ameliorate Zinc Deficiency in Human Beings

S.S. Dhaliwal[1], A.K. Shukla[2] and Hari Ram[3] and G.S. Mavi[3]

[1]Department of Soil Science, Punjab Agricultural University, Ludhiana, Punjab
[2]ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh
[3]Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, Punjab

A field experiment was conducted in the Department of Soil Science, PAU, Ludhiana for two consecutive years (2007-08 to 2008-09) in a randomized block design with three replications. Fifteen wheat cultivars which include eight bread wheat (PBW 175, PBW 343, PBW 373, PBW 502, PBW 509, PBW 527, WH 542 and PBW 550), four triticale (TL 1201, TL 2408, TL 2908 and TL 2942) and three durum wheat (PDW 233, PDW 274 and PDW 291) cultivars, with (+Zn) and without (-Zn) foliar application of zinc. Four foliar sprays of 0.5% heptahydrate zinc sulphate @ 0.5% were applied at maximum tillering stage, flower initiation stages, milk and dough stage. The Zn content in grain was estimated using AAS. The Zn concentration of fifteen wheat cultivars varied from 23.3 (PDW 233) to 32.4 (WH 542) μg g^{-1} with their mean concentration of 26.6 μg g^{-1}. With respect to bread wheat, triticale and *durum* wheat cultivars the concentration of Zn varied from 24.5 to 32.4, 24.3 to 26.3 and 23.3 to 26.6 μg g^{-1} respectively.

All the wheat cultivars of wheat showed enhancement in grain yield varying in their magnitudes with foliar application of $ZnSO_4.7H_2O$ over their respective control. The grain yield of bread wheat, triticale and *durum* wheat cultivars ranged from 4.32-5.64, 4.43-5.16 and 4.76-5.35 t ha^{-1}, respectively. Fertifortification of wheat cultivars reported increase in grain yield with four foliar application of 0.5 per cent $ZnSO_4.7H_2O$ and maximum grain yield was accrued by PBW 550 cultivar followed by PBW 343, WH 542 and PBW 175 cultivars. Among fifteen cultivars bread wheat cultivars reported reasonably greater increase in yield as compared to triticale and *durum* wheat cultivars.

The concentration of Zn in all the fifteen cultivars ranged from 23.3-32.4 μg g^{-1} (initial seed Zn), 27.7-32.5 μg g^{-1} (-Zn) and 56.7-68.0 μg g^{-1} (+Zn). The mean concentration of Zn in bread wheat, triticale and *durum* wheat cultivars ranged from 44.2-49.7, 42.7-48.5 and 44.5-46.3 μg g^{-1} with fertifortification of fifteen wheat cultivars with Zn. The data further revealed that application of Zn raised the maximum concentration of Zn to 68.0 μg g^{-1} (WH 542) and 67.5 μg g^{-1} (PBW 343), which were 126.7 and 112.3 per cent higher respectively, over no Zn (control). Among triticale cultivars the application of Zn raised the maximum concentration of Zn to 66.4 μg g^{-1} (TL 2408) followed by 65.9 μg g^{-1} (TL 2942), which was 117.7 and 133.7 per cent higher respectively, over no Zn (control). However, among the *durum* wheat cultivars the highest percent increase in Zn concentration was reported by PDW 233(133.9%) followed by PDW 274 (104.0%) cultivars of wheat. Also, with fertifortification the increase in Zn concentration ranged from 28.6-38.0, 28.0-37.7 and 29.7-37.1 μg g^{-1} among bread wheat, triticale and *durum* wheat cultivars respectively, over control (-Zn). Compared with control (-Zn) it was observed that Zn was more efficiently absorbed by foliage of WH 542 (bread wheat), TL 2942 (triticale) and PDW 233 (*durum* wheat) cultivars as compared to their respective controls which confirmed their behavior towards differential absorption of Zn.

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Yield and Copper Nutrition of Wheat as Influenced by Method of Application

Navneet Jaryal, J.S. Manchanda, D.S. Bhatti and Amanpreet Kaur
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab

Seed priming with nutrient solutions provides a simple and inexpensive method for improving plant nutrition. In this investigation, two concentrations of 0.03 and 0.06% $CuSO_4.5H_2O$ solution and a soaking interval of six hours standardized in the laboratory study for Cu seed priming along with soil application @10 kg Cu ha^{-1}, foliar application (0.1% $CuSO_4.5H_2O$ + lime), seed coating (3g $CuSO_4.5H_2O$ kg^{-1} seed) alone and in combination (Total 10 treatments) were used to evaluate their effect on Cu nutrition of wheat (cv PBW 550 and PDW 233) in a Cu deficient soil (DTPA- Cu 0.18 mg kg^{-1} soil) under field conditions. Grain and straw yield increased significantly by 6.86 and 5.41% with soil application and by 11.5 and 12.3% with Cu seed priming with 0.03% $CuSO_4.5H_2O$ + foliar application over control, respectively. Copper concentration and its removal by grain and straw increased significantly over control with Cu fertilization. The differences in the yield, Cu concentration and its uptake by wheat with soil application and Cu seed priming with 0.03% $CuSO_4.5H_2O$ with or without foliar application were not significant, thereby indicating that both these treatments were equally effective for Cu fertilization of wheat. Furthermore, the yield, Cu concentration and its removal by PDW 233 were significantly lower than that of PBW 550. These results indicated that either the Cu requirements of *durum* wheat may be lower than that of bread wheat or the translocation of Cu from root to shoot of PDW 233 may be poor as compared to *aestivum*. In the absence of any visual symptoms of Cu deficiency, an increased activity of ascorbate peroxidase in the leaves as a result of Cu fertilization suggested that wheat might have suffered from hidden hunger of Cu under the conditions where these investigations were undertaken.

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Effect of Different Sources of Sulphur on Wheat Yield under Wheat-Soybean Cropping System

S.P. Saini*, B.S. Brar, G.S. Dheri and Vijay Singh
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab
**Email: satpalsaini@pau.edu*

In recent years, sulphur (S) deficiencies in wheat have become more common, particularly on coarse textured soils. In this study two field experiments were conducted under wheat–soybean system in textually different soils at Research Farm, Department of Soil Science, Punjab Agricultural University, Ludhiana (30°53′28.64″ N 75°46′56.96″ E and 274 m from above mean sea level) Punjab. The region belongs to C_4 climatic zone characterized by semi arid sub–tropical. These experiments was conducted in loamy sand and sandy loam soils with six treatments *viz*., Recommended dose of fertilizer without S (RDF), RDF with S as gypsum, RDF with S as SSP, RDF with S as elemental S, RDF with S as bentonite, RDF with S as spray (sulphex 80WP) at 20 kg S ha^{-1}. Grain yield of wheat increased significantly with the application of S under both the soils, irrespective of sources applied. The response of wheat to S was statistically at par among different S sources (SSP, gypsum, bentonite, and elemental sulphur). The yield of wheat was highest (5.62 t ha^{-1}) with the application of bentonite and lowest (5.22 t ha^{-1}) without S application in sandy loam soil. However, in loamy sand soil the highest grain yield (5.18 t ha^{-1}) was obtained with SSP lowest in without S application (4.55 t ha^{-1}). Similarly trend was observed with straw yield. The nutrient concentration (N, P and S) in grain and straw increased significantly with S application in both the soils with all sources of S applied. Total uptake of N, P, and S increased significantly with S application and maximum uptake was observed with bentonite in sandy loam soil and with SSP in loamy sand soil. However, the difference among various sources was not significant. The response of wheat to S application was observed because the S content of both the soils was low. Therefore, there is need to apply sulphur to wheat in S deficient soils. All the sources of S *viz*. SSP, gypsum, bentonite, elemental sulphur are equally effective in meeting the S requirement of wheat crop.

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A 42-year Effect of Fertilizers on Potassium Budgeting in Maize-Wheat Cropping Sequence

G.S. Dheri* and B.S. Brar
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab
**Email: gsdheri@pau.edu*

Fertilizer use in India is highly unbalanced especially with respect to potassium (K). The depletion of available K might take place if intensive cropping is practiced without the external supply to the soil. Hence, sustainable management of plant nutrients requires regular monitoring of the nutrient budget in soils. Crop responses to applied nutrients may not judge from single season or short-term fertilizer experiments. Therefore, long-term experiments provide an interesting avenue to view results accumulating over a period of time and to obtain from the emerging trends, indications for possible modifications of the current fertilizer practices to maximize fertilizer use efficiency for sustainable production. The present paper presents the influence of chemical fertilizers (N, NP, NPK) and organic manure (FYM) on K removal in crop plants, changes in soil status and balance in the maize-wheat cropping sequence studied for the 42 years of a long-term experiment at Punjab Agricultural University, Ludhiana. Soil status of K improved as compared to its antecedent value in treatments where K was supplied externally. In-spite of higher uptake of K in NPK, 150% NPK and NPK+FYM treatments, soil K status improved by 23, 38 and 39%, respectively, whereas it decreased by 13, 11 and 4% in control, N and NP, respectively. The results showed that K uptake by wheat was about 1.31 times that of maize.

The inputs and outputs balance sheet of K indicated that present recommended doses of K in maize and wheat are not sufficient to match the total uptake of K by these crops. Contribution of the non-exchangeable K towards total K removal was 100% in the absence of applied K which decreased to about 66, 52 and 28% in NPK, 150% NPK and NPK+FYM treatment, respectively. Budgeting of K revealed that non-exchangeable K has considerable contribution in total uptake as compared to available soil K. Long-term application of FYM along with NPK reduced the contribution of K by 38% as compared to the NPK alone. The results suggested the need for modifying the existing K fertilizer recommendations to compensate for gradual loss of native soil K fertility in maize-wheat cropping sequence.

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Economic Viability of Organic Manures Application in Rice-Wheat Cropping Sequence

G.S. Dheri*, B.S. Brar and H.S. Uppal
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab
**Email: gsdheri@pau.edu*

Rice and wheat are the most important staple foods in India and therefore dominant cropping sequence in the Indo-Gangetic-Plains. The era of the Green Revolution started during the early 1970s with the introduction of high yielding varieties and adoption of improved agronomic managements including chemical fertilizers application. The use of chemical fertilizers has been the third most important input of Green Revolution after HYV seeds and irrigation. However, prolonged application of chemical fertilizers without the addition of organic manures, is generally believed non-sustainable for overall soil health and productivity. Therefore, combined use of chemical fertilizers and organic manures are advocated for sustaining the soil and crop productivity on long-term basis. Although, organic manures are good for soil health, the monetary viability of their application is not studied properly. To compare the relative economics of chemical fertilizers and organic manures application in rice-wheat cropping sequence, the treatments of N, NP, NPK, NPK (P to wheat only), NPK+FYM, NPK+GM and NPK+straw were selected from an ongoing long-term fertilizers experiment since 1999. The benefit cost ratio (B:C) of different treatments was computed by considering the package and practices recommended by Punjab Agricultural University for the cultivation of rice and wheat crop in the Punjab.

The application of chemical and organic manures have differential influence on the economic returns of rice and wheat crop. The B:C ratio for rice, wheat and rice-wheat sequence was minimum for control and maximum for NPK+FYM treatment. Among the chemical fertilizers, B:C ratio of rice was maximum in NPK (P to wheat only) (2.51) followed by NP (2.42), NPK (2.32) and minimum in N (2.29) which indicate that the application of P to rice crop only is more economically beneficial over its application to both wheat and rice. Moreover, addition of K has adverse effect on B:C ratio of rice due to non-significant improvement in rice yield with K application. Use of FYM (2.65) and GM (2.65) in rice was economically better as compared to the incorporation of straw (2.60). Direct application of P in wheat improved grain yield which reflects through the maximum B:C ratio (3.06) among the chemical fertilizers followed by NP (2.94), NPK (P to wheat only) (2.86) and minimum in N (2.35) treatment. The residual effect of FYM (3.23) applied in rice on wheat maintained highest B:C ratio followed by GM (3.09) and minimum in straw (2.92) treatment. Considering all the costs and benefits, the combined use of chemical fertilizers and organic manures are viable both in term of productivity and economical return in rice-wheat cropping sequence. Omitting the application of P to rice in rice-wheat cropping sequence has economical and environment advantages.

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Continuous Fertilization and Manuring on Yield and Fertility Status in Post-harvest Soil of Maize Hybrid in Long-term Fertilizer Experiment of Coimbatore

K. Arulmozhiselvan, S. Sathya, M. Malarkodi and M. Elayarajan
Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, 641 003, Tamil Nadu

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 Experiment (LTFE) in 1972. As one of the centre, LTFE is being maintained in 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 and fertility status of finger millet under finger millet-maize cropping system.

Ten treatments with four replications under randomized block design with a plot size of 20 m × 10 m are being evaluated in LTFE. The experimental soil (Periyanaickenpalayam soil series) is sandy clay loam in texture and taxonomically grouped under Vertic Ustropept. In the year 2013, the highest grain yield of 7422 kg ha^{-1} and straw yield of 10150 kg ha^{-1} were recorded in the treatment that received 100% recommended dose of fertilizer N, P and K along with farmyard manure (10 t ha^{-1}) and it was closely followed by 150% NPK. Omission of S and K recorded comparable yield to that of 100% NPK. Continuous addition of N alone significantly and remarkably reduced the grain and straw yield of maize hybrid when compared to other fertilized and manured treatments. Grain, straw and total uptake of NPK was also high in the INM practice. The results also revealed that pH and EC in post-harvest soil of maize hybrid was not significantly altered due to continuous fertilization. INM practice also recorded higher organic carbon than inorganic fertilization. Available NPK was also found to be high under INM practice. Regarding micronutrients, DTPA extractable zinc, copper and iron were found to be deficient whereas manganese was sufficient in all the treatments, except in Zn applied where available Zn was sufficient.

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Available Sulphur and DTPA-extractable Micronutrient Cations in Mustard Fields of Madhya Pradesh

S.K. Trivedi, Brajkishor Rajput and S.S. Rajput
Department of Soil Science and Agricultural Chemistry, R.V. S.K.V.V., College of Agriculture, Gwalior, Madhya Pradesh

The status of available sulphur (S) and DTPA-extractable micronutrient cations and effect of soil properties on their status were studied in mustard growing fields of Morena, Bhind and Gwalior district of northern Madhya Pradesh. The available-S in studied area ranged from 4.36 to19.58 mg kg ^{1} with the mean value of 15.31 mg kg ^{1}. The DTPA-extractable Zn, Cu, Fe and Mn contents varied from 0.18 to 2.56, 0.12 to 4.62, 1.25 to 18.65 and 0.36 to 16.65 mg kg ^{1} with the mean values of 0.69, 1.14, 5.55 and 4.36 mg kg^{-1}, respectively. About 25.0% samples were found deficient and 75.0% medium and none of samples under sufficient category of available S. The available Zn and Fe were deficient in 46.0 and 35.3% while Cu and Mn both deficient in 6.66% of the samples of studied area. The sulphur, Zn and Fe deficiency increased with an increase in pH and calcium carbonate content whereas it decreased with an increase in organic carbon content in mustard growing fields of northern Madhya Pradesh.

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Changes in Soil Chemical Properties as Influenced by Long-term Application of Chemical Fertilizers and Manure in an Alfisol

R.C. Gowda, D.C. Hanumanthappa and P. Veeranagappa
AICRP on LTFE, Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bangalore, Karnataka

Long-term fertilizer experiment at Bengaluru was started during 1986 with eleven treatments and four replications in an Alfisol with finger millet- maize cropping sequence. The results of the ongoing experiment after 27 crop cycles of finger millet and hybrid maize on changes in soil chemical properties revealed that application of inorganics alone resulted in impaired soil fertility status over balanced fertilizer application. There was a decline in soil reaction over the initial status and the maximum decrease was observed in 100% NP (-1.46), 100% N (-1.20) and 150% NPK. Application of 100% NPK+FYM+lime (T_{10}) maintained the soil pH compared to all the other treatments. Organic carbon content of soil in all the treatments was higher compared to the initial status, however, maximum increase in organic carbon content was registered with application of balanced fertilizers along with organic manure.

Among the major nutrients status in soil available nitrogen content in soil was decreased in all the treatments except in 100% NPK+hand weeding and 150% NPK, maximum reduction in available N content of soil was observed in absolute control (T_{11}). Except absolute control and only N, all other treatments recorded build up of available phosphorus in soil over the initial value, however super optimal dose (150% NPK) resulted in about 140.2 kg ha^{-1} build-up of phosphorus followed by 100% NPK+FYM+lime (86.05 kg ha^{-1}) and other treatments. Maximum potassium buildup of 90.77 kg ha^{-1} was recorded with application of 150% NPK followed by 100% NPK+FYM+lime and other treatments, the available potassium content in soil was depleted in treatments where K was not applied (T_6, T_7 and T_{11}) and also on application of 50% NPK (T_1). All the secondary nutrients in soil found an increase in all the treatments oner the initial value, however application of balanced fertilizers resulted in higher buildup of secondary nutrients in soil compared to absolute control and inorganics alone. Among the micronutrients in soil Mn content was depleted to about 50% over the initial status and Cu content was also reduced to a lesser extent in almost all the treatments over the years due to crop uptake and soil nutrients interaction. Iron content of soil found an increase over the initial status in all the treatments and the Zn content followed the similar trend. Application of balanced fertilizers along with organic manure resulted in maintaining and sustaining the soil fertility and productivity over the period. Application of inorganics alone impaired the soil fertility thus resulted in nutrient depletion from soil. The depletion of plant nutrients from soil led to decline in their available status over the years due to crop growth and uptake.

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Yield Pattern and Nutrient Uptake by Finger Millet and Maize in Long-term Fertilizer Experiment under Eastern Dry Zone of Karnataka

R.C. Gowda, D.C. Hanumanthappa and P. Veeranagappa
AICRP on LTFE, Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bangalore, Karnataka

Long-term fertilizer experiments (LTFE's) are valuable assets for determining yield trends, changes in nutrient dynamics and balances, assessing soil quality and system sustainability under a particular soil fertility management practices. Effect of management practices on crop productivity and soil quality are best evaluated through long-term fertilizer experiments. A long-term fertilizer experiment at Bengaluru was started during 1986 with eleven treatments and four replications in an alfisol with finger millet-maize cropping sequence.

The data on yield pattern of finger millet indicated that application of 150% NPK (T_3) resulted in higher yield (4.67 t ha^{-1}) over the years followed by addition of 100% NPK+FYM+lime (T_{10}: 4.45 t ha^{-1}) and were superior over rest of the treatments whereas, yield of hybrid maize was significantly higher on application of 100% NPK+FYM+lime (T_{10}: 3.03 t ha^{-1}), followed by 100% NPK+FYM (T_8: 3.01 t ha^{-1}) and 150% NPK (T_3: 2.88 t ha^{-1}). Application of FYM and lime resulted in better yield crop productivity over the years.

Application of 100% N or 100% NP (imbalance nutrition) resulted in better crop yields during the initial years compared to control, but the treatments did not sustained the productivity over the years. The productivity of crops remained at low levels in these treatments. Application of lime did not result in significant yield increase however, this has showed better response to maize crop. The productivity of crops sustained under balanced and super optimal dose of fertilizers (150% NPK). In general the uptake of nutrients by finger millet was high on application of 150% NPK followed by 100% NPK+FYM and 100% NPK+FYM+lime. The average uptake of nutrients by both the crops were low in treatments - absolute control (T_{11}), 100% N (T_7) and 100% NP (T_6). Uptake of nutrients by hybrid maize was higher on application of 100% NPK+FYM+lime (T_{10}), 100% NPK+FYM (T_8) and 150% NPK (T_3), this showed the beneficial effect of balanced applications of organics and inorganics. Higher crop productivity and yield can be achieved through the application of super optimal dose (150% NPK) of nutrients but to sustain the productivity of both crops and soil balanced application of organics and inorganics proved better over inorganics alone.

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Grain Yield of Chickpea, Nutrient Uptake and Quality as Influenced by Zinc Application

R.N. Katkar, Ritesh Chavan, A.B. Age, D.B. Tamgadge and S.R. Lakhe
AICRP on Micro and Secondary Nutrients, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444 104, Maharashtra

The field study was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *rabi* 2014-15 with the objective to study the effect of zinc (Zn) application on nutrient uptake, yield and quality of chick pea in Inceptisol. The soil of the experimental site was slightly alkaline in reaction, medium in organic carbon, moderately calcareous in nature, low in available N, medium in available P and high in available K, marginal in available S and sufficient in micronutrients but deficient in available Zn.

The seven treatments comprised of control, soil application of 10, 20 and 30 kg $ZnSO_4$ through $ZnSO_4$ and the foliar application of Zn-EDTA @ 0.25%, $ZnSO_4$ @ 0.50% at the time of flowering stage and incorporation of green gram residue in randomized block design with three replications. The significantly highest grain yield (1.83 t ha^{-1}) was recorded with treatment soil application of $ZnSO_4$ @ 30 kg ha^{-1} followed by the treatment foliar application of $ZnSO_4$ @ 0.50% (1.76 t ha^{-1}) and soil application of $ZnSO_4$ @ 20 kg ha^{-1}. The grain yield of chickpea was significantly increased from 10 kg $ZnSO_4$ (T_2) to 30 kg $ZnSO_4$ ha^{-1} indicating response of chickpea to application of Zn in medium deep black soil. The increasing levels of soil application of $ZnSO_4$ found beneficial for improving yield of chickpea. Foliar application of $ZnSO_4$ and Zn-EDTA at flower initiation stage improved the yields significantly as compared to control.

The significantly highest number of pods per plant (149.8) and total chlorophyll (10.2 mg kg^{-1}) were recorded with the soil application of $ZnSO_4$ @ 30 kg ha^{-1}. Significantly highest protein content (18.0%) were recorded under the treatment soil application of $ZnSO_4$ @ 30 kg ha^{-1} followed by the treatment of foliar application of $ZnSO_4$ @ 0.50%. The highest test weight (24.1 g) was recorded under the treatment of soil application of $ZnSO_4$ @ 30 kg ha^{-1}, followed by the treatment foliar application of $ZnSO_4$ @ 0.50% and soil application of $ZnSO_4$ @ 20 kg ha^{-1}. Significantly larger seed size (452 mm^3) and shiny seed colour were recorded under the treatment soil application of $ZnSO_4$ @ 30 kg ha^{-1}, followed by the treatment foliar application of $ZnSO_4$ @ 0.50%. The higher N, P, K and zinc content and uptake was recorded with the soil application of $ZnSO_4$ @ 30 kg ha^{-1} followed by $ZnSO_4$ @ 20 kg ha^{-1}. It is inferred that, the soil application of $ZnSO_4$ @ 30 kg ha^{-1} + RDF (25:50:30 kg ha^{-1} N, P_2O_5, K_2O) at the time of sowing recorded highest chickpea grain yield, nutrient uptake, nutrient use efficiency and grain quality *viz*., test weight, seed size, seed colour and protein yield of chickpea with improvement in soil fertility.

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Cotton Productivity, Profitability and Nutrient Availability under Different Nutrient Management Practices

Ranjith Mudigiri, Sridevi Surapaneni, Venkata Ramana Maparla and Chandrasekhar Rao Palli

Department of Soil Science and Agricultural Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana

**Email: ranjithagric034@gmail.com*

Cotton is an important fibre crop of global significance, which is, cultivated in tropical and sub-tropical of more than seventy countries the world over. A field experiment was conducted during *kharif,* 2013 to evaluate the nutrient requirement of *Bt cotton vis-à-vis* fertilizer practices in vogue. At different growth stages, except control, all other treatments recorded higher number of monopodial and sympodial branches than 100% RDF. Incremental doses of fertilizers increased number of bolls plant^{-1} but very doses practiced by farmers did not help in increasing boll number. Kapas yield increased with increasing fertilizer dose from 100 to 150% the but was on par with the yield realized in 100% NPK and soil test based fertilizer application. Quality parameters like seed index, lint index and ginning out turn were not influenced by the fertilizer treatments. Availability nitrogen was lowest in control and highest in farmers' practice. Availability phosphorus and potassium was lowest in control and highest in soil test based fertilizer application. Available sulphur content in soil was lowest in control and highest in 150% RDF+S @ 30 kg ha^{-1} treatment. Micronutrient status in soil at flowering and harvest stages was not significantly influenced by the fertilizer treatments. Economic analysis also indicated that application of very high doses of fertilizers did not help in getting higher net returns or higher benefit cost ratio. It is logical to resort of soil test test based fertilizer application or to adopt the present recommendation of 150:60:60 kg NPK ha^{-1} for profitable cultivation of *Bt* cotton in Warangal district of Telangana state.

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Characterization, Classification and Evaluation of Soils of BSP Farm (*Khanapur Block*-B), VNMKV, Parbhani

Snehal Shilewant* and V.D. Patil
Department of Soil Science and Agricultural Chemistry, College of Agriculture, V.N. Marathwada Krishi Vidyapeeth, Parbhani, 431 402, Maharashtra
**Email: shilewant.snehal145@gmail.com*

Characterization, classification and evaluation of soils of BSP Farm (Khanapur Block-B), VNMKV, Parbhani was carried out during 2012. The total gross area of 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 data on natural resources were collected. Total 110 soil samples were drawn to study the soil properties and nutrient status. The results revealed that, soils of BSP Farm (Khanapur Block-B) were Typic Haplusterts (40%), Vertic Ustochrerts (36%) and Lithic Ustorthents (24%). These soils are dark brown to black in colour and clay in texture. These soils are slightly to moderately alkaline in nature, safe in total soluble salt concentration, moderately calcareous to calcareous and moderately high organic carbon. In all 88.3 per cent soil samples were low and 11.8 per cent are placed as very low in available N content. Available phosphorus content was found to be low in 7.3%, medium in 50% and 42.7% soils of moderately high P_2O_5. The availability of potassium found to very high in BSP farm. In case of sulfur availability 81.8% are deficient and 18.2% soils are sufficient. The soils of farm found to be high and sufficient in available calcium and magnesium. The DTPA-Fe and boron deficiency was major concern in all soils of BSP Farm (Khanapur Block-B). These soils are found to be low to high in DTPA-Zn content, and rich in available copper and manganese. The pH content was positively correlated with available P and K, available Ca and Mg, as well as DTPA-Zn and HWS-B. The organic carbon content showed in positive and significant relation with available N and DTPA-Cu, Fe, Zn and HWS-B. Available N, K, S , Ca and Mg showed positive relation with calcium carbonate. Thus, the soils of BSP Farm (Khanapur Block-B) representing Typic Haplusterts and Vertic Ustochrepts showed moderate to high suitability for all the crops to be grown. If little modifications in pH, organic carbon and $CaCO_3$ are done then these soils may support the crops *viz.,* wheat, soybean, sugarcane and cotton.

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Soil Test-based Fertilizer Recommendation for Targeted Yield of French bean (*Phaseolus vulgaris* L.) under Rice-French bean Cropping System

Sowmya Pogula, Antaryami Mishra and S. Saren
Department of Soil Science and Agricultural Chemistry,
Orissa University of Agriculture and Technology, Bhubaneswar, 751 003, Odisha

A field experiment was conducted in E block of the Central Research Station of Orissa University of Agriculture and Technology, Bhubaneswar during *rabi* season of 2014-2015 to study the response of french bean (*Phaseolus vulgaris* L.) to graded dose of fertilizer and to formulate soil test based fertilizer recommendation for targeted yield of french bean under rice-french bean cropping system. Before taking up the experiment, detailed morphological and physico-chemical study of a typifying pedon of the experiment site was made. As per 'soil taxonomy' the soils were classified as fine, mixed, hyperthermic family of Vertic Haplustepts. Horizon wise study of available macro and micronutrients (organic carbon, available nitrogen, phosphorus, potassium, sulphur, iron, manganese, copper, zinc and boron) were made to know the vertical distribution of nutrients. In the *kharif* season, three fertility gradient strips were created (B_1, B_2, B_3) by application of no fertilizer, recommended dose of fertilizer (80:40:40 N:P_2O_5:K_2O ha^{-1}) and twice of recommended dose of fertilizer (160:80:80 N:P_2O_5:K_2O kg ha^{-1}), respectively. Rice was grown in these three fertility gradient strips in *kharif* season. After harvest of rice (cv. Lalat) crop, each of these fertility gradient strips were divided into 24 sub-plots and superimposed with 21 different combinations of N, P and K and 3 absolute control plots. The composite soil samples were taken from 72 subplots and analysed for initial soil test value of N, P and K. French bean (cv. Anupam) was taken up during *rabi* season. The graded doses of N was 30, 50, 70 kg ha^{-1} that of P_2O_5 was 60, 80, 100 kg ha^{-1} and that of K_2O was 60, 80 and 100 kg ha^{-1}. After harvest of french bean crop, the pod and plant of french bean were properly dried, weighed and then preserved for laboratory analysis. The uptake of N, P and K was evaluated by analyzing the pod and plant samples. The highest rice yield (4.48 t ha^{-1}) was obtained at the fertilizer dose of 80 kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1} and French bean (9.15 t ha^{-1}) was obtained at 70 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} doses. Basic parameters for developing targeted yield equation such as nutrient requirement (NR) per cent contribution from soil available nutrients (Cs), from fertilizer (Cf) and from organic matter (FYM) (Co) were calculated. Based on NR, Cs, Cf and Co values the fertilizer prescription equations were calculated, which will be of great use to the farmers of Odisha.

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Effect of Nutrient Levels on Fertility Status of Soil and Quality of Ajwain (*Trachyspermum ammi* L. Sprague)

S.S. Hadole, Eetela Sathyanarayana, S.M. Ghawade and G.S. Laharia
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra

In order to study the effect of nutrient levels on fertility status of soil and quality of ajwain, an experiment was carried out during *rabi* season of 2014-15 at Chilli and Vegetable Research Unit of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, (MS). The experiment was conducted based on design randomized complete blocks with five treatment and four replications. The treatment consisted of five levels of nitrogen (0, 20, 40, 60 and 80 kg ha^{-1}), five levels of phosphorus (0, 10, 20, 30 and 40 kg P_2O_5 ha^1 and five levels of potassium (0, 10, 20, 30 and 40 kg K_2O ha^{-1}). The essential oil was extracted by Clevenger type apparatus method. Results indicated that increasing application of N, P and K increased fertility status of soil (available nutrients *viz.,* N, P and K after harvest of ajwain crop) and highest essential oil yield (44.70 L ha^{-1}) was obtained from T_5 treatment, which was 80 kg N + 40 kg P_2O_5 and 40 kg K_2O ha^{-1}.

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Evaluation of Various Potassium Management Options for Rice-Rice System followed under Sub-Tropical Condition

Suchismita Mohapatra[1], K.K. Rout[1], C.M. Khanda[2], Sheetal Sharma[2], Amit Mishra[2] and Sudhir Yadav[2]

[1]Department of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar, 751003, Odisha
[2]International Rice Research Institute, Los Banos, Philippines
**Email: kkrout42@yahoo.com*

Under the IRRI-OUAT Collaborative Students' Research Programme, a field experiment was conducted with rice crop (cv:Lalat) grown on an acidic medium land located in the Central Research Farm of Orissa University of Agriculture and Technology, Bhubaneswar during *rabi*, 2013-14 and *kharif*, 2014 in order to evaluate different potassium (K) management practices with respect to K nutrition, crop yield, K-balance and soil biological health in soil. The experiment was laid out in RBD with three replications and nine treatments consisting of three treatment with three levels of K, 40, 60 and 80 kg K_2O ha^{-1}, three treatment with half of the above doses + straw, one treatment with only : rice straw incorporation, one treatment with fertilizer K at 40 kg K_2O ha^{-1} + one foliar spray @ 1% KNO_3 at panicle stage, and a control without K. Application of fertiliser K @ 40 kg K_2O ha^{-1}along with a foliar spray of 1% KNO_3 at panicle initiation (PI) stage yielded highest in both *rabi* (3.84 t ha^{-1}) and *kharif* (5.35 t ha^{-1}) season. Equivalent yields were also obtained with application of fertilizer @ 60 kg K_2O ha^{-1} in Rabi and 80 kg K_2O ha^{-1} in Kharif and combined application of both fertilizer K @ 30 kg K_2O ha^{-1} and straw in both the seasons. The K absorption up to PI stage was 20% more in *kharif* than in *rabi* season. Relatively low yield in *rabi* is attributed to poor tillering caused by reduced absorption of both N and P. There was more release and use of non-exchangeable K from surface layer in treatment that received lower dose of fertilizer K + straw. Total crop uptake of K strongly correlated with available K of both surface and sub surface soil in *rabi* season and available K and reserve K of sub surface soil in *kharif* season. Treatment that received K through fertilizer with or without foliar spray showed negative K-balance in soil where as application of K through straw either alone or in combination with moderate dose of fertilizer showed positive balance. When calculated on annual basis total K balance varied between -140 to 89.1 kg ha^{-1} $year^{-1}$ with the treatment that received 40 kg K_2O with foliar spray and produced highest yield in both *rabi* and *kharif* seasons resulted in highest negative balance and the treatment, 30 kg K_2O as fertilizer along with straw caused highest positive balance. Combined application of moderate dose of K through fertilizer and straw maintained better soil health than the treatment that received only fertilizer. Based on the grain yield, effect on soil health and K balance, combined application of moderate dose of fertilizer K (30 kg ha^{-1}) along with straw incorporation is suggested for recommendation to rice-rice system followed under sub tropical condition.

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Effect of N, P and K Fertilization on Performance of Popular Varieties of Blackgram in Vertisols of Krishna Zone of Andhra Pradesh

P. Madhu Vani, A. Lalitha Kumari and G. Kishore Babu
Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, Andhra Pradesh

Fertilizers should be applied at the level required for optimal crop growth based on crop requirements and agro-climatic considerations. Over application of fertilizers induces neither substantially, greater crop nutrient uptake nor significantly higher yields. It is economically costlier and can damage the environment. On the other hand, inadequate application can retard crop growth and lower yields in the short term, and in the long term jeoparadize sustainability through soil mining. Recently released and widely cultivated varieties of pulses are highly nutrient responsive. In this context, an experiment was conducted in black cotton soils at RARS, Lam during *kharif* 2014 to study the nutrient response of high yielding popular varieties of blackgram in Krishna zone of Andhra Pradesh for maximization of yields.

The experimental soil was non saline, clayey in texture with slightly alkaline in reaction. The soil was low in organic carbon and available nitrogen and high in phosphorus and potassium. The influence of enhanced N and P doses and response to applied potassium was studied in three popular varieties of blackgram *viz.*, LBG787, 752 and PU31 with four levels of fertilization was studied in a factorial randomized design. Highest mean root nodulation, plant height, number of pods, drymatter per plant and grain yield was recorded in LBG 752 followed by LBG 787 and PU 31 irrespective of the level of fertilization. Among the fertilizer levels, application of potassium @ 60 kg ha^{-1} along with recommended dose of nitrogen and phosphorus recorded highest root nodulation, plant height, number of pods, drymatter per plant and grain yield and the lowest with 100 per cent recommended dose of nitrogen and phosphorus in all the three varieties.

It was further observed that there was no significant difference among the varieties with enhanced dose of nitrogen and phosphorus over 100% RDF and application of potassium @ 30 and 60 kg ha^{-1}. This indicated that application of 20 and 50 kg of nitrogen and phosphorus was sufficient and there was no need of potassium application in soils rich in potassium.

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Nutrient Management for Hybrid Maize using Nutrient Expert Decision Support Tool

Rakesh Kumar, Amrit Jha[1], Asha Kumari Sinha, Arun Nath Puran, Bhupendra Kumar and S. Dutta[2]

Department of Soil Science and Agricultural Chemistry, Birsa Agricultural University, Kanke, Ranchi, Jharkhand

[2] International Plant Nutrition Institute (East India & Bangladesh)

[1]KVK, Sahebganj, BAU, Jharkhand

Twelve experiments, comprising three treatments (Farmer's fertilization Practices, Recommend dose of fertilizer and recommendation of Nutrient Experts) were carried out on hybrid maize (Pioneer 30V92) in different location of Shahebganj (N-25°18′516″ to 25°11′186″ and E-87°34′283″ to 87°32′457″) at farmers field with targeted yield of maize (6.5 t and 9.0 t ha^{-1}) on basis of resources of farmers. The experiments were conducted in the month of June and harvested in the month of October. Yield data was recorded and the results showed that application of fertilizer on the basis of Nutrient expert decision support tools achieved the maximum yield target 90-91 per cent (5.9 to 8.4 t ha^{-1}), respectively in comparison to other treatments. Lowest yield (1.9 to 4.1 t ha^{-1}), was observed with the application of fertilizer on the basis of FFP.

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Revisiting of Fertilizer Doses of Finger Millet (*Eleusine coracana*) through STCR's Targeted Yield Approach

Y. Sandhya Rani, T.S.S.K. Patro, U. Triveni, S. Jyothsna and B. Neeraja
All India Coordinated Small Millets Improvement Project, Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Vizianagaram, 535 001, Andhra Pradesh

Relay on input of inorganic fertilizers often lead to non sustainability in production and also pose a serious threat to soil health. However, considering the economics and physiological potential of varieties, complete dependence on organic sources of nutrients may not be adequate to attain the highest productivity. Due to the changes in soil fertility caused by imbalanced fertilizer use, acidity, alkalinity, salinity and declining in soil organic matter, there is every need to continuously monitor the changes in soil properties and adopt the best management practices for maintenance and enhancement of soil health. For enhancing the soil health and sustaining productivity, fertilizer prescriptions based on STCR's targeted yield approach which take into account nutrient demand of the crops for a targeted yield goal and relative contributions from soil and fertilizer sources under a given set of farming situation, revealed inadequacy of the conventional fertilizer recommendation followed. A field experiment was conducted to reveal that unholy yield barrier in high yielding varieties owing to poor nutrient management could be successfully reversed by restoration of soil fertility and crop nutrition through soil test based fertilizer input. The results indicated that higher yields recorded in the treatment 200% RDN + 100% RDP+ 100% RDK + 25% RDZn + 25% RDS + 25% RDB + 2 t ha^{-1} Vermicompost in soils whose nitrogen levels are low (below 140 kg ha^{-1}), high phosphorus levels and medium potassium levels.

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Response of Mustard to Varieties and Fertility Levels

Poonam Sharma and V.K. Jain
Ambah Post Graduate Autonomous College, AMBAH (Morena), 476 111, Madhya Pradesh

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}, 1*N* ammonium acetate extractable K_2O-390 kg ha^{-1}, Morgan S 16 kg ha^{-1} and DTPA extractable Zn 40 mg kg^{-1}. Five promising varieties (Varuna, Kranti, Rohini, JM-2 and JM-1) and 4 levels of N:P:K:S:Zn (60:30:15:22.5:15, 80:40:20:30:20, 100:50:25:27.5:25 and 120:60:30:45:30 kg ha^{-1}) were evaluated in split plot design with three replications. Full dose of P_2O_5 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 Wheat to Integrated Plant Nutrient Management

R.J. Tiwari, Laxmi and R.P. Sharma
RVSKVV - Krishi Vgyan Kendra, Dewas, 455 001, Madhya Pradesh

Wheat has played an important role to meet the food security system 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 considerable 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 2014-15 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 $KMnO_4$ extractable N 180 kg ha^{-1} and 1*N* ammonium acetate extractable K 395 kg ha^{-1}. There are two practices were adopted [Farmers practices (80 kg N and 40 kg P_2O_5 ha^{-1} and improved practices (120, 60 and 40 kg N, P_2O_5 and K_2O ha^{-1}) + 5 t FYM ha^{-1}+1 liter liquid PSB ha^{-1} for experiment. All the doses and 30 kg N ha^{-1} were applied at the time of sowing. Remaining dose of N was applied in three equal splits at I, II and III irrigation scheduling. Six farmers' fields were selected for the experiment. A common package of practices and pest management practices were adopted for the experiment.

The growth and yield parameters were influenced by the treatment. Highest tillers/plant (7.4), earhead length (8.9 cm), seed yield (4.25 t ha^{-1}) and 13.1% increase in yield over farmer practices were recorded under improved practices against the farmers practices i.e. tillers/plant (6.7), earhead length (8.8 cm) and seed yield (3.76 t ha^{-1}). Highest cost of cultivation (Rs. 21767 ha^{-1}) gross return (Rs. 61692 ha^{-1}), net return (Rs. 39925 ha^{-1}) and B:C ratio (2.83) were recorded under improved practices. However, lowest cost of cultivation (Rs. 20238 ha^{-1}) gross return (Rs. 54891 ha^{-1}), net return (Rs. 34653 ha^{-1}) and B:C ratio (2.71) were recorded under farmers practices.

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Response of Maize to Micronutrient Concentration and Nutrient Uptake Affected by Application of Soluble Fertilizer

Swati Mundhe*, M.S. Deshmukh, A.S. Dhawan and Anuradha Pawar
Department of Soil Science and Agricultural Chemistry,
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, 431 402, Maharashtra
**Email: swati.mundhe88@gmail.com*

Maize is one of the most important cereal of the world and known as queen of cereals. Among the various ways of supplying nutrient to the crops, the efficient utilization of nutrients by the plants is made through foliar application. To understand the effects of application of micronutrients an experiment was carried out during *rabi* 2011-12 at Research farm, Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani on Vertisol to evaluate the effect of soluble fertilizer on yield, micronutrient concentration and uptake of maize (*Zea mays* L.). The experiment was laid out in randomized block design (RBD) with 10 treatments and replicated thrice Maize yield was recorded from each net plot and converted on hectare basis. The results revealed that the application of 100% RDF + two spray of starter and booster recorded significantly higher grain and dry matter yield followed by 100% RDF + one spray of starter and booster. Nitrogen, phosphorus and potassium concentration in maize straw increased by application of 100% RDF and two spray of starter and booster followed by T_4 (100% RDF + one spray of starter and booster). In straw N, P and K concentration was varied from 0.559 to 0.791, 0.240 to 0.391 and 0.64 to 1.13 per cent, respectively. Among the micronutrient concentration Zn 53.1 mg kg^{-1}, Cu (9.8 mg kg^{-1}), Fe (133.5 mg kg^{-1}) and Mn (55.8 mg kg^{-1}) was significantly increased with application of 100% RDF + multimicronutrient Grade II. Among the treatment combinations the uptake of major nutrients was highest in 100% RDF and two spray of starter and booster followed by 100% RDF + multimicronutrient Grade II. Uptake of total major nutrient was recorded as nitrogen (26.36 to 52.63 kg ha^{-1}), phosphorus (11.25 to 26.01 kg ha^{-1}) and potassium (31.75 to 75.78 kg ha^{-1}), respectively.

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Effect of Foliar Application of $ZnSO_4$ and ZnO Nanoparticles on Growth Biomass Production and Uptake of Cole Crops

G.C. Satisha*, T.N.V.K.V. Prasad[1], K. Bharathi, T.S. Shruthi, Mazhar Jamil and A.N. Ganeshamurthy

ICAR- Indian Institute of Horticultural Research, Hessaraghatta Lake Post, Bangaluru, 560089, Karanataka

[1]Institute of Frontier Technology, Acharya N.G. Ranga Agricultural University, Tirupati, 517502, Andhra Pradesh

**Email: satishagc@gmail.com*

Zinc (Zn) plays an important role in nutrition of horticultural crops and its deficiency is now know to be widespread in soils of India. The corrective measures involve application of zinc fertilizers ($ZnSO_4$ to the soils or to foliage as sprays. Recently the colloidal solution of zinc oxide nanoparticles is known to be better source of Zn as fertilizer without the harmful factors of chemical fertilizer and also have potential to boost the yield and growth of crops. The effect of foliar application of zinc oxide nanoparticles (ZnO NPs) on growth and biomass production of Cole crops *viz*., cabbage and cauliflower was studies in a field experiment conducted during *rabi* season of 2014-15 at Indian Institute of Horticultural Research, Bangalore. At 45 days after planting, plant height, plant growth parameters and plant dry matter yield were measured. Zn contents were partitioned into leaves, stump and roots. Plant height and dry matter yield of both cabbage and cauliflower differed markedly between different levels of nano ZnO and $ZnSO_4$ (a common source of Zn supplement). A positive significant growth response was apparent in plants sprayed with ZnO NPs as compared to control. A significant increase in all plant growth parameters was obtained at the concentration of 150 mg L^{-1} ZnO NPs. In contrast, a significant reduction of the growth parameter measured was obtained at a concentration of 250 mg L^{-1}. Analysis of the Zn contents in plants sprayed with ZnO NPs showed that substantial amount accumulated in the leaves, stump, and roots of these crops.

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Evaluation of Phosphate Rocks Acidulated with Sulphuric Acid as a Source of P in Alkaline Calcareous Soil

B. Mhalla, R.D. Singh, Nayan Ahmed and D.R. Biswas
Division of Soil Science and Agricultural Chemistry,
ICAR-Indian Agricultural Research Institute, New Delhi, 110012

Phosphorus (P) is one of the major essential nutrients needed to ensure the sustainability in agriculture. The application of phosphate rock (PR) as a source of P can contribute to sustainable agriculture particularly for those developing countries that have indigenous PRs deposits. However, the application of PR in calcareous soil is not common because of low availability of P. Thus, the objective of this study was to characterize and acidulate phosphate rocks in order to increase P availability in calcareous soil. For this, incubation and greenhouse studies were conducted to evaluate the effect of partially acidulated phosphate rocks (PAPRs) on P release pattern in alkaline calcareous soil (pH 8.8) as well as their agronomic effectiveness on wheat crop. Phosphate rocks acidulated with sulphuric acid at two levels *i.e.* 25% and 50% were used to prepare various PAPR products from four sources of PR namely, Syrian PR, Jordanian PR and two of Indian origin namely, Udaipur PR and Purulia PR. The products were analyzed for different phosphate fractions *i.e.* total P, water soluble P (WSP), citrate soluble P (CSP) and citrate insoluble P (CISP). The results showed that both total and CISP fractions deceased with increase in degree of acidulation, whereas WSP and CSP as a percentage of respective total P increased with increase in the acidity levels. In the incubation study, the phosphatic fertilizers were applied to the soil @ 40 mg P kg^{-1} soil, then the soil was incubated under moist aerobic conditions for 15, 30, 45, 60 and 90 days @ 28±1 °C. The results revealed that Olsen's extractable P from PAPRs treated soils was increased significantly over control throughout the incubation period for 90 days irrespective of sources and levels of acidulation. However, they were significantly inferior to single superphosphate (SSP). Available P was increased with increase in the degree of acidity. In pot culture study, the trend of results obtained closely followed the pattern observed in the incubation study. Plant attributes of wheat crop (dry matter yield, P content, P uptake and relative agronomic effectiveness) increased significantly as compared to no-P (control). Effectiveness of PRs as source of P to wheat followed the order of Jordanian PR> Syrian PR=Purulia PR>Udaipur PR. This was also reflected in available P status of soil. However, applied P through SSP was more effective in enhancing P content in soil and plant, P uptake and dry matter yield of wheat as compared to those obtained with PAPRs.

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Soil Health, Cane and Sugar Yield under Sugarcane Monocropping as Influenced by Different Nutrient Management Practices

Ch. S. Rama Lakshmi, T. Sreelatha, D.V. Ramana Reddy, K. Veerabhadrarao and N. Venugopalarao

Regional Agricultural Research Station, Anakapalle, Visakhapatnam district, Andhra Pradesh

Sugarcane cultivation in India is characterized by raising of as many number of ratoons owing to its substantially low cost of production. Ratoon crops however, seldom receive proper care and inputs due to being considered a free crop by majority of farmers poor in resources. Monocropping of sugarcane is highly profitable to the farmers and sugar industry as it reduces the production cost by 30-40%. But productivity of sugarcane under multiratooning is declined by 30-50% every year due to alteration of soil physical, physicochemical and biological properties which leads to reduction in cane population per hectare. Continuous use of higher doses of chemical fertilizers on the other hand raises the cost of production so high that renders the system unprofitable. Adoption of proper management practices with balanced nutrition improves soil environment in terms of soil physical, chemical and biological properties. Keeping these points in view, the present study was undertaken to study the effect of different agronomic and nutrient management practices for sustainable soil and crop productivity under sugarcane monocropping. A field experiment was conducted at Regional Agricultural Research Station, Anakapalle, Andhra Pradesh with a variety 2001A63 since 2011-2012 onwards in an Inceptisols. Results revealed that, irrespective of the year of ratooning, plots which received 50% recommended dose of chemical fertilizers + 25% nitrogen though vermicompost + 25% nitrogen through green manure incorporation resulted in the higher organic carbon content and microbial load compared to chemical fertilizers alone. With increasing the levels of nitrogen the available nitrogen is increasing, There was no particular trend was observed in case of available phosphorus, however highest available phosphorus and potassium status was recorded in the plots with 150% RDFN. Results on soil biology under sugarcane monocropping (3rd ratoon) revealed that significantly highest microbial population *i.e. Azospirillum* (314×10^3 c.f.u. g^{-1} soil), *Azotobacter* (245×10^3 c.f.u. g^{-1} soil) and PSB (660×10^3 c.f.u. g^{-1} soil) was recorded in the treatment which received 50% RDFN + 25% N though vermicompost + 25% N green manure incorporation, where as lowest *Azospirillum* and *Azatobactor* population counts were recorded in the plots with 200% recommended dose of chemical fertilizers and lowest counts of phosphorus solubilizing bacteria were recorded in 100% chemical fertilizer treatment. There was no particular trend observed in between the increased levels of nitrogen fertilizers, however the plots received organic nutrient sources recorded highest microbial counts when compared to chemical fertilizers alone. The results on cane and sugar yields were increased with increasing levels of nutrient doses. Among different treatments highest cane yield of 68.71 t ha^{-1} and sugar yield of 8.62 t ha^{-1} was recorded with 150% recommended dose of chemical fertilizers. It can be summarized that inclusion of different organic sources *i.e.* vermicompost, cane trash *insitu* decomposition, green manure incorporation and need based foliar sprays of nutrients in sugarcane multi-ratoon system enhanced not only the soil physical properties, soil organic carbon and microbial activity but also adequately met the nitrogen requirement leading to similar yield as with plant crop.

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Combined Application of Fertilizers and Manures on Crop Productivity of Sunflower in Century Old Permanent Manurial Experiment of Coimbatore

M. Elayarajan, S. Sathya, M. Malarkodi and K. Arulmozhiselvan
Department of Soil Science and Agricultural Chemistry,
Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

The Permanent Manurial Experiment is being conducted at Tamil Nadu Agricultural University, Coimbatore which is the oldest one in India, similar to Permanent Manurial Experiments of Rothamsted Permanent Manurial Experiments in U.K. This experiment was started in the year 1909. The experiment consists of 18 treatments *viz*., combination of two or more inorganic fertilizers nutrients with or without organic manures, having plot size of 100 m^2, imposed as non replicated plot. The main objective of the experiment is to investigate the effect of continuous application of fertilizer nutrients either singly or combination of two or three nutrients with and without organic manure on yield, uptake and available nutrient status of soil. Application of recommended dose of 100 per cent NPK along with farmyard manure at 12.5 t ha^{-1} (INM) recorded the highest sunflower hybrid seed yield of 1702 kg ha^{-1} and stalk yield of 2213 kg ha^{-1}, which was comparable to yield recorded under STCR-IPNS. The INM practice recorded its superiority by recording 24.3 and 142.8 per cent increase in grain yield and 12.62 and 67.52 per cent increase in straw yield over 100% NPK and control respectively. Application of organic manures alone and sole application of inorganic fertilizers did not produce higher yield like that of balanced fertilization and INM practice. Similarly, total NPK uptake by sunflower was also found to be high in INM practice. Regarding the pH and EC, there was not observed changes in all the treatments. Continuous application of fertilizer nutrients along with organic manures had a profound effect on available nutrients and organic carbon status in post harvest sunflower hybrid grown soil. The results also revealed that the status of organic carbon, available nitrogen and available 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 (30.3 kg ha^{-1}) followed by INM and STCR-IPNS. When compared to balanced NPK fertilization, skipping of any one or two of the fertilizer nutrients reduced remarkably the available nutrient status of soil.

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Crop Productivity of Maize Crop in Four Decades of Long Term Fertilizer Experiment of TNAU, Coimbatore

K. Arulmozhiselvan, M. Elayarajan, M. Malarkodi and S. Sathya
Department of Soil Science and Agricultural Chemistry, Directorate of Natural Resource Management, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

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. Thehighest 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, P_2O_5 and K_2O ha^{-1} is followedfor 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 (3.36 t ha^{-1}) during 1992-97. Among the treatments the highest grain yield was recorded in 100% NPK+FYM (INM) (3.30 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 (2.99 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 1.60 to 5.0 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 (3.85 t ha^{-1}), which was 19.2 per cent higher than the yield (3.23 t ha^{-1}) recorded under 100% NPK. Application of 150% NPK recorded grain yield of 3.54 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 (1.51 t 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 (3.23 t ha^{-1}) and 100% NP (3.07 t ha^{-1}) were similar, indicating least requirement of fertilizer K addition.

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Optimizing Nutrient Management for Drip Irrigated Mature Cashew Plantations

T.R. Rupa*, D. Kalaivanan, Vijay Singh and B.R. Srividya
ICAR-Directorate of Cashew Research, Puttur, 574 202, Karnataka
**Email: sairupa.tr@gmail.com*

A field experiment was carried out in 9 year old cashew plantation variety 'Bhaskara' at the Experimental Farm of ICAR-Directorate of Cashew Research, Puttur, Karnataka during 2009-2013 to find out the most efficient and economic combination of different nutrients and method of biofertilizer consortia application to mature cashew plantations. The experiment was laid out in a split plot design with four main plots (method of biofertilizer application) *viz.,* M1:No inoculation; M2:Biofertilizer consortia (*Azospirillum, Acetobacter,* PSB and AMF 50 g each/tree) 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, and five sub plots (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 (135g N, 39g P_2O_5, 34 g K_2O and FYM 5.6 kg /tree/annum) and T5) Soil test based fertiliser recommendation (Major nutrients through inorganic fertilizers) through drip. In the present study, the soil microbial population showed signiûcant changes in response to method of biofertilizer consortia application. Inoculation of biofertilizer consortia both to the tree basin at a radius of 45 cm and in the rectangular trenches taken in the middle of four trees (M4) followed by inoculation of biofertilizer consortia to the tree basin at a radius of 45 cm (M2) resulted in higher population of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers. On an average, the populations of bacteria, fungi, actinomycetes, N-fixers and P-solubilizers in M4 treatments were about 6.96 ($128.9 \times 10^5\ g^{-1}$); 3.47 ($50.7 \times 10^3\ g^{-1}$); 2.11 ($38.3 \times 10^5\ g^{-1}$); 3.44 ($65.0 \times 10^2\ g^{-1}$) and 4.72 ($40.1 \times 10^4\ g^{-1}$) times higher over control. Evaluation of method of biofertilizer consortia application demonstrated signiûcant changes in the nut yield. On an average, there was a cumulative nut yield response of 8.6, 3.4 and 14.4 per cent with the application of biofertilizer consortia to the tree basin at a radius of 45 cm (M2), application of biofertilizer consortia in the rectangular trenches taken in the middle of four trees (M3) and application biofertilizer consortia both to the tree basin at a radius of 45 cm and in the rectangular trenches taken in the middle of four trees (M4), respectively. Three fertilizer doses *i.e.* 100% of recommended NPK + FYM (T4) (39.43 kg $tree^{-1}$), 75% of recommended NPK + FYM (T3) (38.29 kg $tree^{-1}$) and soil test based fertilizer recommendation (T5) (38.11 kg $tree^{-1}$) produced higher and almost at par cumulative nut yield for 4 years in two methods of biofertilizer consortia application *i.e.* M4 and M2. The increase in cumulative nut yield with fertilizer doses and method of biofertilizer consortia application over control plot (M1T1) was 17.8, 23.8, 21.0, 27.3, 31.1 and 26.7 per cent with M2T3, M2T4, M2T5, M4T3, M4T4 and M4T5 treated plots, respectively. The treatment M4T4 resulted in maximum net profit of Rs. 2,24,435/- ha^{-1}, followed by M4T3 (Rs. 2,16,570/- ha^{-1}). The treatments M2T3, M2T4, M2T5, M4T3, M4T4 and M4T5 have been found economically better with a B:C ratio of 4.81, 5.03, 5.07, 4.81, 4.93 and 4.90, respectively. The results of the present study indicated that application of biofertilizer consortia [*Azospirillum*, *Acetobacter*, Phosphate solubilizing bacteria and AMF) at a radius of 45 cm along with 75% of recommended dose is found to be the best nutrient management strategy for drip irrigated mature cashew plantations in terms of maximum profit.

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Leaf Nutrient Composition, its Correlation with Yield of Commercial Grape Varieties as Influenced by Grape Rootstock and Own Root

D. Vijaya and G. Ram Reddy
AICRP (F) on Grape, SKLTHU R'Nagar, Hyderabad

An experiment was conducted during 2014-15 at AICRP on Grape, SKLTSHU, RajendraNagar, Hyderabad (Telangana) to study the petiole nutrient content of commercial grape varieties its correlation with yield as influenced by different rootstocks. Different treatments consisted of Thompson Seedless, Flame Seedless and Kishmish Chorni grafted on three rootstocks (1103 P, SO4 and Dog Ridge) and own root as control. The experiment was laid in a randomized block design with four replications and four vines under each replication. Around 60 petioles from each replication were collected from the 5th leaf during bud differentiation stage and were analyzed for the nutrient content. The results showed there was significant influence of rootstock on the yield and nutrient composition of grape varieties with different grape varieties recording higher yield and nutrient composition with different rootstock composition. Higher yield was recorded with Kishmish Chorni on 1103 P which was on par with Kishmish Chorni on Dogridge, Flame Seedless on 1103 P and Thompson Seedless on own root. Similarly even with respect to nutrient composition interaction effect was significant with Thompson Seedless on SO4 recording the highest N content at bud differentiation whereas, at full bloom stage Thompson Seedless and Flame Seedless on own root and Kishmish Chorni on 1103P were on par with each other. In case of P,Thompson Seedless on own root recorded significantly highest P at both stages. Significantly highest K was recorded with Kishmish Chorni on own root at full bloom stage. Thompson Seedless on SO4 and Flame Seedless on own root recorded significantly highest Ca at bud differentiation and full bloom respectively. Thompson Seedless on 1103P and Dogridge and Flame Seedless on 1103P recorded higher Fe content. Thompson Seedless on own roots recorded highest Zn at both the stages. Yield of the scion varieties Thompson Seedless, Flame Seedless and Kishmish Chorni raised on three different rootstocks and on their own root was correlated with petiole nutrient concentration of grape varieties. There was negative correlation between petiole N concentration and yield except in case of Thompson Seedless where a positive correlation was obtained between yield and N accumulation in the petioles at full bloom stage (r = 0.68) indicating that whichever rootstock absorbed more N during full bloom recorded more yield . The yield of all three varieties had positive correlation with the petiole P content of scions raised on different rootstocks and ownroot. There was no strong correlation in case of petiole K content however the relation was negative during bud differentiation and positive during full bloom stage and it was vice versa in case of Ca. In case of micronutrients there was strong positive correlation between yield of Thompson Seedless and Zn accumulation in the petioles at both stages (r = 0.50).

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Study on Micro, Secondary and Heavy Metals Content in Edible Part of Crops Growing in Ranchi District

D.K. Shahi, Arvind Kumar and N.K. Roy
Department of Soil Science and Agricultural Chemistry,
Birsa Agricultural University, Ranchi, 834006, Jharkhand

Ranchi district is hub of vegetable cultivation and it is main enterprise to sustain livelihood of farmer in the district. Due to increasing intensive cropping, low use of organic matter and unbalanced use of high analysis fertilizer, fertility status of the cultivable soil declining day by day. So, it is need of present scenario to reassess fertility status, its management and translocation of nutrients in soil, plant and animal continuum. To study the content of micro, secondary and heavy metals, 63 plant samples were collected from different blocks of Ranchi district. Interestingly among 63 plants samples (edible part) S, Ca, Mg, B, Zn, Cu, Fe, Mn, Pb Ni and Co content (mg kg^{-1}) were found maximum in mustard (*Brassica juncea*) than that of other crops. As per maximum permissible concentration of heavy metals in different food material, most of the analyzed heavy metal found below the permissible limit in edible part of crops. On the basis of Fe, Zn, Cu and Mn analysis mean value in edible parts of vegetables and spices, it was calculated that if farmers of study areas intake is 200 g fresh mixed vegetable and spices in their diet per day, would not fulfill the requirement a healthy human as per prescribed nutritional diet.

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Improving Fertilizer Use Efficiency by Crop Plants Employing Engineered Nanoparticles: An Overview

Kuldeep Singh*, Naleeni Ramawat and Brijesh Kumar
Amity Science, Technology and Innovation Foundation,
Amity University, Sector-125, Noida 201303, Uttar Pradesh
**Email: ksing6@amity.edu*

Research in nanotechnology can benefit society through applications in agriculture. Nano-scale materials and devices are found in a growing number of applications offering numerous opportunities as well as challenges. The use of nanotechnology in agriculture has only begun to be appreciated. The potential benefits of nanotechnology will continue to drive this growing market into all realms of society including agriculture, nutrition and health. In the last decades nano-materials have attracted a great deal of attention due to their many technologically interesting properties. Manufactured nano-particles (NPs) have a wide range of application due to the unique properties compared with their bulk counter parts. Several reports are available for the production of highly productive nano fertilizers to boost agricultural production. Nano-fertilizers can supply essential nutrients for plant growth, have higher use efficiency and can be delivered in a timely manner to a rhizospheric target or by foliar spray. Nano-materials can be used in producing more soluble and diffusible sources of fertilizers. Higher specific surface area and reactivity of NPs compared to bulky fertilizer may improve their solubility, diffusion in soil and hence better availability to plants. The impact of nano-fertilizer products like ZnO-NPs on physiological biochemical, nutritional and morphological changes in plants and the fate of nano-products in soil and plant system have to be studied. During the last years, some works have been published about absorption and uptake of nano-particles by plants, dealing with their putative adverse effects. At the same time reports underline positive or no adverse effects of NPs on higher plants are also emerging in larger numbers. In order to understand the possible benefits of applying nanotechnology to agriculture, the first step will be to analyze penetration and trans-port of nano-particles in the plants. Whether Zn nano-particles accumulate or enhance plant Zn uptake which may result in increased storage of Zn in vegetative tissues or also in grains in sufficient quantity and increase the Zn use efficiency in plants can only be ascertained in long term experiments covering the whole life cycle of the crop plants. New prospects for integrating nanotechnologies into fertilizers should be explored, cognizant of any potential risk to the environment or to human health. Clearly more research work is needed on the application of nanotechnology to agriculture in general and relationship between plants and nano-materials in particular.

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Effect of Integrated Phosphorus Management on Yield of Pigeonpea under Dryland Conditions

V.M. Amrutsagar, A.S. Takate, B.D. Tamboli and A.B. Pawar
Zonal Agricultural Research Station, Solapur, 413002, Maharashtra
**Email: vijayamrutsagar@rediffmail.com*

A field experiment was conducted during the year 2010 to 2014 at Dry Farming Research Station, Solapur to study the effect of integrated phosphorus (P) management on yield of pigeonpea on Inceptisol under dryland conditions. The experiment was laid out in randomized block design with six treatment and four replications. The soil of experimental plot was clayey in texture with pH 7.22, EC 0.22 dS m^{-1}, organic carbon 0.49%, available N, P and K 151, 12.7 and 620 kg ha^{-1}, respectively. Different doses of pressmud cake (PMC) along with chemical fertilizer were assessed in pigeonpea (cultivar Vipula). The treatment consist of T_1: Control, T_2:RDF (25:50 N: P_2O_5 kg ha^{-1}), T_3: RD of P through PMC, T_4: 2/3 RD of P through PMC+1/3 RD of P through chemical fertilizer, T_5:1/2 RD of P through PMC+1/2 RD of P through chemical fertilizer, T_6:1/3 RD of P through PMC+2/3 RD of P through chemical fertilizer ha^{-1}. The pooled result revealed that application of ½ RD of P through PMC+ ½ RD of P through chemical fertilizer recorded significantly higher grain and straw yield (9.07 and 49.89 kg ha^{-1}), water use efficiency (1.81 kg ha^{-1} mm), total nutrient uptake (72.7, 12 and 75.5 N, P and K kg ha^{-1}, respectively). The application of 2/3 RD of P through press mud cake + 1/3 RD of P through press mud cake significantly recorded higher values of N, P and K (189, 19.0 and 642 kg ha^{-1}, respectively). The yield contributing character like number of branches per plant, number of pods per plant and as well as 100 grain weight showed significant result. From the present studies, it is inferred that application of 50% RD of P through PMC + 50% RD of P through chemical fertilizer was beneficial for increasing pigeonpea yield and improving soil fertility status of soil and B:C ratio.

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Effect of Levels of Mangala Setright in Sodic Soil on Growth and Yield of Rice and Soil Properties

K.M. Prakhyath, S.S. Prakash, S.B. Yogananda, R. Krishna Murthy and N. Srinivasa

Department of Soil Science and Agricultural Chemistry,
College of Agriculture V.C. Farm, Mandya, Karnataka

A field experiment was conducted during *kharif* 2014 at ZARS, V. C. Farm, Mandya to study the effect of levels of Mangala Setright in sodic soil on growth and yield of rice and soil properties. The experiment was laid out with nutrient management practices (RDF, STCR, and SSNM) as main plot and amendments (gypsum, pressmud and mangala setright) as subplot treatment under split plot design. The mangala setright was used at four levels *viz*., 200, 400, 600 and 800 kg ha^{-1} and gypsum and pressmud at 100 percent GR. The initial characteristics of experiment field were: pH- 8.96, EC- 1.22 dS m^{-1}, exchangeable Na – 5.53 cmol(p^{+})kg^{-1}, ESP – 22.6%. The results revealed that application of pressdmud @ 100 % GR recorded higher panicle length, grains per panicle and test weight (16.88 cm, 99.11 and 20.41 g, respectively) compared to no amendment control and other amendment treatments. Whereas, highest number of panicles, and productive tillers per hill (12.44 and 12.44, respectively) were recorded due to application of setright @ 600 kg ha^{-1}.

Application of RDF recorded significantly higher grain yield (2.27 t ha^{-1}) as compared to SSNM (2.11 t ha^{-1}) and STCR (2.15 t ha^{-1}) treatment. Significantly higher grain and straw yield of rice (2.59 t ha^{-1} and 6.04 t ha^{-1}, respectively) were recorded on application of pressmud @ 100% GR over control but it was on par with application of 400 kg ha^{-1}setright (2.46 t ha^{-1}). Application of RDF with pressmud @ 100% GR significantly increased the grain and straw yield of rice (2.93 t ha^{-1} and 6.23 t ha^{-1}, respectively) followed by RDF + sertight @ 600 kg ha^{-1} (2.90 and 5.40 t ha^{-1}, respectively) compared to other combinations. A significant reduction in soil pH (8.50) was recorded due to application of gypsum @ 100 % GR and while exchangeable sodium and ESP were reduced significantly due to application of setright @ 400 kg ha^{-1} treatment (1.78 cmol(p^{+})kg^{-1} and 6.52, respectively). The available nutrient content was increased due to amendments application and nutrient management practices after harvest of the crop. Highest N and K content were recorded in RDF treatment and P was in SSNM treatment. Among the different amendment application, most of the macronutrients availability was higher in treatment of pressmud @ 100% GR. whereas micronutrients was higher in setright and gypsum amended plots. Thus, application of pressmud @ 100% GR or setright @ 400 kg ha^{-1} along with RDF is more beneficial in enhancing the crop yield as well as correcting soil sodicity.

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Influence of Nutriseed Pack Placement on Yield and Nutrient Uptake of Rice

N. Kalaiselvi[1] and K. Arulmozhiselvan[2]

[1]National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore, Karnataka
[2]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

Nutriseed pack is an innovative manifestation of fertilizer application to reduce labour cost and is a small tubular assembly consisting seed with bio inoculants on top, manure pellet in middle and fertilizer pellet at bottom. A field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore to evaluate the effect of levels of major nutrients and phosphorus (P) fertilizer sources used in Nutriseed Packs on nutrient uptake and yield of rice under puddled condition during 2012-2013. The experimental soil was clay loam in texture classified taxonomically as Typic Haplustalf of Noyyal series. Available nutrient status of the soil was low in nitrogen (N), medium in P and high in potassium (K). The experiment consisted of seven treatments which were replicated thrice in randomized block design. The treatments are, T_1-100% NP(DAP)K as Nutriseed Pack, T_2-75% NP(DAP)K as Nutriseed Pack, T_3- 100% NP(SSP)K as Nutriseed Pack, T_4- 75% NP(SSP)K as Nutriseed Pack,T_5-100% NPK surface application of fertilizers, T_6- 75% NPK surface application of fertilizers, T_7- Control (No fertilizers). The results revealed that deep placement of nutrients as Nutriseed Pack with DAP as P source (T_1) recorded the highest grain and straw yield of 5.82 and 7.88 t ha^{-1} which was followed by 100% NP(SSP)K as Nutriseed Pack. Unfertilized control recorded a lower value of grain and straw than other treatments. Nutriseed Pack as 100% NP(DAP)K or 100% NP(SSP)K proved its superiority by recording 93 and 80 per cent increased grain yield over control, respectively and 18 and 9 per cent increase over surface broadcast method. With the advancement of growth stages of rice, height and dry matter production increased progressively from tillering to harvesting stage. Invariably at all stages, placement of 100% NP(DAP)K as Nutriseed Pack recorded the highest dry matter production which was followed by the treatment 100% NP(SSP)K as Nutriseed Pack. Yield attributes were also found to be high in Nutriseed Pack with DAP. The nutrient uptake of rice crop was recorded higher in 100% NP(DAP)K as Nutriseed Pack compared to all the treatments. The increased doses of fertilizers had shown their direct influence on nutrient uptake by increasing the uptake of nutrients. But the different sources of P *viz.*, DAP and SSP did not shown any significant difference in nutrient uptake of rice. Overall the higher grain yield and nutrient uptake were recorded in Nutriseed Pack treatments than surface application and control.

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Effect of Integration of Chemical and Biofertilizers on the Availability of Nitrogen and Phosphorus in the Soil and Growth of Young Natural Rubber Plants

M. Joseph, K. Joseph, J. Mathew, G. Hareeshbabu and R.S. Elias
Rubber Research Institute of India, Rubber Board, Ministry of Commerce and Industries, Kottayam, 686009, Kerala

The highly weathered acid soils of South India subjected to continuous cultivation of natural rubber (*Hevea brasiliensis*) have medium to high organic matter status. This is largely attributed to luxuriant growth of leguminous cover crop planted along with rubber which cover the inter row area completely by the second year and lasts for four to five years till the canopy of the rubber closes. Build -up of phosphorus (P) was recorded in these soils due to the regular application of P-fertilizer. However, imbalance in nutrient availability and declining soil fertility is observed in recent years. Our hypothesis was that integration of chemical fertilizers with biofertilizers will improve the availability and uptake of nutrients and thus improve the growth of plants, with the added advantage of reducing the use of chemical fertilizers and sustaining soil health. Field experiment with young natural rubber plants was conducted at two locations for four years. The first location had high and the second location had medium organic carbon content. The experiment was laid out in randomised block design with three replications and the treatments were graded levels of nitrogen (N) and P in combination with bioinoculants, bioinoculants alone (as per the general recommendations of natural rubber) and also no fertilizer control. Nitrogen and P treatments along with common dose of potassium (K) and magnesium (Mg) as per the general recommendation was applied in the form of urea, rock phosphate, muriate of potash and magnesium sulphate, respectively, once during September in the first year of planting and during June and September from second year onwards. The bioinoculants were isolates of *Azotobacter sp.*, phosphobacteria (*Bacillus sp.*), PGPR (*Pseudomonas sp.*) isolated from rubber rhizosphere by Rubber Research Institute of India and arbuscular mycorrizal fungus (AMF) from The Energy and Resources Institute, New Delhi. Twenty gram each of lignite based preparation of *Azotobacter*, phosphobacteria and PGPR having 10^8 cells g^{-1} and 5 g of AMF having 200 propagules g^{-1} were applied at the time of planting during the first year and twice during the subsequent years with a gap of 21 days between the chemical fertilizer application and bioinoculant application. Growth of rubber plants did not show significant difference between the treatments indicating lack of response of rubber plants to applied nutrients. Ammoniacal N was improved by biofertilizer treatments either alone or in combination with chemical fertilizers. The beneficial effect of phosphorus solubilizers on P transformation was indicated through the significant difference in the P fractions, especially Fe-P fraction. Differential response was recorded between locations on the major P fractions. The positive effect was more pronounced in location one where the organic carbon status of the soil was high. The influence of fertilizer P was directly reflected on the Ca-P fraction. Nitrogen concentration in the leaves was high in treatments where N was applied in combination with bioinoculants and in bioinoculants alone application. Yet this did not lead to any improvement in growth compared to the other treatments. Better understanding of the nutrient dynamics, having continuous uptake even from the deeper layers of the soil and from the slowly available inorganic fractions and organic forms is required to explain the soil test crop response correlation in a perennial crop like natural rubber.

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A Comparative Study on Different Silicon Sources on Growth and Silicon Content of Wet Land Rice

T.S. Sandhya and N.B. Prakash*
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengalore, Karnataka
**Email: nagabovanalliprakash@rediffmail.com*

Continuous and intensive cultivation of rice can deplete the available pool of silicon (Si) in the soil and to replenish this, addition of different Si sources have been suggested. Iron and steel mill slags and rice residues are rich sources of Si and largely available in India. A greenhouse study was conducted to know the effect of different Si sources on Si content, growth and yield of wet land rice under acidic and alkaline soil condition. Five Si sources used were calcium silicate (CS), EAF slag, LF slag, rice husk (RH) and rice husk ash (RHA) with a Si content of 10.82, 7.20, 2.20, 7.67 and 34.84% respectively and applied at two levels (250 and 500 kg Si ha^{-1}). All the source materials were milled to < 0.2 mm sieve size.

The application of Si sources and levels had a significant effect on the Si content, growth and yield of rice. In acidic soil, highest Si content in straw and grain was obtained with RH treatment (7.54 and 4.21%), followed by RHA, EAF slag, CS and LF slag. Significant increase in total Si uptake was observed with RH (1.71 g pot^{-1}), EAF slag (1.18 g pot^{-1}), CS (1.14 g pot^{-1}) and RHA (0.89 g pot^{-1}) compared to control. In alkaline soil, highest Si content in straw was recorded with RHA (8.24%), and on par with EAF slag (8.13%) followed by RH and CS treatments. Significantly higher grain Si content was noticed in plants treated with EAF slag (4.53%), CS (4.47%), RHA (4.34%) and RH (3.98%). Plants treated with RH (0.69 g pot^{-1}) and EAF slag (0.64 g pot^{-1}) achieved highest total Si uptake in alkaline soils. The highest content and uptake of Si was recorded when Si sources applied at 500 kg Si ha^{-1} both in acidic and alkaline soils. Although, plant height was highest with RH treatment in both acidic and alkaline soils, significant reduction in plant height was observed with application of LF slag and RHA in acid soil and with LF slag and CS in alkaline soil. In alkaline soil, higher SPAD readings were recorded with the application of RH (41.50), EAF slag (36.03) and CS (35.67) compared to control (19.60). In acidic soil, there was a significant increase in number of filled grains and test weight with RH, EAF slag and CS treatments and with EAF slag and RH treatments in alkaline soil. In acid soil highest grain (9.09 g pot^{-1}) and straw (18.77 g pot^{-1}) yield was noticed with RH @ 500 kg Si ha^{-1} followed by CS and EAF slag @ 500 kg Si ha^{-1}. Treatment with RH @ 500 kg Si ha^{-1} and EAF slag @ 500 kg Si ha^{-1} recorded highest straw and grain yield respectively in alkaline soil. There was a significant increase in plant available Si in both acidic and alkaline soil with the application of RH, CS, EAF slag and RHA with an exception to LF slag.

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Validation of Soil Test Crop Response-based Integrated Plant Nutrition System for Hybrid Cotton through Drip Fertigation on Inceptisol

R.Santhi*[1], S. Praveena Katharine[1], S. Maragatham[1], K.M. Sellamuthu[1] and Pradip Dey[2]
[1]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, 641 003, Tamil Nadu
[2]ICAR-Indian Institute of Soil Science, Bhopal, 462 038, Madhya Pradesh
**Email: santhitnau@yahoo.co.in*

The increasing demand for the cultivation of hybrid cotton coupled with signs of nutrient mining, decline in fertilizer use efficiency, escalating cost of fertilizers, stagnation in crop productivity and shrinking water resources in different parts of our country are to be relooked so as to achieve higher crop productivity with sustained soil health. In this context, soil fertility evaluation under drip fertigation plays a major role for mitigating the above issues and provides valuable guidance to various stakeholders for judicious nutrient and water use. Therefore, by adopting inductive cum targeted yield methodology, fertiliser prescription equations (FPEs) under IPNS were developed for Vertic Ustropept (mixed black calcareous soils) under drip fertigation. The FPEs are FN = 8.51 T - 0.47 SN - 0.73 ON ; FP_2O_5 = 4.41 T - 2.25 SP - 0.75 OP; FK_2O = 6.59 T - 0.18 SK – 0.66 OK; where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T is the yield target in q ha^{-1}; SN, SP and SK, respectively are alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg ha^{-1} and ON, OP and OK are the quantities of N, P and K supplied in kg ha^{-1} through FYM. With a view to verify the FPEs, validation experiments were conducted with hybrid cotton at TNAU Farm, Coimbatore during 2012-2013 and at two farmers' holdings of Salem district (North Western zone) of Tamil Nadu during 2014-15 on Vertic Ustropept (mixed black calcareous soils). There were nine treatments *viz.,* blanket, STCR-NPK alone - 3.0, 3.5 and 4.0 t ha^{-1}, STCR-IPNS (NPK + FYM @ 12.5 t ha^{-1}) - 3.0, 3.5 and 4.0 t ha^{-1}, farmer's practice and absolute control. The sources of fertilizers for N, P_2O_5 and K_2O were urea, SSP and MOP, respectively. The results revealed that the targeted yield has been achieved within ±10 per cent variation proving the validity of the equations. The highest mean yield of 3.97 t ha^{-1} of seed cotton was recorded in STCR-IPNS - 4.0 t ha^{-1} with an increase of 41.3 and 44.9 per cent, respectively over blanket and farmer's practice. Further, it has proved its superiority over all other treatments in terms of RR, BCR and quality parameters. Post-harvest soil fertility resulted in buildup of soil available N, P and K and the magnitude of build-up was higher with STCR-IPNS as compared to STCR-NPK alone, blanket and farmer's practice. Therefore, targeting of 4.0 t ha^{-1} for hybrid cotton under IPNS through drip fertigation is found to be ideal on Vertic Ustropept soils.

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Effect of STCR-IPNS Prescriptions for Rice under SRI on Yield and Enzymatic Activities on an Alfisol

Neethu Thankam[1], R. Santhi[1]*, S. Maragatham[1], K.M. Sellamuthu[1] and Pradip Dey[2]
[1]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore , 641 003, Tamil Nadu
[2]ICAR-Indian Institute of Soil Science, Bhopal, 462 038, Madhya Pradesh
**Email: santhitnau@yahoo.co.in*

Effective nutrient management is considered as a key factor to sustain the productivity of crops which can prevent nutrient mining and environmental degradation thereby improving the soil health. Therefore, fertilizer prescriptions should be based on magnitude of crop response to applied nutrients at different soil fertility levels. At this juncture, soil test crop response based integrated plant nutrition system (STCR-IPNS) is one of the best nutrient management technologies for achieving yield enhancement of crops through balanced nutrition with sustained soil fertility. In this regard, a field experiment with rice (var. White Ponni) under SRI was conducted during 2013-14 on Noyyal soil series (Typic Haplustalf) at farmer's holding of Ikkarai Boluvampatti village, Thondamuthur block, Coimbatore district. The experiment comprised of nine treatments *viz*., blanket recommendation, STCR-NPK alone @ 6, 7 and 8 t ha^{-1}, STCR-IPNS @ 6, 7 and 8 t ha^{-1} (NPK + FYM @ 12.5 t ha^{-1}), farmer's practice and absolute control with three replications in randomized block design.

Among the nine treatments, the highest grain yield of 6.51 kg ha^{-1} was recorded in STCR-IPNS - 7 t ha^{-1} which proved its superiority by recording an yield increase of 37.1 and 41.2 per cent over blanket and farmer's practice respectively. The results clearly revealed that the per cent achievement of yield targets was within ± 10 per cent variation at 6 and 7 t ha^{-1} yield target levels proving the validity of the existing fertiliser prescription equations for rice (var. White Ponni) under SRI up to 7 t ha^{-1} yield target. Among the treatments, STCR-IPNS - 7 t ha^{-1} performed better in terms of RR and BCR. With regard to enzymatic activities, irrespective of the treatments, the urease, alkaline phosphatase and dehydrogenase activities increased steadily from active tillering to flowering stage and declined at harvest stage. Irrespective of stages, higher activity was recorded in STCR-IPNS-7 t ha^{-1}, which was on par with STCR-IPNS-8 t ha^{-1} and was significantly higher than all other treatments. At all stages of crop growth, STCR-IPNS treatments recorded comparatively higher enzymatic activities than STCR-NPK alone and significantly higher than blanket, farmer's practice and absolute control which might be due to combined application of FYM with balanced supply of inorganic sources of nutrients. The correlation between urease activity and grain yield (r=0.961**) and total N uptake (r=0.975**), P uptake (r=0.963**) and K uptake (r=0.979**) was significant and positive which indicated the synergistic effect of urease activity on grain yield and uptake. Similar to urease, the correlation between alkaline phosphatase and grain yield was also found to be positive and significant, which indicated the important role of the phosphatase enzyme in P availability. A highly significant and positive correlation was observed between dehydrogenase activity and grain yield (r=0.950**) and N uptake (r=0.963**), P uptake (r=0.974**) and K uptake (r=0.980**) which imply the significant role of biota in enhancing the nutrient availability towards higher yield and nutrient uptake by rice.

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Balanced Fertilizer Prescription through IPNS for Glory lily on an Alfisol

K.M. Sellamuthu[1], R. Santhi[1], S. Maragatham[1] and Pradip Dey[2]

[1]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

[2]ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

**Email: kmsella75@gmail.com*

Fertilizer prescription equations (FPEs) were developed for glory lily under IPNS on Palaviduthi series (Typic Rhodustalf) of Tamil Nadu. FPEs under IPNS are FN = 41.45 T - 0.53 SN – 0.71 ON; FP_2O_5 = 23.21T - 2.07 SP - 0.81 OP ; FK_2O = 30.45 T - 0.21 SK - 0.64 OK; where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T is the yield target in t ha^{-1} ; SN, SP and SK, respectively are alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-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. To validate the FPEs test verification trials were conducted in four locations during *rabi* 2015 in Dindigul District, Tamil Nadu. There were nine treatments *viz.*, blanket, STCR-NPK alone for 5.5, 6.5 and 7.5 q ha^{-1}, STCR -IPNS for 5.5, 6.5 and 7.5 q ha^{-1} and farmer's practice and control. Based on the initial soil test values of available N, P, K and yield targets aimed, fertilizer doses were calculated and applied for STCR treatments. For IPNS treatments, 12.5 tonnes of FYM were applied basally and fertilizer N, P_2O_5 and K_2O doses were adjusted accordingly. Using the data on seed yield and fertilizer doses applied, per cent achievement and response ratio (RR) and B:C ratio were worked out. Post-harvest soil samples were collected and analyzed for available N, P and K status.

The results indicated that the seed yield in the first year crop at Location I and II, STCR-IPNS-6.5 q ha^{-1} had recorded relatively higher seed yield (658 and 656 kg ha^{-1}) with a mean increase in yield of 34.9 and 43.1 per cent, respectively over blanket and farmer's practice. The seed yield in the second year crop at Location III & IV indicated that, STCR-IPNS-7.5 q ha^{-1} had recorded relatively higher seed yield (760 and 745 kg ha^{-1}) with a mean increase in yield of 31.2 and 40.6 per cent, respectively over blanket and farmer's practice. The highest B:C ratio of 1.63 in first year and 1.76 in second year was recorded under STCR-IPNS treatment with yield targets of 6.5 and 7.5 q ha^{-1}, respectively. Post-harvest soil fertility values of $KMnO_4$-N, Olsen-P and NH_4OAc-K indicated the build-up and maintenance of soil fertility due to soil test based fertilizer recommendation under IPNS. The fertility status was maintained in STCR-IPNS as compared to STCR-NPK alone.

The results of the verification trials revealed that the targeted yield has been achieved within ±10 per cent variation proving the validity of the equations. Hence, soil test crop response based fertilizer prescriptions under integrated plant nutrition system (STCR-IPNS for 6.5 q ha^{-1} in first year and 7.5 q ha^{-1} in second year) *i.e.* application of N, P_2O_5 and K_2O based on initial soil test values along with FYM @12.5 t ha^{-1} can be recommended for achieving higher yield, response ratio and BCR with glory lily on Palaviduthi series (red non-calcareous) with sustained soil fertility.

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

K.M. Sellamuthu[1]*, R. Santhi[1], S. Maragatham[1] and Pradip Dey[2]

[1]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu

[2]Indian Institute of Soil Science, Bhopal, Madhya Pradesh

**Email: kmsella75@gmail.com*

Field experiments were conducted to evaluate the fertilizer prescription equations (FPEs) for rainfed maize in red sandy loam (Typic Ustropept), non-calcareous soil based on targeted yield model. The FPEs under IPNS are FN = 32.3 T - 0.42 SN - 0.52 ON ; FP_2O_5 = 15.1 T - 1.98 SP - 0.94 OP ; FK_2O = 17.3 T - 0.21 SK - 0.48 OK ; where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T is the yield target in t ha^{-1} ; SN, SP and SK, respectively are alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-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. Field experiments were carried out at six farmers' holding in Dindigul District (Southern one) of Tamil Nadu during *rabi* 2014 and 2015 with TNAU Maize hybrid Co 6. There were nine treatments *viz.*, blanket, STCR-NPK alone for 4 to 6 t ha^{-1}, STCR -IPNS for 4 to 6 t ha^{-1} and farmer's practice and control. Based on the initial soil test values of available N, P_2O_5, K_2O and yield targets aimed, fertilizer doses were calculated and applied for STCR treatments. For IPNS treatments, 12.5 t of FYM were applied basally and fertilizer N, P_2O_5, K_2O doses were adjusted accordingly. The treatments were imposed and cultivation practices were carried out periodically and the grain yield was recorded at harvest. Using the data on grain yield and fertilizer doses applied, per cent achievement and response ratio (RR) were worked out. Post-harvest soil samples were collected and analyzed for available N, P and K status.

The mean values of the six test verification trials indicated that the highest grain yield of rainfed maize was recorded with STCR-IPNS-6 t ha^{-1} (5013 kg ha^{-1}) followed by STCR-IPNS-5 t ha^{-1} (4861 kg ha^{-1}). The per cent achievement of the targeted yield was more than 90 per cent proving the validity of the equations with STCR-IPNS-5 t ha^{-1} followed by STCR-IPNS-4 t ha^{-1} and STCR-NPK-5 t ha^{-1}. The highest mean response ratio (17.47 kg kg^{-1}) and B:C ratio (2.28) were recorded in STCR-IPNS-5 t ha^{-1}. The farmer's practice recorded relatively lower yield and response ratio as compared to blanket and STCR treatments while the STCR-IPNS treatments recorded the higher per cent achievement and response ratio among all the treatments. Post-harvest soil fertility values of $KMnO_4$-N, Olsen-P and NH_4OAc-K indicated the build-up and maintenance of soil fertility due to soil test based fertilizer recommendation under IPNS. Despite higher removal of nutrients, the fertility status was maintained in STCR-IPNS as compared to STCR-NPK alone. This could be due to the prevention of losses of nutrients under IPNS, even after meeting the crop needs. Thus, the results of the verification trials confirmed the validity of fertilizer prescription equations developed for rainfed maize on Irugur series (red non-calcareous) for an yield target of 5 t ha^{-1} with sustenance of soil fertility.

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Nitrogen Management in Maize-Wheat System under Conservation Agriculture

D. Mahala, M.C. Meena, B.S. Dwivedi, Suresh Chand, G. Gena and Ashok Kumar
Division of Soil Science and Agricultural Chemistry,
ICAR-Indian Agricultural Research Institute, 110 012, New Delhi

Conservation agriculture (CA), an alternative practice that involves minimum soil disturbance, crop residue retention and crop rotation, is postulated to conserve soil organic matter (SOM), energy, irrigation water and biodiversity. On the other hand, conventional tillage practices (CT) characterized by excessive tillage, residue removal and monoculture are often associated with the degradation of soil mainly in terms of depletion of soil organic carbon (SOC), sub-soil compaction and loss of biodiversity. As fertilizer nitrogen (N) is one of the key input in food production, it is typically required in larger quantities than any other nutrients by the crop for its growth and development. Therefore, proper management of N is essential to reap high yield, profit and ultimately with safe environment. In view of scarcity of information on N management protocols under CA, a field experiment was initiated in *kharif* 2013 at IARI farm, to evaluate different N management options *i.e.* basal application of 80, 50 and 33% of total fertilizer requirement followed by need-based top dressing as suggested by GreenSeeker, and N sources and methods of application on crop yield, N uptake, N use efficiencies (NUE), and temporal changes in SOC and mineral-N in maize (*Zea mays* L.)-wheat (*Triticum aestivum* L.) cropping system under CA and CT practices. Results revealed that maize grain yield was statistically similar under both cultivation practices *i.e.* CA (7.47 t ha^{-1}) and CT (7.48 t ha^{-1}), whereas grain yield of wheat was significantly higher under CA (5.0 t ha^{-1}) than that under CT (4.71 t ha^{-1}). The N top dressing requirement as assessed by using GreenSeeker was relatively less under CA in both the crops, which ultimately curtailed fertilizer N application in this practice. Averaged across N management options, it was possible to curtail 62 kg fertilizer N ha^{-1} without any grain yield penalty in maize-wheat system. Such advantages of CA were apparently due to higher N use efficiency and better mineralization of N during the cropping period. On an average, N use efficiencies in wheat computed as agronomic efficiency (AE_N), partial factor productivity (PFP_N) and recovery efficiency (RE_N) were 23.2 kg grain kg^{-1} N, 38.4 kg grain kg^{-1} N and 52.5%, respectively under CA; the corresponding values under CT were 15.1 kg grain kg^{-1} N, 26.1 kg grain kg^{-1} N and 37.5%. Among N sources and methods of application band placement of slow release modified urea materials (*i.e.* USG and IFDC-product) resulted in higher yields and NUE compared with urea broadcasting. In CA, Walkley-Black C (WBC) and mineral-N (NH_4^+-N + NO_3^-N) contents were significantly higher compared with CT in the surface layer (0–15 cm depth). Results thus indicated superiority of CA over CT particularly with respect to increase in SOC and mineral-N content and enhancement in the NUE. The benefits associated with CA present a greater potential for its adoption to sustain soil health and crop productivity of maize–wheat cropping system.

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Effect of Urea Phosphate Foliar Spray on Yield and Yield Attributing Characteristics of Rice Grown in Acidic Soil of Odisha

M. Monica, A.K. Dash and N. Panda
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha

A field experiment was conducted in the farmer's field at Delang block of Puri district during *kharif* season of 2014 in order to study the effect of urea phosphate foliar spray on yield and yield attributing characteristics of rice. The soil of the experimental site was sandy loam, acidic in nature (pH 4.95) with medium organic carbon content (6.3 g kg^{-1}). The soil is low in available nitrogen (193 kg ha^{-1}), phosphorus (18.7 kg ha^{-1}) and potassium (194 kg ha^{-1}). The rice (Cv. - Swarna) seedling was transplanted in the field in a randomized block design with 3 replications and 10 treatments. These treatments were *viz*., T_1: control; T_2 : 50% recommended dose of fertiliser (RDF); T_3: 75% RDF; T_4: 100% RDF; T_5: 50% RDF + twice foliar spray of 1% urea phosphate; T_6: 50% RDF + twice foliar spray of 2% urea phosphate; T_7: 75% RDF + twice foliar spray of 1% urea phosphate; T_8: 75% RDF + twice foliar spray of 2% urea phosphate; T_9: 100% RDF + twice foliar spray of 1% urea phosphate; T_{10}: 100% RDF + twice foliar spray of 2% urea phosphate.

The result revealed that highest total chlorophyll content, nitrogen content and phosphorus content of rice leaves collected at different growth stages were recorded with T_{10} (100% RDF + twice foliar spray of 2% urea phosphate) . Foliar application of 2% urea phosphate recorded highest values for these parameter than that of 1% urea phosphate spray irrespective of nutrient levels. Mean total chlorophyll content of rice leaves at different growth stages indicated that chlorophyll content was increased from 25 DAT to 47 DAT and thereafter the chlorophyll values were decreased up to 60 DAT. Highest yield (4.58 t ha^{-1}) of rice was observed with T_{10} where as lowest grain yield was observed with T_1 (Control). Highest nutrient use efficiency (57.8 kg of grain / total kg of nutrient) was recorded with T_2 (50% RDF) where as highest agronomic efficiency (15.34 kg of grain / kg of nutrient applied) was recorded with T_6. The highest cost of cultivation (Rs. 38198), gross return (Rs. 66578), net return (Rs. 28380) and benefit: cost ratio (1.74) of rice crop was recorded with T_{10}.

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Enhancing the Efficiency of Applied Fertilizer Nutrients in Pigeonpea through STCR Approach

P.K. Basavaraja*, H. Mohamed Saqeebulla and C.R. Nethradhaniraj
AICRP on STCR, Department of Soil Science and Agricultural Chemistry, University of Agricultural Sciences, GKVK, Bangaluru, 560065, Karnataka
**Email: pujarikbraj@gmail.com*

Soil test crop response approach is the most scientific approach of nutrient application for crops by using the soil test values and targeted yield equation which was developed by considering the contribution of nutrients from soil, manures and fertilizers. In this study, STCR fertilizer prescription equation was developed during 2013-14 under dry land conditions by the standard procedufres of gradient and main experiment. This STCR targeted yield equation was evaluated in comparison with recommended dose of fertilizer nutrients application and STL approach at GKVK, Bangaluru, during 2014-15.

The results clearly indicated that the STCR targeted yield fertilizer prescription equation developed for pigeonpea can be well adopted in zone-6 of Karnataka state. Pigeonpea grain yield was significantly high (28.14 q ha^{-1}) in STCR target of 20 q ha^{-1} where nutrients were added through integrated approach. NPK uptake by pigeonpea was highest in 20 q ha^{-1} target either through purely inorganic fertilizers or through integrated STCR approach. However, higher uptake of NPK in STCR target of 20 q ha^{-1} through only inorganic's didn't influence in increasing the grain yield of pigeonpea. The NPK nutrient use efficiency was significantly higher in the treatment where nutrients were applied through STCR integrated approach, whereas lowest P and K uptake and nutrient use efficiency was recorded in POP treatment. This clearly indicated that the application of fertilizer nutrients by adopting STCR targeted yield equation through integrated approach will helps in enhancing the efficiency of applied fertilizer nutrients thereby increasing the yield of dry land pigeonpea crop.

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Fertility and Heavy Metal Status of Puddled Rice Soils, Irrigated with Low Quality Musi Project Water

M. Uma Devi, N. Elvis Karunakar, K. Avil Kumar, V. Ramulu, D. Sandeep Kumar and V. Praveen Rao

*Water Technology Centre, Professor Jayashankar Telangana State Agricultural University (*formerly part of ANGRAU*), Rajendranagar, Hyderabad, 500030, Telangana*
**Email: baby_makam@rediffmail.com*

An investigation was carried during 2012-13 to study the quality of soils in command area of Musi project which was constructed across Musi River, a tributary of the Krishna River, in Telangana State. The Musi project with a live storage of 130.31 Mm^3 (4.6 TMC) of water intended to irrigate culturable command area of 13,360 ha during *rabi* season, having major crops of rice, cotton and pulses. The river flows through the city of Hyderabad carrying heavy load of nutrients and pollutants. Land use / land cover map prepared during *rabi* 2012-13 indicated that, out of 26,786 ha of study area, *rabi* rice occupied 41.55% of area and other crops occupied around 12%. The soils in the command area were irrigated with surface water (canal water) as well as ground water (bore wells and open wells). Surface soil samples (56 no) at 0-20 cm depth were collected from rice grown famer's fields in left and right canal command area along with the GPS data. The soil samples were characterized for different soil quality parameters like pH, electrical conductivity (EC), organic carbon (OC), majornutrients (NPK), micro nutrients (Fe, Mn, Zn and Cu) and heavy metals (Pb, Cd, Co and Ni) composition by following standard procedures.

In all the soil samples collected, majority of the soils were sandy clay loam (59%) followed by sandy loam (13 %), sandy clay (11%), clayey (3%) and loamy (2%) in texture. The pH ranged from 6.82 to 8.30 with a mean of 7.71 and majority were slightly alkaline (68%) in soil reaction followed by strongly alkaline (18%) and neutral (14%). The EC ranged from 0.18 to 1.09 dS m^{-1} with a mean of 0.41 dS m^{-1}. All the sampled soils were non-saline. Organic carbon was high in 64 per cent of soils, followed by medium in 27 per cent and low in 9 per cent soils. It ranged from 0.19 to 1.32 per cent with a mean of 0.81 per cent. All the soils in Musi command area were found to be low in available N ranging from 105 to 144 kg N ha^{-1} with a mean of 132 kg N ha^{-1}. Availability of P was high in 86 per cent of the soils followed by moderate in 14 per cent soils. It ranged from 17 to 81 kg P ha^{-1} with a mean of 44 kg P ha^{-1}. Regarding available K, about 30% of the samples were high, 63% moderate and 7% were low in K. It ranged from 67 to 667 kg K ha^{-1} with a mean of 248 kg K ha^{-1}. All the soils were found to be sufficient in their available sulphur status ranging from 12 to 159 mg S kg^{-1} with a mean of 91 mg S kg^{-1}. Among DTPA-extractable micronutrients, available Fe content was found to be adequate in all the soils (11 to 46 mg Fe kg^{-1}) with a mean of 27 mg Fe kg^{-1}. Available Mn was also adequate in most of the soils (77%) followed by marginal (20%) and low (3%) ranging from 1 to 31 mg Mn kg^{-1} with a mean of 7 mg Mn kg^{-1}. Adequate amount of Cu (0.78 to 8.81 mg Cu kg^{-1}) was found in all the samples with a mean of 2 mg Cu kg^{-1}. Nearly 25% of the samples were found to be deficit in their available Zn and the rest (75%) of samples were sufficient. Mean available Zn was 1.33 mg Zn kg^{-1} ranging from 0.11 to 5.10 mg Zn kg^{-1}. Heavy metals were found to be in safe limits in all the samples. The lead content ranged from traces to 2.91 mg Pb kg^{-1}, Ni ranged from traces to 1.18 mg Ni kg^{-1}, Cd ranged from 0.01 to 0.12 mg Cd kg^{-1} with a mean of 0.03 mg Cd kg^{-1} and Co ranged from traces to 0.64 mg Co kg^{-1}. There is a need to reduce P and K fertilizer doses due to their high levels in these soils. Among the micro nutrients, 25% of the samples were found to be deficit in Zn indicating its need to be included in fertilizers schedule.

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Performance of Different Fertilizer Briquettes on Dolichos bean (*Dolichos lablab* L.) to Yield, Nutrient Uptake and Soil Properties in Lateritic Soils

P.B. Tapkeer, M.C. Kasture, P.B. Sanap and R.V. Dhopavkar
Department of Soil Science and Agricultural Chemistry, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, 415 712, Maharashtra

The present investigation was conducted at Central Experiment Center, Wakawali during *rabi* season 2013-2014. The field experiment was laid out in randomized block design comprising of eight treatments replicated thrice. Treatments comprised of T_1 (control), T_2 (RDF), T_3 (KAB @1 briquette per plant), T_4 (KAB @1 briquette per two plants), T_5 (UB-10:26:26 @1 briquette per plant), T_6 (UB-10:26:26 @1 briquette per two plants), T_7 (UB-DAP @ 1 briquette per plant), T_8 (UB-DAP @ 1 briquette per two plants). The present study was formulated to reduce the fertilizer use by using briquette form. It was observed that KAB, UB-10:26:26, UB-DAP briquette found promising source of nutrients as compared to use of straight fertilizers. Amongst all fertilizer briquettes, UB-10:26:26 briquettes found significant in term of growth attributing characters and yield of *Dolichos* bean.

It was observed that the application of one UB-10:26:26 briquette in between two plants at sowing was found significant in respect of yield and recorded higher plant height and number of pods per plants. It was also observed that the quality of the pods in terms of protein content increased as well as higher total N, P and K uptake. The available nutrient status (N, P and K) in soil after harvest was found to be improved due to application of all three types of briquettes as compared to RDF.

In general, it was observed that the applications of fertilizer briquettes was found beneficial for getting higher green pod yield. It is concluded that the application of UB-10:26:26 briquettes @ one briquette in between two plants was found promising in enhancing the green pod yield of Konkan bhushan variety in lateritic soils of Konkan. The application of nutrients in the form of UB-10:26:26 briquettes can reduce the dose of recommended NPK fertilizer to the extent of 50 per cent.

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Integrated Nutrient Management in Chilli through Application of Briquettes in Soils of Konkan

M.C. Kasture, S.S. Prabhudesai and P.C. Haldavanekar
Department of Soil Science and Agricultural Chemistry, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, 415 712, Maharashtra

The present investigation was conducted at Central Experiment Center, Wakawali during *rabi season* 2010-2011. The field experiment was laid out in randomized block design comprising of twelve treatments replicated thrice. Treatments comprised of T_1 (control), T_2 (RDF), T_3 (Urea-DAP briquettes first two at transplanting and second one at 30 DAT), T_4 (Urea-DAP briquettes first at transplanting, second at 30 DAT and third at 60 DAT), T_5 (Urea-Godavari briquettes first two at transplanting and second one at 30 DAT), T_6 (Urea-Godavari briquettes first at transplanting, second at 30 DAT and third at 60 DAT), T_7 (Urea-Suphala briquettes first two at transplanting and second one at 30 DAT), T_8 (Urea-Suphala briquettes first at transplanting, second at 30 DAT and third at 60 DAT), T_9 (RDF based on soil test), T_{10} (FYM N based), T_{11} (vermicompost N based) and T_{12} (poultry manure N based).

It is observed that the application of Urea-Godavari briquettes (3 briquettes per plant) first at transplanting, second at 30 DAT and third at 60 DAT was found significantly superior over rest of all the treatments in respect of yield and recorded higher plant height and number of pods per plant. It was also observed that the quality of the pods in terms of ascorbic acid and capsaicin content increased with application of organic manures alone. Application of Urea-Godavari briquettes first at transplanting, second at 30 DAT and third at 60 DAT recorded higher total N and P uptake while application of Urea-Suphala briquettes first at transplanting, second at 30 DAT and third at 60 DAT recorded higher total K uptake. However, the total uptake of micronutrients was found non-significant except Cu.

The available nutrient status (N, P and K) in soil after harvest was found to be improved due to application of all three types of briquettes as compared to RDF and RDF based on soil test. While, RDF based on soil test significantly increased the available nutrient status over manure application. However, DTPA-extractable micronutrient content in soil *viz.* Fe, Mn, Zn and Cu was found non-significant except Fe at 90 DAT. In general, it is observed that the applications of fertilizers briquettes were found beneficial for getting higher yield of green chilli. It is concluded that the application of Urea-Godavari (14:35:14) briquettes, first briquette at transplanting, second at 30 days after transplanting and third at 60 days after transplanting was found promising to enhancing the green chilli pod yield of Pusa Jwala variety in lateritic soils of Konkan.

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Influence of Continuous Cropping, Fertilizer, Lime and Manure Application on Different Forms of Phosphorus in Acid Soil of Jharkhand

Swati Singh, N.C. Gupta, P. Mahapatra and R.N. Singh
Department of Soil Science and Agricultural Chemistry,
Birsa Agricultural University, Ranchi, 834 006, Jharkhand

Maize-wheat is the third most important cropping system in India and it is also prevalent cropping system adopted in uplands of Jharkhand. A permanent manurial trial with different combinations of nutrient management practices under maize-wheat is in progress since 1956 at BAU farm, Kanke. The present investigation on the soils of the ongoing permanent manurial trial was undertaken to estimate different forms of P and their interrelationship in soil-plant system. The treatments details are control, N alone, NP, NPK, NPK+ lime, FYM only (organic) and FYM+ NPK (INM practice). Continuous application of P over a period of 59 years resulted in build up of inorganic P fractions in soil. Sequential extraction of inorganic soil P fractions (% of total P) follow the order Fe-P (14.54-25.62%) > Al-P (10.76-12.96%) > Ca-P (2.06-10.82%) > reductant soluble-P (1.83-7.62%) > saloid-P (0.48-2.0%). The saloid-P was very low in comparison to all other forms of inorganic soil P fraction. Transformation of total-P to saloid P was highest (2%) in FYM alone treated plots, followed by NPK+ lime (1.99%) and FYM+ NPK (1.91%). The Al-P and Fe-P was higher in treatments receiving NP and NPK as compared to other treatments. Balanced application of NPK along with lime/FYM reduced Al and Fe-P content. The Ca-P and reductant soluble-P fractions increased due to continuous cropping, fertilization, manuring and lime as compared to the control and the increase for Ca-P was 10.82, 9.05 and 7.19% of total P for the treatment FYM, NPK+ lime and FYM+ NPK (INM) treatment, respectively. The maximum water soluble phosphorus (16.59 mg kg^{-1}) was recorded in FYM+ NPK treated plot which was significantly at par with FYM (14.25 mg kg^{-1} P) over all the other treatments. Correlation studies clearly indicate that almost all fractions of P were positively and significantly correlated with each of them as well as with total P except Ca-P. The maximum yield of wheat was recorded in the NPK+ lime, which was significantly superior over all the other treatments while minimum yield was recorded in N treated plot.

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Effect of Graded Levels of Phosphorus and Phosphorus Solubilizing Bacteria on Growth and Yield of Maize Crop under High P Status Soil

P. Rakesha[2], G.G. Kadalli[1]*, S.S. Prakash[2] and M.A. Ananthakumar[1]
[1]Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS (B), Hassan, 573225, Karnataka
[2]Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS (B), VC Farm, Mandya, Karnataka
**Email: ggkadalli@rediffmail.com*

There is a considerable build-up in available phosphorus (P) in soils of many parts of our country due to its fixation in soil and increased rates of application of phosphatic fertilizers. Therefore, there is a need to explore the native soil P by using phosphorus solubilising bacteria (PSB) with reduced dose of P. Hence, a field experiment was conducted during *kharif* 2015 to evaluate the effect of graded levels of P and PSB on growth and yield of maize in high P status soil at College of Agriculture, V.C. Farm, Mandya, Karnataka. The experiment was laid out in a randomized complete block design (RCBD) with ten treatments and three replications. Five levels of P *viz*., 0, 25%, 50%, 75% and 100% recommended dose of P (RD-P) were tried with and without PSB. 100% RD-P was taken as control treatment. Recommended dose of N and K and FYM were applied commonly to all treatments. The results revealed that inoculation of PSB along with graded levels of P significantly influenced on growth and yield parameters of maize crop. Though higher grain and stover yield of maize (7.68 and 8.39 t ha^{-1}, respectively) was obtained with application of 100% NPK + PSB, it was found on par with application of 100% RD-NK + 50% RD-P + PSB (7.22 and 8.15 t ha^{-1}, respectively). Significant increase in nutrient content and uptake of nutrients (N, P and K) by maize crop was also observed in these treatments. However, the highest B:C ratio of 3.01 was obtained with application of RD-N and K + 50% RD-P + PSB due to 50% reduction in the cost of phosphatic fertilizers. Hence, application of 100% RD- N and K + 50% of recommended dose of P along with PSB can be recommended for profitable maize cultivation under high P status soils.

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Long-term Effect of Organic Manure Application on Nutrient Uptake and Yield of Wheat in Pearl Millet and Wheat Cropping System

Sanjay K. Kashyap, Kiran K. Khokhar*[1], Dev Raj[2] and R.S. Antil[2]
[1]Regional Research Station, Karnal, Haryana
[2]Department of Soil Science, CCS Haryana Agricultural University, Hisar, Haryana
**Email: kirankhokhar123@gmail.com*

A field experiment was conducted during the year 2014-15 at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar. The pearl millet and wheat cropping system was adopted for this field trail. The experiment consisted of seven treatments, laid out in randomized block design with three replications and the plot size was 10 m × 8 m. The seven treatments were control (T1), 50% RDF through NPK (T2), 100% RDF through NPK (N -150 kg ha^{-1}, P_2O_5 - 60 kg ha^{-1}, K_2O - 60 kg ha^{-1}), 50% RDF through NPK+ 50% N through farm yard manure (T4), 50% RDF through NPK + 50% N through wheat straw (T5), 50% RDF through NPK+ 50% N through green manure (T6) and farmer's practice (T7). Well decomposed farmyard manure (FYM) was incorporated in the soil about 35-45 days before the sowing of pearl millet in 2013. The wheat straw obtained after harvest was cut into small pieces and then incorporated into the soil. *Dhaincha* as green manuring crop was grown on a separate field and it was harvested after 40-45 DAS and chopped into small pieces and incorporated into the soil. Amount of organic materials added to the soil to substitute 50% of N was calculated on the basis of their N content and it was calculated to be *i.e.* 5, 12 and 2.5 t ha^{-1} FYM, wheat straw and green manure, respectively. The results revealed that the maximum grain (5.81 t ha^{-1}) and the straw (5.98 t ha^{-1}) of yield was obtained on application of 50% RDF through NPK+ 50% N through FYM (T4) Likewise, maximum accumulation of nutrient content in grain (N: 2.22%; P: 0.373% and K: 0.283%) and in straw (N: 0.45%; P: 0.09% and K: 0.06%) was also observed in T4. Substitution of 50% N through FYM considerably increased the total N (158 kg ha^{-1}), P (28.63 kg ha^{-1}) and K (79.84 kg ha^{-1}) uptake by the wheat crop over 100% RDF application.

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Effect of Foliar Application of Micronutrients on Growth and Yield of Okra (*Abelmoschas esculentus* L. Moench)

G.C. Satisha*, K. Bharathi, T.S. Shruthi, Mazhar Jamil and A.N. Ganeshamurthy
ICAR-Indian Institute of Horticultural Research, Hessarghatta Lake Post, Bengaluru, 560089, Karnataka
**Email: satishagc@gmail.com*

Okra (*Abelmoschus esculentus* L. Moench) popularly known as 'bhendi' find a prominent place among vegetables in India. The wide spread deficiency of micronutrients has been reported in most soils of India. Zinc (Zn) and boron (B) deficiency is widely encountered micronutrient deficiency in vegetable growing regions of Karnataka. A field experiment was carried out during *kharif* 2013 and 2014 at Indian Institute of Horticultural Research, Hesaraghatta, Bangalore with the objective to find out the effect of foliar application of micronutirents on growth and yield of okra (cv. Arka Anamika). The treatments consisted of B, Zn, molybdenum (Mo), different spray combinations of varying concentration of Zn, B, Cu, Fe and Mn and control and the experiment was laid out in RBD with three replications. All the micronutrients were applied in three sprays at an interval of ten days starting from 30 days after sowing. In general, all the treatments showed significant increase in growth and productivity of okra. The application of Zn, B, individually or combination recorded significantly higher yields as compared to control. Application of spray combination (G2 mixture) of Zn (4.0%), B (3.2%) and Mo (0.0025%) with adjuvant at 5 g l^{-1} gave maximum plant height (123.2 cm), fruit length (17.6 cm), fruit weight (26.5 g) and fruit yield (17.1 t ha^{-1}) followed by Arka IIHR vegetable special (15.89 t ha^{-1}), while the lowest yield was recorded in the control.

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Evaluation of Human Urine as a Source of Nutrients for French bean and Maize Cropping Sequence in Lateritic Soils of Karnataka

G. Sridevi*[1] and C.A. Srinivasamurthy*[2]

[1]Department of Soils and Environment, Agricultural College and Research Institute, Madurai, Tamil Nadu
[2]Department of Soil and Agricultural Chemistry, UAS, GKVK, Bangalore, Karnataka
**Email: smathareddy@gmail.com*

The global population is expected to grow by about 35% by 2050, increasing the demands on agricultural production and use of chemical fertilizers. Although the use of chemical fertilizer is the fastest way of counteracting the pace of nutrient depletion, its increasing cost and limited availability deter the farmers from using these inputs in balanced proportions thereby paving way for the problems of environmental pollution. Scientists are currently interested in developing alternative technology to minimize the dependence on chemical fertilizers and encourage the other viable options use of human urine as a source of fertilizer. With this regard a, field experiments were conducted at the University farm on French beans and Maize was the test a crop in succession for 2 years in the same field was done with 10 treatment combinations. To assess the fertilizer value of human urine field experiments were conducted. The results of the field experiments of french bean and maize crops yield were significantly highest in treatment receiving human urine + FYM followed by human urine alone. T_5 (4.87 t ha^{-1}) which received 40% recommended N through FYM basal+ 60% through human urine was the best when compared to other treatments. The lowest was recorded in control T_9 (1.19 t ha^{-1}). Similarly, in the second crop maize also, T5 treatment registered highest yield (6.89 t ha^{-1}) when compared to other treatments. The control was recorded the lowest grain yield (3.89 t ha^{-1}). The available nutrients content of harvest soil *viz.*, N, P and K had significant influence on it. The results of these experiments were quite encouraging. The crop yields obtained in plots receiving human urine was found to be slightly higher compared to chemical fertilizer applied plots, thus illustrating the fertilizer value of human urine and also helps to provide better sanitation, help farmers to save the cost on fertilizers.

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Soil and Crop Productivity in the Khadin System of Arid Rajasthan, India

P. Raja*, R.N. Kumawat and R.K. Goyal
ICAR-Central Arid Zone Research Institute, Jodhpur, 342 003, Rajasthan
**Email: rajacazri@gmail.com*

Khadin is a traditional runoff farming cultivation widely practiced in arid region of Rajasthan. It is one of the best example of rain water harvesting for raising field crops under conserved soil moisture. In the present study soil and crop productivity were studied in a *khadin* system located in the catchment area near Baorli-Bambore and soil samples were collected at different depths (0-15, 15-30, 30-45 and 45-60 cm) for studying physicochemical properties. Soils are mostly sandy loam in texture, moderately alkaline (pH 8.1 to 8.88), calcareous in nature and soil organic carbon varied from 0.05 to 0.2 per cent. Soils are moderate in available potassium (117-280 kg ha^{-1}) and low in available phosphorus (<10 kg ha^{-1}). Soils of the *khadin* system is deficient in diethyl triamine penta acetic acid (DTPA) extractable zinc (0.13 to 0.65 mg kg^{-1}). Other micronutrients such as iron (>2 mg kg^{-1}), copper (>0.2 mg kg^{-1}) and manganese (>5 mg kg^{-1}) are sufficiently available in soils. A crop experiment was conducted during *kharif* 2013 in Bambore (Jodhpur district) *khadin* to study the effect of soil applied zinc and foliar applied thiourea and NPK on the growth and productivity of pearlmillet crop. The experiment was laid out in a strip plot design with control and soil application of $ZnSO_4$ @ 25 kg ha^{-1} in main strips and three levels of foliar applied 1% NPK, 750 ppm thiourea and water sprayed control in sub-strips with four replications. Pearl millet variety MH 169 was sown in the first week of July at the onset of monsoon at 30 cm × 10 cm spacing using seed rate of 4 kg ha^{-1}. Zinc sulphate was applied at the time of sowing while aqueous solutions of 1% NPK, 750 ppm thiourea and water were applied on the foliage at 40 days old crops. The results showed that soil application of $ZnSO_4$ and foliar application of 1% NPK caused significant improvement in yield attributes over control. Similarly, soil application of $ZnSO_4$ recorded 38.5 and 19.3 per cent higher grain and straw yield over control. The grain and straw yield increased to the tune of 20.19 and 12.15 per cent due to foliar application of 1% NPK over water sprayed control that recorded 1530 kg ha^{-1} grain yield and 2758 kg ha^{-1} straw yield. The study concluded that by following the appropriate management practices crop productivity could substantially increased in the *khadin* system.

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Effect of Conjunctive Use of Biogas Slurry and Chemical Fertilizers on Productivity and Fertility of Soil under Pearl Millet Wheat Cropping System

D.S. Dahiya*, S.S. Dahiya, Dev Raj and R.S. Antil
Department of Soil Science, CCS Haryana Agricultural University, Hisar, 125004, Haryana
**Email: daljitdahiya@hau.ernet.in*

A field experiment was conducted during four successive years (2011 to 2015) at Research Farm Department of Soil Science CCS Haryana Agricultural University Hisar t o study the effect of biogas slurry in conjunction with chemical fertilizers on yield and available nutrient status in soil. The experiment was conducted in randomize block design with three replications having four dose of biogas slurry (2.5, 5.0, 7.5 and 10 t ha^{-1}) along with 50, 75 and 100% recommended dose of N and P fertilizers. The total treatment comprising thirteen including one treatment of recommended dose of chemical fertilizers taken as control. The highest mean grain yield of wheat (5.95 t ha^{-1}) was recorded with 100 percent RD of NP along with 10 t of biogas slurry and magnitude of increase was about 9 per cent over RD of N and P. In other treatment the increase in yield was not significant over control. The pearl millet crop was grown after wheat in the same plots with recommended dose of N and P fertilizers and observed the similar trends having highest grain yield of 2.7 t ha^{-1} which was about 16 per cent higher than recommended dose of N and P fertilizers. After the harvest of four wheat and three pearl millet crops, the organic carbon content increased in all the treatments from its initial values (from 0.47 to 0.52%) except in control. The available N decreased from its initial level however, available P and K were increased over initial level.

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Available Nitrogen and Phosphorus Status and Their Balance Sheets in Different Cropping System in Haryana

B.S. Duhan* and J.P. Singh
Department of Soil Science, CCS Haryana Agricultural University, Hisar, 125004, Haryana
**Email: dr.bsduhan@gmail.com*

In different cropping system the nutrients mining and their balance in soil may be different. Therefore, if we know the nutrients removal pattern in different cropping system we can develop nutrient management practices for sustaining soil fertility. Nutrient input and output allow the calculation of nutrient balance sheets for both for individual fields and geographical regions. For computing the balance sheet of nutrients in soil we have to monitor the soil fertility for a long period. To monitor the soil fertility status under different cropping system ten benchmark sites have been selected all over the Haryana State having different cropping system such as rice-wheat, cotton wheat, sugarcane-sugarcane, legume wheat, bajra-mustard and mix cropping system. Soil samples were taken from all the sites at the start of study. All the soil samples were analyzed for physicochemical properties and different forms of N and P. All these soil samples have been preserved in the Department of Soil Science for comparison of soil fertility decline in various systems in different areas of state. After the completion of five years of this study soil samples were collected from all the same sites. During the course of study nutrients apply to each crop, grain and straw yield of each crop and N and P uptake by grain and straw of each crop were recorded from all the sites every year for five years. So, a total of N and P applied to the different crops at different location were calculated during five years. Likewise, a total of N and P uptake by different crops at different location were also calculated. These soil samples were analyzed for physicochemical properties as well as the nutrients mentioned above. Balance sheets of N and P were prepared on basis of differences between initial and final values of N and P in the soil taking in to account of total addition and removal of N and P in the soil.

The results from long term monitoring experiment indicated that the net loss of available nitrogen over initial status ranged from 3.5 to 13.7%. The lowest net loss of N (3.5%) was observed in case of pigeon pea- wheat cropping system and highest (13.6%) was in case of rice- wheat system. However, build up in total N after five years was observed and increase in total N over initial status ranged from 2.6 to 7.8%. The highest build up of N was in rice- wheat cropping system and the lowest was in bajra-mustard cropping system. In case of available P slightly net gain amounting to 1.6% was observed in sugarcane cropping system. The net loss of P ranged from 2.8% in rice- wheat cropping system to 10.1% in mixed cropping system. In case of Total P, net loss was observed only at two locations in bajra wheat system (-0.7%) and in sugarcane cropping system (-20.4%). Whereas, highest net gain in total P (7.6%) was observed in pigeon pea–wheat cropping system and lowest (0.8%) mixed cropping system.

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Performance of Promising Pre-release Clones of Sugarcane under Saline Water-irrigated Condition

B. Asha Jyothi, T. Sujatha and K. Jhansi
Acharya N.G. Ranga Agricultural University, Sugarcane Research Station, Vuyyuru, Krishna District, 521 165, Andhra Pradesh

A field experiment was conducted during 2013-14 at Ayodhya, Challapalli mandal in the farmer's field to study the performance of promising pre-release clones of sugarcane using saline water for irrigation. Seven early promising pre-release clones *viz.,* 2003 V 46, 2004 V 96, 104, 105, 2005 V 29, 66 and 2006 V 41 were tested with standard Co 6907 in ratoon crop. Experiment was conducted in soil having pH 7.90, EC 0.641 dS m^{-1}. Soil is low in available N (257.5 kg ha^{-1}) and high in available phosphorus (89 kg ha^{-1}) and potassium (600 kg ha^{-1}). Treatments were replicated thrice in RBD design. Irrigation water used has pH 7.60, E.C 2.41 dS m^{-1}, TDS 1566 mg L^{-1}, total hardness 540 ppm and chlorides 600 ppm. Data was collected on germination percentage, shoot population at different stages of crop growth, yield and quality. Whole cane samples were collected during grand growth period and analysed for uptake of N, P and K using standard methods. The SPAD values were collected using SPAD chlorophyll meter and super oxide dismutase enzyme activity was estimated during grand growth period. Post-harvest soil samples were collected after harvesting the crop and were analysed for pH, EC, available nutrient status using standard methods.

2006 V 41 recorded highest cane yield of (102.6 t ha^{-1}) among the early clones tested and 2003 V 46 (95.21 t ha^{-1}), 2004 V 104 (91.02 t/ha) and 2005 V 29 (92.45 t ha^{-1}) are on par with 2006 V 41. Juice sucrose % and CCS % were also more with 2006 V 41 (19.27% sucrose and 13.91 CCS%). 2003 V 46, 2004 V 96, 2005 V 29 and 2005 V 66 are on par with 2006 V 41 Juice sucrose and CCS %. CCS yield was also high with clone 2006 V 41 (14.25 t ha^{-1}). 2003 V 46 (13.06 t ha^{-1}) and 2004 V 104 (12.18 t ha^{-1}) are on par with 2006 V 41. Superoxide dismutase enzyme activity and SPAD values were also more with 2006 V 41 (1.33 od/g fresh wt./min. and 36.15, respectively) than 2003 V 46 (1.507 od/g fresh wt/min and 35.16 respectively).

2006 V 41 resulted with highest phosphorus uptake (112 kg ha^{-1}) followed by 2003 V 46 and 2004 V 104. 2006 V 41was also resulted with more potassium uptake (917 kg ha^{-1}) and 2003 V 46 is on par with it. Highest EC, organic carbon, available nutrient status of nitrogen, phosphorus and potassium were more in the post-harvest soils of 2006 V 41 among the early clones tested. Superoxide dismutase enzyme activity and SPAD values were also more with 2006 V 41 (1.33 od/g fresh wt./min. and 36.15, respectively) 2003 V 46 (1.507 od/g fresh wt/min and 35.16, respectively). Based on the results of screening of sugarcane genotypes for salinity tolerance, it can be concluded that 2006 V 41, 2003 V 46, 2004 V 104 and 2005 V 29 are tolerant and give good yields when saline irrigation water is used for irrigating the crop among the promising pre-release clones tested.

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Effect of Long-term Integrated Nutrient Management on Nutrient Balance in Rice-Rice Cropping System

S. Sridevi* and M. Venkata Ramana
AICRP on Integrated Farming Systems, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, 500030, Telangana
**Email: sridevikarlapudi@gmail.com*

Nutrient budgeting is a useful tool to understand the present and future productivity in relation to land management as well as undesirable effects of nutrient mining and development of toxicities. An attempt has been made to calculate N, P, and K budgets in a long term experiment under continuous rice-rice cropping system on permanent plots for 25 years with different nutrient management practices at PJTSAU, Rajendranagar. The experiment was laid out with twelve treatments comprising of chemical fertilizers alone and in conjunction with FYM, paddy straw and gliricidia at 50% and 25% nitrogen substitution during *kharif* and with 100% and 50% RDF during *rabi* on sandy clay loam soil in randomized block design with three replications. Inclusion of manures at both 50% and 25% N substitution during *kharif* substantially reduced net negative balance when compared to application of chemical fertilizers alone. Nutrient removal over 25 years of experimentation was high in the treatments where in 100% recommend dose of fertilizers were applied through chemical fertilizers and also in treatments where 25% or 50% of N is substituted for with gliricidia green leaf manure. Of the total applied nitrogen through different sources, about 24 to 37.5% nitrogen was recovered by the rice crop in various treatments, gaseous losses were accounted to 12-13% and about 26 to 39.9% of N was subjected to leaching losses. The positive P balance was ranging from 6.6 to 824 kg ha^{-1} over 25 years in different treatments. Nitrogen substitution through paddy straw maintained lower negative balance of potassium over FYM, glyricidia substituted treatments or with application of 100% RDF.

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Soil Physical, Chemical and Biological Changes under Long-term INM in Rice-Rice Cropping System

S. Sridevi*, M. Venkata Ramana, K. Suresh and M. Madhavi
AICRP on Integrated Farming Systems, College of Agriculture, PJTASU, Rajendranagar, Hyderabad, 500030, Telangana
**Email: sridevikarlapudi@gmail.com*

A long-term experiment with a rice–rice cropping system was established at the College Farm of PJTSAU, Rajendranagar, Hyderabad, during *kharif* 1988-89. The experiment was laid in randomized block design with three replications and twelve treatments comprising of chemical fertilizers alone and in conjunction with FYM, paddy straw and gliricidia at 50% and 25% nitrogen (N) substitution during *kharif* and with 100% and 50% RDF in *rabi.* The changes in the bulk density were noticed to be significant only in the upper 30 cm layers of the soil and ranged from 1.31 to 1.48 Mg m^{-3} in the surface layer (0-15 cm) and varied from 1.58 to 1.82 Mg m^{-3} in the subsequent 15-30 cm layer at the end of 25 cropping cycles. In sub surface layers (30-45 and 45-60 cm) the treatment effects with reference BD were insignificant. A significant improvement in organic carbon was evidenced by the integrated nutrient supply through 50 or 25 per cent substitution of nitrogenous fertilizer in the *kharif* season with FYM or rice straw. Application of recommended dose of NPK through fertilizers significantly increased the availability of nutrients compared to control. The trend of available nitrogen over years imply that the fertility of the soil can be better sustained by substituting 25 or 50% N fertilizer with FYM or *glyricidia* twigs in the *kharif* season than only through chemical fertilizers. Considerable build up in the available phosphorus (P) was recorded with all the integrated nutrient management practices. By the end of 25th year it ranged from 37.1 to 43.2 kg ha^{-1} in various INM treatments and was at par with 100% NPK (45.2 kg ha^{-1}). On an average the potassium status at the end of 25 years of rice-rice sequence was in the range of 156-195 kg ha^{-1} and irrespective of the treatments there was depletion in the available potassium (K) compared to initial status of 220 kg ha^{-1}. There was a depletion of available copper (Cu) and iron (Fe) contents in all the treatments when compared to the initial status. Manganese (Mn) depletion was also seen with all other treatments except with 50% NPK+50% N substituted treatment, in which a slight build-up was noticed. All the substituted treatments could maintain the Zn to its initial status and 50% NPK+50% N substituted treatment showed a build-up. The amount of total SOC sequestered over 24 years in 0-60 cm depth was lowest with control (41.0 Mg C ha^{-1}) and was highest with 50% RDF + 50% N substitution through FYM (60.6 Mg C ha^{-1}). Highest dehydrogenase activity was recorded under 25% N substitution through gliricidia. Acid and alkaline phophatases activity was higher under 50% N substitution through FYM and urease activity was high under rice straw substitution.

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Verification Trial of Lentil in Tribal Areas of West Bengal through Soil Test and Target Yield Approach

A.R. Saha[1], S.P. Mazumdar[1], D. Ghosh[1], B. Majumdar[1], S.K. Abdullah[1] and P. Dey[2]

[1]Division of Crop Production, Central Research Institute for Jute and Allied Fibres, Barrackpore, Kolkata, 700120, West Bengal

[2]ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

[*]Email:amitsaha60@yahoo.co.in

Fertilizer prescription equation for lentil (B256) was developed at experimental farm of CRIJAF, Barrackpore, West Bengal. Target yield equation developed for lentil was verified through trials in the tribal areas of Nadia district, West Bengal. The objectives of the trials were to verify the fertilizer dose based on soil test target yield (ST-TY) approach against farmers' practice. Farmers from four different tribal villages namely South Bramhapur, Panchkahania, Digha and Kapileswar were selected. In South Bramhapur of Nadia district sixteen farmers were selected. ST-TY based fertilizer application recorded higher grain yield of lentil than farmers' practice. Highest lentil grain yield (1.18 t ha^{-1}) was recorded in ST-TY (1.2 t ha^{-1}) +FYM treatment. Target yield of lentil was achieved in ST-TY treatment with (±) 10% yield deviation. In Panchkahania village trials were conducted in three farmers' field whereas in Digha and Kapileswar trials were conducted in five and three villages, respectively. In these three villages also target yield (1.0 and 1.2 t ha^{-1}) of lentil was achieved with (±) 10% yield deviation in soil test targeted yield treated plots. Average lentil grain yield in ST-TY treated plots of Panchkahania, Digha and Kapileswar were 1.08, 1.01 and 1.01 t ha^{-1} where as in farmers' practice the lentil grain yields were recorded as 0.96, 0.80 and 0.75 t ha^{-1}, respectively. Higher response ratio recorded under STCR–FYM treatment as compared to farmers' practices might be attributed to balanced supply of nutrient from fertilizers, efficient utilization of applied fertilizer nutrients in the presence of organic sources.

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Impact of Sewage Sludge with and without Inorganic Fertilizers on Soil Properties and Yield of Wheat in an Inceptisol

N.P.S. Yaduvanshi, S.K. Singhal, S. Kumar, S.P. Datta and R.D. Singh
Division of Soil Science and Agricultural Chemistry,
ICAR-Indian Agricultural Research Institute, New Delhi, 110 012

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. To develop an appropriate sewage sludge based prescription for sustainable productivity of maize (*Zea maize*) - wheat (*Triticum aestivum* L.) system and without affect the soil health was initiated in the year 2014-15 at IARI, New Delhi with the following treatment combinations: T1, Control; T2, 100% RDF NPK (150:60:50); T3, 25% N by SS + NPK; T4, 50% N by SS + NPK; T5, 100% N by SS + PK; T6, 200% N by SS ; T7, 300 % N by SS and T8, T2 + 2.5 t sludge ha^{-1}. The experimental soil had pH 8.2, available N 171, available P 28.1 kg ha^{-1}, available K 265 kg ha^{-1}, DTPA-Zn 1.91 mg kg^{-1}, DTPA-Mn 3.39 mg kg^{-1}, DTPA-Fe 4.22 mg kg^{-1} and DTPA-Cu 1.33 mg kg^{-1}. The Sewage sludge was applied 15 days before sowing of wheat as per treatments.

Results showed that wheat responded significantly to fertilizer N and P. Combined application of 100% NPK with 2.5 t ha^{-1} SS increased significantly in comparison to 100% NPK alone treatment. Highest yield of wheat was obtained with 100% NPK combined with 2.5 t ha^{-1} SS which was more or less equal yield of wheat with the application of 25% or 50% N substituted by SS with NPK fertilizers. However, there was no significant difference in the yield of wheat amongst 100% NPK alone and 25% or 50% N substituted by SS with NPK treatments. Increasing the dose of SS from 100% to 300% N substituted by N significantly decreased grain yield of wheat. The results further showed that wheat yields could be maintained even at 50% N substituted by SS when used in conjunction with NPK fertilizers. Incorporation of SS resulted in slightly build-up of soil available N, P, K, Zn, Fe and Cu except Mn content and greater nutrient uptake by the crops. The results suggest that conjunctive use of 50% N substituted by SS with NPK is extremely important for sustaining wheat yield and improving soil health.

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Response of Organics and Industrial By-Products on Yield and NPK Uptake in Sugarcane

D. Venkatakrishnan
Department of Soil Science and Agricultural Chemistry, Annamalai University, Annamalainagar, 608002, Tamil Nadu

Sugarcane is a commercial crops plays pivotal role in agriculture. Sugarcane is cultivated to an extent of 50.64 lakh ha producing nearly 338.96 million tonnes with a productivity of 66.94 t ha^{-1}. The present study was conducted to investigate the influence of organics/industrial by-products and fertilizer on yield and NPK uptake of cane. An average of 1.0 kg N, 0.6 kg P_2O_5 and 2.25 kg K_2O are removed by a tonne of sugarcane. The sugarcane plant crop experiment was conducted in farmers field Periyanellikollai village in clay loam soil at Chidambaram taluk, Cuddalore district, Tamilnadu. The soils of Periyanellikollai was classified as Typic Haplustert comes under Kondal series having clay laom texture, the available nutrient status was low in N, medium in P and K.

The treatments consisted of T_1 – seasoned pressmud @ 25 t ha^{-1}, T_2 – T_1 + enriched gypsum @ 1 t ha^{-1}, T_3 – T_1 + enriched gypsum @ 1 t ha^{-1} + $ZnSO_4$ @ 37.5 kg ha^{-1}, T_4 – T_1 + lignite fly ash @ 25 t ha^{-1}, T_5 – vermicompost @ 5 t ha^{-1} + seasoned pressmud @ 25 t ha^{-1}, T_6 – vermicompost @ 5 t ha^{-1} + enriched gypsum @ 1 t ha^{-1}, T_7 – T_6 + $ZnSO_4$ @ 37.5 kg ha^{-1}, T_{-8} – vermicompost @ 5 t ha^{-1} + lignite fly ash @ 25 t ha^{-1}, T_9 – biocompost @ 5 t ha^{-1}, T_{10}-T_9 + enriched gypsum @ 1 t ha^{-1}, T_{11}-T_9 + enriched gypsum @ 1 t ha^{-1} + $ZnSO_4$ @ 37.5 kg ha^{-1}, T_{12} – T_9 + lignite fly ash @ 25 t ha^{-1}, T_{13} – FYM @ 10 t ha^{-1}, T_{14} – NPK alone (RDF). All plots received recommended dose of inorganic fertilizer. The experiment was laid out in randomized block design and var. CO 86032 was planted. The highest cane yield of 1694 t ha^{-1} was obtained with T_3 received seasoned pressmud @ 25 t ha^{-1} + enriched gypsum @ 1 t ha^{-1} + $ZnSO_4$ @ 37.5 kg ha^{-1}. The highest stem uptake of N (126.7 kg ha^{-1}), P (54.1 kg ha^{-1}), K (54.1 kg ha^{-1}) was noticed in treatment T_3. The maximum tops and trashes uptake of N (121.3 kg ha^{-1}), P (52.9 kg ha^{-1}) and K (173.5 kg ha^{-1}) was observed in treatment (T_3).

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Nutrient Dynamics in Aerobic and Flooded Ecosystems

J. Saralakumari and V.R. Ramakrishna Parama
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka

A field experiment was conducted at farmer's field in eastern dry zone of Karnataka to study the nutrient dynamics in rice soils under aerobic and flooded conditions. There were seven treatments replicated thrice. The findings of the study revealed that major nutrients N and K content were higher in aerobic system whereas available P was higher in flooded system. By applying 100 per cent RDF+FYM (T_2) maximum available N, P and K content was recorded at 30 days and minimum at harvest. Similar trend was followed in all other treatments. T_2 recorded significantly higher nutrient content and was statistically superior to all other treatments while control recorded lower available nutrient contents. Application of only FYM (T_6) also contributed to increase in available nutrients compared to control (T_7) at all stages of crop growth. Secondary nutrient contents (Ca, Mg and S) and micronutrients (DTPA Fe, Mn, Zn and Cu) in both ecosystems were significantly higher in 100 per cent RDF+FYM (T_2) than fertilizer treatments. T_2 was significantly superior to all other treatments while control (T_7) recorded lower nutrient contents. Grain yield of KRH-2 paddy was higher in flooded system whereas straw yield was higher in aerobic system. In aerobic and flooded system significantly higher grain yield (8.33 t ha^{-1} and 8.35 t ha^{-1}) was realized by applying 100 per cent RDF+FYM (T_2) followed by (8.25 t ha^{-1} and 8.27 t ha^{-1}) 50 per cent RDF+FYM and (8.00 t ha^{-1} and 8.24 t ha^{-1}) 150 per cent RDF without FYM (T_1). Addition of only organics (T_6) also contributed to higher yield (7.20 t ha^{-1} and 7.39 t ha^{-1}) compared to control (6.30 t ha^{-1}). A similar trend in straw yield was followed among the treatments. Significantly higher straw yield (8.98 t ha^{-1} and 8.58 t ha^{-1}) was recorded in T_2 and lower straw yield (6.73 t ha^{-1} and 6.53 t ha^{-1}) was recorded in control. T_2 was superior compared to rest of the treatments. Crop yields in both aerobic and flooded systems positively correlated with OC, enzyme activities, available N, P, K, exch.Ca and Mg, avail. S. Fe, Zn, Cu but relationship with Mn was negative in aerobic paddy and positive with flooded rice. Water use efficiency in aerobic ecosystem was higher than flooded ecosystem.

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Soil Test Crop Response Approach of Fertilizer Recommendations for Food Security

Ibajanai Kurbah, S.P. Dixit and Sushil Kumar Kharia
CSK Himachal Pradesh Agricultural University, Palampur, 176062, Himachal Pradesh

The increasing population of the world demands increasing food grain production. Land availability for crop production is decreasing and there is hardly any scope for further expansion in area under cultivation, so additional food grain production has to come only through increased productivity. Fertilizers have played a major role in creasing crop yield per unit area, but their continuous under and over use have resulted in many problems that include in deterioration of soil health, reduction in fertilizer response, water pollution and greenhouse gas emission. Therefore, precise application of fertilizer based on soil test nutrient availability and crop response to fertilizer applied for specific yield target seems to be a viable option to achieve target food grain production as well as reducing environmental degradation. Soil test crop response approach of fertilizer application was first advocated by Trough (1960) which involved both soil and plant analysis in a scientific basis that proved to be a refined and unique technique for most efficient use of fertilizer and soil nutrients. A large number of field trial experiments have been conducted across the country under different climatic conditions, diverse soils and different management practices. This approach resulted higher uptake of nutrients, build up of nutrients and higher yield as compared to control, farmer's practices and general recommended dose. Another advantage of this approach is that farmers can select different yield targets according to his resources and management conditions. Therefore, research and efforts are required to strengthen this approach not only from economic point of view but also for sustaining soil productivity.

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Seaweed Cultivation for Economic Rehabilitation of Coastal Farmers in Andhra Pradesh

G.V. Lakshmi, K. Hema, A. Sambaiah and E. Narayana
ANGRAU-AICRP-Saline Water Scheme, Bapatla, Andhra Pradesh

Seaweeds are wonder plants of the sea and considered as medical food of the 21st century. They have innumerous applications in food, pharmaceutical, textile and chemical industries and world demand is inceasing every year. Seaweeds are also found to provide a strong base for growth promoters of several plants because of their properties such as cytokinine, auxin and gibberllines. Therefore, seaweeds will be the major source of raw material for biofertilizer to start organic agriculture revolution in the country. Seaweed cultivation cent percent eco-friendly with sustainable income to the coastal poor.

Seaweed plants are an important renewable resource in the marine environment and have been a part of human civilization. Seaweeds synthesize a wide range of chemicals, some of which stand the only natural resource of agar, carrageenan and lignites. Seaweed farming offered 144 to 161 days of employment for annum in the coastal areas of fishermen in Rameswaram and Mandapam areas in Tamilnadu. It has been estimated that India can produce one million tons of dried seed, provide employment to 200 thousand families with annual earnings of Rs.0.1 million per family which occupation alone takes these households above the poverty line. Seaweed farming indicates a low cost simple technology, which can provide substantial returns, can find a better adoption among the coastal fisherflock. Seaweed (*Kappaphycus alverzii*) also produces ethanol and its cultivation does not need pesticides. More recently, Central Salt Marine and Chemicals Research Institute (C SMCRI), a CSIR centre in Bhavanagar, Gujarat, has developed liquid biofertiliser from *Kappaphycus* sap and edible seaweeds as a nutritional supplement in Indian diet.

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Poor Quality (Alkaline) Irrigation Water: A Desirable Trait for Fennel Production

O.P. Aishwath, P.N. Dubey, R.S. Mehta, R.K. Yadav, R.L. Meena, B.K. Jha and Balraj Singh

ICAR-National Research Centre on Seed Spices, Tabiji-305 206, Ajmer, Rajasthan

Crop production in the arid and semi-arid regions during winter season is mostly dependent on irrigated agriculture. However, good quality of underground irrigation water is rarely available in sufficient quantities to fulfil the need of all the crops grown in these area. Therefore, use of available saline/alkali water in crops become inevitable in these areas, which is a limiting factors for most of crops. There are two options to overcome this problem, one is to ameliorate the water and other is to replace the crop with tolerant one. The first option is cost intensive and unsustainable, while second one is cost effective and far sustainable. Keeping in view, an experiment was carried out under control conditions on fennel (Ajmer fennel-1) with irrigation water having residual sodium carbonate (RSC) 4.0, 8.0, 10.0, 12.0, 14.0 and 16.0 me L^{-1} and these were compared with control having RSC < 1.0 me L^{-1}. Results revealed that plant height, number of branches (primary and secondary) and number of seeds per umbelets were more even with higher RSC water up to 12.0 me L^{-1}. In case of number of umbel per plant and number of umbelets per umbel remained constant at higher level of RSC. Seed and stover yields were highest at RSC 10 as compared to other treatments and control. However, drastic yields reduction took place with RSC 14.0 and it's beyond levels. Yield enhancement in seed and stover with RSC 10.0 accounted as 22.1 and 21.0 per cent over the control, respectively. However, seed and stover yield reduction with RSC 16.0 was 9.5 and 10.7 per cent, respectively. Macro- and micronutrient content in seeds decreased with increase in RSC except iron. Sodium content in both seed and stover increased with increase in sodicity of water. Nitrogen, iron, zinc and manganese content was more in stover up to RSC 12.0 and reduced thereafter in comparison to control. However, content of P, K and Cu was not influenced much with increase in alkalinity of water. Uptake of macro and micronutrients was more with RSC 10.0 to 14.0 me L^{-1} than the lower or higher levels as the seed yield and biomass accumulation was more with this sodic water. Soil available N, P and micronutrients decreased with increase in RSC levels. However, potassium and sodium availability increased with increase in sodicity of water. Increased availability of K may be due to collapse of soil structure released the K from its lattice. There was an inverse relation with EC and pH which might be due to precipitation of divalent cations in soil at higher pH. Based on the findings of the investigation, it could be concluded that fennel has capability to draw the nutrients, water and withstand well up to RSC 12.0 me L^{-1} of irrigation water. Higher growth and yield realized at RSC < 10.0 me L^{-1} could be recommended as desirable traits of alkali water for fennel production, even though such water deteriorates soil properties remarkably in relation to other field crops.

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Effect of Varied Levels of Cogen Ash Application on Soil Properties

N. Hamsa*, C.A. Srinivasamurthy, V.R. Ramakrishna Parama, L.R. Varalakshmi[1] and S. Bhaskar

Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka
[1]Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, Karnataka
**Email: hamsanraj@gmail.com*

Cogen ash is a by-product of sugar mills obtained during co-generation process to produce heat and electrical energy by burning bagasse and/or coal. The cogen ash produced by Sri Chamundeshwari Sugars Ltd., K.M. Doddi, Mandya characterised by collecting the samples at monthly interval and also a field experiment was conducted in two plots at research block with paddy as test crop during *kharif* 2014 with 13 treatments (T_1: RDF+RD FYM, T_2-T_5: RDF+cogen ash at 2.5, 5.0, 10 and 15 t ha^{-1}, respectively, T_6-T_9:RDF+RD FYM+cogen ash at 2.5, 5.0, 10 and 15 t ha^{-1}, respectively and T_7-T_{13}: RDF+50% RD FYM+cogen ash at 2.5, 5.0, 10 and 15 t ha^{-1}, respectively) replicated thrice using RCB design to study the effect of varied levels of cogen ash on soil properties. The soil of the experimental site was sandy clay loam in texture with slightly alkaline pH, medium in macronutrient contents and the secondary nutrients were in sufficient amounts.

The cogen ash used had more of silt sized particles. MWHC was 61.1%, alkaline in nature (pH 8.43) with medium EC, traces of total nitrogen and carbon content. The total phosphorus (P), potassium (K), sodium (N), calcium (Ca), magnesium (Mg) and sulphur (S) contents were 0.82, 1.19, 0.09, 0.79, 0.31, 0.014%, respectively. The total iron (Fe), manganese (Mg), copper (Cu), zinc (Zn), boron (B), chromium (Cr) and nickel (Ni) contents were 10321.3, 353.0, 69.09, 135.44, 174.93, 286.52 and 74.77 mg kg^{-1}, respectively. Total lead (Pb) and cadmium (Cd) contents were not detected. The DTPA-extractable chromium and nickel were not detected in the cogen ash samples. The pH and EC of soil after the harvest of paddy crop did not vary significantly due to application of varied levels of cogen ash. Maximum BD was observed in the treatment T_5. MWHC of the soil was increased from 34.92% of mean initial value to 45.09% after the harvest of crop and significantly higher available P, K, S, exchangeable Ca and Mg content was observed in T_9 treatment which received RDF+100% RD of FYM+15 t ha^{-1} of cogen ash. Significantly lower available N, P, Ca, Mg and S content of soil was observed in the treatment T_2. Lower K and Fe content of soil was observed in treatments T_1 followed T_2 by whereas, Cu and Zn content in T_9 treatment. The population of bacteria, actinomycetes and dehydrogenase activity of soil was found to be higher at 45 DAT, 90 DAT and at harvest in T_9 treatment. Fungal population and urease activity was higher in the treatment T_6 (RDF+100% RD of FYM+2.5 t ha^{-1} of cogen ash) and lower values were observed in T_2 treatment. Cogen ash contains plant nutrients in appreciable amounts and can be effectively used in agriculture for improving soil fertility and provide means to recycle this waste in an eco-friendly manner. It would be more beneficial, if applied along with other organic manures and fertilizers.

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Impact of *Jhum* Fallow Length and Phages on Soil Health in Sub-tropical Ecosystem of Mizoram

Lungmuana, S.B. Singh, Y. Ramakrishna, Vanthawmliana, S. Saha, S.K. Dutta, A.R. Singh, T. Boopathi and S. Chowdhury

ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib,796081, Mizoram

Shifting cultivation (*jhum*) is adopted by many farmers as a main source of livelihood in North Eastern India such as Mizoram. It has often been reported about its dependence on the fallow length and soil improvement after burning as a reason for its sustainability and these changes may be reflected by soil microbial biomass and enzymatic activity. Our objective is to assess the dynamics of microbial biomass carbon (MBC), dehydrogenase (DHA) and acid phosphomonoesterase (AP) enzyme activity, available N, P and K of surface soil by *jhum* fallows [old (>20), medium (10-20) and young (<10 years)] and phases. Results revealed that old fallow contained significantly (P <0.05) highest amount of nitrogen (226 kg ha^{-1}). However, the highest content phosphorus and potassium was observed in young (13.67 kg ha^{-1}) and medium (175 kg ha^{-1}) fallow suggesting that more than 20 years of vegetative fallow in *jhum* system conserves nitrogen. The old fallow has also exerted significantly highest MBC (603 mg kg^{-1}), DHA (9.8 mg kg^{-1} h^{-1}) and AP enzyme activity (761 mg kg^{-1}) and decreased thereon further suggesting that these biological soil health indicators were dependent on the fallow period. MBC and DHA decrease after burning till harvest although may vary on the fallow length while AP activity decreases after burning and increase during the harvesting period of rice suggesting that important indicator of soil health such as phosphatase enzyme can be revived within a year of burning. Overall, our results suggest that soils under *jhum* system may differ depending on the length of fallows and phages, burning have a tremendous effect on biological parameters but may show resiliency towards soil health.

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Effect of Tillage, Green Manure and Straw Management on System Productivity and Soil Health in Rice-Wheat System

H.S. Thind*, Sandeep Sharma, Yaduvinder Singh, Varinderpal Singh and Bijay Singh
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141 004, Punjab
**Email: harmit_thind@yahoo.co.in*

Knowledge about the changes in productivity and soil properties under different tillage and crop residue management practices is necessary to assess the feasibility of adoption of resource conservation practices for sustainable rice-wheat (RW) cropping system. A long-term field experiment was initiated in 2010 to evaluate the effect of straw management, tillage and green manure (*Sesbania aculeate*, GM) on system productivity and soil health in transplanted RW system. The experiment was conducted in a split plot design having four treatment combinations of wheat straw (75 and 100% removed) and GM (with and without) in main plots and three combinations of tillage and rice straw removal (CTW), (2) zero till wheat after rice straw removal (ZTW), and (3) ZTW with rice straw retained as mulch using Happy Seeder (ZTW+M). wheat and rice crops were raised following recommended package of practices except that 50% of recommended N dose was applied to rice in GM amended plots.

The results revealed that rice grain and straw yields were not significantly affected by wheat straw and green manure treatments. GM application however, saved 50% fertilizer N in rice. Total N, P and K uptake by rice were similar in all the treatments. The ZTW without straw produced significantly lower grain as well as straw yield than CTW and ZTW+M. There was no residual effect of treatments applied to rice on the yield and nutrient uptake of following wheat. The lower grain and straw yields of ZTW caused a significantly lower uptake to total N,P and K than CTW and ZTW+M. Organic carbon content in 0-7.5 cm soil layer increased significantly under ZTW+M as compared to CTW and ZTW. Dehydrogenase activity in 0-7.5 cm soil layer after wheat 2014-15 increased significantly with application of GM, irrespective of tillage and rice straw management in wheat. However, dehydrogenase activity increased significantly in ZTW without straw as compared to CTW which further increased significantly under ZTW+M, irrespective of wheat straw and GM treatments. This study suggests that adoption of GM in transplanted rice and retention of crop residues using Happy Seeder in wheat can help in sustainable production of RW system in north-western India.

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Effect of Fly ash as a Source of Silicon and Potassium for Mitigating the Salinity Stress under Rice Cultivation

P. Balasubramaniam[1], P.P. Mahendran[2] and N. Marikannu[3]

[1]Department of Soil Science and Agricultural Chemistry, Anhil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirappalli, 620009, Tamil Nadu

[2] Department of Soil Science and Agricultural Chemistry, Agricultural College arid Research Institute, Tamil Nadu Agricultural University, Killikulam, Tamil Nadu

[3]Saraswathi KVK, Karur, Tamil Nadu

**Email: balu_tnau@yuhoo.co.in*

Rice *(Oryza saliva* L.) is the most unique staple food for over three billion people of Asia. In Tamil Nadu, it is being grown throughout the year at different seasons under low land submerged conditions. Due to intensive rice cultivation, mining of silicon (Si) and potassium (K) from soil leads to its deficiency. The rice crop shows the largest uptake of Si and K playing a major role for mitigating the various biotic and abiotic stresses. The fly ash contains Si and K in considerable amount irrespective of different source of fly ash *viz.*, fly ash from sugar factory, thermal power station and modem rice mill. The availability of this fly ash is plenty, which pose problem to the environment. Hence, the present investigation was carried out to study the possibility of utilizing the fly ash as a source of Si and K for mitigating the salinity stress in rice. In view of the above, field experiments were conducted in two different locations in the farmer's field viz., Malathangulam and Orathur villages of Ariyalur District having salinity level of 2.6 to 4.3 dS m^{-1} to study the effect of thermal power station Fly ash (FA) at 25 t ha^{-1} with silicate Solubilizing Bacteria (SSB) @ 2 kg ha^{-1} and farmyard manure (FYM) @ 12.5 t ha^{-1} with graded level of soil test based Potassium (STBK) on yield and uptake of silicon and potassium in rice. The experiments were conducted at in split plot design with two replication. The results revealed that application of fly ash @ 25 t ha^{-1} with SSB @ 2 kg $ha.^{-1}$ and FYM @ 12.5 t ha^{-1} with graded levels of STBK increased the yield of grain and straw over control under salinity stress condition in farmer's field of Malathangulam and Orathur villages in Ariyalur district. However the magnitude of yield increase due to fly ash treatments was more pronounced in Orathur village having more EC of 4.3 dS m^{-1} compared to Malathankulam having low salinity level of 2.6 dS m^{-1}. The uptake of Si and K in both grain and straw at different locations was significantly increased by the application of fly ash @ 25 t ha^{-1} with SSB @ 2 kg ha^{-1} and FYM @ 12.5 t ha^{-1} with graded levels of STBK over control.

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Evaluation of Zinc and Iron Requirement in Salt Affected Soil for Pearmillet-Mustard Cropping System

B.L. Meena[1]*, P. Kumar[1], A. Kumar[1], R.L. Meena[1], S.K. Ambast[2] and D.K. Sharma[1]
[1] ICAR-Central Soil Salinity Research Institute, Karnal, 132001, Haryana
[2]ICAR-Indian Institute of Water Management, Bhubaneswar, 751023, Odisha
**Email: blmeena2008@gmail.com*

In saline-sodic soils the deficiencies of zinc (Zn) and iron (Fe) is commonly observed. Ameliorating the deficiencies of Zn and Fe in pearl millet and mustard under salt-affected soils are required for managing sustainable production of these crops. Adequate attention has not yet been paid to optimize the requirement in relation to their deficiencies in salt affected soils. With this view, a field experiment was conducted on salt affected soil (pH 8.45 and EC_e 10.71 dS m^{-1}) at Nain research farm of CSSRI, to evaluate the Zn and Fe requirement and their relative efficacy of soil and foliar application in combating deficiency of these micronutrients. The experiment was conducted with 12 treatments replicated three times in RBD. The treatments were T_1- Control, T_2- 5 kg Zn, T_3- 6.25 kg Zn, T_4- 7.5 kg Zn, T_5- 7.5 kg Fe, T_6- 10 kg Fe, T_7- 12.5 kg Fe, T_8- 5 kg Zn+10 kg Fe, T_9- 5 kg Zn+10 kg Fe + 10 t FYM, T_{10}- Foliar sprays of 0.5% $ZnSO_4$ (twice), T_{11}- Foliar sprays of 1% $FeSO_4$ (twice at 30 and 45 DAS) and T_{12}- Combined foliar sprays (0.5% $ZnSO_4$+1% $FeSO_4$; twice). Zinc and Fe were applied by $ZnSO_4.7H_2O$ and $FeSO_4.7H_2O$, respectively at the time of sowing of pearlmillet and mustard. Foliar sprays of Zn and Fe were applied through inorganic salt of Zn and Fe ($ZnSO_4.7H_2O$ and $FeSO_4.7H_2O$) in both the crops at 30 and 45 days after sowing. The results of experiment showed that, application of FYM 10 t ha^{-1} along with 5 kg Zn+10 kg Fe significantly improved the effective tillers, ear length, test weight and yield of pearlmillet followed by combined application of 5 kg ha^{-1} Zn and 10 kg ha^{-1} Fe as soil application. The results of experiment also indicated that increase in mustard seed yield (2.26 t ha^{-1}) and pearl millet grain yield (3.73 t ha^{-1}) was 44.3 and 58 per cent higher over control, due to combined application of 5 kg Zn+10 kg Fe +10 t FYM, however, yield improvement was 22.8 and 35.9 per cent due to application of 5 kg Zn+10 kg Fe without FYM, respectively, in mustard and pearl millet over control.

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Effect of Factory Effluent and Inorganic Fertilizers on Yield and Nutrient Uptake by Spinach Beet (*Beta vulgaris* var. bengalensis) in Lateritic Soil of Konkan

S.D. Zodge, S.B. Dodake, N.B. Gokhale, M.C. Kasture and P.B. Sanap
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dapoli, 415712, Dist. Ratnagiri, Maharashtra

A field experiment on effect of factory effluent and inorganic fertilizers on growth, yield and nutrient uptake by spinach beet (*Beta vulgaris* vas. Bengalensis) in lateritic soil of Konkan was conducted with randomized block design comprising nine treatments replicated thrice at Central Experiment Station, Pangari Block, Wakawali, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri during *rabi* 2013-14. The effect of application effluent before sowing and after first harvest (cutting) with and without NPK fertilizers @ 100, 50 and 25% of recommended dose on growth, yield nutrient content and uptake, chemical properties and nutrient availability in soil were studied. Application of effluent before sowing with inorganic fertilizers or application of effluent before sowing and after first cutting with inorganic fertilizers significantly increased yield, content and uptake of macro and micro nutrients over recommended dose of NPK fertilizers. The data on soil fertility revealed that there was significant increase in soil pH, EC, organic carbon, available macro and micronutrients and microbial population in the soils, indicating build-up soil fertility with the compined application of effluent and inorganic fertilizers.

Based on the yield response, uptake of nutrients by plants and build-up of soil fertility, applicaton of effluent before sowing with or without inorganic fertilizers and application of effluent before sowing and after 1st cutting with inorganic fertilizers was found to be suitable for spinach in lateritic soild of Konkan. However, keeping in view the optimum net return with good B:C ratio, application of effluent before sowing+100% RDF was found to be useful for enhancing the spinach production with increased profit.

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Screening of Bt Cotton Hybrids (*Gossypium hirsutum*) for Salt Tolerance in Vertisols of Andhra Pradesh

K. Hema, Y. Sudha Rani and G.V. Lakshmi
AICRP Saline Water Scheme, Bapatla, ANGRAU, Andhra Pradesh

Salinity is the most serious problem that poses threat to productivity of field crops. Cotton (*Gossypium* spp) is an important crop grown for fibre fuel and edible oil. In Andhra Pradesh, it is grown in an area of 10.46 lakh ha and producing 43.9 lakh bales mainly under rain fed conditions. Cotton is salt tolerant crop, but it is sensitive during germination. Major area of the cotton cultivation in Andhra Pradesh is occupied with Bt. Cotton hybrids and the information on salt tolerance of these hybrids is not available. Keeping this in view, evaluation of salt tolerance in Bt. cotton hybrids experiment was carried out with seven hybrids *viz*., Santhi, Bhakthi BG II, Bunny BG II, Dr. Brent BG II, RCH 2BG II, First class BG II and Jadoo BG II and were replicated thrice in randomised block design.in farmer's field at Ammanabrolu village of Prakasam district during *kharif*, 2014. The experimental soil was moderately alkaline (pH: 8.6) and saline (ECe: 8.8 dS m^{-1}) in nature.

Among the hybrids, First class Bt. cotton recorded significantly highest kapas yield (2.24 t ha^{-1}) followed by Dr. Brent Bt. cotton (2.24 t ha^{-1}) and Jadoo Bt.cotton (1.99 t ha^{-1}) . Significantly highest boll weight was recorded in Bhakti Bt. cotton (5.36 g) followed by first class Bt. cotton (5.16 g) and Jaddu Bt. cotton (5.10 g). The highest lint index (6.37 g) and ginning out turn (41.62%) was recorded in Dr. Brent Bt. Cotton followed by Bhakti Bt. The significantly highest span length (30.41 mm) and bundle strength (23.32 g tex^{-1}) of fibre were recorded in First class Bt. followed by Jadoo Bt. and Bunny Bt.The results indicated that First class Bt., Dr. Brent Bt. and Jadoo Bt. were performed better than the other hybrids.

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Characterization of Salt Affected Soils in Mailam Block of Villupuram District, Tamil Nadu and its Relationship with Water Management

M. Lalitha, S. Dharumarajan, Rajendra Hegde and S.K. Singh
ICAR-NBSS&LUP, Bangalore, 560024, Karnataka

Land resources in recent years are under tremendous pressure with highly competing and conflicting land use demands and a large proportion of the land is affected by different kinds of degradation, which in turn affecting country's agricultural productivity and food security. Currently, at least 20 per cent of the world's irrigated land is salt affected and/or irrigated with waters containing elevated levels of salts and salinization of irrigated land causes annual global income loss of about US$ 12 billion. The total salt affected area in Tamil Nadu is 4.7 lakh hectares (3.5% of TGA) which is increasing year after year.

The satellite imagery of LISS IV with 5.8 m resolution and Cartosat-1 having 2.5 m resolution during the year 2010-12 (three seasons) for Mailam block was used for the delineation of salt affected soils in the block. Out of the total geographical area (28,516 ha), the area affected by salt in the block is 11,108 ha (39% of TGA). The soil profiles were studied in the salt affected areas and the colour of the soil is varied from greyish brown to dark greyish brown. Well defined illuviation of clay and bases in B- horizon has markedly altered the soil colour to darker shades. Surface soil texture varied from sandy clay loam to clay loam and the subsurface horizon is mostly dominated by clay. Presence of 20 to 40 cm thick lime concretion layers occurred between 60 to 90 cm soils depths. The size and thickness of lime concretion was found to increase with the increasing degree of soil sodicity. Soils show high pH values ranging from 8.57 to 9.65 (>8.5); electrical conductivity ranged from 0.396 to 1.025 dS m^{-1} (<4 dS m^{-1}) and exchangeable sodium percentage (ESP) in the range of 6.5-37.2% (>15%). The elevation taken from DEM showed that the salt affected areas were mostly found in the elevation ranges of 40 to 60 m above MSL which is mostly found in lowland areas occupied by water bodies and tanks. The average pH (8.93), electrical conductivity (0.62 dS m^{-1}) and exchangeable sodium percentage (16.28%) is also found higher in the lowland areas compared uplands and midlands. The availability of phosphorus and zinc was found low under sodic soils. Though the topography of the area is gentle to very gently sloping nature, the establishment of vast network of tanks across the drainage course in the recent years arrested the free flow of water and subsequently, the water table started rising in surrounding low lying fields. Along with the rising water table, the salts also moved to the surface and deposited after the evaporation of the water. So poor drainage due to the neglect of water ways, channels and consequent rise in the water table, aggravated the extent and severity of sodic soils observed in the area. So provision of proper drainage and sound water management techniques are the keys to prevent the formation of sodic soils in the area.

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Effect of Manganese Seed Priming and Foliar Applied Manganese on Yield and Nutrition of Oats (*Avena sativa* L.) Fodder

Jasdeep Kumari, D.S. Bhatti and J.S. Manchanda
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab

In Punjab manganese deficiency was first reported in wheat during 1980. Oat fodder is the second most important crop after berseem in Punjab during *rabi* season. It is being cultivated on an area of 0.9 lakh ha^{-1}in Punjab and is relatively more sensitive to manganese (Mn) deficiency than wheat. A pot culture experiment was conducted to study the effect of seed priming and foliar application of manganese on oats (*Avena sativa* L.) fodder in highly (0.94 mg Mn kg^{-1} soil) and moderately (2.60 mg Mn kg^{-1} soil) Mn deficient soils. The seeds were primed in 0.0, 0.2 and 0.4 M manganese sulphate solution for 8 h before sowing and as per the treatments 0, 1, 2 and 3 foliar applications of 0.5% manganese sulphate solution were given at weekly intervals starting from 18 days after sowing (DAS). The crop was harvested at 75 DAS. The mean dry matter of shoot and root, root length, Mn influx rate and SPAD value increased significantly with Mn seed priming treatments and foliar applications of manganese sulphate in both the soils. In the absence of Mn seed priming, the highest dry matter was obtained by 3 sprays in highly deficient soil and by 2 sprays in moderately. However, along with Mn seed priming treatment only 2 and 1 sprays were required to get the highest dry matter, respectively in highly and moderately deficient soil. The mean half distance between neighbouring roots and root radius reduced with seed priming treatments and foliar applications of manganese sulphate solution. The mean shoot Mn concentration increased significantly with foliar application of $MnSO_4$ only, however Mn uptake increased significantly with Mn application either through seed priming or foliar sprays. The seed priming with manganese sulphate solution was effective in alleviating Mn deficiency symptoms by 10 to 15 days over control. The results of the study indicated that one spray can be saved by priming the seed with 0.4 *M* manganese sulphate solution. Though, there is a need to further investigate and verify the effect of Mn seed priming on Mn utilization by oats under field conditions.

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Crop Residue Management in Rice-Rice Cropping System

T. Venkata Sridhar[1]* and D. Srinivas
Department of Soil Science, APRRI & RARS, Maruteru, 534122, Andhra Pradesh
[1]Office of Dean PG Studies, ANGRAU, Rajendranagar, Hyderabad, Andhra Pradesh
**Email: sridhar119@yahoo.com , sridhar.tammineni@gmail.com*

Crop residues of rice identified as one of the good source of plant nutrients and are important components for sustainable agricultural productivity. With the advent of mechanized harvesting substantial quantities of rice residues (around 12 t ha^{-1}) are being burnt in situ which cause loss of nutrients and organic matter and biological activity of the soil. Unlike removal or burning incorporation of straw can build-up soil organic matter and improves soil nutrient status upon its mineralization, which however is generally slow due wide C:N ratio. Mineralization of cereal residues can be enhanced by mixing with green manures, Fertilizer N or inoculation with microbial cultures. An experiment was therefore conducted during kharif and *rabi* of 2007 and 2008 with six treatments *viz.*, T_1: straw removed, T_2: straw (5 t ha^{-1}) burnt and ash incorporated, T_3: straw (5 t ha^{-1}) incorporated 20 days before planting rice,T_4: straw (5 t ha^{-1}) incorporated 20 days before planting along with 25% N of RDF (as urea–N) applied at the time of incorporation of straw,T_5:Straw (5 t ha^{-1}) incorporated 20 days before planting along with green manure applied @ 5 t ha^{-1} at incorporation, T6: straw incorporated @ 5 t ha^{-1} 20 days before planting after microbial inoculation. The results revealed that the application of straw @ 5 t ha^{-1} incorporated 20 days before planting along with GM 5 t ha^{-1} (T_5) recording the higher grain yield of 5.97 t ha^{-1} during kharif, 7.04 t ha^{-1} during *rabi* and 5.07 t ha^{-1} during *kharif*, 5.04 t ha^{-1} during *rabi*, among different methods of straw incorporation. Similarly, content and uptake of nutrients and nutrient status in the post-harvest soil were significantly higher with T_5 compared to other treatments during both the seasons. It was followed by the treatment with incorporation of straw (5 t ha^{-1}) 20 days before planting along with 25% RDN as urea applied at the time of incorporation of straw. The lower grain yield as well as content & uptake of nutrients and nutrient status in the post harvested soil were recorded in treatment T_3 (straw @ 5 t ha^{-1}, 20 days before planting).

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Performance of Salt Tolerant Varieties in Salt-affected Soils of Haryana

D.S. Jakhar, J. Nain and L.S. Beniwal
Krishi Vigyan Kendra, Sirsa, Haryana

In Sirsa District (Haryana) about 3000 ha area of salt affected. Rupana, a village adopted by Krishi Vigyan Kendra Sirsa under National Initiative on Climate Resilient Agriculture (NICRA) project is one of these villages where 120 ha area is salt affected. Even in *rabi* season the traditional wheat varieties could not withstand due to the higher salt accumulation. So demonstrations were conducted for two years *viz.* 2013-14 and 2014-15 to adjudge the suitability of two salt tolerant varieties developed by CSSRI Karnal in the existing agro climatic situation. During the first year, the seed of salt tolerant variety KRL-210 was supplied as critical input and traditional variety PBW 343 was sown as check. During second year, salt tolerant variety KRL 213 was introduced and compared with KRL 210. During the year 2013-14, KRL 210 gave better results as compared to the existing PBW 343 with an yield of 3.24 t ha^{-1} as compared to the control (1.02 t ha^{-1}). The benefit cost ratios were 1.5 and 0.5, respectively. Amongst two salt tolerant varieties, KRL 213 surpassed KRL 210 and was found more suitable under existing conditions with grain yield (3.9 t ha^{-1}) as compared to 3.4 t ha^{-1} in case of KRL 210. The respective B:C ratios were 1.8 and 1.6.

Commission 3.5: Soil Degradation Control, Remediation, and Reclamation

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Effect of different Grazing Management Practices in *Lasiurus sindicus* Grasslands of Arid Western Plain on Soil Health

N.R. Panwar, Sharmila Roy, C.B. Pandey, Prakash Mal and Khushbu Khichi
ICAR-Central Arid Zone Research Institute, Jodhpur, 342 003, Rajasthan

Grasslands form major land use of Arid Western plains of India and support livestock based economy of the region. *Lasiurus sindicus* is one of the dominant species and found to have the best water and energy use efficiency among the palatable desert grasses. Due to increasing human/livestock population, degradation of the grasslands is rampant thereby making management and preservation of the remaining natural resource essential. Degradation of soil habitat is closely associated with soil properties thus understanding soil chemical and biochemical properties becomes critical for better management of ecosystem, these properties were ultimately controlled by soil microbial biomass. Changes in the organization of microbial biomass due to land management influences soil fertility and productivity, helping in grassland restoration. *Lasiurus sindicus* grasslands under different grazing management practices were evaluated on the basis of soil organic carbon (SOC), carbon management index (CMI), microbial biomass carbon (MBC), dehydrogenase activity (DHA), fluorescent diacetate activity (FDA), ammonium N (NH_4^+-N), nitrate N (NO_3^--N), important index value of grass (IVI) and micro-arthropod fauna. Evaluation was carried out at active phases of grass growth starting from 26th to 50th meteriological week. Land management practices influenced the SOC, LC, FDA, DHA and micro-arthropod fauna and vegetation composition. Significantly high values were found for silvipasture, protected natural grassland as compared to high input grassland and arable land conditions. Silviculture systems, managed pastures and natural grassland with control grazing have higher values for SOC, CMI, MBC and DHA in comparison to the reference soil (undisturbed soil). The IVI of *Lasiurus sindicus* was 100 per cent in controlled grazing conditions while it varied from 45 to 80 per cent in open grazing sites. Highest faunal build-up was recorded under controlled grazing condition either by small ruminants or cattle. Higher enzymes concentration was found between 26th to 32nd meteriological weeks, the active grass growth period. The Microarthropods build-up was synchronized with FDA and DHA activity. Arthropods abundance was correlated with LC (r =0.76) and FDA (r = 0.73) and Carbon Management Index (r=0.80). Results indicate that management practices have direct role on soil chemical and biological health of soil. Silvipasture system and controlled grazing in grasslands have a beneficial role in restoring soil health in arid Western Rajasthan.

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Heavy Metals and Micronutrients Status of Soils and Crops Irrigated with Mixed Industrial Effluent Water in Industrial Area of Ahmedabad District

G.J. Mistry*[1] and K.P. Patel[2]

[1]Micronutrient Research Project, ICAR Unit-9, Anand Agricultural University, Anand, 388110, Gujarat
[2]B.A.College of Agriculture, Anand Agricultural University, Anand, 388110, Gujarat
**Email: gimistry910@yahoo.in*

Rapid urbanization and industrialization in Gujarat especially in Ahmedabad has caused several problems of soil-water pollution due to used of mixed industrial effluent water as a source of irrigation in agricultural in view of increasing demand for irrigation water supply. Such effluent water act as a carrier as well as a prominent source of heavy metals besides higher nutrients *viz.*, P, K, S and micronutrients in agricultural land and ultimate in ground water. Therefore, survey work was carried out in nearby areas of khari river/ canal(Ahmedabad) which carried mixed industrial effluents of vatwa and Naroda (Ahmedabad) industries as well as adjoining areas irrigated with tube well water to find out the heavy metals as well as micronutrient accumulation in mixed industrial effluent as well as tube well water irrigated soils, agricultural crops as well as naturally growing plant species in both the areas. The study was carried out to assess the level of contamination of heavy metals as well as micronutrients in soil-water-plant system as well as naturally growing plant species/tree. The effluent water, soil and plant samples were collected from 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 analysed for different heavy metals *viz.*, Cd, Ni, Cr, Co and Pb as well as micronutrient *viz.*, Fe, Mn, Zn and Cu by standard method.

The result revealed that the effluent water and soil-plant system were found contaminated with heavy metals (Cd, Ni, Cr, Co and Pb) and also found accumulated with micronutrients (Fe, Mn, Zn and Cu). The level of Cd and Cr was alarming due to their content above the permissible limits. The general quality of the effluent as well as tube well water was poor with respect to its suitability for irrigation. The BOD and COD values of the effluents water were above permissible limits for field application. The effluent irrigated fields showed higher content of heavy metals and micronutrients besides higher nutrients viz., P_2O_5, K_2O, S compared to tube well irrigated fields. The soil contaminated more soluble salts up to 45 cm depth in the profile compared to tube well irrigated non-contaminated soil. The content of heavy metals as well as micronutrients showed decreasing trend with increasing in depth. The content of heavy metals as well as micronutrients in almost all groups (cereals, oil seed, vegetables, fruits, trees, forage and others) of crops/trees were higher grown in contaminated soil. The results indicated the variable behaviour of heavy metals and accumulation capacity is governed by contents and biomass of different crops and naturally growing trees.

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Effect of One Time Application of Distillery Spentwash RO Reject on Soil Properties

Adiveppa Mallappa Asangi, C.A. Srinivasamurthy*, V.R. Ramakrishna Parama, C.T. Subbarayappa, S. Bhaskar[1] and B.C. Mallesha[2]

Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka
[1]Department of Agronomy, UAS, GKVK, Bengaluru, Karnataka
[2]Department of Agricultural Microbiology, UAS, GKVK, Bengaluru, Karnataka
**Email: casmurthy@yahoo.com*

Under the present trend of exploitative agriculture in India, inherent soil fertility can no longer be maintained on sustainable basis. It is said that nutrient supplying capacity of soil declines steadily under intensive cropping system. The use of optimum levels of nitrogen (N), phosphorus (P) and potassium (K) failed to maintain yield levels probably due to increasing secondary and micronutrient deficiencies and also unfavorable alterations in the physical and chemical properties of soil. The preliminary analysis of spentwash R. O. reject revealed that it contains good amount of essential plant nutrients like K, N, Ca, Mg, S and micronutrients and high amount of organic matter besides having some plant growth promoters. Judicious use of distillery spentwash is required for crop nutrition and to maintain soil health.

A field experiment was conducted in a farmer's field near M/s J P Distilleries Pvt. Ltd. Kunigal taluk, Tumkur district, during *kharif* 2013 to study effect of one time application of distillery spentwash R O reject on soil properties with seven treatments replicated thrice using RCBD design. The distillery spentwash (DSW) R O reject had pH of 7.29, high electrical conductivity (44 dS m^{-1}), total dissolved solids (48000 mg L^{-1}) and suspended solids (37100 mg L^{-1}), high BOD (53560 mg L^{-1}) and COD (87280 mg L^{-1}). It contained N (1800 mg L^{-1}), P (450 mg L^{-1}) and K (11887 mg L^{-1}) and also secondary and micronutrients in appreciable amounts.

There was significant change in pH of soil due to one time application of distillery spentwash R O reject. Higher soil pH (7.32) was recorded in treatment receiving 150% N through DSW R.O. reject (T_7). The higher EC values and organic carbon content were recorded in treatment receiving 150% N through distillery spentwash R.O. reject (T_7) (0.98 dS m^{-1} and 1.61%, respectively). Significantly higher amount of available N, P and K were recorded in treatment receiving 150% N through distillery spentwash R.O. reject (T_7) (423, 44.9 and 1649 kg ha^{-1}, respectively). The higher value of Ca, Mg and S was in treatment T_7 receiving 150% N through distillery spentwash R.O. reject (4.70, 2.43 cmol(p^+)kg^{-1} and 34.64 mg kg^{-1}, respectively). There was no significant change in DTPA-extractable Fe, Mn, Zn, Cu and hot water extractable B content of soil due to application of distillery spentwash R O reject. However higher amount of Fe, Mn and Cu (24.0, 28.0 and 1.23 mg kg^{-1}, respectively) were found in treatment T_6 (125% N through DSW R.O. reject). The higher Zn content of soil (0.80 mg kg^{-1}) was in T_7 which received 150% N through distillery spentwash R.O. reject and higher value for B (0.34 mg kg^{-1}) was in T_5 (100% N through DSW R.O. reject). The large quantities of plant nutrients present in distillery spentwash R O reject offers an excellent opportunity to use it as a liquid fertilizer, thus enabling the farmers to save on fertilizers and at the same time achieve higher yield of crops.

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Effect of One Time Application of Distillery Spentwash R O Reject on Growth and Yield of Maize (*Zea mays* L.)

Adiveppa Mallappa Asangi, C.A. Srinivasamurthy*, V.R. Ramakrishna Parama, C.T. Subbarayappa, S. Bhaskar[1] and B.C. Mallesha[2]

Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka
[1]Department of Agronomy, UAS, GKVK, Bengaluru, Karnataka
[2]Department of Agricultural Microbiology, UAS, GKVK, Bengaluru, Karnataka
**Email: casmurthy@yahoo.com*

Maize (*Zea mays* L.) is one of the important cereal crops next to wheat and rice in the world. In India, it ranks fourth after rice, wheat and sorghum. The distillery spentwash R O reject is a dark brown liquid which contains higher amounts of potassium (1.3%), sulphur (0.4%) and appreciable amounts of nitrogen (0.2%) and acts as a slow release liquid fertilizer. Moreover, it contains large amount of calcium, copper, manganese, zinc and a substantial quantity of organic matter essential for soil health. So that it can be used as a liquid fertilizer for improving soil health and yield of crops.

A field experiment was conducted in a farmer's field near M/s J P Distilleries Pvt. Ltd. Kunigal taluk, Tumkur district, during *kharif* 2013 with seven treatments replicated thrice using RCBD design to study effect of one time application of distillery spentwash R O reject on growth and yield of maize (*Zea mays* L.). Results revealed that, at all the crop growth stages, the treatment receiving 150% N through DSW R.O. reject (T_7) recorded the higher plant height, number of leaves per plant and leaf area at 30, 60, 90 and 120 days after sowing (DAS) over the control (RDF only) (T_1).

The higher number of rows per cob, number of grains per cob and test weight were recorded in treatment receiving 150% N through DSW R.O. reject (T_7) (16.7, 564.7 and 25.8 g, respectively) followed by 125% N through DSW R.O. reject (T_5) (15.7, 514.7 and 25.2 g, respectively). The treatment T_7 receiving 150% N through DSW R.O. reject recorded significantly higher grain yield (4.66 t ha^{-1}) followed by T_6 treatment receiving 125% N through DSW R.O. reject (4.48 t ha^{-1}) and lower grain yield (3.18 t ha^{-1}) was recorded in RDF only (T_1). The results indicated that treatment T_7 receiving 150% N through DSW R.O. reject recorded significantly higher stover yield (8.28 t ha^{-1}) followed by 125% N through DSW R.O. reject (T_6) (7.53 t ha^{-1}). Significantly higher uptake of nitrogen (126.2 kg ha^{-1}), phosphorus (40.5 kg ha^{-1}), potassium (192.3 kg ha^{-1}), calcium (41.9 kg ha^{-1}), magnesium (19.2 kg ha^{-1}), sulphur (28.6 kg ha^{-1}) and micronutrients were recorded in treatment T_7 receiving 150% N through DSW R.O. reject followed by other treatments.

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Safe Disposal of Processed Industrial Biomass as Alternative Organic Manure in Agriculture

V.P. Ramani*, K.P. Patel[1] and S.B. Patel[2]

AICRP on Micronutrients, Anand Agricultural University, Anand, Gujarat
[1]B.A. College of Agriculture, Anand Agricultural University, Anand, 388 110, Gujarat
[2]College of Agriculture, Anand Agricultural University, Vaso, 387 380, Gujarat
**Email: vpramani@yahoo.com*

It is necessary to dispose generated industrial wastes in safe way to overcome the further pollution. After proper treatment to the industrial waste, it can be use in agriculture for good quality higher food production. In order to evaluate the effect and rate of processed industrial biomass on yield, contents, uptake and soil status in maize, a field experiment was conducted during 2009 - 2011 at Anand on loamy sand soil for two years. The treatments of different levels of NPK *i.e.* 100% RD, 75% RD and 50% RD were kept to study the possibility of reduction in fertilizer application with the use of processed biomass (BM) in different proportion with FYM (RD= recommended dose, FYM= farmyard manure, BM= processed biomass.)

The results revealed that the effect of application of organics (FYM/BM) with recommended dose of NPK fertilizers increased grain, straw and total yield significantly over control during both individual years and in pooled also. The significant highest grain yield of maize on individual years and in pooled was recorded under the treatment of 75% NPK + BM application @ 10 t ha^{-1}. There is saving of 25% recommended dose of NPK when combined with BM application @ 10 t ha^{-1} or 50% saving of oraganics when applied with full dose (100%) of NPK. The content of Mn, Zn and Cu showed non-significant improvement due to different treatments, while Fe content of maize straw were found altered significantly due to different treatments on pooled basis and it was noticed that biomass application at 7.5 t ha^{-1} along with recommended dose of NPK showed significant enhancement in Fe content of straw over other treatments. Among heavy metals, Co, Pb and Cr contents of grain were found significantly altered due to application of different treatments variably during the pooled. However, at higher rate of BM application *i.e.* of 10 t ha^{-1}, there was slight increase in heavy metal content of grain/ straw as well as DTPA heavy metals in soil; although the increase was not alarming

Thus, the overall results indicated that the application of BM at 5 t ha^{-1} along with full dose of NPK is beneficial to get higher yield of maize without affecting soil / plant health adversely. It also indicated that the 5 t BM ha^{-1} could be utilized in place of 10 t FYM ha^{-1} where FYM availability is scarce. The 10t BM ha^{-1} helps to reduce load of chemical fertilizer up to 25 per cent in agriculture. The lower use of agro-chemicals is always favors safe environment. However, the continuous use of biomass needs periodical monitoring to check any buildup of heavy metals in soil/ plant over the years.

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Scope of Using Treated Paper Mill Effluent in Different Soil Types – A Case Study in Eastern India

Madhumita Das, O.P. Verma, R. Sethi and A.K. Nayak
ICAR–Indian Institute of Water Management, Chandrasekharpur, Bhubaneswar, 751 023, Odisha

Water scarcity is a chronic problem and going to hit agricultural production under vulnerable eco-system. With time, industrial activities will be accelerated which further curtail the allocation of water for irrigation. In contrast a huge amount of wastewater generates particularly from paper mill industry may play a role for being utilized for supplying plant nutrients despite containing toxic substances, in irrigated agriculture. A study was undertaken to determine the potential of agro-residue based paper mill in different soil types, dominated in Odisha. Treated paper mill effluent (PME), collected from COS Board, Jagatpur, Cuttack was neutral in reaction (pH 7.0), low saline (EC1.32 dS m^{-1}), contained excess amount of Ca (154.7 mg L^{-1}), Mg (53.28 mg L^{-1}), Cl (779.9 mg L^{-1}), HCO_3 (91.5 mg L^{-1}), SO_4 (88.5 mg L^{-1}), and moderate to low content of NO_3, organic carbon, Zn, Cu, Fe and Mn. No Cd and Pb was detected in collected PME sample. It was used for leaching of four different soil types at constant head method up to the level of equilibrium followed by normal water washing till to get stabilized with leachate parameters.

Important properties of leachate collected at different intervals revealed that the equilibrium was attained after 145 to 195 min of leaching with PME, and after 80 to 120 min of leaching with normal water. In regards of parameter wise comparison of leachate qualities, a 7% increase in pH and 18% enrichment in HCO_3 content with normal water over its corresponding PME leached leachate was obtained under neutral coarse textured alluvial soil type. Use of PME however increased soil EC, organic carbon, N, P, K, Ca and Mg but substantially decreased EC in a tune of 15.3 to 166 per cent and other attributes at different magnitudes after washing with water in four different soil types. On the basis of leachate quality parameters of treated Paper Mill Effluent of COS Board, Jagatpur, Cuttack, and soil properties the wastewater has found as a supplementary source of irrigation for acidic to neutral, non-saline soils in humid to sub-humid regions.

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Evaluation of Sewage Sludge as a Source of N and P for Pearl millet-Wheat Cropping System

Dev Raj*, R.S. Antil, D.S. Dahiya and Kiran K. Khokhar
Department of Soil Science, CCS Haryana Agricultural University Hisar, 125004, Haryana
**Email: devraj_chauhan@ rediffmail.com*

A field experiment was conducted during 2011 to 2014 at research farm Department of Soil Science CCS HAU Hisar to investigate the availability of N and P from sewage sludge to pearl millet-wheat cropping system and also monitor the changes in soil properties. The sewage sludge was applied to wheat crop @ 5 t ha^{-1} alone and in combination with 50 and 75% recommended dose of fertilizer nitrogen (N) and compared with 100% recommended dose of fertilizer nitrogen. After harvesting of wheat crop, the pearl millet was grown with 75% recommended dose of N along with 75 and 100% recommended dose P and 100% recommended dose of N along with 75 and 100% recommended dose of P in a split plot design. After three years of experimentation, the grain yield of wheat was still lowest when only sewage sludge was applied. However, a significant increase in yield was obtained when 100% RD of N (150 kg ha^{-1}) or sewage sludge @ 5 t ha^{-1} was applied in conjunction with 50 and 75% RD of N. There was an increase of about 103, 86 and 97% in wheat grain yield upon application of 100% RD of N, sewage sludge @ 5 t ha^{-1} + 50% RD of N, and sewage sludge @ 5 t ha^{-1} + 75% RD of N over sewage sludge @ 5 t ha^{-1} applied alone. In pearl millet, 8, 15 and 26 per cent higher grain yield was observed with the application of 75% RD of N + 100% RD of P, 100% RD of N + 75% RD of P and 100% R D of N and P both over 75% RD of N and P both. The post harvest organic carbon content was increased @ 0.02% per year. The post harvest N was highest where 100% RD of N was applied alone. The available P and K was highest in sewage sludge treatment. The toxic metal content in soil was almost equal in all the treatment.

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Post-Harvest Soil Properties of Babycorn as Influenced by Enriched FYM, SWE, NAA and Inorganic Fertilizers in Vertisols

S. Srinivasan, A. Angayarkanni and R. Raghunath
Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Annamalai University, Annamalainagar, 608 002, Tamil Nadu

A potculture experiment was conducted on a Vertisols soil with babycorn cv. COBC 1 during March, 2014 to study the effect of enriched farmyard manure (EFYM), sea weed extract (SWE), naphthalene acetic acid (NAA) and inorganic fertilizers on post-harvest soil properties. The study was carried out in the Department of Soil Science and Agricultural Chemistry, Annamalai University. The experimental design was completely randomized block (CRD) design with ten treatments, *viz.*, T_1 – Control , T_2 – 100% RDF, T_3 – 75% RDF, T_4 - 75% RDF + EFYM, T_5 – 75% RDF + SWE , T_6 – 75% RDF + NAA, T_7 – 75% RDF + EFYM + SWE, T_8 – 75% RDF + SWE + NAA, T_9 – 75% RDF + EFYM + NAA , T_{10} 100% RDF + EFYM + SWE + NAA. Each treatment replicated thrice. The recommended dose of N, P_2O_5 and K_2O for babycorn crop was 135: 62.5: 50 kg ha^{-1}, respectively. EFYM @ 750 kg ha^{-1} was applied as a basal dose. SWE @ 5% and NAA @ 40 ppm were applied 25 and 40 DAS to the respective pots as per treatments. After the harvest of babycorn, post-harvest soil samples from each treatment were analysed for their bulk density, porespace, water holding capacity, pH, EC, and OC content based on standard procedures. The BD, PD, PS and WHC of an initial soil were 1.37 Mg m^{-3}, 2.42 Mg m^{-3} , 43.3 and 35.7 per cent, respectively. Similarly, pH, EC and OC were 7.9, 0.92 dS m^{-1} and 4.8 g kg^{-1} respectively. The results revealed that application of 75% recommended dose of N: P_2O_5: K_2O @ 135: 62.5: 50 kg ha^{-1} + EFYM @ 750 kg ha^{-1} + SWE @ 5% + NAA @ 40 ppm (T_{10}) recorded significantly decreased soil pH (7.10) and EC (0.43 dS m^{-1}) whereas, organic carbon content (9.80 g kg^{-1}) improved significantly . This was might be due to increase in partial pressure of CO_2 and production of organic acids due to organic matter decomposition. However, the treatments did not have significant influence on soil bulk density (1.32 Mg m^{-3}), porespace (46.40%) and water holding capacity (38.28%). From this study, it is concluded that integrated application of organic manures, inorganic fertilizers and growth regulator improved soil health of babycorn in Vertisols soil.

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Effect of Inorganic Anions on Pb Uptake by *Toria* (*Brassica compestris* var. Toria) and its Fractions in Pb-contaminated Soil

Davinder Singh, R. Sikka* and B.S. Sekhon
Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004, Punjab
**Email: sikkar@pau.edu*

Contamination of soil with heavy metals has become a major environmental concern. Among heavy metals lead (Pb) is a widespread contaminant of soil all over the world. 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 organic and inorganic amendments to the soil. We studied the effects of inorganic anions on lead (Pb) fractions and absorption by Indian rape (*Brassica compestris* var. Toria) in lead contaminated soil. In a greenhouse pot experiment four levels of Pb (0, 50, 100, 200 mg Pb kg^{-1} soil) were added to a sandy loam soil which was further amended with potassium salts of four anions ($H_2PO_4^-$, Cl^-, SO_4^{2-}, CO_3^{2-}) at four rates (0, 60, 120 and 240 mg kg^{-1} soil). The amended soils were equilibrated for 30 days and Indian rape was grown. Results indicated that plant shoot dry biomass and seed yield of Indian rape were significantly reduced by the contamination of increasing amounts of Pb. However, addition of $H_2PO_4^-$ and CO_3^{2-} anions decreased but addition of Cl^- enhanced the magnitude of reduction in shoot dry biomass and seed yield with Pb contamination. The Pb absorption in shoots and seeds also increased linearly and significantly with increase in Pb contamination levels. Correspondingly, Pb uptake by Indian rape decreased with the addition of $H_2PO_4^-$ and CO_3^{2-} and increased with the addition of Cl^-. Addition of $H_2PO_4^-$ and CO_3^{2-} decreased the water soluble and exchangeable Pb and reduced Pb uptake whereas addition of Cl^- and SO_4^{2-} increased these fractions and Pb uptake. Application of $H_2PO_4^-$ @ 240 mg kg^{-1} soil was most effective in reducing Pb bioavailability. The results suggested that addition of $H_2PO_4^-$ and CO_3^{2-} anions lowers the bioavailability and increases the geochemical stability of soil Pb, so these have the potential for in situ remediation of Pb-contaminated soil.

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Response of Crops to One Time Controlled Land Application of Treated Distillery Spentwash

C.A. Srinivasamurthy, H.R. Savitha*, B. Gayathri, G.K. Madhu[1] and S. Bhaskar[1]
Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru, Karnataka
[1]Department of Agronomy, UAS, GKVK, Bengaluru, Karnataka
**Email: savitha2094@gmail.com*

Molasses an important byproduct of sugar industry is the main raw material for the production of alcohol in distilleries by fermentation proces. The aqueous distillery effluent known as spentwash is a dark brown coloured, organic effluent and is approximately 12-15 times by volume of the alcohol produced. At present, there are 319 distilleries in India with an installed capacity of 3.29 billion litres of alcohol per year. The effect of one time controlled land application of distillery spentwash to different field crops was studied during 2013-2014. The treated distillery spentwash and soil samples were collected at two depths (0-30 and 30-60 cm) at different stages *viz*., before spentwash application, during crop growth stage and at harvest stage of the crop from identified farmer's fields were analysed for pH, EC, available K_2O and Exchangeable Na content. The yield of crops as influenced by distillery spentwash application was recorded at harvest stage of crops. The test crops chosen for the study were maize, finger millet and horse gram, respectively. After one month of spent wash application, sowing of different crops were done by the farmers in spent wash applied plots. For maize crop, spent wash application was done @ rate of 4 tankers per acre (40 KL /ac), for finger millet crop 2 tankers per acre (20 KL /ac) and for horse gram 1 tanker per acre (10 KL /ac) was applied based on nitrogen content of spentwash.

The distillery spentwash was neutral in reaction (pH 7.32) and EC was high (23.5 dS m^{-1}). The biological oxygen demand (BOD) and chemical oxygen demand (COD) of the effluent sample were 5988 and 33568 mg L^{-1}, respectively. The concentration of nitrogen, phosphorus and potassium were 0.12, 0.04 and 1.02 per cent, respectively. The spentwash contained calcium, magnesium, sulphate and sodium to an extent of 1452, 790, 672 and 645 mg L^{-1}, respectively. Chloride content of the effluent was high (4783 mg L^{-1}). The average concentration of iron, manganese, zinc, copper and boron were 22.5, 4.28, 6.52, 2.32 and 1.08 mg L^{-1}, respectively. The soil samples collected at initial stage were found to be acidic in reaction; and EC values indicate that the soils are normal. The available K_2O content of the soil was medium and the exchangeable Na content of the soil was low. During crop growth stage or after 60 days of spentwash application, there was slight increase in the EC values. The available K_2O content of the soil was very high and exchangeable sodium content of soil has also increased due to nutrient addition through spentwash as compared to initial samples. At harvest of the crop, the pH values of all the soil samples showed acidic to near neutral reaction, electrical conductivity, available potassium and exchangeable Na content of the soil were decreased appreciably compared to crop growth stage. The per cent increase in yield of maize, finger millet and horse gram recorded was 33.3, 30.0 and 21.0 per cent, respectively higher over control.

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Phytoextraction of Micronutrients by Different Plant Species Grown on Contaminated Soil

G.J. Mistry*[1] and K.P. Patel[2]

[1]*Micronutrient Research Project, ICAR Unit-9, Anand Agricultural University, Anand, 388110, Gujarat*
[2]*B.A. College of Agricultural, Anand Agricultural University, Anand, 388110, Gujarat*
**Email: gjmistry910@yahoo.in*

The use of industrial effluent for irrigation is a common practice in India especially in Gujarat during the past few decades poses serious public health risks, being a major source of heavy metals and micronutrients. Long-term irrigation with effluents increases micronutrients accumulation/load in soil and ultimately in ground water. The crops grown on such soil lead to entrance in food chain. However absorption and translocation of micronutrients varies with crops and varieties. Keeping this in view the experiment was carried out to study the micronutrients removal/uptake capacity by different plant species grown on contaminated soil under micro-plots (Size 1.5 × 1.0 × 0.5 m^3) at AAU, Anand. The soil in bulk having sandy loam texture was collected from mixed industrial effluent irrigated fields as well as from the adjoin tube well irrigated fields of Lali-vatwa region nearby Ahmedabad industrial zone and utilized in the micro plots. Three levels of irrigation water *viz.*, 100% mixed industrial effluent (I_1), 1:1 diluted effluent (I_2) and tube well water (I_3) were kept to study their effect on growth and yield of different crops [Sunflower (SF) (*Helianthus annus*), 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 overall findings of the present study indicated that the castor could remove more quantity of individual micronutrients *viz.*, Fe, Mn, Zn and Cu as well as total micronutrients (Fe+Mn+Zn+Cu) from contaminated soil in one cropping season than other crops viz., cotton, tobacco and sunflower. Further, castor recorded the maximum and significantly higher total removal /uptake of individual micronutrients *viz.*, Fe, Mn, Zn and Cu as well as total micronutrients (Fe + Mn + Zn +Cu) with effluent irrigation over 1:1 dilution and tube well water irrigation. In general, result clearly revealed that the phytoextraction capacity of total micronutrients (Fe+Mn+Zn+Cu) by castor was higher than other crops both in soil as well as irrigation condition due to higher biomass production and followed the ascending order castor > tobacco > cotton > sunflower.

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Health Risk of Toxic Trace Elements in Vegetables to the General Population in Punjab, India

Shavinderpal Kaur Sidhu, Kuldip-Singh* and Dhanwinder-Singh
Department of Soil Science, Punjab agricultural University, Ludhiana, Punjab
**Email: kuldip@pau.edu*

Toxic trace elements are very harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts. They are neither removed by normal cropping nor easily leached by rainwater. Most of the trace elements are extremely toxic because of their solubility in water. The main purpose of this study was to evaluate potential risk of toxic trace elements from vegetables consumption to human health with the target hazard quotient (THQ). Estimated daily intake (EDI) values of toxic trace elements (As, Cd, Pb, Ni and Cr) were higher through vegetable consumption. Health risk assessment through vegetable consumption was carried out by target hazard quotient (THQ). Among these heavy metals elements, the THQ of As was the highest. The contribution of As from vegetable consumption to THQw was 64.7% of total THQ (TTHQ) value. The THQ for Pb, Ni, Zn and Cu was generally less than 1 at all percentiles for all age groups in Punjab, suggesting that it is not risky for the inhabitants to consume these elements in vegetables. The THQc and THQw for children were higher than that for adults and seniors suggesting that the exposure or risk of toxic trace elements to children through vegetable consumption was higher than to adults and seniors.

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Potash Farmer Awareness: 1st Step Towards Balanced Crop Nutrition

Shashikant N. Bhende
Country Agronomist, Mosaic Indian Private Limited, Gurgaon

The relationship between fertilizer use and food grain production is weakening year after year. Stagnation in foodgrain production and productivity is a matter of great concern in addition to number of other factors, imbalanced and inefficientuse of fertilizers is one of the major factors for stagnation in food grain. There is need to educate the farmers about importance of balanced crop nutrition (BCN) to increase yield and maintain the soil health.

Mosaic is the world's largest producer and marketer of concentrated phosphate and potash. In the global agriculture industry, Mosaic is viewed as a single source of phosphate, potash and nitrogen fertilizers including feed ingredients. In India, Mosaic distributes phosphate and specialty fertilizers both via its own distribution network and to large institutional customers. Mosaic's DAP (Di-ammonium phosphate) has become one of the most preferred brands of DAP amongst farmers.

Mosaic was formed in 2004 through a merger of Cargill's Fertilizer Business and IMC Global. Mosaic Indian is a subsidiary of The Mosaic Company, USA.

Mosaic launched Indian operations in 2002. Its brand of DAP and MOP (Muriate of potash) sells in 9 states. Mosaic toady sells phosphate and potassium fertilizers and feed ingredients to nearly 350 wholesale customers who in turn serve 4,000 relations in Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Gujarat, Maharashtra and Andhra Pradesh.

Mosaic's mission is "helping the world grow the food it needs". The imbalanced use of fertilizer is reducing the farmer income as well as deteriorating the soil health. Our aim is to improve the quality of life of farmers by helping them achieve enhanced farm economics. To support farmers for harvesting better yield, we have used the following approaches to educate the farmers about the importance of use of potash in balance crop nutrition (BCN) in five states *i.e.* Punjab, Haryana, Uttar Pradesh, Rajasthan and Madhya Pradesh.

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