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Spatial Distribution of Organic Carbon and Available Nutrients in the Soils of CRS, Sirsa, Haryana

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Mapping the spatial variability of soil fertility by applying GIS provides elicit information for current and future uses. Thirty four surface soil samples from Cotton Research Station (CRS), Sirsa were collected by grid method using GPS to evaluate the spatial distribution of available nutrients. The soils of the study area were loam to clay loam in texture, non-saline (0.16-0.51 dSm-1) and slightly alkaline to alkaline (7.50-8.20) in reaction. The organic carbon was found low to medium and varied from 0.26-0.65% with mean value of 0.41%. Available nitrogen (N) was low and varied from 84.00 to 133.00 kg ha⁻¹ with a mean value of 111.38 kg ha⁻¹. The soils of the study area were low to medium in available phosphorous (P) and varied from 4.0-15.00 kg ha⁻¹ with an average value of 9.22 kg ha⁻¹. The soils were medium to high in available potassium (K) and varied from 125.00 to 258.00 kg ha⁻¹ with an average value of 176.84 kg ha⁻¹. Available N and K showed high variation as indicated by high coefficient of variation (CV). Organic carbon and available P showed low variation as indicated by CV values. Among the micronutrients, zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) varied from 2.69-5.68, 18.09-24.00, 0.70-3.40 and 10.53-14.04 mg kg⁻¹ with mean values of 4.45, 20.94, 1.82 and 12.29 mg kg⁻¹, respectively. All the micronutrients showed small variation as indicated by low variance. Organic carbon was significantly correlated with N, P, K and micronutrients. A positive and significant correlation was observed among the micronutrients except Zn and Cu suggesting that these elements are functions of the same pedological factors. The spatial variability maps of nutrients provide an insight of fertility status of the area and will help in easy monitoring of precision fertilizer management.
GIS Based Land Suitability Evaluation for Crop Production in Basavapura Micro-watershed, Chamarajanagara Taluk and District of Karnataka - A Case Study

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Land needs careful and appropriate use that is vital to achieve optimum productivity and to ensure environmental sustainability for future generation. Decision on effective management and appropriate use includes the past and present human activities and the status of physical and chemical properties of the land. The intense changes in land use/land cover may result a significant resource imbalance due to the incompatibility of the land with land use, over exploitation of the resources and mismanagement in terms of its capability and suitability. Though crop production is dominant in the study area, the land is not evaluated/assessed and used according to its natural capability and suitability. In view this, a study was carried out in Basavapura micro-watershed (Haradanahalli sub-watershed, Chamarajanagara Taluk and District) to evaluate the physical properties such as soil depth, slope, gravelliness, texture and erosion for its suitability to field and horticultural crops. Basavapura micro-watershed is located in 11°50′-11°52′N Latitude and 76°56′-76°59′E Longitude covering an area of 783 ha bounded by 4 villages (Bandigere, Haradanahalli, Basavapura and Venkataiahachatra). Outcome of the study indicated that soil depth varied from very shallow (<25 cm) to very deep (>150 cm). Very deep (>150 cm), deep (100-150 cm) and moderate deep (75-100 cm) soils are noticed in 360.4 ha, 134.4 ha and 94.4 ha, respectively. Whereas shallow (25-50 cm) and moderately shallow (50-75 cm) are noticed in 48.5 ha and 35.5 ha. Slope varied from nearly level lands to gently sloping. Major portion of watershed has very gently sloping (1-3% slope, 382.5 ha) followed by nearly level (0-1% slope, 267.2 ha) and gently sloping (3-5% slope, 25.8 ha). In this study area 65.2% of area (510.4 ha) was found to be non gravelly (<15%) followed by gravelly (15-35%) in 21.1% (165.4 ha) of the study area. Soil texture in the watershed varied from loamy sand to clay, wherein clay texture was found to be predominant with an extent of 37.7% area (294.9 ha) followed by sandy loam 21.8% (170.5 ha) and sandy clay 16.4% of area (128.7 ha). However, slight erosion was noticed in 86.3% (675.8 ha) of the watershed. Based on this study, soils with shallow depth need to be sown with field crops and deep and very deep soils with horticulture crops. Lands with gently sloping and slightly eroded need to be managed by cultivating across the slope with suitable soil conservation practices. Light textured soils such as sandy loam and loamy sand needs to be added with sufficient quantity of organic manures to improve the water holding capacity.
Remote Sensing and Geographic Information System An Effective Tool for Soil Fertility Evaluation - A Case Study in Siddappanapalya-1 Micro-watershed, Tumkur Taluk, Tumkur District, Karnataka

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Soil nutrients are the major source of soil fertility that helps for the plant growth. Soil resource is now facing threats due to various soil nutrients deficiency. The soil quality is equally important as that of crop production. Mapping of spatial variability of soil nutrients and its quality is vital important and it is particularly significant, where soil fertility is primary source of agriculture. The present study focus on spatial variability and temporal variability of soil quality in Siddappanapalya-1 micro-watershed representing eastern dry zone in Tumkur taluk of Tumkur district. Cadastral map of 1:7,920 scale was used as base map for the study. The satellite image (quick bird 0.6 M) along with cadastral overlaid on grid map was used to collect the soil samples at 320 m grid interval. There were 50 grids in the micro watershed covering an area of 521 ha. Surface soil samples were collected in the respective grids in the field following standard procedure. Soil fertility parameters viz., pH, EC, available macro and micro nutrients were determined and soil fertility maps were prepared using GIS technology from remote sensing data in ArcGIS 10.4. The result revealed that, soil pH varies from very strongly acidic to slightly alkaline. Neutral soils occurs in 27.7% of area (144.2 ha) followed by slightly acidic soils in 25.0% of area (130.4 ha). Very strongly acidic soils were found in 2.6% of area (13.8 ha) and strongly acidic soils in 9.3% of area (48.7 ha). Major portion of the study area, 66.7% of area (347.9 ha) was medium in organic carbon and 80.5% of area was (419.8 ha) low in available nitrogen. The available phosphorous content was high in 83.3% of area (434.3 ha). Available potassium and sulphur content were medium in 71.6% of area (372.9 ha) and 63.1% of area (328.9 ha), respectively. Among all micro nutrients copper, manganese and iron were sufficient in 83.3% of area (434.3 ha). Zinc content was deficient in 38.0% of area (197.9 ha). Hot water extractable boron content was medium in 77.2% of area (402.6 ha). From the study, it can be concluded that very strongly acidic soils need to be treated with lime and FYM. The deficient macro and micronutrient may be replenished to avoid the crops suffering from their deficiency and for optimum utilization of other nutrients.
Application of RS & GIS for Land Suitability Evaluation for Crop Production in Adalapura Micro-watershed, Tumkur Taluk and District of Karnataka

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Land suitability evaluation aims to rate the quality of land for a particular use relative to other land in an area. Geo-referenced soil survey data and field observations have been integrated in a Geographical Information System (GIS) based land use suitability assessment for agricultural planning. GIS has been used to match the suitability for main crops based on the requirements of the crops and to assess the quality and characteristics of land. A study was carried out in Adalapura micro-watershed (Tumkur Taluk and District) to evaluate the physical properties such as soil depth, slope, gravelliness, texture and erosion for suitability of field crops. Adalapura micro-watershed is located in 13°17′9.43″ and 13°18′48.18″ N Latitude and 77°0′17.38″ and 77°2′14.76″E Longitude covering an area of 655 ha. Results of the study revealed that soil depth varied from moderately shallow (50-75 cm) to very deep (>150 cm). Very deep soils were noticed in 596.4 ha followed by moderately shallow soils in 3.1 ha area. Slope varied from nearly level to very gently sloping. Major portion of watershed has very gently (1-3% slope) sloping lands in 489.2 ha followed by nearly level (0-1%) lands in 110.3 ha. The agriculture land has non gravelly soils in 91.5% area (599.5 ha) with slight erosion in 89.8% area (588 ha) and moderate erosion in 1.7% area (11.5 ha). Soil texture varied from sandy loam to clay, where sandy clay soils covered in 50.6% of the area (331.3 ha) followed by clay soils in 26.7% area (174.9 ha). The land suitability for agriculture crops like Maize, Ragi, Redgram, and Mulberry was worked out. More than half 59.3% (388.3 ha) of the micro watershed area is highly suitable (S1) for cultivation of Ragi and Redgram. Further, 13.5% is moderately suitable (S2) due to its subsurface gravelliness and texture and 7.2% area is marginally suitable (S3) due to texture and calcareousness of the soil and 30.8% area is highly suitable (S1) for maize and 45.9% of area is moderately suitable due to gravelliness and texture. More than half 64.8% (424.1 ha) area of the micro watershed is moderately suitable (S2) for cultivation of mulberry due limitations of gravelliness and texture. Further, 26.7% area (175.4 ha) is marginally suitable (S3) due to the limitations of gravelliness, texture and calcareousness. Based on this study, area with moderately shallow depth need to be sown with field crops and very deep soils with horticulture crops. Lands with very gently sloping and slightly eroded need to be managed by cultivating across the slope with suitable soil conservation practices. Area with light textured soils such as sandy loam needs to be added with organic manures to improve the water holding capacity.
Preparation of Spatial Variability Map for BHU Agricultural Farm

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One of the greatest challenges the world faces presently is, how to ensure food security and zero hunger. By 2050 of country’s estimated food grain demand is to increase to ~300 Mt for which the country would require ~45 Mt of nutrients. Site specific nutrient management (SSNM) is a production system that promotes variable management practices according to field variability and availability of resource, technology. GIS (Geographical Information System), and GPS (Global Positioning System) are the best accompanying tools to address the variation in the field and can result as a form of soil map. It is expected to provide ways to reverse the productivity and fertility trends in India in a positive direction by creating valid agrotechnological decisions. The soil fertility maps are prepared using ArcGIS 10.3 software with 545 surface soil samples collected during the month of April-May, 2017 from the BHU agricultural research farm. Mapping was done by interpolating the point values using IDW, exponential and spherical krigging methods to get variability trend of the entire area. From the interpolation techniques, different model was chosen for individual parameter by observing the geostatistical parameters namely nugget/sill ratio and R² value. The parameters those observed are pH, EC, oxidisable organic carbon, primary major nutrients and cationic micronutrients (Fe, Mn, Cu, Zn). Judicious use of fertilizer and soil nutrient resources ensuring optimum crop production is possible by fertilizer recommendation for pre-set yield target depending on soil-crop-variety-fertilizer-climate-management interaction for a given situation.
Characterization of Soils of Cold Arid Region of Leh-Ladakh, Jammu & Kashmir for Land Management

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The cold arid Ladakh region of Jammu and Kashmir State is situated in the eastern part of the Kashmir occupies the high altitude ranges in North -Western Himalayas. Majority of area is under snow cover or under glaciers for more than six months with limited connectivity with the world. It is hostile barren, rocky, rugged topography of treeless tract. As Leh-Ladakh region is a cold arid zone, has great differences in climate, vegetation, topography and rocks and so the characteristics of its soil would be quite different with other regions. Because of high altitude zones, severe climatic limitations, terrain condition and soil limitations the vast chunk of land is uncultivated, affected by severe degradation. The climate change scenario affects the agricultural production systems and natural resources. Hence, region needs immediate attention to arrest degradation and land management for livelihood security. Comprehensive information about characteristics of soil of this cold desert is scarce. Therefore, the present study was undertaken to characterize the soils of Leh-Ladakh region for land management. The representative soil profiles occurring on different physiographic settings were studied. Soils are shallow to very shallow in depth, gravelly and coarser in texture, vary widely in colour, texture, structure and permeability depending upon altitude, topography and vegetation. Soils are neutral to moderately alkaline, low to high in organic carbon and variation are associated with altitude, land use and soil texture. It has predominant influence of parent material, physical weathering, frigid and arid pedo-environment. Most of the soil characteristics seem to be inherited from the regolith due to very slow rate of soil forming process. Based on the surface and subsurface diagnostic horizons, morphological, physico-chemical characteristics of the soils, they have been classified as three main soil orders, viz. Entisols, (Lithic/Typic Cryorthents, Typic Ustipsamments), Inceptisols (Typic Cryustepts, Fluventic Cryaquepts) with occasional presence of Alfisols. Valley floors are potential areas for agricultural development. Problems of cold and aridic climatic condition, shallow depth, gravelly texture, low AWC, subsurface stoniness, severe erosion and limited irrigation facilities restrict the use and productivity of agricultural lands. Thus, the proper soils and water conservation measures, adoption of agro-horti-forestry system, pasture land development and organically managed agriculture practices are the best solution for land degradation and improving the soil health for livelihood security of the cold desert region.
Evaluation of Soil Constraints and Soil Sustainability of the Soils of Southern Saurashtra Region of Gujarat

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The representative soils of different landforms of coastal belt in Southern Saurashtra region in Gujarat were evaluated for their soil constraints and soil sustainability. Soil depth and low O.C. (poor soil fertility) are the major soil constraints in the soils belongs to Ustorthents in hilly area as well as Ustorthents and Haplustepts in upper piedmont area. Poor drainage, soil depth, clayey texture and high CaCO₃ are the major soil constraints in the soils belongs to Ustorthents and Haplustepts in lower piedmont area whereas, poor drainage, high CaCO₃, low O.C. and salinity/sodicity hazards are the major soil constraints for crop growth in Calciustepts and Haplustepts in piedmont plain and coastal plain area. The soils at higher elevation have the major soil constraints like shallow depth, fine texture, pH and poor soil fertility (low OC) whereas, at lower elevation have high pH, poor drainage as well as poor soil fertility (low OC) and high bulk density. The soils of pedon P₁ (Sasan) were placed in sustainable class S₂, while the soils associated with the pedons P₂ to P₈, P₁₀ to P₁₃ and P₁₅ were placed in sustainable with high input class S₃. The soils of pedons P₉, P₁₄ and P₁₆ were placed in sustainable with alternate land use class S₄. The management strategies of the soils of different land forms are given in text.
Studies of Land Resource Inventory Based Land Use Planning in Maynaguri Block of Jalpaiguri District, West Bengal

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GIS based land resource inventory (LRI) with fine resolution imagery is considered as most authentic tool for soil resource mapping. Soil resource mapping using the concept of soil series in a smaller scale limits its wide application and also its impact assessment for crop suitability is controversial. In this study, we attempted to develop LRI at large scale (1: 10,000 scale) for block level land use planning (LUP) in Maynaguri block of Jalpaiguri district, West Bengal. The five land forms (upper, lower piedmont, old, young alluvial and active flood plain) representing Indo- Gangetic Alluvial plain soils are classified into two soil orders (Inceptisol and Entisol), 22 landscape ecological units (LEU), 11 soil series mapped in 12 phases and 07 land management unit (LMU). Traditionally, three major land uses were prevalent such as forest, field crops (single and double) and homestead tea. Of the field crops jute-rice-potato/rice-jute/rice-potato/rice-rice/rice-mustard were dominant cropping systems in these areas depending upon irrigation availability but not as per soil suitability. Pulse based cropping systems were negligible areas causing land degradation. Socio-economic data analysis indicated that potato and jute were most vulnerable crops in the areas. Crop suitability inclusive land use plan following LRI based land management unit (LMUs) in 1: 10000 scale for the block development agencies/stack holders have been recommended.
Mapping and Characterization of Salt Affected Soils in Ambala District, Haryana by Remote Sensing

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IRS LISS III data of March, June and October 2010 revealed spatial distribution of salt affected soils in the Markanda and Ghaggar plains of Ambala district, Haryana. Signatures of stagnated surface water in the partially cropped areas indicate temporary waterlogging in the alkali soils. At places, white salt crust indicated soil salinization in irrigated areas along the Bhakra canal command. Red to dark red tones indicated scattered, discontinuous and mottled crop covers in the salt affected areas. High reflectance from riverine sand with no vegetative cover indicated wastelands. High energy absorption from surface water restricted delineation of salt affected soils using IRS data, inputs from ground truth studies was vital for such areas. The ground water depth and quality data indicated deep and marginal quality in general.

Soil profile studies indicated calcium carbonates at sub-surface depths inhibit movement of water in sodic soil. Saline soil was confined in the irrigated areas of Bhakra canal. Significant areas of wastelands were found in the hummocky plain in Naraingarh block. Common source of irrigation is good quality of ground water. Rice-wheat and oilseed crops are common arable crop and forestry plantation is also practiced along the river course. Pedon P1 and P2 were collected from Dangri river plain and P3 and P4 were located in the Markanda plain. The ranges of pHs values (7.9 to 9.4 in P1, 8.5 to 9.6 in P2, 9.1 to 9.5 in P3 and 9.3 to 9.8 in P4) indicated moderate to strongly sodic soils. Low pHs at the surface layers in P1 and P2 indicated reclamation. pHs of P1, P2 and P3 increased at the lower depths while it is consistent in P4. The dominance of Na⁺, Ca²⁺, Mg²⁺, CO₃²⁻ and HCO₃⁻ salts indicated the presence of alkaline parent materials. CaCO₃ content indicated calcareous nature at sub-surface depths and imperfect drainage. Low to moderate CEC values are related to coarse to medium soil texture. Particle size analysis data indicated loam to clay loam and sandy loam. The pHs and ESP (24 to 60) values of P1 indicated careful soil and water management required after gypsum application. Sodicity, calcareous layer and higher clay content (13 to 29%) at sub-surface depths of P2 indicated the need for soil and water management after careful reclamation on GR basis. Higher Na⁺, CO₃²⁻ and HCO₃⁻ contents of P3 indicated residual sodicity and needs low dosage of gypsum application and is also suitable for salt resistant crops. P4 is a strongly sodic soil and loamy soil texture in the Markanda plain. It needs gypsum application @ 6-8 t ha⁻¹ for reclamation followed by salt leaching before putting for arable cropping. The sodic and saline soils covered 4222 and 842 ha, slight and moderately categories salt affected soils covered 4040 and 1024 ha, respectively.
Characterization of Gypsiferous Soils of Thar Desert: An Arid Agroecosystem

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Gypsiferous soils are spread in 207 million ha area of the world. They formed in dry lands of arid regions and very rare in humid temperate regions. The solubility of gypsum is 2.6 g L⁻¹ at 25°C. These soils are considered as marginal for agricultural production. A study was carried out in part of the Thar desert of Rajasthan on occurrence of gypsiferous soils. These soils are present in scattered form in between the sand dunes in the area. Two soil series Mahela and Bherusari were identified; Mahela series belong to coarse loamy, gypsic, hyperthermic, Calcic Petrogypsids and Bherusari series was classified as coarse loamy, mixed, hyperthermic, Sodic Haplogypsids. The soils under Mahela series are non-saline and non-sodic with very thick cemented gypsic layer (>115cm) after 35cm depth. These soils have been disturbed by mining activities. The soils of Bherusari are saline (EC 8-16 dSm⁻¹) sodic (ESP 18-50) and gypsum was present in lower layers in the form of reduced layer under waterlogged condition. The pH of Mahela series was below 8.2 whereas it was around 9.0 in all layers of Bherusari series. Gypsiferous soils of Mahela were developed under hyper aridity due to evaporation and precipitation of gypsum mixed with limestone. The soils of Bherusari were gypsified by mass movement of ions followed by replacement of NaCl by CaSO₄ and its precipitation and accumulation in the form of gypsum in the subsurface horizons. Both the soils are not fit for agriculture due to strong influence of mining and exposure of gypsic layer in Mahela series and high secondary salinization and gypsification under waterlogged condition in Bherusari series.
Characterization and Classification of Soils in Brahmanakotkur Watershed of Kurnool district in Andhra Pradesh

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Twenty one typical pedons representing major landforms in semi-arid ecosystem of Brahmanakotkur watershed in Kurnool district of Andhra Pradesh viz., plains and uplands originated from limestone, dolomite, quartz and shale parent materials under varying land uses were studied for their morphological characteristics, physical and physico-chemical properties and soil genesis. These soils were neutral to strongly alkaline (7.01 to 9.11) in reaction, non-saline (0.10 to 0.82 dSm⁻¹), shallow, deep and very deep in depth and had isohyperthermic temperature and ustic soil moisture regime. The texture, organic carbon (OC), cation exchange capacity (CEC) and base saturation were ranged from gravelly sandy loam to clay, 0.01 to 0.58 per cent, 8.11 to 61.72 cmol(p⁺)kg⁻¹ and 69.14 and 99.71 per cent, respectively. Pedon21 was placed under Entisol due to absence of sub-surface diagnostic horizon and was classified as Lithic Ustorthent whereas pedons4,9 and 10 were grouped under Inceptisol due to presence of cambic (Bw) sub-surface diagnostic horizon and classified as Typic Haplustept and Lithic Haplustept. However, the remaining pedons were classified under Vertisol due to presence of more than 30 percent clay in all the horizons, slickensides and wedge shaped aggregates in sub-surface horizons and cracks in surface horizons and were classified as Typic Haplustert, Sodic Haplustert, Typic Calciustert, Leptic Calciustert and Sodic Calciustert.
Characterization and Classification of Basavapura Micro Watershed Based on Land Capability and Soil Suitability for Crops by using Remote Sensing and GIS

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Remote sensing (RS) plays a key role in generating spatial information and mapping of natural resources and inventory, particularly in soil resource mapping for optimal land use towards sustainable development of agriculture. A study was conducted in Basavapura micro watershed with the objective of assessing crop suitability for field crops viz., maize, finger millet, pigeonpea and horticulture crops like banana and sapota using land capability classification (LCC) through Geographic Information System (GIS) techniques. Basavapura micro watershed (Haradanahalli sub-watershed, Chamrajnagar block and district, Karnataka) is located in 11°50′-11°52′N latitude and 76°56′-76°59′E longitude covering an area of 783 ha bounded by 4 villages (Bandigere, Haradanahalli, Basavapura and Venkataiahnachatra). The land capability classes and sub-classes were assigned based on soil depth, slope, erosion status, surface and sub-surface gravelliness and soil texture of each physiographic unit. A thematic map with the help of GIS tools indicating land capability classes was prepared for the micro-watershed. The LCC of the study area indicated that, out of 783 ha of micro-watershed area, 568.5 ha falls under class II with moderate limitation of soil depth, gravelliness, texture and salinity/alkalinity, 171 ha falls under class III due to marginal limitation of soil depth, gravelliness, texture and salinity/alkalinity and 2.7 ha falls under class IV due to severe limitation of soil depth gravelliness, texture and slope. The crop suitability of the various physiographic units indicated that 107 ha is found to be ‘highly suitable’ for maize and 327.6 ha for finger millet and pigeonpea. About 317.3 ha is found to be ‘moderately suitable’ for maize, 253.3 ha for finger millet and 271 ha for pigeonpea due to gravelliness and rooting depth limitations. In case of horticulture crops, 204.7 ha is found to be highly suitable for banana and 296.8 ha for sapota, while 301.3 ha and 226.3 ha is found to be ‘moderately suitable’ for banana and sapota due to limitation of rooting depth and gravelliness; and 89.6 ha and 101.5 ha is marginally suitable for banana and sapota due to severe gravelliness (35-60%), restricted rooting depth (<50 cm) and poor soil texture. From the present study, farmers could grow the suggested crops instead of crops which are found to be less suitable based on the land capability and soil suitability criteria and attain maximum productivity and profitability.
Preparation of GPS-GIS based Soil Fertility Maps along with Characterization, Classification and Evaluation of Soil under a Toposequence of Mid Central Table Land Agroclimatic Zone of Odisha

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A detailed plot wise surface (0-15cm) soil sample collection and soil profile study was conducted in RRTTS and KVK farm, Dhenkanal located in the Mid-Central Table Land Agro Climatic Zone of Odisha. The study area is situated in the feet of ‘Charakhola hills’ in Dhenkanal forest range. The RRTTS and KVK farm lies along a toposequence with three distinct land types comprising of upland, medium land and low land. Upland soils are the sites of soil erosion with less moisture, more coarse fragments and low fertility status and that of low land soils are mostly characterized by impeded drainage and high water table. Pedon 1, 2 and 3 are classified as Loamy-skeletal, mixed, hyperthermic, Typic Ustorthents, Fine-loamy, mixed, hyperthermic, Udic Haplustalfs and Fine-loamy, mixed, hyperthermic Aeric Ochraqualfs respectively. Since, a well formed toposequence is found in the study area, there were distinct variations in soil morphological, physical, chemical properties including variations in soil fertility status of the surface soil along the toposequence.

The results show that available nitrogen, phosphorus and sulphur content increased towards the lower topographic position which may be attributed to increase in amount of organic carbon content in the lower topographic position due to high moisture content and higher cropping intensity. There was an increasing trend of available potassium observed from higher to lower topographic position which can be attributed to the increasing clay percentage along the toposequence. Available iron, manganese, copper, zinc and boron content was also found to be increasing towards the lower topographic position which can be attributed to increase in amount of organic carbon content in the same. Positive correlation between available Fe, Mn, Cu, Zn with soil organic carbon content and that of negative correlation with soil pH has been found.

Textural class of surface soil samples of the study area were found to vary in between sandy, loamy sand, sandy loam, sandy clay loam and sandy clay. Clay percentage in the medium land and low land were found to be higher than that of upland. The soil reaction was found to be acidic in the entire farm varying between pH of 4.1 to 5.9. Electrical conductivity for all the surface soils were found to be less than 1 dSm⁻¹ and hence are safe for all types of crop production. SOC was found to vary between medium to high range (5.1 to 15.9 g kg⁻¹). Available N (209 to 358 kg ha⁻¹), Bray’s P (5 to 39 kg ha⁻¹ ) of the study area were found to be low to medium in range and that of available K status was observed to be in medium to high range (239 to 698 kg ha⁻¹). Available S status was found to be of low range (3.6 to 15.5 kg ha⁻¹) in the entire study area; that of Fe (31.1 to 99.9 mg kg⁻¹), Mn (10.2 to 40.6 mg kg⁻¹), Cu (0.6 to 2.9 mg kg⁻¹), Zn (0.6 to 1.6 mg kg⁻¹) and B (0.63 to 1.28 mg kg⁻¹) were found to be sufficient. Soil acidity was found to be the major crop production constraint of the study area. So, application of liming materials along with application of soil test based fertilizers and manures will help in optimising crop productivity as well as sustaining soil health.
Soil Fertility and Soil-site Suitability of Biligere Micro-watershed, Tumkur District, Karnataka for Horticultural Crops

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Land resource inventory of Biligere micro-watershed, Tumkur District, Karnataka which is located at North latitude 13°14’39.794″ and 13°16’13.145″ and East longitude 76°58’43.14″ and 77°0’11.714″ covering an area of about 509 ha was made using geospatial techniques. Cadastral map at 1:7,920 scale was used as base map for the study. The satellite image (Quickbird 0.60 m) along with Survey of India toposheet was used for delineation of land forms and physiographic units. Transects were identified in different landforms in which soil profiles were studied. Grid soil samples collected at 320 m interval were analysed for various physical and chemical properties. The study and understanding of soil physical and chemical properties and their distribution over an area has proved useful for the development of soil and crop management plan for efficient utilization of limited soil resources. Soil map indicating nineteen phases was prepared. Soils varied from sandy loam to clay texture. Soil depth varied from moderately shallow (50-75 cm) to very deep (>150 cm). The micro-watershed area has non gravelly (0-15%) soils with slight erosion and very gently sloping. The pH of the soils varied from extremely acidic to neutral (4.04-7.3), electrical conductivity was normal (0.04 to 0.88 dS m⁻¹), organic carbon was low to high (3.0 to 9.9 g kg⁻¹). Among the macro nutrients, available nitrogen content was found low (<250 kg ha⁻¹), available phosphorous content was medium (23-56 kg ha⁻¹) and available potassium content was medium (140-330 kg ha⁻¹). Among secondary nutrients exchangeable Ca was deficient to sufficient [1.0-3.5 cmol(p⁺)kg⁻¹], exchangeable Mg was deficient to sufficient [0.5-3.0 cmol(p⁺)kg⁻¹] and sulphur was low to high (5.19 to 35.58 ppm). The micro nutrients such as copper (>0.20 ppm), manganese (>1.0 ppm) and iron (>4.50 ppm) were sufficient in 89.3% of area (454.3 ha). However, zinc was deficient (<0.60 ppm) in 89.3% area (454.3 ha). Available boron was found low (>0.5 ppm) in 89.3% area (454.3 ha). The land suitability for horticultural crops such as Banana, Mango, Sapota, Guava, Custard Apple, Jackfruit, Jamun, Tamarind, Coconut and Areca nut was worked out. About three fourth i.e., 79.4% area (404 ha) of the micro-watershed are highly suitable (S1) for cultivation of Sapota, Areca nut Jackfruit, Jamun Custard apple and Tamarind. Further, 59.6% area (303.1 ha) is highly suitable (S1) for cultivation of Mango and Coconut and 79.4% area (404 ha) is moderately suitable (S2) for cultivation of Banana and Guava due limitation of soil texture. The database on soils of Biligere micro-watershed can serve as an important advisory for suggesting appropriate crops and suitable intervention in order to increase production.
Effect of Tillage, Crop Residue Mulching and Nitrogen Management on Soil Water Dynamics and Water use Efficiency of Maize-wheat System in An Inceptisol

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Enhancing water use efficiency is of paramount importance in the face of decline in water resources, particularly in arid and semi-arid areas with erratic rainfall patterns. Optimum synergistic combination of water, nutrient and tillage should be found out for different cropping systems, soil types and agro-climatic regions to improve the water use efficiency. A field experiment was conducted on maize-wheat system in a Typic Haplustept at the Indian Agricultural Research Institute, New Delhi during 2016 to 2018 in a split-split plot design with two levels of tillage (Conventional tillage (CT) and No tillage (NT)), two levels of mulching (with or without crop residue mulch @ 5t ha⁻¹) and three nitrogen doses (50, 100 and 150% of the recommended dose of N for maize (150 kg N ha⁻¹) and wheat (120 kg N ha⁻¹)) to study the effect of tillage, crop residue mulching and nitrogen interactions on yield and water use efficiency of maize (cv PMH1) and wheat (cv HD 2967). It was observed that there was significant increase in the soil moisture storage due to application of crop residue mulch. The pooled grain yield of maize under CT was statistically at par with NT though there was reduction in grain yield of maize under NT than that of CT. Effect of crop residue mulch was not significant on grain yield of maize in both the years. Application of 225 and 150 kg N ha⁻¹ significantly increased the grain yield of maize by 37.1 and 34.2% than that of 75 kg N ha⁻¹, respectively. However, there was no significant difference in the grain yield of maize due to 150 and 225 kg N ha⁻¹. The water use efficiency (WUE) of maize followed the similar trend as that of grain yield. It was not influenced significantly due to tillage and crop residue mulching. However, WUE of maize increased significantly due to N application. Application of 150 and 225 kg N ha⁻¹ significantly increased the WUE of maize by 35.7 and 36.8%, respectively than that of 75 kg N ha⁻¹ but there was no significant difference between 150 and 225 kg N ha⁻¹ with respect to WUE of maize. It was observed that during both the years, tillage and residue management did not influence grain yield of wheat significantly, but it increased significantly with increase in nitrogen levels. Pooled grain yield of wheat due to 180 kg N ha⁻¹ was significantly higher than that of 120 and 60 kg N ha⁻¹ by 9.1 and 24.6%, respectively. There was no significant difference between CT and NT on WUE of wheat. However, application of crop residue mulch significantly increased WUE of wheat by 7.3%. The WUE of wheat increased significantly with the increase in N dose in both the years. The WUE of wheat due to 180 kg N ha⁻¹ was significantly higher than that of 120 and 60 kg N ha⁻¹ by 10.6 and 30.9%, respectively. Thus from this study it may be concluded that maize and wheat may be grown under no tillage with crop residue mulch @ 5t ha⁻¹ and with N dose of 150 kg N ha⁻¹ and 180 kg N ha⁻¹, respectively to achieve higher yield and water use efficiency without any significant reduction in crop yield than that of conventional tillage in Inceptisols of Delhi region.
Modeling Infiltration Characteristics of Soils from Arid Region of India

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Infiltration rate of soil is an important hydraulic parameter. It governs partitioning of rainfall events into runoff and soil profile storage. If the rainfall intensity is greater than the infiltration capacity of soil, ponding occurs on soil surface, which generates runoff if slope permits. Therefore, knowledge on infiltration characteristics plays a key role in modeling water balance components and assessing soil loss carrying through runoff water. Keeping in mind this importance, infiltration characteristics of 15 sites from arid region of India was measured using double ring infiltrometer. The experimental infiltration data was further modeled through three standard infiltration models: Green and Ampt model, Horton model and Philips model. Further, regression based models were developed to estimate the infiltration parameters from basic soil properties. Green & Ampt steady state infiltration rate varied from 2.37 cm h⁻¹ at khadin (runoff farming) beds to 75.60 cm h⁻¹ at denuded dune. Corresponding Horton infiltration rate for khadin bed and dune site was observed as 7.32 and 78.22 cm h⁻¹, respectively. Philip model was not able to satisfactorily fit steady state infiltration rate for khadin bed, however, for dune site it was 71.23 cm h⁻¹. Steady state infiltration rate was found positively correlated with gravel content of top soil layer (0-10 cm) (r = 0.87-0.97, p<0.01) and sand content of 0-30 soil layer (r = 0.76-0.79, p<0.01) whereas negatively correlated with silt content (r = -0.86, p<0.01) and clay content (r = -0.69, p<0.05). Based on the findings from correlation matrix, regression based models were developed to estimate infiltration parameters. Green and Ampt model parameters were best estimated through regression based model with R² value of 0.54 and 0.50 for ksat and B, respectively. Since, it is time consuming and tedious to measure infiltration characteristics in field, the developed models in this study may be used to estimate infiltration characteristics and runoff generation potential from watershed catchments of arid region.
Assessment of Temporal Changes in Cotton Growing Soils under Different Management Practices

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Cotton (Gossypium hirsutum) is one of the major kharif crop in the Vertisol region of central India under rainfed conditions. In this study, we evaluated the temporal changes in cotton growing soils under different management practices in ICAR-CICR research farm, Panjri village, Nagpur (Maharashtra) which is used for research on developing management practices and varieties for cotton based system for many decades. We used the data of dynamic properties of the soils at 0-25 and 0-50 cm depth of the year 2000 and compared with present data obtained in 2018. The results showed significant change in most of the dynamic soil properties in organic, inorganic and undisturbed soils under cotton cultivation. The sHC decreased in all soils whereas, organic carbon increased by 23% in surface and 10% in sub-surface soils under organic cultivation. Bulk density decreased from 1.60 to 1.36 in surface and 1.55 to 1.46 in sub-surface layers of soils under organic system respectively. Calcium carbonate decreased in organic as well as undisturbed systems whereas it increased in intensively cultivated soils. Prevalent system of management practices i.e. application of vermicompost and green manuring in cotton growing soils increased the organic carbon in soils, however, it decreased BD, sHC and pH. Moreover, increase in inorganic carbon was observed. Some of these changes such as decrease in sHC could be a threat to the cotton cultivation and suitable management interventions are necessary to sustain cotton production.
Assessment of Soil Quality attributes under Different Tillage, Residue and Nitrogen Management in Maize-Wheat Cropping System in an Inceptisol

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Maintaining soil health/quality is indispensable for sustaining the agricultural productivity at higher level. But indiscriminate tillage of agricultural soils can lead to deterioration in soil health, accelerated erosion, depletion of soil organic matter and fertility and disrupted cycles of water, organic carbon and plant nutrients and consequently reduction in crop productivity. It is estimated that out of the 328 Mha of the total geographical area in India, 120.72 Mha land area is degraded in one way or the other, producing less than 20% of its potential capacity. Soil health including soil physical, chemical and biological health needs to be maintained and improved by appropriate management practices to sustain productivity at higher levels in the long run. Conservation agriculture practices involving reduced tillage, residue retention and crop rotation has emerged as a paradigm shift in agricultural practices having favourable effect on soil health, carbon sequestration and sustainable agricultural production and mitigation of climate change. Keeping this in view, a study was conducted to assess soil health after four years of imposition of different tillage, residue and nitrogen management practices in maize-wheat cropping system in an Inceptisol. Soil samples were collected at three different depths (0-5, 5-15 and 15-30cm) after the harvesting of wheat crop and analyzed for various soil physical, chemical and biological attributes. It was observed that bulk density under no tillage (NT) was slightly higher than that of conventional tillage (CT) and there was reduction in bulk density under crop residue mulch at 0-15 cm soil depth. The mean weight diameter (MWD) under NT was significantly higher than that of CT at 5-15 cm soil depth. Retention of crop residue mulch resulted in higher MWD than no mulch treatment at 0-5 cm soil depth. For other depths, though it was numerically higher under residue treatment then non-residue but the effect was not statistically significant. Soil pH was lower under crop residue mulch and it decreased with the increase in nitrogen doses at 0-5, 5-15 and 15-30 cm soil depth. Total organic carbon under NT and crop residue mulch was significantly higher than that of CT and no mulch treatment, respectively. Available nitrogen was not significantly influenced by tillage and residue management, but increased significantly with the increase in nitrogen doses. Due to addition of crop residue mulch available phosphorus and potassium content increased significantly at 0-5 and 5-15 cm soil depth compared to no mulch treatment. Soil microbial biomass carbon and dehydrogenase activity was significantly higher under NT and crop residue mulch than CT and no mulch treatment, respectively. These soil biological increased significantly with the increase in nitrogen doses. Therefore no tillage with crop residue mulch and recommended dose of nitrogen may be followed in maize-wheat cropping system in Inceptisols of Indogangetic plain region to improve the physical, chemical and biological attributes of soil quality.
Soil Moisture Dynamics in Different Land Use Systems from Temperate Mountainous Ecosystem of Nilgiris

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Soil moisture is an important component for soil function which regulates soil organic matter (SOM) and microbial decomposition. Therefore, soil moisture is highly important for the exchange of CO2 between soil and atmosphere, hence plays significant role in global warming and global climate change. In the present study, fortnightly estimation of soil moisture at 15 cm interval up to a depth of 90 cm was carried out using Aquapro moisture/sensor meter in seven land uses viz., Shola forest, Eucalyptus forest, Wattle forest, Pine forest, mixed forest, tea garden and agricultural field in the temperate ecosystem in the Nilgiris. Soil moisture was found to increase with increasing depth. Soil moisture (Mean) in profile showed increasing trend from July to middle of August. Soil moisture was found less in surface layers and increases with depth towards subsurface layers. However, the moisture content becomes more or less similar in surface and subsurface layers in the middle of August because of continuous rainfall. Our study found highest soil moisture in Shola forest (37.0%) followed by agricultural land (36.0%). Lowest soil moisture (29.0%) was recorded with pine forests during this period. High soil moisture under Shola forest and agricultural land is attributed to high clay content in soils. Also, soils under Shola forest is mostly under shadow conditions of dense trees and therefore evaporation of soil moisture by direct sun light is minimal. In the study area the available soil moisture was distinctly less in the surface soil layer in all the land uses when compared to the subsurface layer. This may be attributed to the fact that the surface soil with well developed stable macro aggregates permits easy infiltration and the deeper soil have more effective volume per unit area for greater moisture storage. Further work is under progress to relate soil moisture status with CO2 emission from the soils of various land use systems in the study area.
Impact of Long-term Zero Tillage on Soil Quality Indices under Mungbean-Wheat and Sorghum-wheat Cropping Systems

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Conservation tillage such as zero tillage and crop rotations play an important role in maintaining soil productivity. The field experiment was conducted on a sandy loam soil to investigate the effects of long-term zero tillage on soil physical properties and carbon fractions. The experiment consisted of three tillage practices as main treatments viz., zero tillage in both kharif and rabi seasons (ZT-ZT), zero tillage in rabi (CT-ZT) and conventional tillage (CT-CT), and two cropping systems as main treatments (mungbean-wheat and sorghum-wheat), and two moisture regimes as sub-treatments (I/CPE = 0.75 and 0.90). After nine years of experimentation, the soil organic carbon and carbon sequestration rate measured at the harvest of wheat crop were found higher with zero tillage practice in both kharif and rabi seasons over other tillage practices in mungbean-wheat and sorghum-wheat cropping systems. The light fraction of soil organic carbon was found sensitive to the changes in soil organic carbon under different tillage practices in both the cropping systems and observed 57.5% higher in ZT-ZT as compared to the conventional tillage. The penetration resistance decreased with reducing the intensity of tillage in both the cropping systems. The effect of zero tillage was observed more pronounced in moisture regime at I/CPE of 0.90. The mungbean-wheat cropping resulted in higher total porosity as compared to sorghum-wheat cropping system.
Long Term Effect of Farming Practices on Soil Physical Properties in Different Soil Types of Haryana (India)

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The major challenge for Indian agriculture in the coming era will be to meet the ever increasing demands for food, fibre and energy, while maintaining or sustaining, if not improving, soil fertility and productivity. Though with the introduction of high nutrient responsive dwarf varieties and increased use of chemicals fertilizers coupled with better irrigation facilities, the area along with the production and productivity of crops increased significantly in the Indo-Gangetic plains but now there are reports of declining or stagnating crop yields and the sustainability of the different farming systems is now under threat. From the literature, the organic farming practices appeared extremely important and superior to conventional farming practices for enhancing soil fertility and maintaining the environmental sustainability. Therefore, a paradigm shifting in management practices through elimination of conventional agriculture is crucial for future productivity gains while sustaining the natural resources. Keeping in view the above concerns the present investigation was carried out to compare the physical properties of texturally different soils of Haryana subjected to organic and conventional farming practices. A total of 50 surface (0-15 cm) soil samples in triplicates were collected from 25 organic farms as well as adjoining conventional farms at 11 districts of Haryana and analysed for soil texture, bulk density, infiltration rate, aggregate size distribution and moisture retention characteristics of soils. Results revealed that shifting from conventional to organic farming had prominent effect and found to significantly reduce the average bulk density from 1.47 to 1.45 Mg m⁻³ as compared to conventional farming system. Expect for sandy soils, infiltration rate was observed to be higher under organic farming but significant differences occurs only for silt loam, sandy clay loam and clay loam soils. Similarly, water stable aggregates (WSA >0.25 mm) of soils under organic farming were higher (39.92%) as compared to conventionally managed soils (35.19%). Overall, under conventional farming, moisture content at field capacity and plant available water were 21.31 and 14.86% which was significantly increased to 23.12 and 16.57% under organic soils. The study concluded that organic soils were found to have better soil quality in terms of physical properties which is considered to be decisive for enhancing productivity while sustaining natural resources.
Investigation of Effect of Soil Properties on Hydraulic Properties in Arid and Semi-arid Regions of Haryana State

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The determination of hydraulic properties and their relationship with different properties of soils is prerequisite for efficient use of water in water management practices in arid and semi-arid regions of the Haryana State. The study was carried out by collecting surface (0-15 cm) and sub-surface (15-30 cm) soil samples from twenty different locations at farmers’ fields of the State. The soils samples were found of six textural classes i.e., sand, loamy sand, sandy loam, loam, silty loam and sandy clay loam on the basis of textural analysis. The saturated hydraulic conductivity (Ksat), soil organic carbon (OC), bulk density, soil moisture retention, and water stable aggregates were determined using standard methods. The Ksat of the soils was found significantly and positively correlated with bulk density (R² = 0.61) at both the depths. The Ksat was also found significantly and negatively correlated with silt+clay content (R² = 0.90) at both the depths. The plant available water (PAW) in sandy clay loam was almost equal in silty loam soils at both the depths but it was higher than that of sand, loamy sand, sandy loam and loam soils. Amongst the texturally different soils, sandy clay loam soil retained highest amount of plant available water of 22.55 and 22.89%, whereas, sand soils had lowest plant available water of 4.99 and 5.53% at 0-15 and 15-30 cm depths, respectively. The soil moisture at field capacity (FC) showed significantly and positively correlation with silt+clay content and soil organic carbon. However, the moistures at FC showed significant and negative correlation with bulk density at both the depths. The water stable aggregates (>0.25 mm) in sandy clay loam soil was measured highest of 66.56% (0-15 cm) and 64.34% (15-30 cm) amongst the texturally different soils. The results indicated that assessment of relationship between hydraulic properties and physical properties of soils might play a strategic role in adopting suitable water management practices in arid and semi-arid regions of the State.
Assessment of Rainfall Variability and its Impact on Groundwater Resources and Recharge Structures in Yarehalli Micro-watershed of Channagiri Taluk, Davanagere District

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The groundwater is a dynamic and replenishable natural resource, but in hard rock terrains its availability is of limited extent and essentially confined to the fractured and weathered horizons, which points towards efficient management of groundwater in these areas, the behaviour of groundwater in the Indian sub-continent is highly complicated due to the occurrence of diversified geological formations. The study on rainfall variability and its impact on groundwater resources and opportunities for recharge structures in watershed gain importance. The groundwater extraction and recharge pattern were studied by monitoring at Yarehalli micro-watershed during 2016-2017. The micro-watershed consists of about 761.9 ha area and having bore well density of around 11 per sq. km. Groundwater levels of selected bore-wells were observed throughout year at monthly intervals and discharge was measured during Kharif (August), Rabi (December) and Summer (May) seasons. The fluctuation of groundwater levels on a seasonal basis showed that groundwater level increased in response to seasonal precipitation. The study revealed that the average fluctuation of discharge during Kharif, Rabi and Summer were 2.52, 2.35 and 1.68 lps, respectively. Similarly, the average fluctuation of groundwater level in the year of 2017 was 22.4 m and the average fluctuation of discharge during Kharif, Rabi and Summer were 2.36, 2.44 and 2.28 lps, respectively. It was observed that the ground water fluctuation and discharge were more in the year 2017 as compared to the year 2016. The total draft of groundwater was found to be 27,09,619 m³ against with the groundwater extractions being 15 times more than the recharge. From the study, there is scope and opportunity of artificial ground water recharge structures in Yarehalli micro-watershed.
Changes in Land Management Practices for Enhancing Rice-wheat Yield and Irrigation Water Productivity

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Land management practices effect crop and water productivity. The present study includes combination of tillage practices for both rice and wheat i.e. deep tillage before rice and wheat and conventional tillage practices in main plots and method of sowing and crop establishment i.e. no-tillage with residue in wheat and direct seeding in rice kept in sub plots. These treatments were compared with conventional tillage in wheat and puddle transplanting in rice. It was reported that deep tillage before rice results in 8% more paddy yield, while before wheat results in 12% more wheat grain yield than conventional tillage. However, among crop establishment methods puddled transplanted rice out yielded direct seeded rice by 11%. Irrespective of crop establishment methods followed in rice, the no-tillage with residue practice in wheat results in 7% more wheat grain yield than conventional tillage. Maximum rice straw was recorded in puddled transplanted rice and conventional tillage wheat combination, while that of wheat straw was recorded in no-tillage with residue in wheat and puddled transplanted rice combination. Soil mechanical strength decreased significantly under deep tillage as the penetration resistance reduced by 30% than conventional tillage in compacted 20-30 cm soil layer. The reduced soil mechanical resistance under deep tillage resulted in 18% and 22% more root length densities of rice and wheat, respectively than conventional tillage. Water transmission characteristics i.e. infiltration rate of soil was also found to be increased under deep tillage than conventional tillage. The irrigation water productivity of both rice and wheat improved under deep tillage than conventional tillage practice. However, the improvement in water productivity was significant under puddled transplanted rice and no-tillage with residue in wheat. Performing deep tillage operation before wheat and sowing with no-tillage along with residue is better land management option in northwest India.
Yield and Water Use Efficiency of Wheat as Influenced by Management Interventions and Climate Change in Punjab

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Field experiments for six seasons (2008-2013) and simulation studies with CERES-Wheat crop growth model for present time slice (PTS; 2008-2013) and mid-century (MC; 2021-2050) were carried out to assess different planting dates, varieties and irrigation schedules in addressing the impact of climate change on grain yield and water use efficiency (WUE) in bread wheat (Triticum aestivum L.). Field experiments demonstrated that growing of late varieties in last week of October with adequate irrigation, and medium to late variety in 1st week of November is the best measure to tackle temperature variability impact on wheat yield. During field experimentation, WUE was unaffected by planting date, however, it was 6% higher in late variety than early variety. Simulation study suggested that in MC, increase in maximum and minimum temperatures compared to PTS would reduce wheat yield by 17-27%. In MC, WUE would be reduced by 14.8% due to shortening of crop duration (1-11 days). The reduction in WUE could be ascribed to relatively more reduction in yield (22%) than ET (4%). The WUE in MC3 (2041-2050) was relatively more than MC1 (2021-2030) and MC2 (2031-2040) due to more yield and less ET. Delaying planting date of wheat crop by 15-30 days in this region emerged as the best adaptation measure to tackle climate change impact for sustaining yield and having higher water use efficiency in mid-century.
How Useful is the Application of Hydro Gels in Augmenting Soil Water Retention and Water Use Efficiency of Agricultural Crops?


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Rainfed agriculture is a highly risky business as moisture stress is a major constraint for crop growth in these areas. Application of water-saving super absorbent polymers (SAP) in to the soil is normally perceived to be an effective way to increase both water and nutrient use efficiency in crops. When polymers are incorporated in soil, it is presumed that they retain large quantities of water and nutrients, which are released as required by the plant. The effect of application of graded doses of PAA hydro gel (@0, 10, 20, 30, 40 and 50 kg ha\(^{-1}\) to soil) on water absorption and retention at various suction levels (0 -15 bar) in three soils of varying textures viz. clay, silty clay loam, and sandy loam, studied at ICAR-IISS Bhopal, revealed that the water retention of these soils was augmented by hydro gel to variable degrees between 0.3 and 1.0 bar of matric suction. The effect seems good only at 0-0.3 bar, beyond which the effect is small that too up to 1 bar. The matric suction of 0 to 1.0 bar, however, is a narrow range especially for rain fed crops where the irrigation water is scarce and a farmer re-irrigates the crops even at 10 bar moisture content. The field experiment on soybean (variety JS: 9560) was conducted with four hydro gel treatments viz., T\(_1\) (No hydro gel), T\(_2\) (20 kg ha\(^{-1}\) hydro gel), T\(_3\) (30 kg ha\(^{-1}\) hydro gel), and T\(_4\) (40 kg ha\(^{-1}\) hydro gel) with nine replications. The rainfall during both the years was normal except some excessive rainfall events and few dry spells during the soybean crop. The number of grains/plant did not show any significant variation due to hydro gel treatment. However, the mean values averaged over two years followed an increasing trend with increase in hydro gel dose but without statistical significance. The biomass yield varied significantly and the mean values of the biomass yield indicated an increase in biomass yield of soybean with increase in the hydro gel doses from T\(_1\) to T\(_4\). During the soybean growth, in both the years, few dry spells were observed and the soil moisture during these spells was determined to ascertain the level of soil moisture maintained by hydro gel application. It was observed that during the dry periods the soil moisture content was higher only by 0.5-1.5% in hydro gel treatments than in control. The field experiment was also conducted on the effect of graded doses of hydro gel application on water use efficiency (WUE) and yield of tomato crop (var Laxmi). Data indicated that tomato fruit yield did not increase significantly with the increasing doses of hydro gel. No significant change was observed in the WUE of tomato crop. The soil bulk density values measured after harvest of second year tomato crop did not show any significant change with increase in the hydro gel doses. The pot experiment was also conducted on tomato on another two soils which were texturally different viz. silty clay loam and sandy loam. In pot experiment the fruiting was less uniform in both the soils. The fruit weight/plant of tomato in silty clay loam soils showed some decrease with increase in the doses of hydro gel. In sandy loam soils, the fruit weight of tomato did not show any statistically significant change with increase in hydro gel levels. In both the soils, the increase in hydro gel doses did not show any significant increase in water use efficiency. The evapotranspiration (ET) losses were recorded under both pot experiments (soil types) by weighing the pots at regular intervals. In both soil types, the cumulative ET losses varied from 7 cm to 44 cm and no significant difference was caused due to hydro gel rate variation under any single irrigation treatment.
Comparative Evaluation of Manurial Qualities of Water Hyacinth Compost and its Effect of Soil Organic Carbon Fraction and Physico-chemical Properties of Sandy Loam Soils of Middle Gujarat

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The experiment was conducted during kharif and summer season of the year 2014-15 and 2015-16 at Anand Agricultural University, Anand, Gujarat. The experiment was laid out in completely randomized design with twenty treatments of water hyacinth composts, FYM and vermicompost combinations of RDF with and without zinc and multi-micronutrient mixture grade-V (MMMG-V). Application of RDF + Water hyacinth compost with saw dust @ 5 t ha⁻¹ + Zn @ 5 ppm, RDF + Water hyacinth compost saw dust @ 5 t ha⁻¹ + MMMG-V @ 25 kg ha⁻¹, Application of RDF + Water hyacinth compost with saw dust @ 5 t ha⁻¹ + Zn @ 5 ppm, RDF + Water hyacinth compost @ 5 t ha⁻¹ + MMMG-V @ 25 kg ha⁻¹, RDF + Water hyacinth compost @ 5 t ha⁻¹ + Zn @ 5 ppm and RDF + FYM @ 10 t ha⁻¹ + Zn @ 5 ppm significantly increased the Major and Micronutrient Status of soil. From the results of organic carbon fraction the priming effect of the application of organic material to the soil which stimulates the microbial activity and mineralization of N forms present in SOC helping thereby in decomposition of SOC with rapid release of water soluble carbon. The supply of additional mineralizable and readily hydrolysable C due to organic manure application resulted in higher microbial activity and higher SMBC. It indicated that manure addition resulted in higher SMBC than inorganic fertilization. So this was clearly indicated that the among all the organic manures water hyacinth composts and FYM showed better results because of its lower C:N ratio. So, use of water hyacinth compost as improved crop yield and quality of crop nutrient status of crop and it was found best option of FYM in addition to the main benefit of cleaning this noxious aquatic weed from the water bodies.
Nitrogen Mineralization Studies of Different Urea Products in Inceptisol of South Gujarat

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A laboratory study was conducted to estimate the nitrogen mineralization of different urea products in Inceptisol of South Gujarat in the year 2018. The 100g of soil was incubated in 96 plastic beakers (150 ml capacity) which consists three products of urea and an absolute control using completely randomized design with four repetitions (destructive method). Nitrogen was applied @ 111mg kg⁻¹ soil from three sources of urea viz. (i) Urea fertilizer (Urea-A), (ii) Neem coated urea (Urea-B) and (iii) Slow release urea (Urea-C) by dissolving in water. All the treated and control soils were maintained at field capacity moisture level throughout the incubation period and sampled at 0 day (1 hour), 2nd day (48 hours), 4th day (96 hours), 6th day (144 hours), 8th day (192 hours) and 10th day (240 hours) for NO₃⁻N and NH₄⁻N analysis. The study revealed that there was significant difference in N mineralization behavior between the three N sources. After completion of 10 days incubation the NH₄⁻N released in soil was 23.54, 73.49, 76.22 and 62.69 mg kg⁻¹ and NO₃⁻N released in soil was 40.06, 96.64, 81.81 and 62.17 mg kg⁻¹ under control, Urea-A, Urea-B and Urea-C treatments respectively. Therefore, N mineralization was recorded 63.61, 170.13 (96%), 158.03 (85%) and 124.87 (55%) mg kg⁻¹ under control, Urea-A, Urea-B and Urea-C treatments respectively. The N mineralization was much quicker under urea-A and Urea-C has slow mineralizing property in laboratory incubation study of clayey soil.
Effect of Organic Manure and Inorganic Fertilizers on Inorganic Fractions of Nitrogen in Soybean

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The field experiment was conducted at Agricultural Research Institute, Hyderabad, Telangana. The experiment was laid out in factorial combination of with and without leaf fall and increasing levels of N along with FYM application in randomized complete block design, with plot size of 6.1 m x 4.2 m and replicated thrice with five treatment viz., 75% RDF, 100% RDF, 75% RDF + FYM @ 5 t ha⁻¹, 100% RDF + FYM @ 5 t ha⁻¹ and in addition absolute control was maintained. ADB-22 (Bhasar) a medium yielding variety of soybean was used as the test crop in this experiment. The soil was clay in texture and moderately alkaline (pH 8.4) in reaction, non-saline in nature (EC 0.16 dS m⁻¹) and medium in organic carbon (0.67%). Leaf fall was collected from the experimental plots, fresh and dry weight was quantified and where the treatments involving with leaf fall left to incorporate after fresh weight was quantified. The maximum leaf fall was recorded with treatments involving 100% RDF + FYM @ 5 t ha⁻¹ (490.28 kg ha⁻¹) at 100 DAS and the highest NH₄⁺-N and NO₃⁻-N (19.48 mg kg⁻¹ and 13.31 mg kg⁻¹ respectively) was recorded with application of 100% RDF + FYM @ 5 t ha⁻¹ at 40 DAS. The NO₃⁻-N and NH₄⁺-N values sharply increased up to 40 DAS, slightly declined at 60 DAS and from 80 DAS onwards there was a steep declining up to harvest. The NH₄⁺-N released at 100 DAS, at harvest. The increased ammonification and nitrification was observed at 20 DAH and 40 DAH.
Nitrogen Transformation and its Utilization as Influenced by Nickel Application under Different Nitrogen Sources in Maize

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A pot experiment was carried out at Net House of Department of Soil Science and Agricultural Chemistry of Navsari Agricultural University, Navsari during in Rabi season in the year 2016-17 to study the “Nitrogen transformation and its utilization as influenced by nickel application under different nitrogen sources in maize”. This experiment was including 16 treatment combinations comprising two levels and two sources of N (UR80, UR120, AS80 and AS120 kg ha⁻¹) and four Ni levels (Ni0, Ni2.5, Ni5 and Ni7.5 ppm) in Factorial Completely Randomized Design with three repetitions. The Ni application through NiCl₂.6H₂O was given before fifteen days of sowing, while N application was made through urea and ammonium sulphate in two splits viz. at 25DAS and 40 DAS.

The experiment was conducted to study the effect of different levels of nickel and nitrogen levels and sources on growth, yield, quality, nitrogen transforming enzymatic activities in maize and availability of nitrogen and important soil properties as influenced by nitrogen and nickel application after harvest of crop.

Urea N application (120 kg ha⁻¹) registered the highest plant height as compared with ammonium sulphate. The Ni application at 5 mg kg⁻¹ caused significant and maximum improvement in plant height as well as dry matter yield. Further, the combined influence of N and Ni application was found most effective to enhance in plant height as well as fresh and dry matter yield when urea was applied at 120 kg ha⁻¹ in conjunction with 5 mg Ni kg⁻¹ soil. The Ni application either at 5.0 or 7.5 mg kg⁻¹ with urea N level (80 kg ha⁻¹) were equally effective in increasing urease enzyme activity in maize leaves. Similar trend was found in soil urease enzyme activity.

In case of protein Ni application at 2.5 mg kg⁻¹ has significant effect on protein content over control. Due to the interaction effect highest protein content was recorded with the treatment UR₁₂₀Ni₂.₅. The highest N content was noticed due to combined effect of 2.5 mg kg⁻¹ Ni and 120 kg N ha⁻¹ through urea application in leaves of maize after 3rd and 7th day of first and second N split application and at harvest of the crop. The Fe content except all macro and micro nutrient which was found significant with N and Ni application.

The available N content in soil was found to be increased with increase in N application. The NH₄⁺-N in soil after 3rd and 7th day of first and second N split application and after harvest of the crop was influenced significantly due to application of N sources as well as Ni. The DTPA-Ni content in the soil was noted higher due to combined effect of urea 120 kg N ha⁻¹ with the Ni application at 7.5 mg kg⁻¹.
Effect of Humic Substance Enriched with Micronutrients on Growth and Yield of Maize

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A field experiment effect of humic substance enriched with micronutrients on soil properties, growth and yield of maize was conducted during Kharif 2017 at College of Agriculture, Vishweshwaraiah Canal Farm, Mandya. The experiment was laid out following RCBD with ten treatments replicated thrice. Soil of the experimental site was sandy loam in texture, neutral in reaction (7.28), high in organic carbon content (9.80 g kg⁻¹). The available nitrogen content was low (242.06 kg ha⁻¹), phosphorus was high (107.72 kg P₂O₅ ha⁻¹) and potassium was medium (213.54 kg K₂O ha⁻¹). The exchangeable Ca and Mg content were adequate and the available sulphur content was high. Among the micronutrients boron content was in deficient range while Fe, Mn, Zn and Cu were sufficient. The humic substance required for the experiment was extracted using 0.1 N NaOH from FYM incubated for 15 days with (200 ppm Fe, Mn and Zn, 20 ppm Cu) and without micronutrients maintaining sufficient moisture and designated as Enriched Humic Substance (EHS) and Humic Substance (HS), respectively. EHS and HS were tested using maize as test crop at two levels i.e., 2.5 and 5 litres ha⁻¹ applied as basal or 30 days after sowing (DAS). The per cent humic substance present in the HS and EHS extracts was found to be 1.70% and 1.80%, respectively. The content of humic substance in both the materials were concentrated to 10% by evaporating the moisture and used for treatment imposition. The results revealed that significantly higher growth and yield parameters at harvest such as plant height (212.80 cm), number of leaves (13.27), leaf area (6173.56 cm²), cob length (20.23 cm), number of grains per row (36.87), grain (7.6 t ha⁻¹) and stover yield (10.3 t ha⁻¹) were recorded with application of RDF + FYM along with EHS @ 5 L ha⁻¹ 30 DAS and this was followed by treatment receiving RDF + FYM along with EHS @ 2.5 L ha⁻¹ 30 DAS. The per cent increase in grain yield over control was 23.55% and 19.76%, respectively by these two treatments. Among the humic substance treated plots, lowest increase (3.27%) over control was observed in treatment with RDF + FYM + HS @ 2.5 L ha⁻¹ as basal. Further, there was significant increase in the growth and yield due to enriched HA treatments compared to corresponding non enriched HA treatments. Similarly, there was also increase in growth and yield with 30 DAS treatments compared to corresponding basal treatments.
Effect of Organic Ligands on Bio-availability of Soil Zinc to Maize (Zea mays) in an Inceptisol

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About 30% of the cultivated soils of the world and 49% of Indian soils are deficient in Zn due to which frequent application of fertilizer Zn is required. Organic ligands release from microorganisms, contained in FYM and use of low molecular weight organic acids such as oxalic and citric acids are reported to mobilize soil Zn in various studies. Keeping this in view a green house experiment was conducted to test the effect of application of FYM, Zn solubilising microorganism and oxalic acid on Zn bioavailability to maize in an Inceptisol deficient in Zn. The treatments were oxalic acid (0, 5 and 10 mg kg⁻¹ soil), FYM (0, 2.5 g kg⁻¹ soil) and Zn solubilising microorganism with different doses of Zn (0, 1.25 and 2.5 mg Zn kg⁻¹ soil) applied as ZnSO₄. The recommended doses of NPK for maize were applied in all the treatments. After the harvest of maize biomass at 50 days after sowing, soil DTPA extractable and plant tissue (di-acid digested) total Zn content was estimated on AAS. All the treatments significantly increased the maize biomass yield, plant tissue Zn content and Zn uptake over control. The maize biomass produced on application of 5 mg oxalic acid kg⁻¹ soil was statistically at par with the treatments viz. 2.5 mg Zn kg⁻¹, zinc solubilising microorganism and its combination with Zn (1.25 and 2.5 mg Zn kg⁻¹), FYM (2.5 g FYM kg⁻¹) and FYM + Zn (2.5 g FYM kg⁻¹ + 1.25 mg Zn kg⁻¹). The treatment 5 mg oxalic acid kg⁻¹ was significantly superior to all the treatments having 10 mg oxalic acid kg⁻¹ with and without Zn. The highest tissue Zn content and uptake was observed under treatment zinc solubilizer + 1.25 mg Zn kg⁻¹. The significant increase in soil DTPA-Zn after the harvest of maize was observed only in the treatments having oxalic acid (5 and 10 mg oxalic acid kg⁻¹) and 2.5 mg Zn kg⁻¹ over all the treatments which revealed that use of oxalic acid mobilized and maintained higher Zn level in the soil. The results showed that 5 mg oxalic acid kg⁻¹ soil could be used for efficient soil Zn management under Zn deficient conditions.
Fractions and Stocks of Soil Oxidisable Carbon under Different Land Use and Cropping Systems of IFS under Semi-arid Conditions of Telangana

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Studies on fractions and stocks of soil oxidisable carbon under different land use and cropping systems were carried out at the end of seven years during 2017-18 in an established crop + horticulture + livestock integrated farming systems unit developed for small and marginal farmers under Irrigated dry situations and evaluated under AICRP-IFS since 2011-12 in 1 ha area. Cultivation of various cropping systems over a period of seven years with continuous application of fertilizers and organic manure resulted in increased in total oxidisable carbon stock over the initial status of the soil. The maximum improvement in TOC stock (0-105 cm soil) was recorded in fodder block (50.91 Mg C ha\(^{-1}\)) with a sequestration of 15.72 Mg C ha\(^{-1}\) and sequestration rate of 2.25 Mg C ha\(^{-1}\) Yr \(^{-1}\) and it was followed by orchard block (44.25 Mg C ha\(^{-1}\)) with a sequestration of 9.06 Mg C ha\(^{-1}\) and sequestration rate of 1.29 Mg C ha\(^{-1}\) Yr \(^{-1}\). Lowest sequestration was noticed Bt cotton + greengram-fodder sorghum (40.38 Mg C ha\(^{-1}\)) with a sequestration of 5.19 Mg C ha\(^{-1}\) and sequestration rate of 0.74 Mg C ha\(^{-1}\) yr \(^{-1}\). However the build was noticed in all the cropping systems in 0-15 cm but up to 30 cm soil depth in fodder block. In the subsequent soil layers the trend was not distinctly evident.

Among all the fractions of SOC, very labile fraction was the prominent fraction constituting to nearly 50-60% under various treatments. Maximum stock of very labile carbon stock (0-105 cm soil) was recorded in fodder block (29.51 Mg C ha\(^{-1}\)) with a sequestration of 9.20 Mg C ha\(^{-1}\) and sequestration rate of 1.31 Mg C ha\(^{-1}\) yr \(^{-1}\) and it was followed by orchard block (25.58 Mg C ha\(^{-1}\)) with a sequestration of 5.27 Mg C ha\(^{-1}\) and sequestration rate of 0.75 Mg C ha\(^{-1}\) yr \(^{-1}\). Lowest sequestration was noticed Bt cotton + greengram – fodder sorghum (23.26 Mg C ha\(^{-1}\)) with a sequestration of 2.95 Mg C ha\(^{-1}\) and sequestration rate of 0.42 Mg C ha\(^{-1}\) yr \(^{-1}\). Similar to Total SOC stocks, the build was noticed in all the cropping systems in 0-15 cm but up to 30 cm soil depth in fodder block. In the subsequent depths the trend was not distinctly evident.

Labile fraction was the next prominent fraction constituting to nearly 20-30% under various treatments. Maximum stock of labile carbon (0-105 cm soil) was recorded in fodder block (16.65 Mg C ha\(^{-1}\)) with a sequestration of 5.23 Mg C ha\(^{-1}\) and sequestration rate of 0.75 Mg C ha\(^{-1}\) yr \(^{-1}\). In all other cropping systems the sequestration of this fraction was 1.65 to 2.98 Mg C ha\(^{-1}\) with a sequestration rate of 0.24 to 0.43 Mg C ha\(^{-1}\) yr \(^{-1}\). Similar to Total SOC stocks and very labile carbon stocks, the buildup was noticed in all the cropping systems in 0-15 cm but up to 30 cm soil depth in fodder block. In the subsequent depths build up was not distinctly evident. Less labile fraction constituted to nearly 10-20% under various treatments. Maximum less labile carbon stock (0-105 cm soil) was recorded in fodder block (9.83 Mg C ha\(^{-1}\)) with a sequestration of 3.05 Mg C ha\(^{-1}\) and sequestration rate of 0.44 Mg C ha\(^{-1}\) yr \(^{-1}\). In all other cropping systems the sequestration of this fraction was ranging between 0.99 to 1.74 Mg C ha\(^{-1}\) with a sequestration rate of 0.14 to 0.25 Mg C ha\(^{-1}\) yr \(^{-1}\). Unlike the total SOC stocks, very labile carbon stocks and labile carbon stocks, the buildup of this fraction was almost similar in all the cropping systems in 0-15 cm and also in subsequent depths with marginally higher quantities under fodder block.

The stable and desired non labile fraction constituted 5-10% under various treatments. Maximum quantities of non labile carbon stock (0-105 cm soil) was recorded in fodder block (3.14 Mg C ha\(^{-1}\)) with a sequestration of 0.99 Mg C ha\(^{-1}\) and sequestration rate of 0.14 Mg C ha\(^{-1}\) yr \(^{-1}\). In all other cropping systems the sequestration of this fraction was ranging between 0.31 to 0.59 Mg C ha\(^{-1}\) with a sequestration rate of 0.04 to 0.08 Mg C ha\(^{-1}\) yr \(^{-1}\) and the buildup of this fraction was almost similar in all the cropping systems in 0-15 cm and also in subsequent depths.
Nickel (Ni) is an essential element for plants. Abundant information exists on Ni toxicity in soil-plant system but not much is available on its critical level of deficiency (CLD) in soils and plants. Five hundred surface soil samples (0-15 cm) were collected from different locations of Varanasi districts, India. These soils were analysed for DTPA-extractable Ni content. Out of these, on the basis of Ni content, 21 soils were selected (7 from each group) by broadly grouping them as low (<0.2 mg kg\(^{-1}\) Ni), medium (0.2- 0.4 mg kg\(^{-1}\) Ni) and high (> 0.4 mg kg\(^{-1}\) Ni). The bulk soil samples were collected from 21 selected locations to conduct the pot experiment. The experiment was conducted under pot culture condition in green house of the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (India). Three levels of Ni \(i.e.\) Ni\(_{0}\), Ni\(_{7.5}\) and Ni\(_{12.5}\) (0, 7.5 and 12.5 mg Ni kg\(^{-1}\) soil) were applied in all 21 soils and triplicated thus, constituting a total of 189 (21×3×3) pots. The range and mean of Ni (mg kg\(^{-1}\)) extracted by 0.01M EDTA-0.1M (NH\(_4\))\(_2\)CO\(_3\), 0.005M DTPA-CaCl\(_2\), 0.3N NH\(_4\)\(_2\) oxalate, 1N Mg(NO\(_3\))\(_2\) and 1N NH\(_4\)OAc varied from 0.14 to 0.71 (mean, 0.37), 0.13 to 0.65 (0.31), 0.10 to 0.59 (0.27), 0.06 to 0.53 (0.23) and 0.04 to 0.45 (0.16) mg kg\(^{-1}\), respectively. The amount of Ni extracted was correlated with Ni concentration and uptake by barley. The critical level of Ni in soil below which response to applied Ni may be expected was 0.32 (0.29 with graphical method), 0.22, 0.19, 0.11 and 0.08 mg kg\(^{-1}\) for 0.01MEDTA-0.1M (NH\(_4\))\(_2\)CO\(_3\), 0.005M DTPA-CaCl\(_2\), 0.3N NH\(_4\)\(_2\) oxalate, 1N Mg(NO\(_3\))\(_2\) and 1N NH\(_4\)OAc extractable soil Ni, respectively. The critical limit of Ni for barley plant was determined as 2.40 mg kg\(^{-1}\) with graphical procedure and 2.74 mg kg\(^{-1}\) with statistical method. The result showed that 0.005M DTPA-CaCl\(_2\) had highly significant positive correlation (0.924**) with uptake of Ni by barley shoot among all extractants. According to the results obtained in this study, 0.005 M DTPA -CaCl\(_2\) is the most effective soil extractant for Ni in Inceptisols of Varanasi that had a critical limit of 0.22 mg kg\(^{-1}\) below which economic response of applied Ni could be expected in these soils. As regards to the critical limit of Ni in barley plant, it was 2.40 mg kg\(^{-1}\) by graphical procedure and 2.74 mg kg\(^{-1}\) by statistical procedure. Application of 7.5 mg kg\(^{-1}\) Ni in soil caused a significant increase in Ni concentration in shoot of barley in all the soils irrespective of the initial Ni status. Out of 21 soils, only six low Ni soils (<0.2 mg kg\(^{-1}\) Ni) showed increase in dry matter yield of barley with application of 12.5 mg kg\(^{-1}\) Ni in soil.
Bio-availability of Soil Phosphorus to Fodder Maize 
(Zea mays) under the Influence of Different Organic 
Ligands in an Inceptisol

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About 98% of Indian soils are classified under low to medium soil P fertility which requires proper soil and 
fertilizer P nutrient management for higher sustainable yield of crops. Various studies have indicated that 
organic ligands release from microorganisms, plants root, contained in FYM and use of low molecular 
weight organic acids such as oxalic and citric acids mobilize soil P. Keeping this in view release kinetics of 
soil P in presence of different organic ligands was studied in P deficient Inceptisol and most promising 
treatments were tested in a green house pot experiment using fodder maize (variety African tall) as test crop 
grown for fifty days. Treatments for pot culture experiment were various combinations of P (0, 12.5 and 25 
mg P kg⁻¹ soil), citric acid (0, 10 and 20 mg kg⁻¹ soil) and oxalic acid (0, 10 and 20 mg kg⁻¹ soil). All the 
treatments significantly increased maize biomass yield, tissue P content, P uptake and soil Olsen-P over 
control (0 mg P kg⁻¹ soil). Maize biomass obtained under oxalic acid applied @ 10 mg kg⁻¹ (24.2 g pot⁻¹) was 
statistically at par with the treatments having 12.5 mg P kg⁻¹ (22.4 g pot⁻¹) and 20 mg citric acid kg⁻¹ (25.3 g 
pot⁻¹). The treatment oxalic acid 10 mg kg⁻¹ + 12.5 mg P (30.5 g pot⁻¹) was non-significantly different with 
the treatments 25.0 mg P kg⁻¹ (29.1 g pot⁻¹), 20 mg kg⁻¹ citric acid + 12.5 mg P kg⁻¹ (26.6 g pot⁻¹) and split 
application of citric acid (10 mg kg⁻¹ + 10 mg kg⁻¹) with half dose of P (12.5 mg P kg⁻¹). Olsen’s-P significantly 
increased from 4.6 mg kg⁻¹ in control to 7.7 mg kg⁻¹ in 10 mg kg⁻¹ oxalic acid and 9.2 mg kg⁻¹ in 20 mg kg⁻¹ 
citric acid treated pots after the harvest of the maize. The results showed that the most effective treatment 
was citric acid (20 mg kg⁻¹) and oxalic acid (10 mg kg⁻¹) which can reduce 50% P use. However, extensive 
long term field experimentations with many crops and different combination of oxalic acid and citric acid 
with P treatments are required.
Distribution of Forms of Carbon and Carbon Stock in Different Land Management Units of Kanginhal Sub-watershed in Northern Dry Zone of Karnataka

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A study was undertaken during 2017-18 to identify the distribution of forms of carbon and carbon stock in different land management units (LMUs) of Kanginhal sub-watershed in Gadag district of Karnataka. Six land management units were identified in the sub watershed based on the soil properties. From each LMU, one series was selected and for each series one representative profile was selected for the study. From each LMU, horizon-wise soil samples were collected and analysed for organic carbon, water soluble carbon, active carbon, inorganic carbon and total carbon. Organic carbon, water soluble carbon and active carbon were decreased with depth in all the LMUs, whereas inorganic and total carbon did not follow any definite trend. Water soluble carbon and active carbon exhibited significant positive relationship with organic carbon, whereas inorganic and total carbon exhibited significant and positive relationship with CaCO$_3$. Organic, water soluble and active carbon were significantly and positively correlated with each other, whereas inorganic and total carbon were significantly and positively correlated with each other. Highest organic carbon stock was recorded in LMU-5, whereas inorganic and total carbon stocks were recorded in LMU-6. Inorganic carbon stock contribution was more to the total carbon stock compared to organic carbon stock.
Performance of Wheat (*Triticum aestivum* L.) under Graded Saturation of P-Fixing Capacity of Two Different Soil Types

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A field experiment was conducted at two different locations, (i) Agronomy farm, B.A.C.A, AAU, Anand and (ii) Tribal Cum Training Research Centre, AAU, Devgadh Baria, Dist. Dahod (Gujarat) during the *rabi* season of the year, 2016-17 to study the effect of graded saturation of P-fixing capacity of two different soil types on growth and yield of wheat (*Triticum aestivum* L.). The experiment was laid out in a randomized block design with ten treatments which were replicated in thrice. These ten different treatments are as follows: T1: Only N (120 kg ha⁻¹), T2: NP (120:60:00 kg ha⁻¹RDF), T3: NPK (120:60:60 kg ha⁻¹), T4: RDF + P equivalent 50% Phosphorus fixing capacity of the soil, T5: RDF + P equivalent 75% Phosphorus fixing capacity of the soil, T6: RDF + P equivalent 100% Phosphorus fixing capacity of the soil, T7: RDF + P equivalent 100% Phosphorus fixing capacity of the soil + Fe (50 kg FeSO₄ ha⁻¹), T8: RDF + P equivalent 100% Phosphorus fixing capacity of the soil + Zn (25 kg ZnSO₄ ha⁻¹), T9: RDF + P equivalent 100% Phosphorus fixing capacity of the soil + Fe (50 kg FeSO₄ ha⁻¹) + Zn (25 kg ZnSO₄ ha⁻¹), T10: RDF + P equivalent 100% Phosphorus fixing capacity of the soil + Fe (50 kg FeSO₄ ha⁻¹) + Zn (25 kg ZnSO₄ ha⁻¹) + K₂O @ 60 kg ha⁻¹. The growth and yield attributes like plant height, number of spikes per plants and number of grain per spikes as well as grain and straw yield of wheat was significantly increased due to treatment containing additional dose of phosphorus with K, Fe and Zn along with RDF (T10: RDF + 100% P-fixing capacity of soil + 50 kg FeSO₄ ha⁻¹ + 25 kg ZnSO₄ ha⁻¹ + 60 kg K₂O ha⁻¹) but remained at par with treatment (T6: RDF + 100% P-fixing capacity of soil). Among the nutrients content analysed, it was indicated that P content in grain and straw of wheat were significantly increased due to treatment T6 (RDF + 100% P-fixing capacity of soil) and K, Fe and Zn content in grain and straw of wheat significantly increased due to treatment T10 (RDF + 100% P-fixing capacity of soil + 50 kg FeSO₄ ha⁻¹ + 25 kg ZnSO₄ ha⁻¹ + 60 kg K₂O ha⁻¹) as compared to other treatments at both the locations.
Effect of Chelated Zinc and Iron Application on Growth, Yield and Chemical Composition of Pearl Millet in middle Gujarat Conditions

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The present investigation was undertaken to study the effect of chelated zinc and iron application on growth, yield and chemical composition of pearl millet in middle Gujarat conditions during *kharif* 2016, at Agronomy Farm, B.A. College of Agriculture, Anand Agricultural University, Anand. Pearl millet variety GHB 558 was used as test crop. The experiment was laid out in a randomized block design with four repetitions. The ten treatments were comprising of T1 - Zn0Fe0, T2 - Zn0Fe50, T3 - Zn0.5Fe50, T4 - Zn1.0Fe50, T5 - Zn1.5Fe50, T6 - Zn25Fe0, T7 - Zn25Fe0.5, T8 - Zn25Fe1.0, T9 - Zn25Fe1.5, T10 - Zn25Fe50. Zn and Fe fertilizers applied through ZnSO4 (25 kg ha-1) and FeSO4 (50 kg ha-1) as well as chelated forms of Zn and Fe (0.5, 1.0 and 1.5 kg ha-1).

Plant height was improved due to 25 kg ZnSO4 ha-1 + 1.5 kg Chelated Fe ha-1 to the tune of 5.84 per cent over control. Significantly higher grain (3085 kg ha-1) and total yield (9266 kg ha-1) were registered under the application of 25 kg ZnSO4 ha-1 + 50 kg FeSO4 ha-1 applied followed by 1.5 kg Chelated Zn ha-1 + 50 kg FeSO4 ha-1. Application of 1.5 kg Chelated Zn ha-1 + 50 kg FeSO4 ha-1 produced significantly higher straw yield followed by 25 kg ZnSO4 ha-1 + 50 kg FeSO4 ha-1.

Improvement in Fe and Zn content of grain were observed to the tune of 20.2 and 19.6 percentage respectively over control, with application of 25 kg ZnSO4 ha-1 + 1.0 kg Fe ha-1. Significantly higher Fe and Zn uptake by grain were found with application of 1.5 kg Zn ha-1 + 50 kg FeSO4 ha-1 (T3) and 25 kg ZnSO4 ha-1 + 1.0 kg Fe ha-1 (T3) respectively, over control. Significantly higher Fe content of straw was found due to application of 25 kg ZnSO4 ha-1 + 50 kg FeSO4 ha-1, while 25 kg ZnSO4 ha-1 + 0 kg Fe ha-1, 25 kg ZnSO4 ha-1 + 0.5 kg Fe ha-1 and 25 kg ZnSO4 ha-1 + 1.5 kg Fe ha-1 produced higher Zn content by straw, over the control. Application of 25 kg ZnSO4 ha-1 + 50 kg FeSO4 ha-1 (T10) recorded higher removal of Fe and Zn by straw over control (T1). Leaf content of Fe at 30 DAS was found significantly higher due to application of 25 kg ZnSO4 ha-1 + 1.5 kg Fe ha-1 (T5) over rest of treatments. There was not any significantly changed in soil status of DTPA extracted Fe, Mn, Zn and Cu after harvest of pearl millet by different treatments of Zn and Fe.

The overall result pointed out that application of Zn and Fe containing fertilizer through inorganic as well as chelated sources on Zn and Fe deficient to marginal soil found beneficial to increase the yield and nutrients removal of pearl millet crop grown on loamy sandy soil. However the performance of chelated Zn and Fe source were found at par with conventional sources.
Assessment of Soil Organic Carbon Stock and Sequestration Potential Under Different Land Uses

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Present investigation was carried out in Latur, Osmanabad and Beed districts. The study area were located in between 18°05' to 18°25' N latitude and 76°25' to 77°25' longitude, 18°28' to 190 26' N latitude, 740 54' to 760 57' East longitude respectively. The soils under different land use viz., fallow land, glyricidia, grape, soybean, sorghum, pigeon pea and cotton in Latur, Osmanabad and Beed district, soils were shallow to deep in depth, dark brown (10 YR 3/3) to reddish brown (7.5 YR 6/6) in color, granular to angular blocky in structure. The bulk density varies from 1.24 to 2.16 Mg m⁻³. The saturated hydraulic conductivity varies from 0.28 to 35.50 cm hr⁻¹. These soils are slightly to moderately alkaline in reaction (6.65 to 8.37) and low in electrical conductivity (0.08 to 0.90 dSm⁻¹), low to medium organic carbon content (0.20 to 1.02%) The cation exchange capacity of soil varied from 15.67 to 69.45 cmol (p⁺) kg⁻¹. The Ca⁺⁺ is dominant cation followed by Mg⁺⁺, Na⁺ and K⁺. The maximum SOC at surface and 0-15 soil depth was noticed under glyricidia due to the addition of organic matter. Moreover, the SOC is significantly positive correlated with OC, Clay and CEC (r=544, r=0.564 and r=0.558 respectively). This indicates the clay content and CEC favours to increases the vegetative growth of crop and added more amount of organic matter in. The SIC varied from 1.16 to 85.06 t ha⁻¹. The minimum SIC was found under glyricidia (4.2 to 10.86 t ha⁻¹) where as the maximum SIC was noted under sorghum (19.44 to 85.06 t ha⁻¹) crop. Moreover, SIC significantly positive correlation with CaCO₃ content (r=0.536). The maximum TSCS was found under sorghum (50.04 to 61.73) where as minimum under grape (20.7 to 22.7 t ha⁻¹) at 0-15 cm soil depth. The carbon sequestration potential, was found varies with land use (0.21 to 1.8 t ha⁻¹ year⁻¹). The maximum carbon sequestration potential was found under glyricidia (1.6 to 1.8 t ha⁻¹ year⁻¹) followed by soybean, pigeon pea, sorghum, cotton, grape and fallow land. Moreover, the significant positive correlation with OC and SOC (r= 0.687 and r=0.749 respectively). This indicated that OC and SOC increases it increased the carbon sequestration potential. From the above result however concluded that the maximum SOC stock and carbon sequestration potential was found under glyricidia followed by leguminous crop, cereal crop, cash crop and horticultural crop. This suggested that the agronomic and horticulture land use need to improve high management practices for restoring the carbon stock.
Transformation of Micronutrients in Soil as Influenced by Rice Establishment Methods, Tillage and Rice Straw Management Practices under Rice-wheat Cropping System

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Intensive cultivation has been associated with increased dependence of chemically pure fertilizers which cause depletion of micronutrients and decreasing emphasis on the use of organic sources. Micronutrient’s availability and their transformation is influenced by various factors particularly the soil mineral content, pH, organic matter and different tillage practices. Therefore, the present investigation was undertaken to know the relationship between different chemical pools of micronutrients and their transformations with rice establishment methods, tillage and rice straw management practices under rice-wheat cropping system. The knowledge of various fractions of micronutrients present in soil and conditions under which these become available to plants is pre-requisite in assessing their availability to plants. Hence, the present investigation was planned with the sole objective to estimate the effect of different tillage practices and rice establishment methods on available component of micronutrients and their transformation in other fractions under rice-wheat system.

The present research investigation was carried out under an on-going field experiment at Department of Soil Science, Punjab Agricultural University, Ludhiana in split plot design with three replications. The soil of experimental field was loamy sand in texture, taxonomically classified as Typic Ustrochrept. The experiment comprised of twelve treatment combinations. The main plots consisted of four rice establishment methods viz. direct seeded rice under zero tillage (DSR-ZT), conventional tillage (DSR-CT), reduced tillage (DSR-RT) and puddled transplanted rice (PTR) and three subplots in wheat viz. conventional tillage without rice straw (CTW-R), zero tillage without rice straw (ZTW-R) and zero tillage with rice straw (ZTW+R). In this study, soil samples were collected from each treatment with auger, processed in the laboratory and analyzed for different chemical pools of micronutrients using sequential extraction procedure. The concentration of different micronutrient’s fractions was determined with atomic absorption spectrophotometer (Varian AAS FS 240 Model). The results of the investigation reported that water soluble and exchangeable (WSEX), specifically adsorbed (SpAd) and manganese held by oxide surfaces (MnOx) of all micronutrient cations (Zn, Cu, Fe and Mn) were found higher under ZTW+R as compared to ZTW-R and CTW-R. On the other hand, WSEX-Zn, Fe and Mn were found higher for the conservation tillage than for the conventional tillage treatments and these results were supported by Falatah (2009). Similarly, among rice establishment methods, the higher concentration of WSEX-Zn, SpAd-Zn and MnOx-Zn fractions was reported by reduced tillage which is further followed by conventional tillage and zero tillage (DSR-RT > DSR-CT > DSR-ZT > PTR) however for WSEX-Fe, WSEX-Mn, SpAd-Fe, SpAd-Mn, MnOx-Fe and MnOx-Mn content were found significantly higher under PTR as compared to DSR-RT, DSR-CT and DSR-ZT. The AFeOx and CFeOx fractions showed reverse trend as compared to the WSEX, SpAd and MnOx fractions for Zn, Cu, Fe and Mn by specifying higher content under CTW-R instead of ZTW+R and ZTW-R. ZTW+R showed increased transformation of micronutrient cations from occluded fractions (AFeOx and CFeOx) towards bio-available (WSEX and SpAd) forms which might be due to the higher soil organic carbon (SOC) content as they form strong complexes with OM. RES fraction of all the micronutrient cations was found to be the most dominant fraction next to the Total fraction and WSEX fraction was found to be least dominant in soil. OM-bound fraction of all the micronutrient cations studied was found to be most important fraction contributing towards micronutrient uptake by both rice and wheat crops.
Chemistry of Manganese in Neutral to Alkaline Soils of Punjab, North-west India

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Manganese is the second most abundant metal element in the earth crust after Iron, to which it has many similarities in relation oxidation-reduction reactions in soil-water systems. The aqueous Mn$^{2+}$ specie in the soil solution also considered to be the primarily cation absorption by the plant roots in different soils. The objective of the present investigation is to study the release of aqueous Mn$^{2+}$ specie in eighteen soil-water medium under flooded water condition. A laboratory experiment was made to the released of Manganese in eighteen soil-water suspensions after equilibration of 24th and 240h periods. After equilibration periods, pH, EC soluble Manganese (Mn) bicarbonate (HCO$_3^-$), sulfate (SO$_4^{2-}$) and phosphate (PO$_4^{3-}$) were determined for each soil-water equilibrated systems. Water sample were analyzed as per the standard procedure given by American Public Health Association. Red-ox potential in terms of pe was measured after 24 and 240 h of equilibration period in all the eighteen soil-water systems. Supernatant aliquots were taken from each samples by using a syringe, centrifuged, filled and acidified with a drop of nitric acid prior to their analysis for Mn, S and P. Analysis of water samples for Mn, S and P was carried out on Thermo Electron Corporation Emission spectrometer. Total dissolved Mn released increased from a range of 0.03-0.41 mg L$^{-1}$ (mean 0.13 mg L$^{-1}$) to a range of 0.45-44.44 mg L$^{-1}$ (mean 22.40 mg L$^{-1}$) with the increase in incubation period from 24 to 240 h. The amount of Mn released varied depending upon red-ox potential (pe) created by incubation conditions. After 24 h of equilibration period, pe of soil-water suspension ranged from -1.75 to 0.77 (mean -0.24). Increasing the incubation period to 240 h, pe of soil-water suspensions declined in the range of -4.49 to -2.74 (mean -3.29). Pourbaix diagram for stability field area of manganese illustrate aqueous Mn$^{2+}$, Mn$_2$(OH)$_3$$^+$, Mn(OH)$_2$, MnHPO$_4$ (c), Mn$_3$O$_4$ (c) and Mn$_2$O$_3$ (cr) as the predominant soluble species and solid phases in the alluvial soil-water suspensions under oxidized conditions and reduced condition.
Assessment of Soil Carbon Stock and Physico-chemical Properties of Mango (*Mangifera indica L.*) and Litchi (*Litchi chinensis Sonn.*) Orchards of Muzaffarpur District of Bihar

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Soil organic carbon has a significant effect on chemical and physical characteristics of soil and it is one of the essential components of soil quality assessment. A study was conducted to evaluate the soil carbon stocks and physicochemical properties in soils of land use systems viz. litchi, mango orchard, field crop and fallow lands. The tree of mango and litchi were traditionally grown in Bihar, maintained under different age group viz. 10, 20 and 25 years respectively. The soil samples were collected at depth 0-15 cm, 15-30 cm and 30-45 cm respectively for estimation of different soil parameters. Based on the study the highest carbon stock was recorded in soils of Litchi orchard ranges from 14.97 to 22.32 t ha\(^{-1}\), mango 9.82 to 14.76 t ha\(^{-1}\) in 25 years old tress and in cultivated land 5.57 to 8.54 t ha\(^{-1}\) and fallow land 7.14 to 8.96 t ha\(^{-1}\) at 0-15 cm soil depth. Whereas, equivalent CO\(_2\) was also recorded highest in litchi orchard (54.96 to 81.91 t ha\(^{-1}\)) followed by Mango (38.53 to 41.6 t ha\(^{-1}\)) on 25 years old tree and cultivated land (20.46 to 34.60 t ha\(^{-1}\)). The overall range of pH (7.6 to 7.9) and EC (0.33 to 0.37 dSm\(^{-1}\)) was found in different land use system, however, increased value of pH was found at lower depth of soil. The higher nitrogen content was obtained in soils of litchi and mango orchard. The average value of N, P and S was recorded at 0-15cm (204, 18.4 and 13.4 kg ha\(^{-1}\)), 15-30 cm (174, 15.0 and 10.8 kg ha\(^{-1}\)) and 30-45cm (99.0, 10.4 and 9.1kg ha\(^{-1}\)) in 25 years old litchi trees.
Effect of Submergence on Different Boron Fractions in Soils of Konkan


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A soil submergence study was conducted during July 2016 to November 2016 on fractionation of boron and effect of submergence on different boron fractions in soils of Konkan in the laboratory of Soil Science Department of College of Agriculture, Dapoli. The experiment was laid out in Completely Randomized Design (CRD) comprising of eight treatments replicated thrice and observations were recorded at 30, 60, 90 and 120 days of submergence. The effect of submergence on boron fractions in lateritic, medium black, Manat, coarse shallow, coastal saline, coastal alluvial, reddish brown and acid sulphate soils was studied and also correlations between boron fractions and soil properties as well as amongst boron fractions were analysed.

The readily available B, important from plant nutrition point of view was found to be deficient initially but after submergence of the soils it ranged between the sufficiency levels. Organically bound boron, residual boron and total boron correlate positively with the readily available fraction of the boron in submerged condition. Availability of N, P, K and micronutrients was also found to be increased with the advancement of the submergence period. Residual boron fraction contributed maximum in the total boron pool and it was also found highly significant with total boron in the soils of Konkan. During the submergence period, most soil B existed in the residual or occluded form, while the fractions readily soluble B, specifically adsorbed B and organically bound B represented only a small proportion of the total B content. Correlations between boron pools and soil properties indicated that under different periods of submergence specifically adsorbed B, residual B and total B can participate in boron nutrition of plants like rice. In the regions like Konkan, where high rainfall prevails, this study can be useful to delineate the benchmark for boron fractions.
Critical Limit of Boron for Okra \textit{[Abelmoschus esculentus (L.)]} in Konkan Region of Maharashtra

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The result of the pot culture experiment conducted on three soil groups containing available boron in low to high range under graded boron levels indicated that there was significant response of added boron to okra. The study was conducted with a view to delineate boron responsive and non-responsive soil judged by its critical limit of boron for okra cv. \textit{Varsha uphar}. The treatment comprised of three soil groups having low, medium and high boron content in soil with and four levels of boron consisting 0, 2, 4 and 6 kg B ha$^{-1}$ which were obtained by application of graded dose of boron fertilizer to each set of 30 kg soil in the pot. Each treatment was replicated thrice in a factorial completely randomized design. The soil of pot culture study was low to high in organic carbon content, low to high in available N, very low to medium in P$_2$O$_5$ and high to low in K$_2$O content respectively.

The result of the experiment showed that the high boron status with 6 kg B ha$^{-1}$ significantly improved the plant height, number of fruit, length of fruit and yield of the okra crop. The content and uptake of nutrients such as nitrogen, phosphorus, potassium and boron increased by the application of 6 kg B ha$^{-1}$ with high boron status. The organic carbon, available nitrogen, phosphorus, potassium and boron content were significantly increased with high boron status with the application of 6 kg B ha$^{-1}$. As far as the yield of the okra was concerned, the high boron status with 6 kg B ha$^{-1}$ application significantly increased the stover and fruit yield of crop, as compare to all other treatments. The linear relationship for boron levels with boron application for stover and fruit yield was found positively and significantly correlated and showed linear relationship by the okra crop.

Based on experimental findings, it is concluded that the critical limit value of hot water extractable boron in soils of Konkan and okra plant was 0.52 mg kg$^{-1}$ and 68 mg kg$^{-1}$, respectively. It is suggested to apply boron @ 6 kg ha$^{-1}$ for optimum yield of okra in the soils of Konkan region of Maharashtra.
Dynamics of Organic and Inorganic Fractions of Nitrogen in Maize-Wheat Cropping Sequence

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A field experiment on dynamics of organic and inorganic fractions of nitrogen in maize-wheat cropping sequence was conducted at the Agronomy farm, Rajasthan College of Agriculture, Udaipur during 2015-16 and 2016-17 with the objectives to study the effect of fertilizers and manures on distribution of organic and inorganic fractions of nitrogen, availability of nutrient and their relationship with nutrient availability, uptake and yield of maize and wheat.

The soil of the experimental field was sandy clay loam in texture, non-saline and slightly alkaline in reaction. The experiment consisted of 12 treatment combinations viz., T1-Control, T2-100% N, T3-100% NP, T4-100% NPK, T5-100% NPK + Zn, T6-100% NPK + S, T7-100% NPK + Zn + S, T8-100% NPK + Azotobacter, T9-100% NPK+FYM 10 t ha⁻¹, T10- FYM 10 t ha⁻¹ +100% NPK (-NPK of FYM), T11-150% NPK and T12-FYM 20 t ha⁻¹ with four replications in a randomized block design.

The inorganic fractions of nitrogen i.e. ammonical nitrogen (NH₄⁺-N) and nitrate nitrogen (NO₃⁻-N) was obtained highest with application 100% NPK + FYM 10 t ha⁻¹ and 150% NPK, respectively at 0-15 cm, 15-30 cm and 30-45 cm depth. The NH₄⁺-N and NO₃⁻-N content reduces with depth irrespective of various treatments applied. The value of all organic fractions of nitrogen such as hydrolysable ammonia nitrogen (HAN), hydrolysable NH₄⁺-N + hexosamine-N, hexosamine-N (HSN), amino acid-N (AAN), total hydrolysable nitrogen (THN) and non-hydrolysable nitrogen (NHN) was found highest with application 100% NPK + FYM 10 t ha⁻¹ except unidentified hydrolysable nitrogen (UHN). The highest UHN was observed by applying FYM 10 t ha⁻¹ + 100% NPK (-NPK of FYM). The highest total nitrogen was also observed under 100% NPK + FYM 10 t ha⁻¹ application followed by 150% NPK t ha⁻¹ and FYM 20 t ha⁻¹ at 0-15, 15-30 and 30-45 cm depth. It is also evident from the data that organic and inorganic fractions of nitrogen were more at surface soil (0-15 cm) than the subsurface soil (15-30 cm and 30-45 cm depth) irrespective by application of fertilizer alone or with combination of FYM. As well as total nitrogen contain ammonical-N (3.10%), nitrate-N (0.87%), hydrolysable ammonia-N (16.99%), hydrolysable NH₄⁺-N + hexosamine-N (19.58%), hexosamine-N (2.60%), amino acid-N (18.21%), unidentified hydrolysable-N (34.15%), total hydrolysable-N (71.94%) and non-hydrolysable-N (24.08%) in the surface soil (0-15 cm) under maize-wheat cropping sequence.
Effect of Long Term Manuring and Fertilization on Kinetics of K Release Under Sorghum-wheat Cropping Sequence in Vertisol


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The present study was conducted during 2016-17 to study the impact of manuring and fertilization on potassium release under sorghum-wheat sequence in Vertisol at Akola. The experiment comprised twelve treatments replicated three times in randomized block design. Surface (0-20 cm) and subsurface (20-40 cm) soil sample were analyzed for K release. The results of the present experiment revealed that, all the K release parameter i.e. rate of K release, cumulative K release, potassium release rate constant was assessed at different time intervals (0, 24, 48, 72, 96, 120, 144, 168, 192, 216, 240, 264, 288, 312, 336, 360 hrs). The highest rate of K release was noticed in 100% NPK + FYM @ 5 t ha⁻¹ (to kharif only). At initial time of interval (0 hr.), the rate of K release ranged between 196.7 to 378 mg kg⁻¹ whereas at 360 hrs, the rate of non-exchangeable K release ranged between 60.2 to 175 mg kg⁻¹ in treatment 100% NPK + FYM @ 5 t ha⁻¹ (to kharif only). The cumulative K release exhibit similar trend like non-exchangeable K release. Higher cumulative K release was observed with the combined application of NPK + FYM as compared to control treatment. Four mathematical models were tested to describe the kinetics of non-exchangeable K release from soil as influenced by continuous fertilization. Based on the highest value of coefficient of determination (R²) and the minimum standard error of coefficient (SE), parabolic diffusion and first order equation were best explain the K release kinetics. The grain and straw yield of wheat were increased with successive increase in fertilizer level. Significantly higher grain and straw yield was recorded with the application of 100% NPK + FYM @ 5 t ha⁻¹ (to kharif only) followed by 150% NPK. The uptake was higher due to use of 100% NPK along with sulphur over 100% NPK.
Changes in Soil Nitrogen Fractions in Rice Grown Under Elevated CO2 and Temperature

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Global climate is changing due to increase in the concentration of atmospheric greenhouse gases (GHGs) which resulted in global warming. The combined effect of rising atmospheric CO2 and atmospheric temperature can significantly affect the nutrient cycling especially nitrogen by altering its different pools in soil which maintain a balance between the demand and supply of nutrients to plants. Rice is one of the major crops in India and its productivity is reported to be affected by the changing climate. The following study was undertaken during the kharif season of the year 2017 inside an open top chamber (OTC) in Inceptisol of Delhi to study the interactive effect of elevated CO2 and temperature on changes in soil nitrogen fractions under rice crop. Rice (cv. Pusa Basmati 1509) was grown in crates under two different CO2 levels: ambient (400 ppm) and elevated (550±25 ppm) and with two temperature levels: ambient and elevated (+2°C). Nitrogen was applied in five doses i.e. 0%, 75%, 100% and 125% recommended N dose. Total nitrogen content of soil decreased in no nitrogen treatment due to the mineralization of soil N to meet the demand of rice crop. Inorganic forms of nitrogen i.e., NH4+-N and NO3--N contents in soil also decreased in control treatment. In elevated CO2 plus high temperature treatment, the soil NH4+-N and NO3--N further reduced due to higher decomposition of native soil organic N. High CO2 concentration significantly decreased total hydrolysable N content in soil. The effect of elevated CO2 was more pronounced in the treatments with lower N doses. Higher N demand of the crop under elevated CO2 condition resulted in mineralization of N from native organic pools. When excess N was applied, the plant N demand was met with additional N source thereby causing less depletion of total hydrolysable N. Acid insoluble nitrogen being a stable N pool was not affected by increased CO2 and high temperature condition.
Soil Organic Carbon Stocks Under Different Forest Types in the High Altitude Western Ghats Region, India

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Western Ghats mountain region, spread in 1, 60,000 km² area, is one of the oldest mountain systems in India with its unique geomorphology, flora and fauna and climatic conditions. There are natural and manmade forests in the region especially in higher altitudes of Western Ghats (>2000 m msl) which influences the soil ecosystem differently. Five forest types namely Shola, Wattle, Eucalyptus, Mixed and Pine in the Nilgiris of Tamil Nadu were selected for the present study. Three profiles were morphometrically examined in each land uses at different slope conditions (One profile each at <10%, 10-33% and >33% slope ranges).

Soil samples were collected profile-wise at every 15 cm up to one meter depth along with core samples for soil bulk density. The results show that highest soil organic carbon stocks (SOCS) was found in Shola forest (40.04 kg m⁻³) followed by Wattle, Eucalyptus, Mixed and Pine forest. Soil organic carbon stock in Shola forest ranging from 34.0 to 49.0 kg m⁻³ with a mean of 40.02 kg m⁻³. The SOCS in the wattle forest is 31.26 kg m⁻³. Mixed forest consists of Wattle and Eucalyptus trees recorded the organic carbon stock of 26.34 kg m⁻³. Pine forest has recorded 25.66 kg m⁻³ of SOCS. The SOCS in Eucalyptus forest is 25.54 kg m⁻³ and the highest stock was recorded in <10% slope followed by 11-33% slope and the lowest stock was recorded in >33% slope. The carbon stock is found to be higher in natural forest of Shola as they have not been disturbed for long time due to forest protection act. Among manmade forest, the highest soil organic carbon stock was observed in wattle forest followed by mixed and pine forests. Lowest SOCS was recorded in Eucalyptus forest. The vegetation density and land cover is very high in Wattle forest. Wattle trees have co-colonization ability with other plant species in ground surface under the tree. Hence the organic carbon incorporation is higher under Wattle forest. Lower soil organic carbon stock was observed in mixed forest followed by pine forest and Eucalyptus forest mainly due to collection of fallen leaf litters and poor land cover.
Influence of Tillage and IPNS on Carbon Sequestration Under Pigeonpea-Soybean Intercropping in Inceptisols

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An experiment was laid out to assess the effect of conservation tillage on carbon sequestration under Pigeonpea-soybean intercropping during 2014-15 at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Ten different treatments consisting conventional and minimum tillage, were replicated thrice in randomized block design in alkaline Inceptisols. Similarly, sunhemp was also grown and buried at flowering stage in one of the treatment. It was observed that, intercropping of Pigeonpea + Soybean under minimum tillage (MT) enhanced carbon sequestration in pigeonpea-sunhemp intercropping under minimum tillage. The amount of biomass and carbon sequestration in terms of CO₂ were highest under Pigeon pea + Soybean (1:5) in MT. Similarly, the highest carbon stock (27.74 Mg ha⁻¹) and higher organic carbon 6.83 g kg⁻¹ were recorded under minimum tillage. The adoption of Pigeonpea + sunhemp (GM) under MT registered higher microbial biomass carbon (283.93 mg g⁻¹ soil) and dehydrogenase activity (69.70 mg g⁻¹ soil) as compared to sole cropping under conventional tillage (53.65 mg g⁻¹) indicating the magnitude of conservation tillage. Therefore, Pigeonpea-soybean intercropping under minimum tillage is the most vital way for sequestering carbon, which will help to prevent degradation of soil as well as managing fertility in the changing climate scenario of rainfed agriculture.
Release Dynamics of Some Essential Plant Nutrients from Soil Organic Amendments

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A laboratory incubation study was conducted to examine the release dynamics of some plant nutrients from different soil organic amendments both in quartz sand and a sandy loam (Typic Hapludoll) soil during 2017-2018. The effect of different soil organic amendments on various chemical fractions of micronutrients in soil was also examined at the end of incubation period (120 days). The treatments were Farmyard manure (FYM), Mushroom compost, Poultry manure, Vermicompost, Biogas slurry and Biochar each used @ 15 t ha⁻¹ besides a control in a two factorial completely randomized design with two replications. Acid washed quartz sand and a sandy loam (Typic Hapludoll) soil (each wt. 300 g on oven dry weight basis) were filled separately in plastic containers having a glass wool pad (1 cm height) and basal drainage pores. The leachate from each container were allowed to pass through other plastic containers in the column having a beds of weakly basic cation (IRC 86) and weakly acidic anion exchange (IRA 96) resin spread over a basal glass wood pad. During incubation, the moisture content in quartz sand and soil containers was maintained near to 50 percent of void space through regular make up of evaporation losses gravimetrically. On each observation day, 20 mL distilled water was added to the top of each container for the mobilization of released/mineralized nutrients through the beds of cation and anion exchange resins which were later extracted in 25 ml of 1 N HNO₃. The release dynamics of targeted nutrients was studied at 10, 20, 30, 50, 70, 90 and 120 d from the start of incubation and the extracts were analyzed for some nutrients using standard methods.

The periodic release of all the nutrients was initially low till one month but increased afterwards. The release of all ions except Ca, Mg and Cu mainly depended on their total content in the studied organic amendments. The percent release of nutrients from different organic amendments applied to quartz sand revealed that biochar could be a good source of Zn, Fe and Mn while, the poultry manure could be a good source of Cu, B, Mg and S. For P and K, FYM might serve as a promising source. The incubation study done with soil revealed that organic amendments did alter soil pH significantly, however, application of vermicompost increased soil pH slightly. Irrespective of the type, all organic amendments increased electrical conductivity due to release of nutrient ions during their mineralization and also improve organic C level of soil. For soil application, poultry manure was proved to be a good source of Zn, Cu, Mn, B, P and K while, mushroom compost released more Ca and Mg. The farmyard manure and vermicompost were a plentiful source of S and Fe, respectively. The findings of the present investigation can help in scheduling the application rate of different organic amendments as nutrient source(s) under organic/chemical fertilizer based agriculture.
**Phosphatase and Dehydrogenase Enzyme Activities under Irrigated and Rainfed Fields of Cotton on Saline Vertisols of Bara Tract of Bharuch District (Gujarat)**

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Changes in soil biological characteristics may be other sensible indicators of soil quality, since they are more dynamic and often more sensitive than physical or chemical soil properties. Soil biological properties (dehydrogenase and phosphatase enzyme activity etc.) vary to certain extent in irrigated and non-irrigated fields. The study was carried out with an objective to evaluate biological properties from surface soils of all representative pedons from farmers' field of cotton under irrigated and rainfed situations in Vertisols area of Amod, Vagra and Jambusar talukas of Bara tract (Bharuch district). Twelve representative pedons (6-irrigated and 6-rainfed area) after excavating, surface soils of pedons were analysed for biological properties i.e. phosphatase and dehydrogenase enzyme activities with standard procedure. Surface soils of all pedons irrespective of irrigated and rainfed situation was found to vary widely from mild to strongly alkaline (6.93 to 8.63) in soil reaction. Soils were non-saline to saline in nature. Acidic and alkaline enzyme phosphatase activity (AcPEA and AlPEA) and dehydrogenase enzyme activity (DEA) revealed that in surface-horizon of irrigated pedons, varied from 23.3 to 79.7 µg g⁻¹ hr⁻¹, 46.3 to 133.1 µg g⁻¹ hr⁻¹ and 1.02 to 2.28 µg g⁻¹ 24 hr⁻¹, respectively, while corresponding values of the same for rainfed pedons were 14.0 to 40.1 µg g⁻¹ hr⁻¹, 25.5 to 66.5 µg g⁻¹ hr⁻¹ and 0.92 to 1.28 µg g⁻¹ 24 hr⁻¹, respectively. The highest AcPEA, AIPEA and DEA activities in irrigated pedon-5 indicated improved biological state of soil, while the these enzymatic activities were the lowest in rainfed pedon-8 indicated poor biological state. The soil enzyme activities of acidic phosphatases (r=0.69, p<0.005), alkaline phosphatases (r=0.83, p<0.001) and dehydrogenase (r=0.37) were highly positively correlated with available N and Corg (r = 0.83, 0.79, 0.42, respectively for AcPEA, AIPEA and DEA). Results further revealed that irrigated condition had higher biological/microbial activity like AcPEA, AIPEA and DEA than corresponding rainfed condition, which indicating improved biological state in irrigated soils and poor biological state in rainfed soils. So, for enhancing the potential of crop productivity it would be necessary to add more organics sources like FYM, neem cake, vermicompost etc. coupled with their proper management, which might stimulate the dehydrogenase activity by an increase in microbial population and other living condition (aeration and moisture). As soil enzymes activities play a major role in nutrient availability to plants which in turn help ultimately in improving the crop productivity potential along with improving soil health.
Plant Growth Promoting Bacterial Isolates from *Panchagavya* and their Efficacy in Chilli (*Capsicum annuum* L.)

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Research was carried out with an aim to isolate and characterize beneficial bacteria from *Panchagavya* and evaluate their consortium in promoting plant growth of chilli. *Panchagavya* (PG) - a concoction of desi cow’s direct (Milk, cow dung, cow urine) and 2 derived (curd and ghee) products as well as modified *Panchagavya* (MPG) using additional ingredients like sugarcane juice, yeast and ripened banana were prepared. From these both the organic products, total ten different bacteria were isolated using agar media viz. Nutrient, Sperber, Aleksandrov, Jensen and King’s B. Total 10 bacteria were isolated but finally four isolates V1PG, V3PG, V9MPG and V10MPG proved to be excellent for their plant growth promoting (PGP) efficiency viz. solubilization/mobilization of insoluble phosphate and potash, production of siderophore, cellulase, ACC deaminase enzymes and growth hormone - indole acetic acid. All the four bacteria showed inhibition of plant pathogenic fungi however, isolate V1PG proved to be the best and shown higher zone of inhibition of fungal pathogens *Fusarium oxysporum*, *Macrophomina phaseolina*, *Fusarium solani*, *Aspergillus niger*, *Pythium sp.* and *Alternaria alternata* in dual culture plate assay.

These four bacteria were streaked perpendicularly on nutrient agar and found compatible with each other. Hence, a consortium was prepared using each bacterial fermented broth in equal proportion having ~ 4x10^8 cfu ml^-1.

A pot experiment during 2015-16 was conducted in CRD factorial design with 4 repetitions with 12 treatments comprising of 2 levels of recommended doses of NPK 100 and 75% as well as 6 levels of organic inputs i.e. bacterial consortium (BC), PG, MPG, PG+BC, MPG+BC and control. Results indicated that, BC either alone or in combination with PG and MPG through soil application at either recommended dose of NPK 100% or 75% successfully improved plant growth parameters such as germination percentage, seedling vigor index, shoot and root length, days to flowering and biomass of chilli in a pot experiment. The 16S rRNA gene sequence analysis of the isolates submitted at NCBI, Genbank, USA and were characterized as *Pseudomonas stutzeri* AAU PG1 (V1PG), *Bacillus pumilus* AAU PG2 (V3PG), *Acinetobacter calcoaceticus* AAU PG3 (V9MPG) and *Acinetobacter guillouiae* AAU PG4 (V10MPG). Such plant growth promoting bacteria from *Panchagavya* and modified *Panchagavya* possess enormous promise for Integrated Nutrient Management (INM) as well as organic agriculture.
Development of Potash Mobilizing PGPR Bacterial Consortium and its Efficacy with Graded Dose of Potash in Maize (Zea mays L.)

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To explore plant growth promoting abilities of native rhizospheric potash mobilizing bacterial (KMB) consortium with/without graded doses of potash in maize. A liquid potash mobilizing PGPR consortium was developed and its efficacy on maize was ascertained through field experiments at Main Maize Research Station, Godhra, Panchmahals, India during two consecutive seasons Kharif 2016 and Rabi 2016-17 in Randomized Block Design (factorial) with three replications. Total 116 bacteria were isolated, wherein 42 isolates showed prominent efficiency of potash mobilization, from which, 17 prominent cultures were selected on the basis of the highest zone of solubilization on Aleksandrov agar supplemented with mica. Based on plant growth promoting (PGP) traits like solubilization of phosphate and zinc; production of indole acetic acid and siderophore; showing various enzyme activity viz. ACC-deaminase, lipase, protease, cellulose and tolerance to wide range of pH, temperature, salt (NaCl) concentrations and antibiotics; five native Acinetobacter potash mobilizing PGPR strains viz. A. pittii, A. oleivorans, A. baumannii, A. calcoaceticus and A. junii were screened for compatibility with each other on nutrient agar plate. A liquid KMB consortium based on GYC broth having shelf life of one year was developed for testing efficacy on maize cv. GAYMH-1. Overall results obtained from the field experimentation for two seasons, it was concluded that the highest yield and yield attributing parameters of maize were recorded in treatment receiving KMB consortium @ 5 ml kg⁻¹ seed along with soil application of 60 kg potash fertilizer (RDFK) per hectare. The treatment receiving KMB consortium @ 5 ml kg⁻¹ seed along with 45 kg potash ha⁻¹ was found at par with 60 kg ha⁻¹ suggesting possible saving of 15 kg potash by simple seed treatment with KMB consortium. An innovative potash mobilizing PGPR consortium based on Acinetobacter strains developed and when applied @ 5 ml kg⁻¹ seed along with/without potash fertilizers enhanced growth and yield of maize - a promising life sustaining food and fodder crop.
Isolation of Native PSB Possessing Various PGP Traits for Soybean from Hilly Mining Region Soil

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To investigate efficient native phosphate solubilizing bacteria and to characterize their plant growth promotion abilities, native bacteria were isolated from Pawagadh hilly mining region soils of middle Gujarat. Total 115 suspected bacterial isolates following modified Sperber’s technique were isolated and out of it, 14 were found efficient for \emph{in vitro} P solubilization. Four prominent isolates were chosen for further studies based on their efficiency to solubilize P substrates, tri calcium phosphate (TCP) and rock phosphate (RP).

Isolate P 19 obtained from Pawagadh hilly mining region was found most efficient for TCP and RP solubilization, making available 954.76 and 283.03 µg ml\(^{-1}\) free P. HPLC analysis revealed that P 19 has capacity to produce maximum 35,708.78 µg ml\(^{-1}\) total organic acid. PSB isolates were characterized through morphological, biochemical as well as molecular methods. 16S rRNA sequencing analysis designated native isolates, A 37 as \textit{Burkholderia} sp., A 39 as \textit{Pseudomonas aeruginosa}, P 19 as \textit{Burkholderia cepacia} and P 23 as \textit{Bacillus circulans}. Isolates were able to tolerate wide range of pH, NaCl concentrations and antibiotics. Additionally, \textit{Burkholderia} sp. (A 37 & P 19) were found positive for \textit{nifH} gene and also having capacity to produce IAA up to 58.34 µg ml\(^{-1}\). All the four isolates were found positive for various PGP traits like ACC deaminase production, insoluble potash solubilization, siderophore production, lytic enzyme production and growth inhibition of plant pathogenic fungi. Among the tested isolates \textit{B. cepacia} P 19 inhibited 44% growth of \textit{Macrophomina phaseolina}. Native isolates showed significant growth enhancement of soybean in laboratory and also in pot conditions. In pots, seed + soil and seed + soil + foliar applications of \textit{B. cepacia} P 19 showed significant growth enhancement over control with 25% reduction in chemical P fertilizer usage.
Effect of Bio-fertilizers and Flumioxazin on Microflora and Yield of Groundnut (Arachis hypogaea L.) in Red and Lateritic Soils of West Bengal

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Being an important kharif legume Groundnut (Arachis hypogaea L.) can fix atmospheric nitrogen and improve soil fertility. Herbicides are the most important input in the modern agriculture. The herbicides has been expanding more rapidly than that of other pesticides. The injudicious application of herbicides in agriculture causes the contamination of the soil with toxic chemicals and become harmful to the microorganisms, plant, wildlife and man. But the fate of these chemicals in the soils is becoming very much important since they could be leached and persist on the top soil. The herbicide application not only affect the target organisms but also disturb the microbial communities present in the soil. The basic concept of seed inoculums is to domesticate some of the microorganism in our agricultural production systems, so that vast natural reservoir of nutrients in atmosphere (nitrogen) and soil can be trapped as an additional source to meet our requirements. Biofertilizers inoculums like Rhizobium, PSB, Azotobacter are the cheapest, easily available and ecofriendly than chemical fertilizers, and all such biofertilizers are expected to improve soil fertility, microbial activities and crop yield. Inoculation with PGPR can stimulate plant growth in number of ways and enhanced plant nutrient uptake. So, it is already established that the activity of microflora in soil may plays a great role for maintaining soil physico-chemical properties as well as productivity of crop in any cropping systems. In view of the above, a one year field experiment was conducted during Rabi season of 2015 of Agricultural Research Farm, Institute of Agriculture, Visva-Bharati, Sriniketan located at 23°39′N latitude and 87°4′E longitude with an altitude of 58.9 m AMSL. The soil of the experimental site was sandy loam in texture. The crop variety TAG-24 was sown during first week of February. The recommended doses of fertilizers were applied as per agronomic recommendation. The Experiment was laid out in a Factorial randomized block design with twenty four treatments and three replications. The crop was raised with all the recommended practices and harvested in the first week of June, 2015.

The result of this experiment showed that the application of Flumioxazin 50% SC along with different combinations of biofertilizers Rhizobium, PSB, Azotobacter have no adverse effect on the physic-chemical properties of soil of groundnut oilseed crop when compared at crop growing (initial) and at crop harvest. Irrespective of doses, the Flumioxazin 50% SC along with different combinations of biofertilizers increases the population of NFB, PSB, Fungi, Actinomycetes and available nitrogen content in -78.67 to 277.33%, -27.03 to 586.49%, -93.75 to 12.5%, -83.33 to 383.33% and 43.34 to 148.89% respectively as against initial population content of that microorganisms and available nitrogen content of soil. The result revealed that significantly highest pod yield was recorded in treatment of Azotobacter without application of flumioxazin. Thus seed inoculation with different strains of biofertilizers along with recommended dose of herbicide would be an effective recommendation for better crop management in groundnut in respect of better decomposition of organic matter as well fertilizers due to increase of total microbial population in soil.
Response of Phosphorus, Sulphur and *Bradyrhizobium japonicum* on Growth, Yield and Quality of Soybean

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A field experiment was conducted an experimental farm of Birsa Agricultural University, Ranchi during the *Kharif* season, 2016 to study the Response of phosphorus, sulphur and *Bradyrhizobium japonicum* on growth, yield and quality of soybean. The treatment combinations having two levels of inoculation (I₀ and I₁), three levels of phosphorus (P₄₀, P₆₀ and P₈₀ kg ha⁻¹) and three levels of sulphur (S₀, S₁₅ and S₃₀ kg ha⁻¹) in a split-split plot design replicated thrice. The total number of treatments were 18. The soil of the experimental site was sandy clay loam in texture, Soil pH was 5.2 in soil water suspension (Soil : water ratio 1:2.5), EC (0.08dS m⁻¹), low in organic carbon (2.6 g kg⁻¹), CEC (8.5 cmol(p⁺)kg⁻¹), available nitrogen (181.5 kg ha⁻¹), medium in available phosphorus (23.9 kg ha⁻¹) and available sulphur (17.0 ppm) was above the critical range. Microbial population in initial soil was 29.33×10⁴ Propagules g⁻¹, 22×10⁶ CFU g⁻¹, 8.9×10⁶ CFU g⁻¹ for fungi, bacteria and actinomycetes, respectively. The results of the present investigation revealed that different levels of phosphorus and sulphur along with microbial inoculation significantly influenced the nodulation parameters and yield attribute such as number of nodules (33.05), fresh weight of nodule (0.69 g), dry weight of nodule (0.31 g) and number of pods per plant (43.27) were recorded maximum with application of phosphorus @ 80 kg P₂O₅ ha⁻¹ having statistical equivalence of 60 kg P₂O₅ ha⁻¹ except fresh and dry weight of nodules per plant. Yield of soybean remarkably increased with increasing doses of phosphorus and recorded maximum of 2.3 t, 2.7 t and 5.1 t ha⁻¹ grain, straw and biological yield, respectively, with 80 kg P₂O₅ ha⁻¹. Similarly, application of sulphur also influence grain yield of soybean but there was no significant difference for straw and biological yield of soybean. Application of 15 kg S ha⁻¹ was found equally effective with application of 30 kg S ha⁻¹ in respect to number of nodules, fresh weight, dry weight of nodule, number of pods per plant and grain yield and recorded maximum value of 3.1, 0.67 g and 0.30 g, 4.3 and 2.4 t ha⁻¹, respectively. Microbial inoculation significantly influence the number of nodules (33.77), fresh weight (0.69 g), dry weight of nodule (0.30 g), grain yield (2.3 t ha⁻¹), straw yield (2.6 t ha⁻¹) and biological yield (4.9 t ha⁻¹) of soybean. Based on the present investigation, it is desirable to go for sulphur application @ 15 kg S ha⁻¹ along with the microbial inoculants for enhancing productivity of soybean in an acid soils of Jharkhand.

Application of phosphorus and sulphur significantly enhanced the oil content in soya grain and highest oil content of 19.48% and 19.44% with 80 kg P₂O₅ ha⁻¹ and 30 kg S ha⁻¹, correspondingly and having statistical equivalence with 60 kg P₂O₅ ha⁻¹ and 15 kg S ha⁻¹.

Soybean variety JS-335 gave the highest yield as well as net returns to the tune of ₹ 41955.77 ha⁻¹ with B : C ratio of 1.68 when it was fertilized with phosphorus @ 80 kg P₂O₅ ha⁻¹ and sulphur @ 30 kg S ha⁻¹ along with microbial inoculation.
Assessment of Biological Changes in Soil Influenced by Different Tillage Practices under Cotton in Semi Arid Climatic Conditions of Vidarbha

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An investigation was carried out to study the biological changes in soil influenced by different tillage practices under cotton in semi arid climatic conditions of Vidarbha during the year 2017-18 at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was framed with object to assess the influence of conservation and conventional tillage of biological dynamics of Vertisols and to study the influence of conservation and conventional tillage on seed cotton yield. The study was undertaken on ongoing experiment having the history of six years comprises two treatments i.e. conservation tillage (one harrowing and two wedding) and eight sub plot treatments of integrated nutrient management consisting of control, 100 per cent RDF and use of chemical fertilizer along with organic source of nutrient in which 50 per cent N applied through organic sources (FYM, wheat, straw, green leaf manuring, cotton stalk, vermicompost and phosphocompost).

The application of FYM, Glyricidia leaf manuring, vermicompost and phosphocompost in conjunction with chemical fertilizers recorded significant changes in biological properties viz. SMBC, SMBN, CO$_2$ evolution and DHA with the use of FYM, phosphocompost and vermicompost in combination with 50% RDF as compared to the sole use of chemical fertilizers and control under conservation tillage. Similarly, the chemical properties viz. soil organic carbon, available macro and secondary nutrients were also enhanced under conservation tillage. The highest seed cotton yield was recorded under conservation tillage using phosphocompost and vermicompost in conjunction with chemical fertilizers.

Therefore, it can be concluded that combined and consistent use of FYM, phosphocompost and vermicompost along with 50% recommended dose of inorganic fertilizers under conservation tillage is the most advisable way to maintain the biological sustainability of soil and yield of cotton in long run.
Some Biological Properties of Soil as Affected by Increasing Alkalinity of Irrigation Water

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Soil biological properties were extensively studied under saline soils but not much work has been done to investigate these properties under alkali water irrigation. Therefore, present research study was conducted to observe the effect of increasing residual sodium carbonate (RSC) of irrigation water on soil properties under cotton-wheat rotation at Experimental Farm, Punjab Agricultural University, Ludhiana. Soil samples were collected from two soil depths (0-15 cm and 15-30 cm) of the experimental site irrigated with four levels of sodic water having RSC 0, RSC 3, RSC 6.5 and RSC 10 me L-1. These samples were analyzed for soil microbial biomass carbon (MBC), microbial biomass nitrogen (MBN), and dehydrogenase enzyme activity (DHA) and cold water extractable carbon (CWEC). The results showed that increasing alkalinity from RSC 0 to RSC 10 significantly increased soil EC from 0.22 to 0.69 dS m⁻¹. Similarly, Soil pH also increased with increasing alkalinity but values were more at lower soil depth than 0-15 cm. Results revealed that increasing RSC levels of irrigation water significantly decreased all the biological properties of the soil. Compared to good quality water (RSC 0), mean DHA, MBN and CWEC decreased by 55.9, 57.0, 61.0% and MBC by 39.3% under RSC 10 water irrigation. Significant interaction was observed between RSC levels and soil depth for MBC and CWEC, however, it was non-significant for other parameters. It was also noticed that soil biological properties were more adversely affected at 0-15 cm than 15-30 cm soil depth. In conclusion, out of four soil properties, CWEC was the most sensitive and MBC was the least sensitive biological property under alkali-water irrigated soils.
Effect of Potassium Solubilizing Bacteria and Sources of Potassium on Growth and Yield Attributes of Maize

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Soil microorganisms are supportive in the transformation of soil potassium (K) and are thus an important component of the soil K cycle. A field experiment was carried out at Agricultural Research Farm of Banaras Hindu University, Varanasi during Kharif 2017. Effect of two potassium solubilizing bacteria strains i.e. OVPS 05 (KJ410663) and OVPS (KJ410665) were assessed in combination with mineral k and fertilizer K in Randomized Block Design with three replications using maize (Zea mays L.) as a test crop. Observations on growth of maize as plant height stem girth, number of leaves per plant and chlorophyll; yield attributes as cob length, lines per cob, weight per cob, grain per cob and per cob grain weight were recorded.

Data revealed that combination of inorganic source and mineral source i.e. biotite along with KSB enhanced maize growth and yield attributes. Inoculation with potassium solubilizing bacterial strains, significantly increased growth parameters i.e. plant height, number of leaves plant¹, stem girth, chlorophyll, and yield attributes i.e. cob length, lines per cob, weight per cob, grain per cob and per cob grain weight over uninoculated control. OVPS 05 (KJ410663) appeared to be more effective than OVPS 07 (KJ410665). Treatment 75% RDK + 25% Biotite + OVPS 05 was found as the best treatment combination. Use of these efficient KSB isolates under favorable conditions certainly will contribute to growth and yield of maize crop.
Isolation of Pink Pigmented Facultative Methylo trophs (PPFMs) from the Phyllosphere of Solanaceous Crops and its Efficacy on Tomato, Brinjal and Chilli

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Pink Pigmented Facultative Methylo trophs (PPFMs) were isolated from the phyllosphere of solanaceous crops from Anand on NMS medium supplemented with methanol (1%) by leaf imprinting technique. The isolates were checked for survival on methanol 1 to 5%, 22 isolates were survived to 5% methanol and less, on the basis of enzymatic activity of isolates for methane degradation (Soluble methane monooxygenase and methanol dehydrogenase) five isolates were selected. Morphological, Biochemical and molecular characterization through 16S rRNA sequencing was carried out for identification of selected isolates and all found to belonging genus Methylobacterium viz. Methylobacterium populi AAU PPFM C-7, Methylobacterium radiotolerans AAU PPFM C-17, M. populi AAU PPFM C-19, M. populi AAU PPFM T-2 and M. radiotolerans B-2.

Isolated PPFMs have ability to promote plant growth through one or more mechanisms (PGP traits) viz. production of phytohormones like indole-3 acetic acid (IAA), ACC deaminase, cell wall degrading enzymes (lipase and protease) and siderophore production which were confirmed in laboratory.

The experiments were laid out in completely randomized design with four replications under pot house conditions at Dept. of Agril. Microbiology, Anand during 2017-18. The treatments comprised of (T1: NPK foliar fertigation (19-19-19), T2: Cow urine @ 2%, T3: Vermiwash @ 10%, T4: PPFM consortium, T5: AAU methylotrophic bacterial consortium, T6: Absolute control). The overall results of three pot studies indicated that T4 treatment showed significantly higher growth parameter in tomato, brinjal and chilli viz. shoot length, root length, shoot weight, root weight, number of branches per plant, whereas, T1 showed early flowering and good yield followed by T4 and other treatments, moreover remained significantly superior over control.
Effect of Zinc Solublizing Bacteria on Nutrient uptake, Yield and Nutrient Use Efficiency of Summer Groundnut Grown on Entisol

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A field experiment was conducted during 2016-17 at Post Graduate Institute Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, to study the Effect of Zinc Solublizing Bacteria on Nutrient Uptake, Yield and Nutrient Use Efficiency of Summer Groundnut Grown on Entisol. The experiment was laid out in RBD with three replication and eleven treatments. The treatments comprised of T1: Absolute control, T2: only ZnSB, T3: GRDF, 25:50:00 kg ha⁻¹ N:P₂O₅:K₂O + FYM @ 5 t ha⁻¹, T4 to T7 were GRDF + 100%, 75%, 50% and 25% RD of Zn through ZnSO₄ + ZnSB and T8 to T11 were GRDF + 100%, 75%, 50% and 25% through ZnO + ZnSB. The biofertilizer zinc solubilizing bacteria was given as a seed treatment as well as soil drenching @ 5%.

The soil pH, EC, organic carbon and calcium carbonate content in soil at initial as well as at harvest did not find any differences amongst treatments. The available N, P and K status of soil at harvest were found to be significantly improved due to application of 100% Zn through ZnSO₄ along with ZnSB and GRDF. The DTPA-Fe, Zn, Mn and Cu status of soil at harvest was also found to be significantly increased due to application of 100% Zn through ZnSO₄ + GRDF.

Total uptake of N, P and K by groundnut crop was found significantly increased (132.29, 15.60 and 65.63 kg ha⁻¹, respectively) due to application of 100% Zn through ZnSO₄ along with ZnSB and GRDF. The same trend was also observed in above treatment in respect of total uptake of Fe, Zn, Mn and Cu (1352, 377, 619 and 67 g ha⁻¹, respectively).

The highest zinc use efficiency 5.04% was found in treatment of T₇ (GRDF + 25% RD of Zn through ZnSO₄ + ZnSB) which was followed by T₁₁ (4.60%). The highest agronomic efficiency 11.13 kg kg⁻¹ was found in treatment T₄ (GRDF + 100% RD of Zn through zinc sulphate + ZnSB).

The oil per cent was significantly increased (46.96%) in treatment of GRDF +100% RD of Zn through Zinc sulphate + ZnSB over all the treatment. The pod yield of groundnut was significantly increased (30.63 q ha⁻¹) over all the treatment except treatment of GRDF + 75% of RD of Zn through Zinc sulphate + ZnSB (29.44 q ha⁻¹). Haulm yield of groundnut was significantly increased (62.70 q ha⁻¹) in treatment of GRDF 25:75:00 kg ha⁻¹ N:P₂O₅:K₂O + FYM @ 5 t ha⁻¹ over all the treatment. The cost of cultivation was recorded highest (Rs. 56482/-) in treatment of GRDF +100% RD of Zn through Zinc sulphate + ZnSB. The gross monetary returns was recorded in treatment of GRDF +100% RD of Zn through Zinc sulphate + ZnSB (Rs. 42800/-.)

It can be thus concluded that, the application of 100% recommended dose of Zn through Zinc sulphate @ 20 kg ha⁻¹ + 5% ZnSB to seed treatment at sowing and through drenching at 30 DAS along with 100% recommended dose of nutrients (25:50:00 kg ha⁻¹ N:P₂O₅:K₂O + FYM @ 5 t ha⁻¹) to summer groundnut was found beneficial for improvement in available macro and micronutrients status of soil, agronomic efficiency, total uptake of macro and micronutrient, oil per cent and pod yield of groundnut in Entisol.
The Impact of Organic Manure Prepared by Inoculating Different Agro-wastes with Isolated Cellulolytic and Lignolytic Bacteria on the Biomass Yield of Sorghum Plants

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An experiment was carried out during 2014 to 2017 at Food Quality Testing Laboratory, NAU, Navsari and total of 103 bacteria were isolated from compost, sea water and soil. Based on the performance of qualitative and quantitative enzyme assay for cellulase, laccase, lignin peroxidase and manganese peroxidase enzymes, the best two cellulolytic and lignolytic bacteria were selected and designated as cellulolytic isolate C₁ and cellulolytic isolate C₂ along with lignolytic isolate L₁ and lignolytic isolate L₂, respectively. Organic manures were made by inoculating these selected cellulolytic and lignolytic bacteria on sugarcane trash (S₁), paddy straw (S₂) and banana pseudostem (S₃). A pot experiment with the statistical design CRD and 2 repetition was set up at Food Quality Testing Laboratory, NAU, Navsari to test the prepared organic manures on growth of sorghum (variety: GJ-42) plants. Green and dry biomass yield of sorghum was affected significantly by the manures prepared by different treatments. Manure prepared from banana pseudostem inoculated with cellulolytic isolate C₁ and lignolytic isolates L₂ recorded the highest green and dry biomass yield of sorghum. Therefore, it was concluded that good quality manure can be prepared by inoculating banana pseudostem (S₃) with cellulolytic isolate C₁ (identified as \textit{Bacillus licheniformis} strain C₁) and lignolytic isolate L₂ (identified as \textit{Bacillus} sp. strain L₂) as the application of this manure recorded higher green and dry biomass yield of sorghum.
Available Micronutrients Status and their Relationship with Soil Properties under Different Land Use Systems of District Doda, Jammu and Kashmir

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The available micronutrient cations namely Fe, Mn, Zn, Cu and physico-chemical properties viz. pH, EC, CEC, CaCO$_3$, BD, WHC, sand silt, clay exchangeable Ca, Mg and Na of agriculture, horticulture, forest, grassland, eroded and barren land use systems were assessed in Doda district of Jammu and Kashmir. Two hundred thirty six composite soil samples from different depths were collected and analyzed for available micronutrients and physico-chemical properties. The results showed that pH followed in order of eroded, barren, agriculture, horticulture, grassland and forest land whereas EC exhibited the trends: horticulture, agriculture, eroded, forest, grassland and barren while CaCO$_3$ was in order of barren, grassland, horticulture, agriculture, eroded and forest land. The sand and BD followed similar trends: eroded, barren, grassland, agriculture, horticulture and forest land. The CEC value of surface soils followed in order of forest, grassland, horticulture, agriculture, barren and eroded land while WHC showed the trends as: forest, agriculture, horticulture, grassland, barren and eroded. The sand was in order of eroded, barren, horticulture, grassland, agriculture and forest while silt was observed in order of eroded, barren, forest horticulture, grassland, agriculture, and clay content followed in order of forest, grassland, horticulture, agriculture, barren and eroded in surface soils. The exchangeable Ca. and Mg were followed by trend as: barren, grassland, horticulture, agriculture, forest, and eroded whereas Ex. Na was found in order of forest, horticulture, agriculture, grassland, barren and eroded land. The mean values of available Fe, Cu, Zn and Mn in the surface soil was found in order of forest, grassland, horticulture, agriculture, barren and eroded land. The available Fe in surface soil was highest in the majority of land uses including grassland, horticulture and agriculture. The available Cu in surface soil among all land uses was higher to medium in range, whereas available Zn in surface soil was in medium range. The available Mn in surface soil was found moderate in almost all land use systems. The correlation matrix of micronutrient status with different soil properties showed that Fe, Mn, Zn and Cu had positive correlations with pH, EC, silt, clay, CEC, exchangeable Ca.
Pedogenesis and Land Evaluation of Some Sugarcane Growing Red Soils in Semi arid tropical Region of Telangana

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The study was carried out to characterise and classify the sugarcane growing red soils of Medak district of Telangana State and assessed the suitability for growing sugarcane and develop strong soil resource database for proper appraisal of their productivity potential and their rational use. Based on the morphological characteristics and land elevation, five geo referenced pedons were selected. The area was under the influence of semi-arid monsoon type climate. The selected red soils were developed on weathered granite-gneiss parent material at gently sloping lands. The texture was ranging from gravelly sandy loam (coarse) and sandy clay loam (medium) in the surface horizons and sandy loam and sandy clay loam in sub-surface horizons. The clay content ranged from 13.2 to 22.6 per cent in surface horizons and 14.6 to 31.4 per cent in subsurface horizons. The sand content varied from 72.3 to 75.1 per cent in surface horizons and 56.4 to 77.1 in subsurface horizons. The silt clay ratio ranged from 0.19 to 0.82 indicating the moderate to high weathering. The soils were developed weak pedality with granular structure in the surface horizons and sub-angular blocky peds in sub-surface layers. Soil pH was moderately acidic to neutral (6.0 to 7.5) and non saline. The organic carbon content was low to medium (4.3 to 6.8 g kg⁻¹) in surface horizons and in subsurface horizons it was low to medium ranged from 2.1 to 5.2 g kg⁻¹. The exchangeable bases of soil pedons were in order of Ca²⁺ > Mg²⁺ > Na⁺ > K⁺ on the exchange complex. Based on the morphology, physical, physico-chemical and chemical properties of the soils, the soil pedons were classified as per USDA soil taxonomy. Soils were classified into orders viz., Alfisols and Entisols.
Distribution of Micronutrients in Soils Under Different Land-uses in South-western Plains of Punjab

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The rising population and socio-economic needs impart pressure on agricultural production system which ultimately leads to unplanned changes in land-use systems. One of the crucial challenges in recent days is to meet these necessities through balanced land-uses by keeping the soil fertility intact. Maintenance of the reserves and availability of soil micronutrient has become a serious issue along with maintaining higher productivity. Distribution of micronutrients in soil depends on soil reaction, organic matter content and several physical, chemical and biological conditions of the rhizosphere which could be altered by different land-uses. The present investigation was undertaken in the south-western plains of Punjab which is moderately erosion prone area having light textured soil mainly and characterised by intensive agriculture which are responsible for reduction in micronutrient availability. Therefore, assessment of micronutrient status under different land-uses is imperative to evaluate the potential of soils as well as for better selection of land-uses for achieving sustainability.

To study the impact of agricultural land-uses on distribution of micronutrients in soil, samples were collected from semi-arid sub-tropical region of Punjab, in and around Dhanaula (30°18′N, 75°27′E); district Barnala, Bhucho (30°15′N, 75°03′E) and Phul (30°19′N, 75°14′E); district Bathinda, under three land-uses viz. cropland (cotton-wheat), horticultural land (Guava) and uncultivated land. The samples were collected from four depths (0-15, 15-30, 30-60 and 60-90 cm) and were analyzed for pH, EC, texture, soil organic carbon (SOC) following standard methods. Standard di-acid mixture (HNO₃:HClO₄::4:1) digestion and DTPA extraction methods were employed to estimate total and available micronutrients and analyzed in atomic absorption spectrophotometer (Varian AAS FS 240 Model). Analysis of Variance (ANOVA) for completely randomized design (CRD) at 5 per cent probability level was used for analyzing the data SPSS-ver. 23 (IBM Corp., 2015) software.

The results indicated that soils were slightly saline in nature and sandy loam to loamy sand in texture. SOC content followed an order horticultural land > cropland > uncultivated land in upper two soil layers while a different trend of horticultural land > uncultivated land > cropland was recorded in two subsequent layers. The total contents varied widely from 28.54.83 mg kg⁻¹ for zinc (Zn), 6.17-11.67 mg kg⁻¹ for copper (Cu), 3825.67-4522.00 mg kg⁻¹ for iron (Fe) and 147.83-200.17 mg kg⁻¹ for manganese (Mn) while DTPA extractable contents varied from 0.20-2.70 mg kg⁻¹ for Zn, 0.41-1.04 mg kg⁻¹ for Cu, 1.84-6.08 mg kg⁻¹ for iron Fe and 2.26-5.89 mg kg⁻¹ for Mn irrespective of land-uses and soil depths. Both the values of total and available micronutrient contents were recorded highest under horticultural land as compared to cropland and uncultivated land along the entire studied profile. No effect of land-uses were noticed in case of available Cu as well as total Fe and Mn contents while in most of the other cases statistical similarities were found between cropland and uncultivated land.
Gradual decrease in DTPA-extractable micronutrients along the depth was observed almost under all three land-uses while in case of total micronutrients, a rise in concentration mostly beyond 30 cm soil depth might be due to their positive correlation between finer particles that increased depth-wise. In surface layer, availability of Zn, Cu and Mn were found moderate to sufficient under cropland which was prominently high under horticulture. In deeper layers, lower availability was observed under cropland except Cu. Uncultivated lands were expected to be deficient in micronutrients due to prolonged erosional loss and lack of input. Widespread deficiency in available Fe under cultivation might be attributed to crop removal and low carbon content as variability of Fe was found highest ($R^2 = 0.847, P < 0.001$) followed by Zn ($R^2 = 0.841, P < 0.001$), Cu ($R^2 = 0.724, P < 0.001$) and Mn ($R^2 = 0.684, P = 0.001$) with respect to soil organic carbon (SOC). Overall sufficiency was noticed under horticultural land regarding the availability of all four studied micronutrients which might be due to comparatively finer soil texture, less pH and greater addition of organic matter in the form of leaf litter fall and root deposition. Significant positive relations of micronutrients with SOC and finer particles (silt, clay and silt plus clay) might be the plausible reason behind it. The present study depicts an important role of land-uses on soil micronutrient distribution and horticultural land-use was found superior in almost every aspect. Hence, selection or inclusion of a suitable land-use would be helpful in the maintenance of micronutrient status as well as health and sustainability of soil.
Effect of Different Levels of Nitrogen, Phosphorus and Bio-fertilizer on Yield of Irrigated Wheat (*Triticum aestivum* L.) in Moisture Conserve Condition

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An experiment was conducted medium black highly saline soil at Agricultural Research Station, Anand Agricultural University, Arnej, Gujarat during *rabi* season of the year 2016-17. Eight treatment combinations comprising of four levels of Nitrogen (N1: 60 kg N ha\(^{-1}\), N2: 60 kg N ha\(^{-1}\) + Bio NPK, N3: 90 kg N ha\(^{-1}\) and N4: 120 kg N ha\(^{-1}\)) and two levels of Phosphorus (P1: 30 kg P\(_2\)O\(_5\) ha\(^{-1}\) and P2: 60 kg P\(_2\)O\(_5\) ha\(^{-1}\)) were tried out in a RBD (Factorial) with four replications. The fertilizers were applied 50% at basal and 25% at 30 DAS and remaining 25% after 45 DAS from the source of Urea and DAP. It could be concluded that for securing maximum grain yield of wheat, application of 120 kg N/ha and 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) from which 50% at basal and 25% at 30 DAS and remaining 25% after 45 DAS from the source of Urea and DAP.
Impact Assessment of Different Tillage Systems and Weed Management Options on Yield and Physico-chemical Properties of Soil Under Cotton-greengram Cropping System of Middle Gujarat

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A field experiment was conducted on sandy loam soil at AICRP-Weed Management farm, B.A.C.A. Anand during 2016-17 to assess the impact of different tillage systems and weed management options on yield and soil physico-chemical properties under cotton-greengram cropping system. The treatments were comprised of five tillage systems viz. conventional - conventional tillage (T1), conventional - zero tillage (T2), zero - zero tillage (T3), zero - zero tillage + residue (T4) and zero + residue - zero + residue (T5) tillage system and three weed management options viz. pendimethalin 900 g ha⁻¹ PE fb IC+HW at 30 & 60 DAS – pendimethalin 500 g ha⁻¹ PE fb IC + HW at 30 DAS (W1), quizalofop ethyl 50 g ha⁻¹ PoE fb IC + HW at 30 DAS – imazethapyr 75 g ha⁻¹ PoE fb IC + HW at 30 DAS (W2) and IC + HW at 15, 30 and 45 DAS – IC + HW at 20 & 40 DAS (W3) for cotton-green gram cropping system, respectively. The experiment was plotted in strip plot design and replicated three times. The initial pH, EC (dSm⁻¹), OC (%), available N, P₂O₅ and K₂O (kg ha⁻¹) values were recorded as 7.80, 0.17, 0.27 and 342, 48 and 298, respectively.

The study revealed that none of the factor i.e. different tillage system and weed management options showed any significance differences in physico-chemical observations in cotton except organic carbon and available phosphorus in tillage and weed management options, respectively. However, the highest EC (0.41 dS m⁻¹), organic carbon (0.37%), available phosphorus (46.4 kg ha⁻¹) and available potassium (207 kg ha⁻¹) were recorded under zero tillage + residue treatment but did not find any following trend of observations within different weed management options. The seed cotton yield (2.19 t ha⁻¹) was found to be significantly differed among tillage systems and recorded highest zero tillage + residue (2.19 t ha⁻¹) and pendimethalin 900 g/ha PE fb IC+HW at 30 and 60 DAS (W1), (2.33 t ha⁻¹). The significant difference in available phosphorus was only observed and recorded highest with quizalofop ethyl 50 g ha⁻¹ PoE fb IC + HW at 30 DAS (W2) in cotton. Similarly, the influence of different tillage and weed management options in greengram did not exhibit any significant differences with the status of soil chemical parameters except organic carbon within tillage systems and available phosphorus and potash under weed management options. However, the significantly highest seed yield (6.8 t ha⁻¹) results were obtained within zero tillage + residue (T5) and pendimethalin 500 g ha⁻¹ PE fb IC + HW at 30 DAS (W1).

Therefore, it can be concluded that impact of zero tillage with residue (T5) and pendimethalin 900 g ha⁻¹ PE fb IC+HW at 30 and 60 DAS (W1) proved to be superior combination over other tillage systems and weed management options with respect to yield of cotton and greengram but did not impart vary significant changes on physico-chemical properties of soil.
Effect of P Sources on Yield, Economics and Water Use of Hybrid Tomato (*Lycoperscion esculentum*) under Fertigation in Inceptisols

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A field study was conducted at experimental farm of Interfaculty Department of Irrigation Water Management, Post Graduate Institute, M.P.K.V., Rahuri, Maharashtra, India for two years during *rabi* season of 2016-17. The experiment was laid out in randomized block design with seven treatments and three replications. The treatments comprised of absolute control (T1); surface irrigation(SI) with 100% recommended dose of fertilizer (RDF) through straight fertilizer *i.e.* urea, single super phosphate and muriate of potash (T2); SI with 100% RDF through straight fertilizer *i.e.* urea, 24:24:0 and sulphate of potash (SOP) (T3); 80% RD of fertigation through 24:24:0 (T4); 80% RD of fertigation through 19:19:19 (T5); 80% RD of fertigation through 13:40:13 (T6) and 80% RD of fertigation through 12:61:0 (T7). The fertilizers were applied as per schedule given below. Fertilizer schedule: % nutrients applied in 18 weekly splits

<table>
<thead>
<tr>
<th>Days after planting</th>
<th>Nitrogen (N)</th>
<th>Phosphorus (P)</th>
<th>Potassium (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-21 (3 weeks)</td>
<td>25</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>22-42 (3 weeks)</td>
<td>47</td>
<td>20</td>
<td>48</td>
</tr>
<tr>
<td>43-63 (3 weeks)</td>
<td>20</td>
<td>35</td>
<td>16</td>
</tr>
<tr>
<td>64-84 (3 weeks)</td>
<td>8</td>
<td>30</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

The pooled results (2016-17) indicated that the application of water soluble fertilizers significantly enhanced the yield of tomato. The significantly higher yield of tomato was obtained in 80% RD of fertigation through 12:61:00 (T7, 60.72 t ha⁻¹); however, it was at par with 80% RD of fertigation through 24:24:00 (T4, 60.25 t ha⁻¹) and 80% RD of fertigation through 13:40:13 (T5, 57.60 t ha⁻¹). The drip method used lowest water use of 501.0 mm as compared with 921.5 mm in surface irrigation method thus recorded 45.75% water saving. In terms of economics, the treatment T7 (DI with 80% RD of fertigation through 12:61:00) was profitable with more net seasonal income (Rs. 2,78,833 per ha), net extra income over control (T2) of Rs. 1,02,124 per ha, B:C ratio (2.89) and maximum water productivity as Rs. 533.5 per mm of water used. On the basis of the results obtained, it can be concluded that drip irrigation with 80% RD of fertigation through 12:61:00 in 18 weekly splits as per schedule was the best treatment for yield, water use and economics of tomato (var. Abhinav) cultivated in clay loam soils of Western Maharashtra.
Conservation of Natural Resources in Deep Ravines of Chambal

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Chambal ravines are very deep in nature and it is very fragile agri-ecosystem and still increasing day by day at a rate of 8000 ha per year and people are forced to migrate from their original locations. Some specific investigations were carried out by the department under Niche Area of Excellence financed by Education Division, ICAR during last 7 years (2012-2017) to control further advancements of ravine. Some indigenous and innovative methods were adopted for this purpose i.e. change in slopes at advancing sites, terracing at advancing sites and Multi step levelling with peripheral bunds. The results clearly indicated that the application of change in slopes at advancing sites and terracing at advancing sites were effective in checking the advancement due to decrease in hydraulic gradient of infiltrating water but could not check soil and water loss from the field while, Multi step levelling was most effective in checking of advancement as well as soil and water losses from the field. Multi step levelling is a unique innovative methodology to check the advancement, control soil and water losses and even greening of ravines along with income generating through crop production from 40% of land.
Effect of Soil and Foliar Application of Zinc on Growth and Yield of Knol Khol (Brassica caulorapa var. gongylodes L.)

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A field experiment was conducted in the farmer’s field at Vijapura, Bangalore Rural District during kharif 2017, with an objective to study the effect of soil and foliar application of zinc on growth, yield and quality of knol khol. The experiment was laid out in a randomized complete block design with 10 treatments replicated thrice. The experimental results indicated that significantly higher plant height (39.90 cm), number of leaves per plant (14.83), leaf length (19.68 cm), chlorophyll content (12.33 SPAD reading) and yield (23 t ha⁻¹) was recorded in the treatment which received RDF and FYM along with 4 kg of zinc through ZnSO₄ as soil application and 0.14 per cent zinc through zinc sulphate as foliar spray. Application of 4 kg of Zinc through ZnSO₄ as soil application + 0.14 per cent zinc through zinc sulphate as foliar spray along with RDF and FYM significantly increased the total soluble (8.83 °Brix) and ascorbic acid content (56.73 mg 100 g⁻¹). Significantly higher zinc content in knol khol leaf (36.48 mg kg⁻¹), knob (38.67 mg kg⁻¹) and total uptake (154.96 g ha⁻¹) was recorded in the treatment which received RDF and FYM along with 4 kg of zinc through ZnSO₄ as soil application and 0.14 per cent zinc sulphate as foliar spray. Application of 8 kg of zinc through ZnSO₄ as soil application along with RDF and FYM recorded higher zinc content of 0.96mg kg⁻¹ in soil at harvest. Higher benefit cost ratio of 3.48 was recorded with application of 4 kg of Zn through ZnSO₄ as soil application + 0.14 per cent Zn through sulphate as foliar spray along with RDF and FYM.
Compensation of Nutrients through Foliar Nutrition in Wheat under Limited Irrigation

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An experiment to study the possibility for compensation of major nutrients through foliar sprays under limited irrigation conditions in wheat was conducted at Agricultural Research Station, Niphad, Dist, Nashik during *rabi* 2017-18. The experiment was comprised of seven treatments replicated three times designed in Randomised Block Design. The results of the experiment revealed that, application of GRDF (90:60:40 N:P:O:K kg ha⁻¹) along with two sprays of water soluble 19:19:19 N:P:O fertilizer @ 2% at 55 and 75 DAS for wheat crop produced significantly higher grain (4.7 t ha⁻¹) yields compared to absolute control. Other all treatments expect only foliar sprays of water soluble 19:19:19 N:P:O fertilizer @ 2% at 55 and 75 DAS and control were at par with the treatment GRDF (90:60:40 N:P:O:K kg ha⁻¹) along with two sprays of water soluble 19:19:19 N:P:O fertilizer @ 2% at 55 and 75 DAS. The foliar spray of water soluble 19:19:19 N:P:O helped to improve the uptake of nutrients in wheat crop ultimately resulting in improvement in grain and straw yields.
Changes in Quality and Quantity of Soil Organic Carbon as Effected by Forty Six Years of Continuous Integrated Nutrient Management

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Improving soil organic carbon (SOC) in arable soils is one of the important strategies to achieve sustainable crop productivity and soil health and to mitigate climate change. The intensive cropping in northwestern Indo-Gangetic Plains (NW-IGP), for past four decades, has been widely reported to cause decline in SOC, both in quantity and quality. It has emerged from the reports of different on-going trials under the aegis of All India Coordinated Research Project on Long Term Fertilizer Experiments (AICRP-LTFE), that integrated nutrient management (INM) can be one option to stabilize crop productivity and have a sustainable system. Nonetheless, scarce reports are available on the effect of INM on quality of SOC. For the investigation, the surface (0-15 cm) soil samples were collected from selected treatments of the on-going AICRP-LTFE, ICAR-IARI, New Delhi under maize-wheat system after wheat harvest in 2017. The selected treatments viz., Unfertilized control, N (Recommended doses of N only), NPK (Recommended doses of N, P and K), 150% NPK (150% of recommended doses of N, P and K) and NPK+FYM (recommended NPK along with 5 t farmyard manure/ha), were studied.

Application of recommended NPK resulted in significant improvement in total SOC compared to unfertilized control or N alone plots. The plots under NPK+FYM and 150% NPK had ~12% higher total SOC compared with NPK plots. The improvements due to continuous INM manifested mostly in very labile and labile pools of SOC, whereas, the treatment effects on non-labile SOC were of lesser magnitude. The very labile SOC was found similar under control, N and NPK, whereas 150% NPK and NPK+FYM had ~15% and 26% higher contents of very labile SOC compared with NPK. The 150% NPK and NPK+FYM also registered significantly higher Walkley-Black carbon (WBC) compared with NPK, whereas, application of recommended NPK yielded higher WBC compared to N alone and control.

The humic acids (HAs) were extracted by sodium hydroxide - sodium pyrophosphate mixture in N2 environment. The HA extracted from NPK+FYM had the highest E4/E6 ratio indicating least aromaticity as compared to very low E4/E6 ratio under control, N and NPK. The Fourier transformed infrared spectroscopy (FT-IR) of different HAs extracted from treatments showed all the representative bands of the functional groups commonly present in HA. The total and carboxylic acidity of purified HA was quantified through Ba(OH)2 and Ca(CH3COO)2 titration. Results indicated least total acidity under NPK+FYM (412 cmol(p+)kg-1), which is significantly lower compared with control, N and NPK. The lower aromaticity and acidity of HA extracted from INM plots indicated a higher inflow of organic matter in those plots, often in excess of the assimilation capacity of soil microbes. Therefore, continuous application of FYM along with recommended NPK not only enhanced the quantity of SOC, but also improved the C quality as indicated by lesser rates of humification, which are beneficial in terms of soil nutrient supplying capacity, soil health and sustainability of the cropping system.
Influence of Zinc and Iron Fertilization on Growth and Yields of Pearl millet and Mustard under Salt Affected Soils

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Zinc and iron (Fe) deficiency mostly found in salt affected soils in arid and semi-arid tracts of the India. The management of zinc and iron nutrition is most important concern in such potential deficient soils. For this reason, the field experiment was conducted during 2013-17 under pearl millet-mustard cropping system to evaluate response of rate and methods of zinc and iron fertilization to mustard crop. A field experiment was conducted, consisting of 12 treatments laid out in randomized block design The 12 treatments of Zn and Fe i.e. T1- Control, T2- 5 kg Zn ha⁻¹, T3- 6.25 kg Zn ha⁻¹, T4- 7.5 kg Zn ha⁻¹, T5- 7.5 kg Fe ha⁻¹, T6- 10 kg Fe ha⁻¹, T7- 12.5 kg Fe ha⁻¹, T8- 5 kg Zn+10 kg Fe ha⁻¹, T9- 5 kg Zn+10 kg Fe + 10 t FYM ha⁻¹, T10- Foliar sprays of 0.5% ZnSO₄ (twice), T11- Foliar sprays of 1% FeSO₄ (twice) and T12- Combined foliar sprays (0.5% ZnSO₄ + 1% FeSO₄; twice). The results of experiment showed that, application of FYM 10 t ha⁻¹ along with 5 kg Zn+10 kg Fe significantly (p=0.05) improved the yield parameters of pearl millet and mustard followed by 5 kg ha⁻¹ Zn and 10 kg ha⁻¹ Fe as soil application. The results also indicated that combined soil application of 5 kg Zn+10 kg Fe + 10 t FYM increased the pearl millet grain yield (36.6 q ha⁻¹) and mustard seed yield (22.7 q ha⁻¹) by 57.1% and 42.8% higher over control, however, yield improvement was 35.6 and 20.7% due to application of 5 kg Zn + 10 kg Fe without FYM, respectively, in pearl millet and mustard over control. Ferrous-iron content in both crops proved to be a better index of Fe nutrition status compared to total plant Fe and DTPA- extractable soil Fe under salt affected soils. Salt affected soils are having vast potential to produce a significant amount of food grain by applying optimum dose of Zn, Fe and FYM in pearl millet and mustard.
Evaluation of Polymer Coated Urea and Neem Coated Urea on Yield and Nutrient Uptake in Maize

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Fertilizer application plays an important role in agricultural production and accounted for about one third of the increase in cereal production. The productivity, profitability and sustainability of these crops are being threatened because of higher inputs costs and lower N-fertilizer use efficiency. The excessive uses of fertilizers also negatively impact the environment. The controlled-release fertilizers can reduce the loss of nutrients, labor, increase the nutrient use efficiency of crops and increase grain yield compared to conventional fertilizers. Among controlled-release fertilizers, polymer-coated urea (PCU) has great potential due to lower nutrient release rate for high N use efficiency and to mitigate the adverse effect of water pollution. Since limited work has been done on polycoated urea, the present study has been undertaken to study the performance of polycoated urea in comparison to neem coated urea with differential doses in maize crops.

The experiments were carried out at Regional Research Station (PAU), Ballowal Saunkhri, Distt Shahid Bhagat Singh Nagar (Punjab) in a randomized block design with three replications in maize crop during kharif 2016 and 2017 with seven treatments i.e. T₁: control (without nitrogen), T₂: recommended nitrogen through neem coated urea (Split doses), T₃: recommended nitrogen through polycoated urea (split doses), T₄: 75% recommended nitrogen through polycoated urea (split doses), T₅: 50% recommended nitrogen - polycoated urea (split doses), T₆: recommended nitrogen through polycoated urea (one basal dose) and T₇: 50% N through poly coated urea and 50% N through neem coated urea using maize variety PMH 1 as test crop. The growth, yield attributing traits and grain yield of maize increased significantly with the application of neem coated and polycoated urea over the control treatment. The 75% recommended N through polycoated urea (Split doses) gave maximum average grain yield (4839 kg ha⁻¹), which was statistically at par with all polycoated urea treatments and significantly higher over 100% recommended dose of neem coated urea and control treatment. Similar to maize yield, nitrogen uptake increased significantly with the application of different levels of polycoated urea as well as through neem coated urea over the control treatment. The maximum value of chlorophyll content using SPAD was observed with treatment 75% recommended N through polycoated urea (splits) at 30 days and 60 days after sowing. Among soil properties only soil available nitrogen content increased significantly with the application of different levels of polycoated urea over the control treatment. The non-significant variations were observed in soil pH, electric conductivity, organic carbon content, available phosphorus content and available potassium content in soil. Overall, application of 75% polycoated urea (split doses) to maize gave higher grain and straw yield, which was statistically at par with the other 100% poly coated urea treatments and significantly higher over 100% neem coated urea treatment.
Utilization of Enriched Phosphocompost for Improvement in Soil Properties, Nutrient Uptake and Pearl Millet Yield on Vertisol

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Composting manure and biological waste with rock phosphate has been shown to enhance the dissolution of RP and is practiced widely as a low-input technology to improve the nutrient value of manure specially prepared from locally available agricultural wastes. The study was conducted to evaluate the effect of phosphocompost prepared from pearl millet straw and cotton stalks on soil properties and crop yield. The organic C (5.36 g kg⁻¹), available N (242.52 kg ha⁻¹), P (24.57 kg ha⁻¹), available micronutrients Fe (11.97 mg kg⁻¹), Zn (5.10 mg kg⁻¹) and Cu (4.12 mg kg⁻¹) were found higher in the treatment receiving 100% RDF + 2.5 t cotton stalks phosphocompost ha⁻¹ followed by the application of 100% RDF + 2.5 t pearl millet straw phosphocompost ha⁻¹. Available K (264.72 kg ha⁻¹) and available Mn (4.67 mg kg⁻¹) were found higher in treatment receiving 100% RDF + 2.5 t pearl millet straw phosphocompost ha⁻¹ (T₃) followed 100% RDF + 2.5 t cotton stalks phosphocompost ha⁻¹ (T₄). Highest CEC (26.87 Cmol kg⁻¹) was recorded in the treatment receiving 100% RDF + 2.5 t cotton stalks phosphocompost ha⁻¹ followed by 100% RDF + 2.5 t pearl millet straw phosphocompost ha⁻¹ (26.40 Cmol kg⁻¹). Significantly maximum soil microbial biomass C (212.42 g C g⁻¹ soil), N (70.72 g N g⁻¹ soil), P (40.25 g P g⁻¹ soil) and alkaline phosphatase activity (90.43 g P Nitrophenol g⁻¹ soil 24 hr⁻¹) were recorded with 100% RDF + 2.5 t cotton stalks phosphocompost ha⁻¹ (T₄) followed by 100% RDF + 2.5 t pearl millet straw phosphocompost ha⁻¹ (T₃) at flowering. The highest N, P and K uptake by grain (54.65, 27.14 and 32.36 kg ha⁻¹, respectively) and fodder (62.64, 34.58 and 230.14 kg ha⁻¹, respectively) were noticed in treatment receiving 100% RDF + 2.5 t cotton stalks phosphocompost ha⁻¹ (T₄) followed by the application 100% RDF + 2.5 t pearl millet straw phosphocompost ha⁻¹ (T₃). Higher nutrient uptake was also noticed when FYM was applied with 100% RDF over control. The highest grain (42.18 q ha⁻¹) and fodder (75.02 q ha⁻¹) yield of pearl millet was recorded in treatment 100% RDF + 2.5 t cotton stalks phosphocompost ha⁻¹ (T₄) followed by the application 100% RDF + 2.5 t pearl millet straw phosphocompost ha⁻¹ (T₃). However, these phosphocomposts along with 75% RDF (T₇ and T₈) also increased productivity of pearl millet and these four treatment are statistically at par. Organic fertilization is an important mean for improving soil fertility. Therefore, there is need for extensive and consistent research efforts on the addition of this type of organic waste, may be considered as a good strategy for recovering semiarid areas. The phosphocompost application along with chemical fertilizer can play important role in soil properties, which received profitable and quality crop production per unit area, which ultimately fetches high price.
Yield, Nutrient Uptake and Growth Kinetics of Fennel with Applied Nitrogen in Typic Haplustepts

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Study of growth kinetics of crop plants is very important to assess the crop response to nutrients along with other variables like climatic and edaphic which determines the probable yield and behaviour of plant to input. Hence, to assess the growth and yield performance of fennel (*Foeniculum vulgare*), field experiments were carried out consecutively three years during 2015-16 and 2016-17 in sandy loam soil of Ajmer, Rajasthan with various nitrogen levels *i.e.*, 40, 60, 80, 100 and 120 kg ha\(^{-1}\). These treatments were compared with control (without nitrogen with basal doses of other nutrients) and absolute control (without any nutrients/input). Results revealed that all the growth parameters *i.e.* plant height, number of primary and secondary branches, number of umbel and umbellates were higher with increased doses of nitrogen. However, plants height and number of branches were only higher with alternate higher level of nitrogen. Most of the growth and yield parameter were at par with control and absolute control. Moreover tremendous increments were observed in number of umbel and umbellates per plant, which was around 1.5 times higher with 120 kg of N as compare to absolute control. Resultant seed yield was also higher for about 1.5 times with 120 kg N ha\(^{-1}\) as that of absolute control. Likewise strover yield was also followed similar trend to seed yield. The seed yield, number of umbel and number of umbellates were highly correlated with N levels 0-120 kg ha\(^{-1}\) and their corresponding r\(^2\) values were 0.92, 0.95 and 0.98, respectively. Likewise, seed yield of fennel was directly correlated with number of umbel and number of umbellates plant\(^{-1}\) bears r\(^2\) value 1.0 and 0.97, respectively. The seed yield ranged from 17.2 (absolute control) to 24.3 q ha\(^{-1}\) (with 120 kg N). The relative growth rate of root increased exponentially with time, which indicates that fennel root remains in active phase even at maturity of crop. However, relative shoot growth was very slow up to 90 days, there after it increased linearly up to the age of 180 days or maturity. Relative growth rate of root and shoot with nitrogen levels slacked at early growth stage, while its response to higher level of nitrogen was distinctively higher, and hence at the age of 90 to 180 days was nearer to linearity. Hence nitrogen boosts the crop growth with greater impact during later growth stage of crop. Relative growth rate of root was much slower than the relative shoot growth particularly at later stages. This is because of biomass accumulation in root and shoot at various phonological stages of crop. Based on the shoot/root ratio, it could be inferred that shoot growth was higher at 60 and 120 days, however it was sluggish at 90 days or senescence. The trend of shoot/root ratio increased with increasing levels of nitrogen except 60 days of age. Uptake of macro and micro nutrients increased with increased levels of N however, it was almost at par with 80, 100 and 120 kg of applied N.
Potassium nutrition in Groundnut (*Arachis hypogaea* L.)

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A field experiment was conducted to investigate the potassium nutrition in groundnut (*Arachis hypogaea* L.) at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif*, 2016. The experiment was laid out with twelve treatments replicated thrice in completely randomized block design. The soil reaction was near neutral and electrical conductivity was under safer limit with clay texture. Pod yield in groundnut ranged from 3009 to 3617 kg ha\(^{-1}\) due to various potassium nutrition treatments but the difference among them was statistically non-significant. However, split application of 150 per cent RDK, half as basal and half at 30 DAS through muriate of potash with 2 per cent foliar spray of potassium sulphate at 60 DAS recorded highest pod yield (3,617 kg ha\(^{-1}\)) closely followed by basal application of 150 per cent RDK along with 2 per cent foliar spray of potassium sulphate (3,574 kg ha\(^{-1}\)). Control, recorded the lowest pod yield (3009 kg ha\(^{-1}\)) in groundnut. Split application of 150 per cent RDK through MOP plus 2 per cent foliar spray of SOP at 60 DAS significantly enhanced the oil (47.84%) and protein (37.98%) contents in kernel with 6.07 and 6.89 per cent increase, respectively over control. The treatment with 150 per cent RDK through muriate of potash in split (half as basal + half at 30 DAS) plus 2 per cent foliar spray through potassium sulphate at 60 DAS recorded highest gross (Rs. 1,51,592 ha\(^{-1}\)) and net (Rs. 94,449 ha\(^{-1}\)) returns with higher B: C ratio (2.65) whereas, control recorded the lowest gross (Rs. 1,26,293 ha\(^{-1}\)) and net (Rs. 70,917 ha\(^{-1}\)) returns with lower B:C ratio (2.28). Thus, split application of 150 per cent RDK through MOP plus foliar spray of one per cent SOP at 60 DAS is beneficial over basal application of 100 per cent MOP.
Evaluation of Efficacy of Sulphur and Zinc Containing Complex Fertilizers for Maximizing Yield through Balanced Nutrition in Soybean-wheat Cropping Sequence Grown on Vertisol

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The deficiencies of secondary and micronutrients in Indian soils and crops are on the increase on account of adoption of modern agricultural practices with an increased use of NPK fertilizers free from micronutrients and limited use of organics as well as restricted recycling of crop residues. Crop responses to Zn and S application have also been obtained in alluvial, red and lateritic and swell-shrink soils. Besides some customized fertilizer products, zinc sulphate is the only Zn and S fertilizer available for the farmers' in the market. Therefore, a field experiment was carried out to evaluate the efficacy of Zn and S containing fertilizers (NPS-1, NPS-2 and NPSZn) as alternatives for Zn and S nutrition for soybean-wheat cropping system grown on Vertisols of Bhopal, Madhya Pradesh, with eleven treatments each with three replications under randomized block design (RBD). The treatments used for study were absolute control (No NPK) (T1), recommended dose of NPK (T2), recommended dose of NPKS (T3), recommended dose of NPKSZn (T4), recommended dose of NPK+ FYM (T5), recommended dose of P through NPS-1 (T6), recommended dose of P through NPS-2 (T7), recommended dose of P through NPSZn (T8), recommended dose of NPK + Sulphur equivalent to NPS 1 supplied in T6 (T9), recommended dose NPK + Sulphur equivalent to NPS 2 supplied in T7 (T10), recommended dose of NPK + sulphur and Zn equivalent to NPSZn supplied in T8 (T11). The seed yield of soybean (Cv. JS-9560) varied from 0.75 to 1.55 t ha\(^{-1}\) and 0.81 to 1.47 t ha\(^{-1}\) under different treatments at two different locations of experimentation. Wheras, wheat grain yield varied from 3.11 to 4.96 t ha\(^{-1}\) for Cv. HD-2987 and 3.62 to 5.96 t ha\(^{-1}\) for Cv. Lok-1 under different treatments. Application of sulphur and zinc either in the form of direct fertilizers or through NPS-1, NPS-2 and NPSZn produced higher seed/grain yield in soybean crops at both the locations. Higher crop responses under NPKSZn treatments over NPK treatment were recorded for both the crops. Total S uptake by soybean varied from 4.90 to 9.60 kg ha\(^{-1}\) and 3.1 to 6.0 kg ha\(^{-1}\) under different treatments at two places of experimentation. Whereas, total S uptake by wheat Cv. HD2987 ranged from 11.6 to 22.4 kg ha\(^{-1}\) and by Cv. Lok 1 ranged from 17.0 to 38.5 kg ha\(^{-1}\) under different treatments. Total Zn uptake by soybean varied from 55.8 to 119 g ha\(^{-1}\) and 58.1 to 137 g ha\(^{-1}\) under different treatments at two places of experimentation. Whereas, total Zn uptake by wheat Cv. HD2987 ranged from 191 to 319 g ha\(^{-1}\) and by Cv. Lok 1 ranged from 180 to 378 g ha\(^{-1}\) under different treatments. Application of S and Zn along with NPK enhanced S and Zn uptake by the crops compared to NPK application alone. The uptake of S and Zn by the crops under direct fertilizer application was at par with S and Zn uptake of the crops obtained under application of NPS-1, NPS-2 and NPSZn.
Effect of Humic Acid on Soil Fertility and Productivity of Groundnut (*Arachis Hypogaea* L.) in An Alfisol

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A pot culture experiment was conducted to study the effect of humic acid from vermicompost and commercial source on soil fertility and productivity of groundnut (var. GPBD-4) in an Alfisol during *kharif* 2017 at the Main Agricultural Research Station, UAS, Dharwad with thirteen treatments and three replications laid out in completely randomized design. Humic acid extracted from vermicompost contained good amount of plant nutrients and higher recovery per cent (5.2) than FYM (4.40) and hence humic acid extracted from vermicompost was used in the study.

Application of humic acid @ 20 kg ha⁻¹ supplemented with 0.2 per cent foliar spray significantly improved growth attributes namely leaf area index and relative chlorophyll content. The same treatment resulted in higher number of pods (24) and pod yield (14.80 g) per plant. There was improvement in the crop quality in terms of kernel oil (46.12%) and protein (25.38%) contents. The total uptake of major (N, P, K and S) and micro (Fe, Zn, Mn and Cu) nutrients were also significantly higher in the same treatment.

There was significant improvement in soil microbial population, enzymes activity (dehydrogenase, urease, phosphatase and nitrate reductase), available nitrogen (253.33 kg ha⁻¹), phosphorus (44.50 kg ha⁻¹), potassium (285.00 kg ha⁻¹) and sulphur (26.80 kg ha⁻¹) and DTPA extractable micronutrients namely Zn (0.90 mg kg⁻¹), Fe (14.70 mg kg⁻¹), Mn (4.90 mg kg⁻¹) and Cu (1.46 mg kg⁻¹) due to application of humic acid @ 20 kg ha⁻¹ with 0.2 per cent foliar spray and statistically similar to same rate of soil application with 0.1 per cent foliar spray.

Application of humic acid extracted from vermicompost @ 20 kg ha⁻¹ with 0.2 per cent foliar spray resulted in higher pod yield (14.80 g plant⁻¹) with an improvement in the kernel oil (46.12%) and protein (28.38%) contents.
Effect of Integrated Nitrogen Management on Soil Properties and Yield of Rice in Sodic Soil of Gujarat

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A field experiment was conducted to study the effect of integrated nitrogen management on soil properties and yield of rice in sodic soil of Gujarat at the Agronomy Farm, College of Agriculture, Anand Agricultural University, Vaso, during Kharif season of 2017. The experiment was laid out in randomized block design with four replications. The treatments consisted of ten integrated nitrogen management combinations i.e. T1 - Control (RDN: 100 kg N ha⁻¹ from inorganic fertilizer), T2 - 100% RDN through FYM, T3 - 100% RDN through vermicompost, T4 - 100% RDN through castor cake, T5 - 50% RDN through FYM + 50% RDN through inorganic fertilizer, T6 - 50% RDN through vermicompost + 50% RDN through inorganic fertilizer, T7 - 50% RDN through castor cake + 50% RDN through inorganic fertilizer, T8 - 25% RDN through FYM + 75% RDN through inorganic fertilizer, T9 - 25% RDN through vermicompost + 75% RDN through inorganic fertilizer, T10 - 25% RDN through castor cake + 75% RDN through inorganic fertilizer. Significantly higher grain yield (4461 kg ha⁻¹) was observed with 50% RDN through castor cake + 50% RDN through inorganic fertilizer (T7) compared to application of 100% RDN through inorganic, FYM or vermicompost but it was at par with rest of the treatments. However, straw yield (7974 kg ha⁻¹) was observed significantly higher with application of 100% RDN through castor cake (T4) as compared to rest of the treatments but it was at par with application of 50% RDN through castor cake and 50% RDN through inorganic fertilizer treatment. The organic carbon content of soil as well as status of available nitrogen, phosphorus, potash were remarkably improved and also significantly reduced ESP after harvest of rice crop.
Effect of Nitrogen Management Treatments on Growth, Yield, Economics, Soil and Plant Quality of Bidi Tobacco
(Nicotiana tabacum L.) Nursery

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A field experiment was conducted during kharif 2017 to study effect of nitrogen management treatments on growth, yield, quality, economics, soil and plant quality of bidi tobacco (Nicotiana tabacum L.) nursery at Bidi Tobacco Research Station, Anand Agricultural University, Anand, Gujarat. The experiment was laid out in Randomized Block Design (RBD) with four replications and twelve treatments. Plant stand recorded at 15 DAS did not exerte their significant effect. Treatment T12 (75% RDN + Foliar spray Vermiwash 2.0% at 30 DAS) was found significantly higher in root and shoot length of seedlings than other treatment at 45 and 55 DAS. At 30, 45 and 60 DAS, the higher fresh weight and dry weight of 10 seedlings was observed under treatment T5 (RDN + Foliar spray Urea 2.0% at 30 DAS). Number of transplantable seedlings ha⁻¹ was significantly higher in treatment T12 (75% RDN + Foliar spray vermiwash 2.0% at 30 DAS) (2425 × 10³ ha⁻¹) but, it was statically at par with treatments T11 and T5. Maximum net realization of ₹ 6,02,548 ha⁻¹ with BCR of 5.22 was obtained from treatment T12 (75% RDN with foliar spray 2.0% vermiwash at 30 DAS). Treatment T11 (75% RDN + foliar spray 1.0% cow urine at 30 DAS) and T5 (RDN + foliar spray of urea 2.0% at 30 DAS) also recorded higher net return of ₹ 5,90,241 ha⁻¹ and ₹ 5,80,055 ha⁻¹ with BCR of 5.15 and 4.90, respectively. Available nutrients status of soil did not exert their significant effect on organic carbon, available nitrogen, phosphorus and potassium status of the soil after harvest of the crop. Higher nitrogen content in bidi tobacco seedlings (2.25%) was recorded at harvest under Treatment T5 (RDN + Foliar spray of Urea 2.0% at 30 DAS). Phosphorus and potash content in bidi tobacco seedlings recorded at harvest the highest under Treatment T12 (75% RDN + Foliar spray 2.0% Vermiwash at 30 DAS).
Effect of Boron Fortified Briquettes on Yield and Quality of Arecanut in Coastal Soils of Konkan

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An experiment was conducted on arecanut during the year 2013-14 to 2015-16 in coastal soils of the Konkan region for maximization of yield and to avoid the cracking of the nuts. Total seven treatments comprising the levels of nitrogen and boron were applied through the straight fertilizers as well as through the boron fortified Konkan Annapurna Briquettes (KAB). The treatment included viz; T1- Recommended Dose of Fertilizers, T2- RDF + 4 kg B ha⁻¹ through soil application, T3- RDN + 4 kg B ha⁻¹ containing KAB, T4- RDN + 2 kg B ha⁻¹ containing KAB, T5- 150 % RDF + 4 kg B ha⁻¹ through soil application, T6- 150 % RDN + 4 kg B ha⁻¹ through KAB and T7- 150 % RDN + 2 kg B ha⁻¹ through KAB. The experiment was laid out in randomized block design replicated thrice.

The application of the Boronated KAB as well as application of straight fertilizers showed the significant results with respect to reducing the splitting of nuts as well as increasing the yield of arecanut. The pooled data indicated that the treatment T6 in which 150% RDN along with 4 kg B ha⁻¹ through KAB was applied showed significant increase in all the nutrients in the nut and husk, which helped to reduce the cracking of the nuts as well as increasing the yield of arecanut. The available nitrogen, phosphorus and potash showed significant results with the application of higher doses of nutrients through KAB along with the Boron application. The hot water extractable boron found maximum (0.58 ppm) in the T6 treatment in which 150% RDF along with 4 kg B ha⁻¹ was applied through KAB and found at par with T3 and T5 treatments in which boron was applied @ 4 kg ha⁻¹.

It is concluded that the application of 150% RDN along with 4 kg B ha⁻¹ through KAB (T6) recorded highest B: C ratio with higher yield and lowest percentage of splitting of the nuts in the arecanut of Konkan region.
Integrated Nutrient Management on Yield Attributes, Yield and Quality of Pearl Millet in Clay Loam Soil

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Pearl millet [Pennisetum glaucum(L.)] is the fifth most important cereal crop in the world after rice, wheat, maize and sorghum. It is a widely grown as rainfed cereal crop in the arid and semi-arid regions of Africa and southern Asia and can be grown in areas, where rainfall is insufficient (200 to 600 mm year\(^{-1}\)) for cultivation of maize and sorghum. Grain is more nutritious with high protein of good quality. Now a day’s need for Intensive agriculture, involving exhaustive high-yielding varieties led to heavy withdrawal of native nutrients from the soil. To curb the trend of declining yield in pearl millet, there is a need to adopt the concept of integrated nutrient management (INM). Organic manure is an important component of INM and would help to recover soil health. A field experiment was conducted during 2016 at venganur village, perambalur district, Tamil Nadu with pearl millet cv. CO-7. The experimental soil was clay loam with a pH of 7.85, EC of 0.43 dSm\(^{-1}\) and CEC of 30.4 cmol (p\(^{+}\)) kg\(^{-1}\). The available nitrogen, phosphorus, potassium and sulphur contents were 272, 14,255 kg ha\(^{-1}\) and 12.5 mg kg\(^{-1}\) respectively. The treatments consisted of application of increased levels of recommended dose of fertilizer with organic manures for pearl millet. The treatments were; T\(_{1}\)-100% RDF, T\(_{2}\)-125% RDF, T\(_{3}\)-75% RDF, T\(_{4}\)-100% RDF + FYM @ 12.5 t ha\(^{-1}\), T\(_{5}\)-100% RDF + Poultrymanure @ 5 t ha\(^{-1}\), T\(_{6}\)-100% RDF + Vermicompost @ 5 t ha\(^{-1}\), T\(_{7}\)-100% RDF + Pressmud @ 5 t ha\(^{-1}\), T\(_{8}\)-125% RDF + Poultry manure @ 5 t ha\(^{-1}\), T\(_{9}\)-125% RDF + Vermicompost @ 5 t ha\(^{-1}\), T\(_{10}\)-125% RDF + Pressmud @ 5 t ha\(^{-1}\), T\(_{11}\)-75% RDF + Poultry manure @ 5 t ha\(^{-1}\), T\(_{12}\)-75% RDF + Vermicompost @ 5 t ha\(^{-1}\) and T\(_{13}\)-75% RDF + Pressmud @ 5 t ha\(^{-1}\). The experiments was laid out in randomized block design (RBD) and replicated thrice. The growth attribute viz., plant height was recorded on 30, 60 and 90\(^{th}\) days after transplanting. The number of tillers per hill was recorded on 60 and 90\(^{th}\) days after transplanting. The earhead weight, length, girth and thousand grain weight was recorded at harvest. The stover and grain yield were recorded at harvest. The ash, protein and fibre contents were also estimated in the grain at harvest stage. The result of the experiment revealed that the application of 125% recommended dose of fertilizer + vermicompost @ 5 t ha\(^{-1}\) (T\(_{9}\)), significantly increased the growth, yield, quality and nutrient uptake of pearl millet followed by, T\(_{10}\) (125% recommended dose of fertilizer + Pressmud @ 5 t ha\(^{-1}\)) respectively. The data on the available nutrients status of post-harvest soil revealed that availability was decreased in the treatments.
Effect of Graded Levels of Sodicity on Growth and Yield of Onion Varieties in Calcareous Sodic Soil

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A field experiment was conducted to assess the effect of different Exchangeable Sodium Percentage (ESP) levels of soil on growth and yield of onion and to fix optimum sodicity tolerance limits of onion based on the performance under different soil sodicity levels. This experiment was continuous and permanent one, so far different crops were tested for their tolerance to sodicity. In existing experimental field, based on the ESP existed in the different main plots, the sodium bicarbonate was applied to main plots and mixed thoroughly with the soil to create different gradient ESP levels viz., 8, 16, 24, 32, 40 and 48 artificially. Further, the ESP 8 and 16 were created through application of gypsum and leaching with good quality water. The experimental plot was thoroughly ploughed individually to bring optimum soil tilth and the ridges and furrows were formed and onion bulb of local variety and seedlings of Co 5 were planted with a spacing of 45 x 10 cm with the application of fertilizers viz., 60:60:60 kg N, P₂O₅ and K₂O (50% of N at basal and remaining 50% at 30 DAS). The experiment was carried out with five levels of ESP in main plot and two onion variety in strip plot design with four replications. The results revealed that among the different levels of ESP, the bulb yield declined with increased ESP levels from 8. However, more than 50 per cent yield could be achieved up to 24 ESP level. Among the varieties Co 5 (seed) and local (Bulb), the performance of Co 5 was superior over local. The highest onion bulb yield of 14206 and 16213 kg per hectare was recorded in local (onion bulb) and Co 5 (seed) varieties, respectively. Similar trend with respect to the individual bulb weight per plant was also recorded. Hence, it is concluded that the onion can be grown in sodic soil up to the ESP level of 24 where the 50 per cent of yield could be realized.
Evaluation of Efficacy of Sulphur and Zinc Containing Complex Fertilizers on Growth, Yield and Quality of Groundnut


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Due to introduction of high yielding varieties and use of sulphur and micronutrients containing free high analysis fertilizer in recent agriculture have caused widespread deficiencies of sulphur and micronutrient in soils of the country. The deficiency of S and Zn recorded 45 to 60 and 25 to 35 per cent in different regions of Gujarat, respectively. Thus, S and Zn have assumed increasing importance for food productivity in Gujarat agriculture. Field experiment was conducted during summer 2016 and 2017 to evaluate the effect of S and Zn containing customized fertilizer on groundnut. The experiment was arranged with eleven treatments considering of RDF with the conventional as well as different grate of customized fertilizers (i.e., NPS1, NPS2 and NPSZn) in randomized block design with three replications. The significantly higher pod yield of groundnut was recorded under equal P, S and Zn levels through traditional sources as well as grade fertilizers treatments. However, the maximum improvement in yield was to the tune of 24.8% due to recommended dose of P, S and Zn through traditional sources over control. In case of average total yield of groundnut, both the sources found equally effective to increase the yield over no application of S and Zn treatment. With the application of S and Zn containing fertilizers, there were significant increase in S and Zn contents in both kernel and haulm which indicated improvement in quality of groundnut produce in general. The significant improvement in sulphur and zinc contents in soil was noticed due to different treatments over control. Thus, S and Zn application is required to get higher pod production of groundnut along with NP application in Zn deficient and S marginal soil.
Identification of Soil Fertility Constraints in Shivapura Micro-watershed, Jalhallihundi Sub-watershed, Chamarajanagara District, Karnataka

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Soil and water are the two precious natural resources and essential for crop production. Rainfed agriculture is under severe stress due to erratic distribution of rainfall, indiscriminate use of fertilizers, adoption of improper land management practices, soil erosion, decline in soil fertility and ground water resources leading to lower productivity of crops. The Shivapura micro watershed is situated between 76°52'20.259” to 76°54'18.171” E longitude and 11°53'23.654” and 11°55'9.522” N latitude, Chamarajanagar district, Karnataka. Land resource inventory was carried out using geospatial techniques. Cadastral map at 1:7,920 scale was used as base map for the study. The soil texture, slope, erosion and gravel classes were studied parcel wise. A grid of 320 m² spacing was overlaid on the cadastral map and 48 grids samples were collected in the micro watershed covering an area of 507 ha. Soil fertility maps were prepared by using Geographical Information System (GIS) tools. In 222.9 ha the soil texture was sandy loam (44.0% of the total area). Gravelly soils occupied 399.3 ha (78.7% of the area) followed by non gravelly soils 60.1 ha (11.9%), very gently sloping lands covers an area of 358.7 ha and slight erosion was observed in 463.1 ha. The results of the soil analysis revealed that the soils of the micro watershed have slightly acidic to moderately alkaline reaction. Neutral, Slightly alkaline and moderately alkaline soils occurs in 168.9, 180.1 and 108.9 ha, respectively covering 33.3, 35.5 and 21.5 per cent of the area, respectively. The soils are medium in organic carbon (462.0 ha), available phosphorus (261.2 ha) and available potassium (286.6 ha) and low in available nitrogen (463.1 ha) content, covering 91.1, 51.5, 56.6 and 91.4 per cent of the total area, respectively of the micro watershed. The exchangeable calcium and magnesium content are found to be sufficient in 463.1 ha (91.4% of the area). Sulphur content is low in 190.8 ha (37.7% of the area). Among micro nutrients manganese, copper and zinc are found to be sufficient in 463.1 ha (91.4%) and iron is deficient in 383.7 ha (75.6% of the area). The boron content is medium in 455.0 ha (89.8% of the area). The study revealed that, soil organic carbon, available nitrogen, phosphorus, potassium, sulphur and iron were important soil fertility constraints indicating their immediate attention for sustained crop production. In addition, soil and moisture conservation practices need to be done for very gently sloping lands in order to enhance productivity and restrict further degradation of land.
Iron and zinc deficiencies are the most widespread micronutrient deficiencies in crop plants especially in cereals, resulting in decreased crop yields and nutritional quality. Cereal crops play an important role in satisfying daily calorie intake in the developing world but they are very low in grain iron and zinc concentration particularly when grown under zinc deficient soils. Therefore, it is essential to increase the iron and zinc concentration in cereal grains particularly in bajra which ranks third after rice and wheat and is a major source of dietary energy and nutritional security. With this prime objective the present nutrient enrichment investigation was carried out at Research farm, Agricultural Research Station, Utukur, Kadapa in Alfisols of the Southern Agro-Climatic zone of Andhra Pradesh. The experiment was carried out with nine treatment combinations viz., T1. RDF; T2. RDF + ZnSO4 50 kg ha⁻¹, T3. RDF + ZnSO4 25 kg ha⁻¹, T4. T1 + one ZnSO4 0.2% Spray at 45 DAS, T5. T1 + one FeSO4 0.2% Spray at 45 DAS, T6. T1 + one ZnSO4 0.2% + one FeSO4 0.2% Spray at 45 DAS, T7. T2 + one ZnSO4 0.2% + one FeSO4 0.2% Spray at 45 DAS, T8. T3 + one ZnSO4 0.2% + one FeSO4 0.2% Spray at 45 DAS and T9. Control in randomized block design with three replications.

Results revealed that, application of ZnSO4 @ 50 kg ha⁻¹ significantly increased the test weight, grain yield and protein content, which was however on par with treatment ZnSO4 @ 25 kg ha⁻¹ plus 0.2% foliar application and the yield increase to the tune of 1.4 times high over control. The treatment receiving soil plus foliar application of zinc recoded highest zinc concentration in the grain. Similarly, the treatment receiving the foliar application of iron sulphate recorded higher iron concentration in the grain. The increase of iron and zinc concentration in the grain was to the tune of 2.3 times over the treatment receiving only recommended dose of fertilizers. Similar trend was observed with respect to uptake of iron and zinc. Hence, application of zinc sulphate @ 50 kg ha⁻¹ coupled with foliar application of zinc sulphate and ferrous sulphate @0.2% found to be superior in fortifying the grain of bajra.
Effect of Integrated Incorporation of Inorganic Fertilizers (N, P$_2$O$_5$, K$_2$O & B), Enriched Composts and Phyto-Hormone on Sunflower in *Typic ustifluvent* Soil

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Sunflower (*Helianthus annuus* L.) is the second most important oilseed crop next to soybean, containing oil of high quality (USFA- as linolenic and linoleic acids (900 g kg$^{-1}$), anti-cholesterol properties). Water hyacinth (*Eichhornia crassipes* mart. (Solms.) is the worst aquatic weed found abundantly in almost all types of wetlands. It is a rich source of plant nutrients. On decay, it creates the problem of eutrophication. It was composted and converted into valuable manure (EWHC). Boron plays an important role in the production of oilseeds, which performs many physiological functions. Phyto-hormones are physiological intercellular messengers, that are needed to control the complete plant lifecycle. To study the effect of integrated incorporation of inorganic fertilizers (N, P$_2$O$_5$, K$_2$O & B), enriched composts and phyto-hormone (NAA) on sunflower, a pot experiment (potculture yard) and a field experiment (Shivapuri Village) were conducted during April-July, 2017 in Cuddalore District, Tamil Nadu. The initial soil was classified as sandy clay loam in texture with a pH of 7.4 and EC of 0.44 dS m$^{-1}$. Sunflower cv. Sunbred was grown as a test crop for both the experiments. A pot experiment comprised of five levels of factor-A (Control, EFYM, EWHC, ENLC and ESDC) and four levels of factor-B (Control, 75%, 100% and 125% RDF) (20 treatment combinations), laid out in FCRD with three replications. The best treatments were screened and imposed into field experiment along with B and NAA through RBD with ten treatments replicated thrice. The results revealed application of 125% RDF (N and K$_2$O) recorded the highest seed yield and stalk yield of 28.83 and 65.27 g pot$^{-1}$, respectively. Similarly, application of enriched water hyacinth compost recorded the highest seed yield and stalk yield of 26.74 and 62.70 g pot$^{-1}$, respectively. In field experiment, the highest seed yield (1879 kg ha$^{-1}$) and stalk yield (2890 kg ha$^{-1}$) were registered with 125% RDF (N:K$_2$O) + 125% P$_2$O$_5$ (SSP) EWHC + B @ 0.2% + NAA @ 20 ppm. This could be due to the rapid mineralization of nutrients and slow and steady availability of nutrients from enriched water hyacinth compost besides the acceleration in translocation of photosynthates from source to sink by micronutrients.
Field experiment on sugarcane was conducted in clay loam soil at Periyannellikollai Village, Cuddalore district Tamil Nadu. Treatment structure includes T1 – Seasoned pressmud @ 25 t ha$^{-1}$ T2 – Seasoned pressmud @ 25 t ha$^{-1}$ + Enriched gypsum @ 1 t ha$^{-1}$ T3 – Seasoned pressmud @ 25 t ha$^{-1}$ + Enriched gypsum @ 1 t ha$^{-1}$ + Zinc sulphate @ 37.5 kg ha$^{-1}$ T4 – Seasonal pressmud @ 25 t ha$^{-1}$ + LFA @ 25 t ha$^{-1}$ T5 – Vermicompost @ 5 t ha$^{-1}$ + Seasonal pressmud @ 25 t ha$^{-1}$ T6 – Vermicompost @ 5 t ha$^{-1}$ + Enriched gypsum @ 1 t ha$^{-1}$ T7 – Vermicompost @ 5 t ha$^{-1}$ + Enriched gypsum @ 1 t ha$^{-1}$ + Zinc sulphate @ 37.5 kg ha$^{-1}$ T8 – Vermicompost @ 5 t ha$^{-1}$ + LFA @ 25 t ha$^{-1}$ T9 – Biocompost @ 5 t ha$^{-1}$ T10 – Biocompost @ 5 t ha$^{-1}$ + Enriched gypsum @ 1 t ha$^{-1}$ T11 – Biocompost @ 5 t ha$^{-1}$ + Enriched gypsum @ 1 t ha$^{-1}$ + Zinc sulphate @ 37.5 kg ha$^{-1}$ T12 – Biocompost @ 5 t ha$^{-1}$ + LFA @ 25 t ha$^{-1}$ T13 – FYM @ 10 t ha$^{-1}$ T14 – NPK alone (RDF). In this experiment, the effect of Seasoned pressmud @ 25 t ha$^{-1}$, Enriched gypsum @ 1 t ha$^{-1}$, Zinc SO$_4$ @ 37.5 kg ha$^{-1}$, Lignite flyash @ 25 t ha$^{-1}$, Vermicompost @ 5 t ha$^{-1}$, Biocompost @ 5 t ha$^{-1}$, FYM @ 10 t ha$^{-1}$ and recommended dose fertilizers and their combinations were tested. There were 14 treatments combinations. All plots received recommended dose of inorganic fertilizers. The design followed was RBD and replicated thrice. The highest cane yield of 169.74 t ha$^{-1}$ was associated with the treatment Seasoned pressmud @ 25 t ha$^{-1}$ + Enriched gypsum @ 1 t ha$^{-1}$, Zinc SO$_4$ @ 37.5 kg ha$^{-1}$ along with recommended NPK (T14). The treatment increased cane yield by 39.41 percent over the control while the increase due the application of Vermicompost @ 5 t ha$^{-1}$ + Seasoned pressmud @ 25 t ha$^{-1}$ was 37.04 percent over that of control (T1) RDF alone. The post harvest soil available N (278 kg ha$^{-1}$), P (19.3 kg ha$^{-1}$) were significant in the treatment Seasoned pressmud @ 25 t ha$^{-1}$ + Vermicompost @ 5 t ha$^{-1}$ along with NPK (T3). The post harvest available K (156.4 kg ha$^{-1}$) were maximum in the treatment Seasoned pressmud @ 25 t ha$^{-1}$ + Lignite flyash @ 25 t ha$^{-1}$ along with NPK (T4).
Influence of Integrated Nutrient Management Practice on the Permanent Manurial Experiment of Maize-Green Gram Cropping System

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The experiment on permanent manurial experiment was started in 2011 using maize green gram cropping system. So far four maize (TNAU hybrid maize Co-6) and four green gram (Co-6) crops were raised to study the changes in soil parameters and yield. The main objective of the trial is to study the effect of continuous addition of organics, inorganics and its integrated effect on yield attributes, yield and uptake of maize. Maize crop was raised during rabi and green gram crop at summer. Treatments consisted of control, organic, inorganic and integrated nutrient management. In the inorganic treatment blanket recommendation of 250:75:75 kg NPK ha⁻¹ was applied. Organic plot received the application of farm yard manure on N equivalent basis, while INM plot received 12.5 t FYM ha⁻¹ and blanket recommendation of fertilizer along with biofertilizer. The experiment was conducted in a non replicated trial.

The yield parameters such as grain yield and haulm yield were the highest in INM practice followed by inorganic and organic treatments. The grain yield varied significantly due to various treatments and ranged from 573 to 725 kg ha⁻¹. The control recorded the lowest grain yield. Similarly, the nutrient uptake by the crop at the time of harvest registered significant difference due to different treatment effects. The N and P uptakes were highest in grain compared to haulm whereas K uptake was highest in stalk rather than grain. Among the treatments, INM practice recorded the highest uptake and available nutrients (NPK) followed by inorganic, organic, while the control recorded lowest.

The result indicated that the grain and stover yield ranged from 4131 to 7716 kg ha⁻¹ and 7588 to 10339 kg ha⁻¹, respectively. The highest grain yield was observed in INM practice (7716 kg ha⁻¹), which significantly differed from other treatments. The control recorded the lowest grain yield. The highest stover yield was recorded in INM (10339 kg ha⁻¹) followed by inorganic and organic treatments. The change in available N showed increasing trend in all the treatments except control. In the case of available P, K there was a decline in all the treatments however the rate of decrease was lowest in the case of organic.

The INM practice registered higher growth and yield parameters consequently the higher grain, haulm yield and nutrient uptakes of green gram when compared to others indicating the superiority of INM practice. The same trend was observed in the maize crop also Increase in OC and available N status were observed in INM practice while available P and K contents were slightly reduced. Soil biological properties were enhanced in the INM plot followed by the organic plot.
Effect of Integrated Use of Inorganic and Organics on Soil Quality, Yield and Proximate Composition of Elephant Foot Yam – Blackgram Cropping System in Alfisols

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A field experiment was conducted for three consecutive rabi (winter) seasons during 2015-18 to study the effect of integrated use of lime, inorganic and organic manures on soil quality and yield performance of elephant foot yam-blackgram cropping system in an acid Alfisol of Odisha. The experimental soil is fine sandy loam, mixed, isohyperthermic, typic Haplustalf; acidic (pH 5.16), non saline and having 0.256% organic C, 0.1344% total N, 218, 24.64 and 189 kg ha⁻¹ of available N, P and K, respectively. The soil also contains 33.44, 1.42, 112.8 and 0.52 mg kg⁻¹ of available Fe, Cu, Mn and Zn, respectively.

The results of the study during 2017-18 revealed that integrated application of lime + FYM + NPK + MgSO₄ recorded significantly highest corm yield (26.34 t ha⁻¹) of elephant foot yam with a yield response of 159 % over control. Incorporation of neem cake recorded significantly higher corm yield (16.72 t ha⁻¹) at par with vermicompost (16.53 t ha⁻¹). Application of graded doses of NPK showed a yield response of 37, 65 and 107 per cent due to addition of 50, 100 and 150% of NPK over control, respectively. Addition of lime along with FYM, balanced doses of NPK and micro nutrients showed the yield response in the order of 10.7 > 10.2 > 8.6% in respect of Zn, B and Mg, respectively in comparison to unlimed plots. Significantly highest dry matter (12.83%) and starch content (fresh weight basis) was recorded due to application of lime + FYM + NPK + Borax. Total sugars ranged from 1.32-1.61%. Significantly highest grain and haulm yields of black gram were recorded due to application of lime, FYM, NPK and MgSO₄ (7.08 and 34.05 q ha⁻¹, respectively). Incorporation of neem cake recorded highest grain yield (6.07 q ha⁻¹).

Application of soil test based NPK combined with lime, FYM and MgSO₄ showed the highest dehydrogenase activity (0.521 μg TPF h⁻¹ g⁻¹), whereas highest Fluorescein diacetate activity (0.527 μg g⁻¹ h⁻¹) was recorded due to application of lime + FYM + NPK + Borax. Integrated use of lime + FYM + NPK + MgSO₄ recorded highest acid and alkaline phosphatase activities (32.18 and 30.87 μg PNP h⁻¹ g⁻¹, respectively). Soil bacteria showed significant relationship with phosphatase and dehydrogenase activities, indicating that bacteria plays major role in enzyme mediated reactions in the soil, however, P solubilization as influenced by phosphatase activities were mostly regulated by soil bacteria. Long term application of soil amendments, organic and balanced inorganic fertilizers not only helps to augment the crop yields but also enhances the microbial activities of the soil.
Phosphorus Uptake Pattern and Use Efficiency of Different Sugarcane Varieties Under South Gujarat Condition (Inceptisol)

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In this study, we investigated the variation in P uptake by different sugarcane varieties at varying P doses in an Inceptisol under South Gujarat condition. The field trials were conducted on low P soil with treatment consisted of different sugarcane varieties viz., V1=Co 86002, V2=Co 86032, V3=Co N 5071, V4=Co N 7072 and different levels of phosphorous viz., P0= 0 kg P2O5 ha-1, P1= 50 kg P2O5 ha-1, P2= 100 kg P2O5 ha-1, P3= 150 kg P2O5 ha-1 replicated three times in factorial randomized block design during 2015-16 and 2016-17 at College Farm, Navsari Agricultural University, Navsari. Sugarcane variety CoN 7072 (V4) recorded significantly higher uptake of phosphorus at 180 DAP (13.53, 13.36 and 13.45 kg ha-1), at 270 DAP (21.87, 22.99 and 22.43 kg ha-1) and at harvest (31.96, 36.22 and 34.09 kg ha-1) during 2015-16, 2016-17 and in pooled analysis, respectively. Application of phosphorous at 150 kg P2O5 ha-1 (P3) recorded significantly highest P uptake at 180 DAP (12.70, 12.39 and 12.55 kg ha-1), at 270 DAP (20.05, 20.90 and 20.48 kg ha-1) and at harvest (28.42, 33.30 and 30.86 kg ha-1). Maximum agronomic P use efficiency (242.18, 240.65 and 241.42 kg kg-1) was recorded with treatment V3P2 (CoN 5071 and 100 kg P2O5 ha-1) during both years of experiments as well as in pooled analysis. Physiological P use efficiency were recorded highest (6244.23 kg kg-1) during first year of experiment with interaction treatment V2P1 (Co 86032 and 50 kg P2O5 ha-1) while second year of experiment (5114.93 kg kg-1) with treatment V3P2 (Co N 5071 and 100 kg P2O5 ha-1) and in pooled analysis (5256.88 kg kg-1) with treatment V3P3 (Co N 5071 and 150 kg P2O5 ha-1). Partial factor productivity of P was found maximum under interaction treatment V2P1 (Co 86032 and 100 kg P2O5 ha-1) during 2015-16 (1717.64 kg kg-1) and in pooled analysis (1652.16 kg kg-1), while in case of 2016-17 (1588.72 kg kg-1) recorded with treatment V4P1 (Co N 7072 and 50 kg P2O5 ha-1). On the basis of experimental results, it can be concluded that in P deficient soil for getting higher yield, returns and maintenance of soil P status, sugarcane variety Co N 7072 or Co N 5071 can be fertilized with 150 kg P2O5 ha-1 under South Gujarat conditions.
Nutrient Management through Fertigation in Guava


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An experiment was conducted at Agricultural Research Station for Irrigated crops, A.A.U. Thasra, Gujarat, on sandy loam soil for three years 2015-16 to 2017-18 to study the nutrient management through fertigation in guava. The field trial was laid out in Randomized Block Design with four treatments, N1: 500: 0.250: 0.250 NPK kg tree\(^{-1}\) (RDF), N2: 50% of RDF through fertigation, N3: 75% of RDF through fertigation, N4: 100% of RDF through fertigation (NP from water soluble fertilizer and K from MOP). The investigation indicated that maximum 219.58 no. of fruits plant\(^{-1}\) and 76.21 kg fruit yield plant\(^{-1}\) of guava was obtained under treatment N4 followed by treatment N3 which recorded 211.33 no. of fruits plant\(^{-1}\) and 72.92 kg fruit yield plant\(^{-1}\). The lowest fruit yield plant\(^{-1}\) (55.60 kg) was obtained in treatment N1. The treatment N4 and N3 gave 27.04% and 23.75% more fruit yield plant\(^{-1}\), respectively in comparison to treatment N1. The economics of various treatments revealed that treatment N4 gave the highest net return of Rs. 609683 per hectare with BCR 5.53. However, maximum TSS (7.66%) and vitamin C (140.33 mg 100 gm\(^{-1}\)) was observed under treatment N4 followed by treatment N3 which recorded TSS (7.42%) and vitamin C (134.94 mg 100 gm\(^{-1}\)). Treatment N3 recorded 25% fertilizer saving in comparison to treatment N4.
Effects of Multi-micronutrient Mixture on Growth, Yield and Quality of the Summer Pearl Millet

(*Pennisetum glaucum L.*)

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A field experiment was conducted on loamy sand soil of Anand (Gujarat) during summer season of the year 2017 to study the effects of multi-micronutrient mixture on growth, yield and quality of the pearl millet (*Pennisetum glaucum L.*). The soil used for the experiment was alkaline in reaction with low in available N and high in available P2O5 and K2O. With respect to DTPA-micronutrients, Fe and Mn was deficient, while Zn and Cu were sufficient in status. The higher grain yield was obtained with the 1% foliar spray of multi-micronutrient mixture grade-III (for Fe deficiency) having concentration of Fe-6.0%, Mn-1.0%, Zn-4.0%, Cu-0.3% and B-0.5% at 15, 30 and 45 DAT (Days after Transplanting). While straw and total yield was higher under the soil application of micronutrients of 50 kg FeSO4.5H2O ha⁻¹ and 40 kg MnSO4.3H2O ha⁻¹ as per STV (Soil Test Value). Micronutrient supplementation through 1.0% foliar application of the mixture having concentration of Fe-4.0%, Mn-1.0%, Zn-6.0%, Cu-0.5% and B-0.5% (Grade-IV for Zn and Fe deficiency) was also found beneficial in increasing ear head length, grain, straw and total yield of summer pearl millet.
Effect of Potassium and Sulphur on Yield Attributes, Yield and Quality of Summer Groundnut (*Arachis hypogaea* L.) under Middle Gujarat Condition

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A field experiment was conducted at the college Agronomy farm, Anand Agricultural University, Anand (Gujarat) during summer season of the year 2017 to study the role of potassium and sulphur on yield attributes, yield and quality of summer groundnut (*Arachis hypogaea* L.) under middle Gujarat conditions. The experimental soil was loamy sand in texture having pH of 7.80. The experiment included four levels of potassium *viz.* 0, 25, 50 and 75 kg K$_2$O ha$^{-1}$ and three levels of sulphur *viz.* 0, 20 and 40 kg S ha$^{-1}$. The experiment was laid out in a Randomized Block Design (Factorial) with four replications. Potassium showed significant effect on yield and yield attributes of groundnut. Application of potassium @ 75 kg K$_2$O ha$^{-1}$ produced significantly highest dry matter content at 45 DAS, no. of branches plant$^{-1}$, no. of pod plant$^{-1}$, shelling %, seed index, pod yield, haulm yield and protein content. Application of sulphur @ 40 kg S ha$^{-1}$ produced the highest dry matter content at 45 DAS, no. of branches plant$^{-1}$, no. of pod plant$^{-1}$, shelling %, seed index, pod yield, haulm yield, oil content and protein content. Potassium in combination with sulphur showed significant effect on yield and yield attributes of groundnut. Combined application of potassium @ 75 kg ha$^{-1}$ and sulphur @ 40 kg ha$^{-1}$ resulted significantly the highest no. of branches plant$^{-1}$, no. of pod plant$^{-1}$, pod yield, haulm yield and shelling % of groundnut. On the other hand, in all the cases the lower response was found from the control treatment.
Influence of Potassium, Zinc and FYM on Growth, Yield, Nutrient Contents and Uptake by Forage Maize (Zea mays L.) Grown on Loamy Sand Soil

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The pot experiment was carried out during summer season of the year 2015 at B.A. College of Agriculture, Anand Agricultural University, Anand on loamy sand soil to study the influence of potassium, zinc and FYM on growth, yield, nutrient contents and uptake by forage maize (Zea mays L.). Eighteen treatments comprising with three levels of K$_2$O (0, 30 and 60 kg ha$^{-1}$) and Zn (0, 10 and 20 kg ha$^{-1}$) and two levels of FYM (0 and 10 t ha$^{-1}$) were tried in factorial completely randomized design with three replications. The experimental results revealed that the application of K$_2$O @ 60 kg ha$^{-1}$, Zn @ 20 kg ha$^{-1}$ and FYM @ 10 t ha$^{-1}$ recorded significantly higher plant height, green forage yield, dry matter yield and N, P, K uptake by plant over control. The highest K content in plant was recorded with the application of K$_2$O @ 60 kg ha$^{-1}$ than rest of the levels of K$_2$O at 30 DAS and harvest. However, the application of FYM @ 10 t ha$^{-1}$ and zinc @ 20 kg ha$^{-1}$ recorded significantly higher N content at 30 DAS and at harvest.

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The pot experiment was carried out at nethouse of the department of soil science and agricultural chemistry, B.A. College of Agriculture, Anand Agricultural University, Anand on the interaction effect of potassium and zinc on yield and nutrient uptake of forage maize (*Zea mays* L.) grown on loamy sand soil, during summer season of the year 2015. The experiment was laid out in a completely randomized design (factorial) with three repetitions. The three levels of K$_2$O (0, 30 and 60 kg ha$^{-1}$) and Zn (0, 10 and 20 kg ha$^{-1}$) were selected in the experiment. The combination of potassium @ 60 kg ha$^{-1}$ along with zinc @ 20 kg ha$^{-1}$ gave significantly the highest green forage and dry matter yield over the rest of combinations. Treatment combination of K$_2$O @ 60 kg ha$^{-1}$ along with Zn @ 20 kg ha$^{-1}$ recorded significantly the higher phosphorus, potassium and zinc uptake by the crop than rest of the combinations.
Co-application of Biochar and Chemical Fertilizers for Improvement of Yield and Quality of *Andrographis paniculata* and Soil Health

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As it is necessary for the medicinal plants to be cultivated by maintaining sustainable environment with minimum use of chemicals considering their higher production and therapeutic values, a pot culture experiment was attempted to integrate the biochar prepared from lemongrass (*Cymbopogon flexuosus*) after oil extraction and chemical fertilizers (CF) in different combinations to study their influence on yield, physiology and quality of *Andrographis paniculata* herb and on soil chemical and biological properties. Biochar application, notably improved the soil carbon content, cation exchange capacity and nutrients availability as compared to the un-amended soil. However affects were maximum when biochar application combined with recommended dose of CF. In addition, soils with combined biochar and CF application showed higher values of soil microbial biomass C, fluorescein diacetate hydrolytic, dehydrogenase and alkaline phosphatase activity than the respective sole application and un-amended control. However, biochar affects were non-significant on soil acid phosphates activity. Total phenol/flavonoid contents, as well as antioxidant (DPPH and ABTS) activity, were higher in sole biochar treated plant and it was further increased after addition of CF. In general application of biochar or CF does not have any significance influence on leaf andrographolide content but their combination increase the content and affects were not clear-cut for stem andrographolide. All growth parameters (root/shoot length, dry/fresh weight of root/shoot/leaves and number of branches plant\(^{-1}\)) and yield (g plant\(^{-1}\)) were positively influenced by the integrated application of biochar and CF. Bichar application reduces stomatal conductance and increases water use efficiency, indicates that biochar can be potential candidate to mitigate water deficit stress. Results also indicate that use of biochar alone was not sufficient to boost the plant growth and soil health quality. Therefore, for environmental supportive safe and quality production of medicinal herb, it is recommended to use of combination of biochar and CF which not only improve crop yield and quality performance but also the quality of cultivated soil.
The pot experiment was carried out to study the influence of phosphorus, sulphur and FYM on chemical composition of forage maize (Zea mays L.) grown on loamy sand soil. The three levels of P₂O₅ (0, 30 and 60 kg ha⁻¹), three levels of S (0, 10 and 20 kg ha⁻¹) and two levels of FYM (0 and 10 t ha⁻¹) were tested in the experiment. The P content in plant was significantly higher with application of P₂O₅ @ 60 kg ha⁻¹ than rest of the levels at 30 DAS and harvest except P₂O₅ @ 30 kg P₂O₅ ha⁻¹. Similarly S content was significantly higher under 20 kg ha⁻¹ than control. Application of FYM @ 10 t ha⁻¹ recorded significantly higher N content at 30 DAS and at harvest than no FYM. All interaction effects of P, S and FYM were non-significant for nutrients content of plant at 30 DAS and harvest. The micronutrient (Fe, Mn, Zn and Cu) contents were not significantly modified but application of P₂O₅ @ 60 kg ha⁻¹, S @ 20 kg ha⁻¹ and FYM @ 10 t ha⁻¹ recorded significantly the highest uptake of N, P, K, S, Fe, Mn, Zn and Cu by crop at harvest.

Treatment combination of P₂O₅ @ 60 kg ha⁻¹ along with S @ 20 kg ha⁻¹ recorded significantly higher phosphorus, potassium, zinc and copper uptake by the crop than rest of the combinations except zinc and copper uptake. The interaction of P × F (P₂O₅ @ 60 kg ha⁻¹ with FYM @ 10 t ha⁻¹) recorded significantly the highest uptake of P, K, S, Mn and Cu by maize. Similarly, the interaction effect of S × F (S @ 20 kg ha⁻¹ with FYM @ 10 t ha⁻¹) recorded significantly the highest P and K uptake by maize. The interaction of P × S × F (P₂O₅ @ 60 kg ha⁻¹ + S @ 20 kg ha⁻¹ with FYM @ 10 t ha⁻¹) registered maximum values for P and K uptake, but P uptake was at par with P₃S₂F₂ (P₂O₅ @ 60 kg ha⁻¹ + S @ 10 kg ha⁻¹ along with FYM 10 t ha⁻¹) and K uptake was at par with P₃S₂F₂ (P₂O₅ @ 60 kg ha⁻¹ + S @ 20 kg ha⁻¹ along with FYM 10 t ha⁻¹), P₃S₃F₁ (P₂O₅ @ 60 kg ha⁻¹ + S @ 20 kg ha⁻¹ along with FYM 0 t ha⁻¹) combinations.
Influence of Phosphorus, Sulphur and FYM on Growth and Yield of Forage Maize (*Zea mays* L.) Grown on Loamy Sand Soil

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The pot experiment was carried out at the nethouse of the Department of Soil Science and Agricultural Chemistry, B.A. College of Agriculture, Anand Agricultural University, Anand on the influence of phosphorus, sulphur and FYM on growth and yield of forage maize (*Zea Mays* L.) grown on loamy sand soil during summer season of the year 2017. The experiment was laid out in a completely randomized design (factorial) with three repetitions. The three levels of P$_2$O$_5$ (0, 30 and 60 kg ha$^{-1}$), three levels of S (0, 10 and 20 kg ha$^{-1}$) and two levels of FYM (0 and 10 t ha$^{-1}$) were tested in the experiment.

Application of P$_2$O$_5$ @ 60 kg ha$^{-1}$ and application of S @ 20 kg ha$^{-1}$ recorded significantly higher plant height at 30 DAS and at harvest than control. Significantly higher plant height was recorded with application of FYM @ 10 t ha$^{-1}$ than control at 30 DAS as well as at harvest. Crop fertilized with P$_2$O$_5$ @ 60 kg ha$^{-1}$ and FYM @ 10 t ha$^{-1}$ gave significantly the highest green forage and dry matter yields, respectively. Similarly, application of S @ 20 kg ha$^{-1}$ recorded significantly the highest dry matter, whereas application of S @ 20 kg ha$^{-1}$ recorded higher green forage yield than rest of treatments, except S @ 10 kg ha$^{-1}$. The combination of phosphorus @ 60 kg ha$^{-1}$ along with sulphur @ 20 kg ha$^{-1}$ gave significantly higher green forage yield and dry matter yield than rest of the combinations except P$_2$O$_5$ @ 60 kg ha$^{-1}$ with S @ 10 kg ha$^{-1}$. The combination of P$_2$O$_5$ and FYM (P$_2$O$_5$ @ 60 kg ha$^{-1}$ with FYM @ 10 t ha$^{-1}$) recorded significantly higher dry matter yield of maize than rest of the combinations barring combination of P$_2$O$_5$ @ 60 kg ha$^{-1}$ with FYM @ 10 t ha$^{-1}$. 

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Effects of Organic and Inorganic Fertilizers on Soil and Plant Nutrients of Pearl Millet - Wheat under Sandy Loam Soil of Gujarat

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A study was conducted to assess fertilizer effect on pearl millet-wheat yield and plant-soil nutrients with the following treatments: T1, Control; T2, FYM @ 20 t ha⁻¹ (Only in pearl millet); T3, N kg ha⁻¹ (STV) + FYM @ 20 t ha⁻¹ (Only in pearl millet); T4, NP kg ha⁻¹ (STV) + FYM @ 20 t ha⁻¹ (Only in pearl millet); T5, NP kg ha⁻¹ (STV) + K (equal to N) + FYM @ 20 t ha⁻¹ (Only in pearl millet); T6, N kg ha⁻¹ (STV); T7, NP kg ha⁻¹ (STV); T8, NP kg ha⁻¹ (STV) + K (equal to N); T9, NP Zn, Fe/S kg ha⁻¹ (STV) + K (equal to N) + FYM @ 20 t ha⁻¹ (Only in pearl millet); T10, NP Zn, Fe/S kg ha⁻¹ (STV) + K (equal to N). Treatments differed significantly in influencing soil-plant nutrients and grain and straw yields of both crops.

The application of potash equal to nitrogen along with phosphorus (T5) gave significantly higher grain (4.1 t ha⁻¹) and straw (7.3 t ha⁻¹) yield of wheat. Application of potash equal to nitrogen along with phosphorus and FYM @ 20 t ha⁻¹ (T4 and T9) and T3 treatments gave significantly higher P content in grain. While result of T1 and T5 treatments significantly increased P content in straw of wheat. The higher N and P uptake by grain of wheat were found in T9 treatment whereas, K uptake by grain was noticed higher in T5. Nitrogen uptake by straw were noticed higher in T4. Significantly the highest P uptake by straw were found in the treatment of T5, while significantly higher K uptake by straw was found in the treatment of T5. The application of T3, T4 and T5 treatments showed significantly higher organic carbon, available P₂O₅ and available K₂O after harvest of wheat, respectively.

The application of nitrogen, phosphorus and potash along with FYM (T9) gave significantly higher grain (3.4 t ha⁻¹) and straw yield (7.2 t ha⁻¹). The application of T1, T5, T6, T8 and T10 gave significantly higher K content in grain of pearl millet. The N content in straw of pearl millet was higher due to application of T4 treatment. Application of T8, T9 and T10 showed significantly higher N, P and K uptake by grain of pearl millet, respectively. While K uptake by straw of pearl millet were significantly higher in T7 treatment. The application of soil test based nitrogen along with phosphorus and FYM gave significantly higher organic carbon (0.53%). The higher available P₂O₅ and available K₂O were noted in the treatment of T5. Based on the study, NP Zn, Fe/S kg ha⁻¹ (STV) + K (equal to N) + FYM @ 20 t ha⁻¹ could be recommended for attaining maximum returns of pearl millet-wheat cropping sequence.
Effect of Nutrient Management in Bt Cotton to Break the Yield Stagnation

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An experiment was conducted at Agricultural Research Station for Irrigated crops, A.A.U. Thasra, Gujarat, on sandy loam soil for three years 2014-15 to 2016-17 to study the effect of nutrient management in BT cotton to break the yield stagnation. The field trial was laid out in Factorial Randomized Block Design with treatments consisted of two nitrogen levels viz., N\textsubscript{1} (180 kg ha\textsuperscript{-1}) and N\textsubscript{2} (240 kg ha\textsuperscript{-1}), three potassium levels K\textsubscript{0} (0 kg K\textsubscript{2}O ha\textsuperscript{-1}), K\textsubscript{-1} (50 kg K\textsubscript{2}O ha\textsuperscript{-1}) and K\textsubscript{2} (100 kg K\textsubscript{2}O ha\textsuperscript{-1}) and two STV levels STV\textsubscript{0} (S\textsubscript{0}Fe\textsubscript{0}Zn\textsubscript{0}) and STV\textsubscript{1} [S, Fe, Zn (STV)]. The results of investigation indicated that the highest no. of bolls plant\textsuperscript{-1} (34.81), weight of boll (6.94 g) and seed cotton yield (3.4 t ha\textsuperscript{-1}) were found under the treatment N\textsubscript{2} as comparison the treatment N\textsubscript{1}. Application of 100 kg K\textsubscript{2}O ha\textsuperscript{-1} gave the highest no. of bolls plant\textsuperscript{-1} (34.22) but it was at par with the treatment K\textsubscript{1} in respect to ball weight (6.61g). Non significant differences found in seed cotton yield due to potassium application. Non significant differences were also found in yield attributes and yield due to STV level. The economics of various treatments revealed that treatment N\textsubscript{2} (240 kg ha\textsuperscript{-1}) gave the highest net return of Rs. 56458 per hectare with BCR 1.70.
Study of Different Levels of Cadmium and FYM on Phosphorus Content in Fodder Maize (*Zea Mays L.*) Grown in Texturally Different Soils of Gujarat

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A pot experiment was conducted during summer season 2013 by growing of fodder maize (*Zea mays* L.) var. African tall in loamy sand and clayey soils of Anand and Karvan village (Dabhoi taluka) of Gujarat state respectively with five levels of Cd (0.0, 2.5, 5.0, 7.5 and 10.0 mg kg⁻¹) and two levels of FYM (0 and 10 t ha⁻¹) to find out the effect of Cd doses with or without FYM on phosphorus content in plant components and total phosphorus content in the crop. The polythene lined earthen pots were filled with 15 kg soil. Before transferring the soil to pots, calculated amounts of FYM and recommended doses of N (80 kg ha⁻¹) in form of urea and P₂O₅ (40 kg ha⁻¹) in the form of DAP were added through solutions. FYM was analyzed for phosphorus and cadmium while DAP was analyzed for cadmium content only. Cadmium was applied as 3CdSO₄·7H₂O in the form of solution. Pots were regularly watered and weed free condition was maintained till required for tasseling stage of maize crop. When the maize was at tasseling stage, the plants were uprooted carefully. The result indicated that on the application of Cd, phosphorus content in shoot and root of plants decreased significantly with increasing dose of Cd and the minimum values (0.129 and 0.787% in shoot and root respectively) were observed with 10 ppm Cd. The highest P content in shoot (0.155%) and root (0.812%) were recorded with 0 mg kg⁻¹ Cd pot⁻¹. The total Phosphorus content by maize plant significantly decreased at each level of Cd application. The clayey soil recorded significantly more Phosphorus content as compared to loamy sand soils. The more fertility of clayey soil may be the possible reason for higher P content in the plant parts. The significantly higher P content in shoots and roots were recorded when crop was grown in FYM treated soil (F₁) than no FYM application soil (F₀). Beside this, only the S × F interaction significantly influenced the P content in shoot and root of maize plant. The treatment combination S₂F₁ (clayey soil + 10 t ha⁻¹) has recorded significantly the highest P content shoot (0.147%) and root (0.814%) while the treatment combination S₁F₀ (loamy sand soil + no FYM) registered the lowest P content in shoot (0.139%) and root (0.779%).
A study was undertaken to assess the status of available major nutrients in soils of Aravalli district of Gujarat. Total 240 surface (0-15 cm) soil samples were collected from cultivated farmer’s fields of 6 talukas of Aravalli district during 2016. The soil samples were analyzed for available N, P2O5, K2O and S. The available N, P2O5, K2O and S content in these soils ranged from 109.76 to 344.76, 18.75 to 100.40, 120.96 to 967.68 kg ha\(^{-1}\) and 5.11 to 23.87 mg kg\(^{-1}\) with a mean value of 230.30, 51.44, 345.24 kg ha\(^{-1}\) and 14.89 mg kg\(^{-1}\), respectively. Out of 240 soil samples, 61.3 per cent were found to be low in available nitrogen status, 46.7 per cent were found to be medium in available phosphorus status, 56.7 per cent were found to be high in available potassium status and 65.4 per cent were found to be medium in available sulphur status. Overall, soils of Aravalli district had nutrient index values of 1.39, 2.22, 2.55 and 1.99 for available N, P2O5, K2O and S which indicates low, adequate, high and marginal fertility status, respectively.
Nutrient Management in Wheat under Middle Gujarat Condition

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A field experiment was carried out on the Agronomy farm of B.A. College of Agriculture, Anand Agricultural University, Anand to find out the effect of nutrient management on growth and yield of wheat during *rabi* season of 2012-2013, 2013-14 and 2014-2015. The experiment was carried out in randomized Block Design (RBD) with four replications and was comprised eight treatments *i.e.*, $T_1$: RD of N, $T_2$: RD of N and P (120-60 kg ha$^{-1}$), $T_3$: RD of N and P + ZnSO$_4$ (25 kg ha$^{-1}$), $T_4$: $T_3$ + 0.5 % FeSO$_4$ spray, $T_5$: $T_4$ + K@ 120 kg ha$^{-1}$, $T_6$: $T_5$ + 20 kg S ha$^{-1}$ through gypsum, $T_7$: STV (soil application), $T_8$: Fe-Zn enriched FYM @ 500 kg ha$^{-1}$. The pooled result of three years revealed that treatment receiving RD of N and P + ZnSO$_4$ (25 kg ha$^{-1}$) + 0.5 % FeSO$_4$ spray + K@ 120 kg ha$^{-1}$+20 kg S ha$^{-1}$ through gypsum ($T_8$) gave significantly higher plant height (70.6 cm), spikelet length (7.9 cm), test weight (5.16 g) and grain yield (4560 kg ha$^{-1}$) and straw yield (5926 kg ha$^{-1}$). The pooled result of three years revealed that treatment receiving RD of N and P + ZnSO$_4$ (25 kg ha$^{-1}$) + 0.5 % FeSO$_4$ spray + K@ 120 kg ha$^{-1}$+20 kg S ha$^{-1}$ through gypsum ($T_8$) gave significantly higher plant height (70.6 cm), spikelet length (7.9 cm), test weight (5.16 g) and grain yield (4560 kg ha$^{-1}$) and straw yield (5926 kg ha$^{-1}$). While, significantly higher uptake of N (88.96 kg ha$^{-1}$) and S (8.32 kg ha$^{-1}$) by wheat grain as well as significantly higher uptake of P (8.45 kg ha$^{-1}$) and K (73.61 kg ha$^{-1}$) by straw were recorded under treatment $T_8$ (RD of N and P + ZnSO$_4$ (25 kg ha$^{-1}$) + 0.5 % FeSO$_4$ spray + K@ 120 kg ha$^{-1}$+20 kg S ha$^{-1}$ through gypsum) than rest of the treatments. Same treatment gave significantly higher Mn uptake (125.44 g ha$^{-1}$) in wheat grain then rest of the treatments.
Effect of Integrated Nutrient Management on Wheat Yield and Different Forms of Nitrogen in Soil Under Cotton-Wheat Crop Sequence

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A field experiment was conducted to study the effect of integrated nutrient management on wheat yield and different forms of nitrogen fractions in soil under cotton – wheat crop sequence on loamy sand soil. The treatments comprised viz. T1: 100% RDF ha−1, T2: 75% RDF + 10 t FYM ha−1, T3: 75% RDF + 3 t vermicompost ha−1, T4: 75% RDF + 1.0 t castor cake ha−1, T5: 75% RDF + 1.5 t vermicompost ha−1 + 0.5 t castor cake ha−1, T6: 50% RDF + 6.0 t vermicompost ha−1, T7: 50% RDF + 2.0 t castor cake ha−1 and T8: 50% RDF + 3.0 t vermicompost ha−1 + 1.0 t castor cake ha−1. The wheat (var. GW 173) was grown and treatments were replicated three times in randomised block design. The treatments were applied to both cotton and wheat crops keeping RDF for cotton @ 320 kg N ha−1 and for wheat @ 120 kg N + 60 kg P2O5 ha−1.

The grain (4.0 t ha−1) and straw (6.1 t ha−1) yield and N and P content and uptake by grain and straw of wheat were significantly increased by application of 75% RDF + 10 t FYM ha−1 over control. The increase in grain and straw yields under T2 was 24.74 and 42.29 per cent over T1, respectively. The total K, S and Zn uptake by wheat and protein content (13.71%) in grain was significantly increased with same dose of treatment. The highest values for organic carbon, available P2O5 and K2O after cotton and wheat were recorded with 75% RDF + 10 t FYM (T2) followed by treatments of integration of chemical fertilizers with vermicompost and castor cake. Among the different N fractions i.e. total N, NH4–N, NO3–N and organic N were significantly increased under T5: 75% RDF+10 t FYM ha−1 after harvest of wheat over T1 (100% RDF). The organic form of N was enriched by 58.0 per cent due to addition of 75% RDF + 10t FYM over 100% RDF. The highest total microbial counts of 9.1 × 107 were recorded under treatment T2 (75% RDF + 10 t farm yard manure ha−1) in soil.

The results revealed that supplementation of 75% RDF along with 10 t FYM ha−1 significantly increased grain and straw yield of wheat and nutrients composition and also increased protein content of wheat grain. Among the different N fractions: available N and nitrate nitrogen (NO3–N) were enriched by 25 per cent due to application of 10 t FYM over 100% RDF. Hence, integrated nutrient management practices help in increasing crop yields and quality and also maintain soil quality under cotton – wheat crop sequence.
Effect of Rates of Iron Application on Growth, Yield and Quality of Rice Varieties under Aerobic and Submerged Conditions

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A pot experiment was conducted during summer, 2014 in the nethouse, Soil and Water Management Research Unit, Navsari Agricultural University, Navsari to study the effect of rates of iron application on growth, yield and quality of rice varieties under aerobic and submerged conditions in DTPA-Fe deficient soil. The experiment was laid out in a FCRD, comprising 12 treatment combinations of two levels of moisture, two varieties and three levels of which were repeated three times. The results indicated that among the growth and yield attributes, submerged condition (S2), variety V1 (GNR-2) and iron level F1 (25 kg ha⁻¹ FeSO₄.7H₂O) recorded significantly higher plant height, panicle length, number of tillers plant⁻¹, number of grains/panicle, test weight, grain and straw yields of rice except effect of variety on number of grains/panicle. The magnitudes of increase in grain and straw yields were 7.38 and 9.41, 7.38 and 8.27 and 19.2 and 12.9 per cent under submerged condition over aerobic, variety V1 over variety V2 and iron level F1 over F0 level, respectively. Iron content in brown rice was significantly affected and recorded 2.04, 53.61 and 4.11 per cent more Fe content under submerged condition over aerobic, variety V1 over variety V2 and iron level F1 over F0 level, respectively. In case of total uptake significantly higher in N, P, K and Fe in submerged condition (S2), N and K by variety V1 and Zn by variety V2 and P, K and Fe by F1 and N by F2 were observed. Significant increase EC, available P₂O₅ and DTPA-Fe under submergence and DTPA-Zn under aerobic condition were noted while decrease in available P₂O₅ and increase in DTPA-Fe was observed with raising Fe levels.
Effect of Natural Organic Liquid (NOL) and Inorganic Nutrient on Yield and Quality of Banana cv. Grand Naine

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An experiment was carried out at Horticultural Research Farm, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand during 2011-12, 2013-14 and 2015-16 in the same plot. The experiment consisting of 10 treatments like T1: RDF (300-100-200 g NPK plant\(^{-1}\)) + 10 kg FYM + Biofertilizer AAU PGPR bio NPK consortium; T2: T1 + NOL Drenching @ 500 L ha\(^{-1}\) at 30 and 45 DAP; T3: T1 + NOL foliar @ 50 lit ha\(^{-1}\) spraying at 30 and 45 DAP; T4: T1 + NOL Drenching @ 500 lit ha\(^{-1}\) + NOL foliar @ 50 lit ha\(^{-1}\) spraying at 30 and 45 DAP; T5: 50% RDF + 50% FYM + 50% Biofertilizer AAU PGPR bio NPK consortium; T6: T5 + NOL Drenching @ 500 lit ha\(^{-1}\) at 30 and 45 DAP; T7: T5 + NOL foliar @ 50 L ha\(^{-1}\) spraying at 30 and 45 DAP; T8: T5 + NOL Drenching @ 500 L ha\(^{-1}\) + NOL foliar @ 50 L ha\(^{-1}\) spraying at 30 and 45 DAP; T9: NOL Drenching @ 500 L ha\(^{-1}\) + NOL foliar @ 50 L ha\(^{-1}\) spraying at 30 and 45 DAP and T10: RDF without P\(_2\)O\(_5\) + FYM of banana cv. Grand Naine with three replications under Randomized Block Design (RBD). Among different treatments, T2 (300-100-200 g NPK plant\(^{-1}\) + 10 kg FYM + Biofertilizer AAU PGPR bio NPK consortium @ 1 mL plant\(^{-1}\) + NOL Drenching @ 500 L ha\(^{-1}\) at 30 and 45 DAP) was found significantly influence on bunch weight, number of hands per bunch and yield of banana in 3 years pooled results, while in case of quality parameters was concerned treatment T6 i.e. 150-50-100 g NPK plant\(^{-1}\) + 5 kg FYM + Biofertilizer AAU PGPR bio NPK consortium @ 0.5 ml plant\(^{-1}\) + NOL Drenching @ 500 L ha\(^{-1}\) found better for pulp peel ratio whereas, total sugar and non-reducing sugar were found significantly superior with T7 (150-50-100 g NPK plant\(^{-1}\) + 5 kg FYM+ Biofertilizer AAU PGPR bio NPK consortium @ 0.5 ml plant\(^{-1}\) + NOL foliar @ 50 L ha\(^{-1}\) spraying at 30 and 45 DAP) and T8 (150-50-100 g NPK plant\(^{-1}\) + 5 kg FYM + Biofertilizer AAU PGPR bio NPK consortium @ 0.5 mL plant\(^{-1}\) + NOL Drenching @ 500 L ha\(^{-1}\) + NOL foliar @ 50 L ha\(^{-1}\) spraying at 30 and 45 DAP), respectively in three years pooled data.
Evaluation of Response of Long Term Effect Organic and Inorganic Farming on Different Soil Properties of Middle Gujarat

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The study was carried out to evaluate the response of long term effect of organic and inorganic farming on physical and chemical properties of soils of middle Gujarat. The survey work was conducted by collecting bulk soil samples at 0-20 cm and 20-25 cm soil depths particularly from 8-10 years old organically and adjoining inorganically managed ten fields of Ahmedabad, Kheda, Anand and Vododara districts of middle Gujarat and were processed and analysed for different soil physical and chemical properties using standard procedures. The results revealed that organically managed soils have low bulk density (BD) and particle density (PD) than inorganic managed soils and these values were increased with depth of soil. The maximum water holding capacity (MWHC) was found to be maximum (16.88%) under organically managed soils than inorganic soils. Soil texture of Anand, Kheda, Ahmedabad and Vododara district was found to be loamy sand, loamy sand to clayey, sandy loam to silt loam and clayey, respectively. These soils are neutral (7.00) to alkaline (8.33) in reaction and have low salinity (EC <0.8 dS m⁻¹). Significantly higher values of Soil organic carbon (SOC), available P₂O₅, K₂O and S were found in organically managed soil whereas significantly higher values of available Fe were found in inorganically managed soils.
Nitrogen Requirement of Direct Seeded Basmati Rice in Conjunction with Organic Manures in Basmati Rice-Wheat System

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Rice is the second most important staple crop of the world after wheat and basmati rice is important to south east Asia both as a staple and as an export crop. Basmati rice is generally grown in sequence with wheat. Water shortage is becoming severe in many rice growing areas of the world. The introduction of aerobic rice including basmati rice means growing of high yielding basmati rice in non-puddled and non-flooded aerobic soil with the support of external inputs like supplementary irrigation, manures and fertilizers. Shifting from submerged paddies to aerobic system of cultivation has led to changes in soil physical, chemical and biological properties resulting in iron deficiency. Further limited use of organics and absence of proper recycling of crop residues also added to deficiencies under this system of cultivation. The organic manures, being alternative low-cost plant nutrient resources have gained prime importance in recent decades and they play a vital role in maintaining long term soil fertility sustenance. The research information on integration of organic manures on N requirement and nutrient availability in aerobic basmati rice production is lacking. Keeping these points in view, a field experiment was initiated to find out the N requirement of direct seeded basmati rice (Pusa basmati 1121) in conjunction with organic manures in basmati rice-wheat system on a sandy loam soil. Five levels of N viz. 0, 20, 40, 60 and 80 kg N ha⁻¹ were tested along with three organic manures FYM, poultry manure and Sunhemp in split plot design. Organic manures were kept in main plots and N levels were kept in sub plots. FYM and poultry manure (PM) was applied @15 and 6.25 t ha⁻¹, respectively and sunhemp was grown for 50 days and then incorporated in the soil. Nitrogen was applied at the recommended time through urea. All other package of practices were followed to grow the crops. The results revealed that the performance of direct seeded basmati rice (DSBR) was significantly better when grown after incorporation of sunhemp or where organic manures were applied than under control. However, the mean yield did not differ significantly under the three organic manure treatments. It was also observed that DSBR responded to upto 40 kg N ha⁻¹ in the treatments where sunhemp was incorporated or where FYM/PM was applied but it responded to 80 kg N ha⁻¹ where no organic manure was applied. Overall improvement in the nutrient status of the soil was observed with organic manure addition. Higher yield of succeeding wheat was also observed in the treatments receiving organic manures.
Effect of Potassium Fertilization on Potato Quality

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Potato with an estimated acreage of 2.15 million thousand hectares and a production of 48.2 million tons is the predominant vegetable crop of India (Third advanced Estimates, Govt. of India, 2017). Similarly, in Punjab with a more than 40% share in acreage under vegetable crops, potato remains the predominant vegetable crop of the state. Content of reducing sugars and colour are two important potato tuber quality parameters. High reducing sugar content causes browning of potato chips through Maillard reaction of reducing sugars with free amino acids during frying. As a result, consumer acceptability of chips or fries gets adversely affected. Potassium (K), an essential nutrient implicated in the synthesis of sugars and starch and translocation of carbohydrates generally favors the lighter color of potato chips because it lowers the content of reducing sugars by activating starch synthesis. High dry matter, as indicated by higher specific gravity, enhances chip yield and reduces soaking of oil during frying. Some studies report favorable effect of K on specific gravity of tubers. To examine the role K in affecting quality parameters of potato, Kufri Pukhraj variety of potato (Solanum tuberosum L.) was raised to maturity on 30 different types of soils in pots to assess the effect of K application (0 and 60 kg K₂O ha⁻¹) on tuber yield and quality parameters such as specific gravity, colour, reducing sugars and total sugar content. Other recommended agronomic practices including nitrogen and phosphorus fertilizer application were followed. Across all soil types, tubers from pots receiving 60 kg ha⁻¹ K exhibited 62.4% less reducing sugar content than pots receiving no K application. The color of potato tubers was assessed by using Hunter Flex Spectrophotometer and the ‘L’, ‘a’, and ‘b’ values suggested that in general across all soils, pots receiving K application yielded lighter coloured tubers. However, our results did not support any favorable effect of K application on specific gravity of tubers. Thus, potassium nutrition can play a vital role in enhancing quality parameters of potato.
Rice Straw Compost – An Alternate to Farm Yard Manure in maize

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A field experiment was conducted for three consecutive years at the research farm of PAU to examine the relative performance of anaerobically produced NASA paddy straw compost (commercial production by Sampurn Agri Ventures Pvt. Ltd.), PAU paddy straw compost (produced aerobically at PAU farm) and farm yard manure (FYM) in maize. The maize variety PMH-1 was sown during Kharif 2015, 2016 and 2017. In the experimental treatments, each of the two paddy straw composts were applied @ 0.15 t ha⁻¹, 0.3 t ha⁻¹ and 0.45 t ha⁻¹ and FYM @ 15 Mg ha⁻¹ over and above recommended dose of fertilizers (RDF) along with a control i.e recommended dose of fertilizers (RDF) only. The experiment was laid out in randomized block design with three replications. During all the three years, the layout/treatments were overlapped in the same plots. Composts and FYM were analyzed for their silica and other nutrient contents. The grain and straw samples after harvest of maize crop were collected, processed and analyzed for silica and other nutrient contents. It was observed that the maize grain yield and stover yield increased significantly with the application of FYM @ 15 t ha⁻¹ or PAU compost and NASA compost @ 0.45 t ha⁻¹ as compared to recommended dose of fertilizers (RDF). Silicon content in maize grains and stover also increased with increasing levels of paddy straw composts and FYM application, however, increase was relatively higher with the application of NASA compost as compared to PAU compost. No significant change in mean grain arsenic content was observed with the increase in silicon (Si) content of maize during three years experiments. Economic returns have also been calculated.
Utilization of Rice-residue Biochar as Soil Amendment in Vegetable Crops

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Worldwide, use of biochar as an agricultural amendment has attracted attention due to its potential to improve crop yield and soil quality parameters. Earlier studies focused on studying the response of biochar on cereal or grain crops but with varying results. However, there is paucity of information on effects of biochar on the vegetable crops. A field experiment was initiated to examine the interactive effects of different rates of rice residue biochar at five levels viz. B0 (0), B1 (0.5), B2 (1.0), B3 (2.0), B4 (4.0) tones ha⁻¹ and four fertilizer levels viz. F0 (Recommended dose of fertilizer, RDF), F1 (75% RDF), F2 (100% RDF) and F3 (125% RDF) on potato-onion system. Biochar was incorporated before sowing potato to monitor its direct effect whereas; its residual effect was noticed on the preceding onion crop. In general, compared to unamended control treatment, potato (direct) and onion (residual) yields showed positive response to addition of biochar. Inorganic fertilizer (F1 and F2) alongwith biochar rate of 0.5 and 1.0 tones ha⁻¹ exhibited higher tuber and bulb yields than F3 rate of fertilizer addition alongwith different rates of biochar. Maximum soil organic carbon (SOC) was noticed where B4 rate of biochar was added alongwith F3 level (125% RDF) of inorganic fertilizer. After first year of experimentation, SOC content in the biochar amended treatments was slightly higher than the unamended treatments since much of the carbon in biochar has been reported to be present in the recalcitrant form. Both pH and EC values did not differ much with addition of biochar and fertilizer levels across various treatments. Early trends from our study confirmed positive effect of applying different rates of biochar with varying inorganic fertilizer levels on vegetable crops and soil quality. In addition, conversion of rice straw into biochar for its use as soil amendment in vegetables could potentially serve as an alternate source of nutrients for these crops.
Effect of N Applied through Neem Coated and Ordinary Urea on the Yield and N Use Efficiency of Wheat

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Of all the nutrients required by crops, nitrogen is the one most often deficient in soils, applied in greater quantities and is subjected to different types of losses. When urea is applied to the soil, it is transformed into other N forms, of which some are susceptible to losses and therefore lead to reduced availability of N to crop plants. In the first step hydrolysis of urea by urease enzyme takes place which rapidly converts amide-N to ammonium-N and in the second step nitrification is brought about by nitrifying bacteria that converts ammonium-N to nitrate-N. Ammonium-N is susceptible to losses via ammonia volatilization or nitrate-N can escape soil-plant system through leaching below the rooting zone and also in gaseous forms via denitrification leading to reduced fertilizer N use efficiency. Use efficiency of urea-N by different crops is very low and it rarely exceeds 50%. In highly permeable alkaline soils of Punjab the applied N is readily converted to NO₃⁻, which is prone to losses via leaching and nitrification-denitrification. Improving efficiency of fertilizer N use is vital to sustain high crop yields and achieve high NUE. Appropriate modification in fertilizer source or management practices can help in reducing N losses and increasing N use efficiency. Neem coated urea (NCU) contains nitrification inhibition properties and thereby delays the bacterial oxidation of ammonium –N by depressing the activity of the nitrosomonas bacteria in the soil. This helps in controlling the loss of nitrate by leaching and or denitrification from the top soil by keeping nitrogen in the ammonium form longer and thereby increasing the N use efficiency and yield of crops. Keeping this in view, studies were conducted on neem coated urea vs ordinary urea at Ludhiana and Kapurthala. At first location (department of Soil Science, Ludhiana), neem coated urea was found to be significantly better source of nitrogen as compared to ordinary urea. The grain yield of wheat obtained with the application of N through NCU was significantly higher at all the levels of N application through ordinary urea. Application of 100 and 120 kg N through neem coated urea resulted in 15.9 and 8.6% increase in yield over the similar application made through ordinary urea. At the second site (Department of Agronomy, Ludhiana), application of N at the rate of 100 and 125 kg ha⁻¹ through NCU resulted in 15.9 and 7.47 per cent higher yields over similar doses through ordinary urea. At Kapurthala, application of 100 and 120 kg N through neem coated urea resulted in 21.2 and 10.9% increase in yield over the similar application made through ordinary urea. The results suggest that application of 100 kg N ha⁻¹ through neem coated urea resulted in wheat yields which were on par with that obtained with 120 kg N through ordinary urea. However, higher yield (3 to 4 quintals) can be obtained by applying additional 20 kg N through neem coated urea.
Effect of Nutrient Management Practices on Yield, Nutrient Use Efficiency and Economics of Rice-Wheat Cropping System in Northwestern India

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Nutrient management practices impact nutrient availability and their use efficiency, which affects the crop yield and economic returns in a cropping system. In a rice-wheat cropping, where farmers’ resort to diverse nutrient management practices, it was imperative to assess the effect of different nutrient management practices to devise strategies for sustaining crop productivity. A field experiment was conducted to study the effect different nutrient management practices (control, N, NP, NK, PK, NPK, FYM, N+FYM and NPK+FYM) on nutrient availability, nutrient use efficiency, crop yield and economic returns from a rice-wheat cropping system. Application of NPK+FYM significantly increased the nitrate-N, ammonical-N, available P and K concentration in the surface (0-7.5 cm) and sub-surface (7.5-15 cm) soil depths, compared with control. Significantly higher rice and wheat grain yield was recorded in plots receiving NPK and NPK+FYM, compared with imbalanced application of fertilizer nutrients. Application of NPK magnified the yield responses with yield increase of 12% for rice and 3.2% for wheat as compared with N application only. Balanced application of fertilizer nutrients significantly increased the agronomic efficiency of N (AE_N) in rice and wheat, compared with control. Highest AE_N of 21.4 kg grains (kg N)^-1 and 24.4 kg grains (kg N)^-1 occurred in NPK treatment for rice and wheat, respectively. Recovery efficiency of N (RE_N) in rice and wheat increased significantly by 10.6 and 14.5%, respectively with NPK+FYM application, compared with NK alone. Physiological efficiency of N (PE_N) increased significantly by 14.9 kg (kg N)^-1 in rice and by 8.1 kg (kg N)^-1 in wheat with NPK application, compared with N alone. Average across the treatments, the PE_N, PE_P and PE_K in rice was 78, 219 and 127 kg grains while in wheat was 121, 254 and 109 kg grains per kg plant N, P and K, respectively. Highest mean gross returns and mean net returns in rice were obtained in NPK; while in wheat highest returns occurred from NPK+FYM. NPK application increased the benefit-cost ratio by 1.57, compared with control. Benefit-cost ratio increased by 1.97 with NPK+FYM application over the NPK alone. Thus, it can be concluded that application of balanced fertilizers along with FYM is best nutrient management practice for increased nutrient availability, use efficiency and yield sustainability of a rice-wheat cropping system.
Assessment of Municipal Solid Waste Compost and FYM on Yield, Nutrient Content and Uptake by Fodder Sorghum

(Sorghum bicolor L.)

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A pot experiment was conducted during summer 2017 at Department of Soil Science and Agricultural Chemistry to find out the effect of MSWC and FYM on content and uptake of N, P and K by fodder sorghum. The experiment consist of ten treatments viz. T1-control (RDF), T2-5.0 t MSWC ha⁻¹, T3-10.0 t MSWC ha⁻¹, T4-15.0 t MSWC ha⁻¹, T5-5.0 t FYM ha⁻¹, T6-10.0 t FYM ha⁻¹, T7-15.0 t FYM ha⁻¹, T8-2.5 t MSWC ha⁻¹ + 2.5 t FYM ha⁻¹, T9-5.0 t MSWC ha⁻¹ + 5.0 t FYM ha⁻¹ and T10-7.5 t MSWC ha⁻¹ + 7.5 t FYM ha⁻¹ laid out in CRD with three repetitions. The polythene lined earthen pots were filled with 15 kg soil. Before transferring the soil to pots, calculated amount of basal RDF (25 kg N and 40 kg P₂O₅ kg ha⁻¹), MSWC and FYM as per the treatment were mixed thoroughly in each pot. Initially 8 healthy seeds of sorghum were sown into each pot at a depth of 5 cm. Remaining dose of nitrogen (25 kg of N ha⁻¹) was top dressed in each pot at 30 DAS. Treatment-wise sorghum plants were taken and tagged at harvest. These samples were air dried and ground in a stainless steel grinder to avoid any contamination. The processed samples were preserved in polyethylene bags for further analysis. The soil was loamy sand in texture and normal with respect to pH (7.8) and EC (0.14 dS m⁻¹) with low in organic carbon (0.35%), medium in available P₂O₅ (35.84 kg ha⁻¹) and high in available K₂O (237.6 kg ha⁻¹). In MSWC nutrient composition is 1.10 % N, 1.0% P and 0.86% K and N, P and K content in FYM is 0.49, 0.38 and 0.43 %. The result revealed that application of 15.0 t MSWC ha⁻¹ registered significantly higher plant height at 25 DAS (94.72 cm) and at harvest (189.2 cm). The green yield (198 g pot⁻¹) and dry yield (58.41 g pot⁻¹) of sorghum were significantly higher under application of MSWC @ 15.0 t ha⁻¹, which at par with T7 and T10. Similarly, the content of N (1.45%), P (0.390%) and K (1.149%) in fodder sorghum were significantly increased with treatment T4 (15 t MSWC ha⁻¹) over control (T1) and also increased of N (847.42 mg pot⁻¹), P (228.03 mg pot⁻¹) and K (671.78 mg pot⁻¹) uptake by crop with same treatment.
Effect of Sulphur and Zinc with and without Organics on Yield and Quality of Fodder Sorghum and Residual Soil Fertility after Harvesting under South Gujarat Condition

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A field experiment was conducted during 2017 to study the effect of soil application of S and Zn in combination with organics on yield and quality of fodder sorghum. There were twelve treatments comprising of three organics treatments [Control(M1), FYM @10t ha⁻¹ (O2) and bio-compost @ 5t ha⁻¹ (O3)] combined with four nutrient treatments [control(M1), 20kg S ha⁻¹ (M2), 5kg Zn ha⁻¹ (M3), and 20kg S ha⁻¹ + 5kg Zn ha⁻¹ (M4)]. S and Zn were applied in the form of S granules and ZnSO₄ respectively. The experiment was laid out in factorial RBD with three replications. The recommended dose of N and P were applied uniformly to all the treatments. Green fodder yield and dry fodder yield of sorghum were significantly increased by the treatments. The per cent increased in GFY due to O₂ and O₃ over O₁ was 15.1 and 11.3 respectively. The treatments M₂ and M₄ increased the GFY by 15.4 and 17.5 per cent, respectively over M₁ (228.3 q ha⁻¹). Similar trend in DFY was noted by organics and S-Zn nutrient treatments. The interaction effect of O × M was found significant on GFY and DFY showed nutrient use efficiency of S and Zn was higher when they were applied along with FYM and bio compost. Quality parameters viz. crude protein content, crude fibre content and HCN content were studied. Application of organics O₂ and O₃, as well as S-Zn treatments favourably influenced quality parameters in comparison to their respective control. A synergistic interaction of O × M on crude protein content indicates improvement in quality of forage sorghum. Residual availability of major and micronutrients and organic C content in soil were favourably influenced by treatments.
Effect of Long Term Application of Fertilizer and FYM on Nutrients Uptake in Soybean and Wheat Crop

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The present study was conducted under the ongoing all India Coordinated Research Project on Long-Term Fertilizer Experiment with soybean-wheat sequence. On a Vertisol during 2015-16 at experimental site of Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur. Experimental result indicated a increasing trend with higher uptake of N, P, K, S and Zn by soybean with successive application of fertilizer over control and the maximum uptake of nutrients was recorded when 100% NPK with FYM applied. Hence, increasing rates of fertilizer addition resulted in successive increment in the uptake of nutrients.

A similar, trend has also been observed with rabi wheat crop and the data indicated that highest uptake of N, P, K, S and Zn by wheat was observed in 100% NPK + FYM treatment followed by 150% NPK. Increasing rate of fertilizer application successively increased the uptake of nutrients by the crops. In general, higher uptake of nutrients N, P, K, S and Zn was recorded in grain rather than the straw at the harvest of the crop. It was also noticed that higher amount of nutrients was harvested by wheat crop in comparison to the nutrient content obtained in soybean.
Effect of Soil and Foliar Application of Potassium on Yield and Yield-attributes of Cotton in South-Western Punjab

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On-farm trials (OFTs) at farmer's fields were conducted during kharif 2016-17 to assess the effect of soil and foliar application of potassium on seed cotton yield and yield attributes of Bt-cotton grown on salt-affected soils in South-Western Punjab (India). Four treatments viz. control (T1), 50 kg MOP ha\(^{-1}\) + 2 sprays of 2% potassium nitrate (T2), 4 sprays of 2% potassium nitrate (T3), and 50 kg MOP ha\(^{-1}\) + 4 sprays of 2% potassium nitrate (T4) were compared at 7 different locations. Soil and or foliar application of potassium resulted in a significant \((p<0.05)\) increase in seed cotton yield and yield contributing attributes viz. plant height, number of bolls/plant and boll weight, compared with control. Data pooled for years and locations revealed that T3 resulted in a significant \((p<0.05)\) increase in seed cotton yield, compared with T2 and T4. There was non-significant yield difference in T3 and T4, indicating that foliar application in cotton is more effective. But the average net returns (ANR) increased by Rs. 1,600/- per ha with four foliar sprays (in T3), compared with T4. The highest benefit-cost ratio of 2.43 was obtained in T3, compared with 2.33 in T4 and 2.31 in T2. Thus, our results showed that there was no yield advantage of soil + 2 foliar applications of potassium on seed cotton yield, but the monetary benefits were increased with foliar application of potassium.
Effect of FYM and Zinc on Yield and Quality of Mustard (*Brassica juncea L.*) in Typic Haplusterts

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A field experiment was conducted at the Instructional Farm (Agronomy) of Rajasthan College of Agriculture, Udaipur, Rajasthan during the rabi season of 2015-16 using randomized block design with three replications to study the effect of FYM and zinc on yield of mustard. The treatments consisting of three levels of FYM (0, 5 and 10 t ha⁻¹) and five levels of zinc (0, 2.5, 5, 7.5 and 10 kg ha⁻¹) were applied to the mustard var. Bio-902 as soil application with uniform application of nitrogen, phosphorus and potassium as per recommended doses. Results revealed that the increasing levels of FYM significantly increased the seed yield, stover yield and oil content of mustard seed. The highest value of seed yield, stover yield and oil content (1.69 t ha⁻¹, 4.04 t ha⁻¹, 39.95%) was found in F₂ (10 t FYM ha⁻¹). Application of 10 t FYM ha⁻¹ significantly increase the seed yield, stover yield and oil content by 45.61, 42.78 and 5.29% as compared to control and also seed and stover yield of mustard increased significantly with increasing levels of zinc. The highest value of seed yield, stover yield and oil content (1.68 t ha⁻¹, 4.01 t ha⁻¹, 40.16%) was found in Zn₄ (zinc @ 10 kg ha⁻¹). Application of zinc under Zn₄ (zinc @ 10 kg ha⁻¹) significantly increased seed yield, stover yield and oil content by 46.46, 41.32 and 8.42% as compared to control. The combined application of FYM and zinc was more beneficial for increasing seed yield of mustard as compared to their individual application. The highest seed yield (1.88 t ha⁻¹) was obtained under the combined application of FYM @ 10 t ha⁻¹ + zinc @ 7.5 kg ha⁻¹, respectively.
Relative Efficiency of Sulphur Fertilizers and their Effect on Yield, Yield Attributes, Sulphur Uptake and Recovery in Gobhi Sarson

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Sulphur (S) is an important nutrient for optimal plant growth. It is a component of three amino acids (methionine, cysteine and cystine) essential for the functioning of proteins, enzymes, vitamins and chlorophyll. A field experiment on gobhi sarson (Brassica napus) was conducted for three years at Punjab Agricultural University’s Ludhiana research farm to evaluate the efficacy of different S sources and levels on yield and yield attributes. The soil of the experimental field was deficient in S and sandy loam in texture. The experimental plan was a randomized complete block design with 10 treatments and 3 replicates. Four levels of sulphur (S; 0, 20, 30, and 40 kg ha\(^{-1}\)) were applied through three sources (bentonite-S, single super phosphate: SSP and gypsum) along with recommended dose of nitrogen (N), phosphorous (P) and potassium (K). The results indicated that application of 20 kg S ha\(^{-1}\) was insufficient to meet the S requirement of gobhi sarson and it responded to higher doses of sulphur (30 kg S ha\(^{-1}\)) significantly. Seed yield increased significantly with S application up to 30 kg S ha\(^{-1}\) irrespective of S sources. The improvement in yield of gobhi sarson was statistically at par under the equivalent rate of S applied through different sources. Application of bentonite-S increased the seed yield over no-S application by 2.97-5.78 q ha\(^{-1}\), whereas single super phosphate and gypsum increased the seed yield over no-S control by 2.54-5.45 q ha\(^{-1}\) and 2.63-5.42 q ha\(^{-1}\), respectively. The seed yield increase was significant with increasing level of S from 20 to 30 kg S ha\(^{-1}\), whereas, the seed yield increase was non-significant with increase of S from 30 to 40 kg S ha\(^{-1}\), irrespective of S sources. The total S uptake increased significantly with the increasing rate of S application which increased from 16.3 kg ha\(^{-1}\) in no-S control to 29.2, 29.8 and 31.3 kg ha\(^{-1}\) with application of 40 kg S ha\(^{-1}\) through SSP, gypsum and bentonite-S, respectively. Application of S through different sources showed significant improvement on yield attributes of gobhi sarson such as plant height, number of siliquae at main shoot and siliquae per plant. The apparent S recovery ranged from 26 to 41.3% and the maximum increase was observed where 30 kg S ha\(^{-1}\) applied through all sources. In conclusion, the application of S @ 30 kg ha\(^{-1}\) in the S deficient soils using bentonite-S or SSP or gypsum is necessary to obtain highest productivity of gobhi sarson.
Effect of Split Application of Vermicompost on Soil Properties and Yield of Chickpea (*Cicer arietinum* L.)

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A field experiment was conducted during *rabi* season of 2015-16 at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan) to study the effect of split application of vermicompost on soil properties and yield of chickpea (*Cicer arietinum* L.). The experiment was laid out in randomized block design with three replications. The treatments consisting of seven split application of vermicompost viz., V0 control, V1 100% RDV at sowing, V2 75% RDV at sowing + 25% RDV at 15 DAS, V3 50% RDV at sowing + 50% RDV at 15 DAS, V4 75% RDV at sowing + 25% RDV at 30 DAS, V5 50% RDV at sowing + 50% RDV at 30 DAS and V6 50% RDV at sowing + 25% RDV at 15 DAS+ 25% RDV at 30 DAS were applied to the chickpea variety Pratap Chana-1 as soil application as per recommended doses. The results showed that increasing the split application of vermicompost significantly increased the plant height, dry matter accumulation, number of pods plant-1, number of seeds pod-1, seed, haulm and biological yield as well as content and uptake of nitrogen, phosphorus, potassium, iron, manganese, copper and zinc by seed and haulm, net return and B:C as compared to control. The porosity and available N, P2O5, Fe, Mn, Zn and Cu content of soil after harvest of crop were increased significantly with increasing vermicompost split application. Microbial count (bacteria, fungi, actinomycetes) and dehydrogenase activity were observed significantly maximum under application of 50% RDV at sowing + 25% RDV at 15 DAS+ 25% RDV at 30 DAS (V6) over control.

On the basis of the results of one year field experiment conducted during *rabi* 2015-16, it may be concluded that 50% RDV at sowing + 25% RDV at 15 DAS+ 25% RDV at 30 DAS appears to be better treatment for organically grown chickpea because it gave the highest grain and haulm yield (1854.00 kg ha-1 and 3194.00 kg ha-1), net return (₹ 52615.00 ha-1) and B : C (1.78) over rest of treatments. This practice also helped to maintain higher soil organic carbon, available nutrients and soil biological activity for sustainable production.
Response of Different Levels of Nitrogen (N), Phosphorus (P) and Bio-fertilizers on Rice (Oryza sativa L.) under Middle Gujarat Conditions

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Rice is grown in over hundred countries and is the primary food for half of the people in the world. World population is expected to 8.5 billion by 2025 and to maintain the self-sufficiency in rice an increase of 2%-3% per year in rice production had to be maintained within limited land. The efficiency of fertilizer use for nitrogen is lower than 50%, for phosphorus lower than 10% and for potassium 40%. This low efficiency of fertilizer use is also associated with other losses by immobilization, volatilization, denitrification, leaching, and clay adsorption. Therefore, use of biofertilizer along with chemical fertilizers to maintain soil health as well as soil fertility and productivity is a need of the time. With these objectives a field experiment was conducted during the Kharif: 2013 to 2015 at Main Rice Research Station, Anand Agricultural University, Nawagam. The farm is located in hot semi-arid eco-region with medium deep black soils and geographically situated at (22.480 latitude, 71.380 longitude and 32.4 m above the mean sea-level). To study the response of different levels of Nitrogen (N), Phosphorus (P) and Biofertilizers on Rice (Oryza sativa L.) under middle Gujarat Agro climatic zone III, 12 treatment combinations consisting three levels of Nitrogen, two levels of Phosphorus and two levels of Biofertilizer were tested in factorial randomized block design with four replications. The three year experimental results revealed that different treatments for Nitrogen levels were found significant for most of the growth and yield contributing characters, while for phosphorus and biofertilizer found non-significant. In pooled data the N level N3 (120 kg N ha⁻¹) gave significantly higher grain yield i.e. 5191 kg ha⁻¹ and found significantly superior over N level N1. The result reveld that potential production and profit from the rice crop could be secured by applying 120 kg Nitrogen ha⁻¹ only to get higher yield in middle Gujarat Agro climatic zone III.
Effect of Silicon and Nitrogen on Yield, Yield Attributes, Growth, Quality, Nutrient Uptake and Nitrogen use Efficiency by Rice under Loamy Sand

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A field experiment was conducted during kharif seasons of 2014 and 2015 on loamy sands soil at Agriculture Research Station, Anand Agricultural University, Jabugam, Gujarat (India) to assess the effects of silicon and nitrogen on yield, yield attributes, growth, quality, nutrient uptake and nitrogen use efficiency by rice under loamy sand. The experiment encompassed four levels of nitrogen viz. 0, 75, 100 and 125 kg N ha\(^{-1}\) from ammonium sulphate and four levels of silicon viz. 0, 200, 400 and 600 kg Si ha\(^{-1}\) from calcium silicate. The experiment was laid out in randomized block design (Factorial) with three replications. Results revealed that individual application of nitrogen at 125 kg ha\(^{-1}\) and Si at 600 kg ha\(^{-1}\) produced the highest number of tillers, plant height, panicle length, chlorophyll content and grain and straw yields of rice. Application of recommended dose of N (100 kg ha\(^{-1}\)) resulted in maximum N uptake by rice grain and the highest N uptake by straw was noticed due to application of 125 kg N ha\(^{-1}\). Application of Si @ 600 kg ha\(^{-1}\) significantly increased average nitrogen uptake by grain and straw. Significantly higher average Si uptake by grain and straw was observed under application of 125 kg N ha\(^{-1}\) which was at par with 100 kg N ha\(^{-1}\). The overall findings of the study suggest that application of 100 kg N ha\(^{-1}\) and 400 kg Si ha\(^{-1}\) was found beneficial to increase rice yield and nutrients uptake besides maintenance of soil fertility. With respect to N and its use efficiency, 100 kg N ha\(^{-1}\) was found optimum. Silicon reduced the agronomic efficiency as well as apparent N recovery while physiological efficiency was higher at 400 kg Si ha\(^{-1}\).
Status of Available Sulphur and Micronutrients in Soils of Patan District of Gujarat

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In order to assess available sulphur and micronutrients (Fe, Mn, Zn, and Cu) in soils of Patan district of Gujarat, three hundred and sixty surface soil sample (0-15 cm) were randomly collected from nine talukas of Patan district. The entire collected soil sample was analyzed for available sulphur and DTPA-extractable micronutrients (Fe, Mn, Zn, and Cu) as per standard procedures. The available sulphur contents in soils of Patan district varied from 2.15 to 92.68 mg kg⁻¹ with mean value of 28.99 mg kg⁻¹. The DTPA- extractable Fe in soils of Patan district ranged from 3.34 to 22.80 mg kg⁻¹ with an average value of 6.99 mg kg⁻¹. As far as DTPA- extractable Mn is concerned, it varied from 3.46 to 37.10 mg kg⁻¹ with mean value of 12.63 mg kg⁻¹. The DTPA- extractable Zn content in soils of Patan district varied from as low as 0.10 to as 2.18 with a mean value of 0.75 mg kg⁻¹. The content of DTPA- extractable Cu in soils of Patan varied from 0.14 to 2.76 mg kg⁻¹ with a mean value of 0.82 mg kg⁻¹. The correlation study showed that the soil pH had highly significant and negative correlation with DTPA- extractable Mn and Zn (-0.209** and -0.260**, respectively), while it was negatively non significantly correlated with DTPA- extractable Fe and Cu. To sum up, the soils of Patan district have adequate status of available sulphur. Whereas, about 22 per cent soil samples of the district are fall in low category. The soils of Patan district have marginal status of DTPA – extractable Fe and Zn, whereas high and very high status in case of DTPA – extractable Mn and Cu, respectively. About 88 and 83 per cent soil of the district are low to medium category of Fe and Zn, respectively. In case of Mn and Cu, most of the soil samples fall under medium to high category.
Effect of N, P and bio-fertilizers on yield, quality and soil chemical properties of summer pearl millet (*Pennisetum glaucum* L.)

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The experiment was conducted during the year 2014 to 2016 to study the response of N, P and bio-fertilizers on summer pearl millet (*Pennisetum glaucum* L.). The experiment was laid out in Randomized Block Design (Factorial) with eighteen treatment combination in three replications. The treatment comprised of three nitrogen levels *viz.* N1: 100 kg ha\(^{-1}\), N2: 120 kg ha\(^{-1}\) and N3: 140 kg ha\(^{-1}\), three phosphorus levels *viz.* P0: 00 kg ha\(^{-1}\), P1: 20 kg ha\(^{-1}\) and P2: 40 kg ha\(^{-1}\) and two bio fertilizer levels *viz.* B0: Control and B1: *Azatobacter + PSB* (seed treatment). The soil of experimental field was loamy sand in texture having good drainage, pH 7.98, EC 0.19 dS m\(^{-1}\), organic carbon 0.40 per cent, available P\(_{2}O_{5}\) and K\(_{2}O\), 54.5 and 210.3 kg ha\(^{-1}\), respectively.

The result indicated that increase in nitrogen application up to 140 kg N ha\(^{-1}\) significantly increased the growth and yield attributes as well as grain and fodder yield in summer pearl millet. Similarly, phosphorus application @ 40 kg P\(_{2}O_{5}\) ha\(^{-1}\) significantly increased the effective tillers, test weight and the grain yield of pearl millet in pooled results of three years. However, bio-fertilizer (*Azatobacter + PSB*) treatment had non significant effect on summer pearl millet.

Nitrogen levels had significant influence on protein content in grains and application of 140 kg N ha\(^{-1}\) were found significantly superior than rest of the nitrogen levels on pooled basis. However, effect of different levels phosphorus and bio-fertilizer were found non-significant on protein content in grain of summer pearl millet.

The soil nutrient status after harvest of summer pearl millet showed that each successive increase in nitrogen application significantly increased the available nitrogen in the soil, while increase in phosphorus levels had significant influenced on available phosphorus in the soil. However, bio-fertilizer had non-significant effect on available nitrogen and phosphorus in soil after harvest of the summer pearl millet.

For securing higher yield of summer pearl millet, it should be fertilized with 140 kg N ha\(^{-1}\) (50% as basal + 50% at 30 DAS) in nitrogen deficient soils and 40 kg P\(_{2}O_{5}\) ha\(^{-1}\).
Response of Castor (*Ricinus communis* L.) to N, P and K under middle Gujarat conditions

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The experiment was conducted during the year 2013-14 to 2015-16 to study the response of Castor (*Ricinus communis* L.) to N, P and K under middle Gujarat conditions. The experiment was laid out in Randomized Block Design (Factorial) with eighteen treatment combination in four replications. The treatment comprised of three nitrogen levels viz. N1: 75 kg ha\(^{-1}\), N2: 100 kg ha\(^{-1}\) and N3: 125 kg ha\(^{-1}\), three phosphorus levels viz. P0: 00 kg ha\(^{-1}\), P1: 25 kg ha\(^{-1}\) and P2: 50 kg ha\(^{-1}\) and two potash levels viz. K0: 00 kg ha\(^{-1}\) and K1: 40 kg ha\(^{-1}\).

The soil of experimental field was loamy sand in texture having good drainage, pH 8.19, EC 0.18 dS m\(^{-1}\), organic carbon 0.30 per cent, available P\(_{2O_5}\) 55.35 kg ha\(^{-1}\) and K\(_2O\) 335.28 kg ha\(^{-1}\).

The results of three years of experimentation showed that application of 100 kg N ha\(^{-1}\) and 125 kg N ha\(^{-1}\) being at par with each other produced significantly higher seed yield than 75 kg N ha\(^{-1}\) during 2013-14 and 2015-16, however different nitrogen levels has no significant effect on seed yield of castor in 2014-15 and in pooled results. Stalk yield of castor was significantly increased upto 100 kg N ha\(^{-1}\) during 2013-14 and 2014-15, however increase in nitrogen application from 75 kg to 100 kg and 125 kg N ha\(^{-1}\) significantly increased the stalk yield during 2015-16 and in pooled results. Phosphorus levels had non significant effect on seed and stalk yield of castor during 2014-15 and in pooled results except 2015-16, however application of 50 kg P\(_2O_5\) ha\(^{-1}\) recorded higher values of seed and stalk yield. Seed and stalk yields of castor were not affected significantly due to potash levels during individual years and in pooled analysis.

The results of EC, pH and organic carbon content of the soil after harvest of castor were not affected by nitrogen, phosphorus and potash levels. Nitrogen levels had no significant effect on available phosphorus and potash status of the soil, however increased in phosphorus levels increased available phosphorus status and potash application increased available potash status in the soil.

In light of above results it can be concluded that application of 75 kg N ha\(^{-1}\) (50% as basal and 50% at 45 DAS) and 25 kg P\(_2O_5\) ha\(^{-1}\) (if phosphorous availability is medium to sufficient in soil) to castor grown in late *kharif* season is sufficient for getting higher yield.
Effect of Different Levels of Municipal Solid Waste Compost and FYM on Yield, Content and Uptake of Micronutrients by Fodder Sorghum (*Sorghum bicolor* L.)

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A pot experiment was conducted during summer 2017 at Department of Soil Science and Agricultural Chemistry to find out the effect of MSWC and FYM on content and uptake of micronutrient by fodder sorghum. The experiment consist of ten treatments viz. T1-control (RDF), T2-5.0 t MSWC ha⁻¹, T3-10.0 t MSWC ha⁻¹, T4-5.0 t FYM ha⁻¹, T5-10.0 t FYM ha⁻¹, T6-15.0 t MSWC ha⁻¹ + 5.0 t FYM ha⁻¹, T7-5.0 t MSWC ha⁻¹ + 5.0 t FYM ha⁻¹ and T10-7.5 t MSWC ha⁻¹ + 7.5 t FYM ha⁻¹ laid out in CRD with three repetitions. The polythene lined earthen pots were filled with 15 kg soil. Before transferring the soil to pots, calculated amount of basal RDF (25 kg N and 40 kg P₂O₅ kg ha⁻¹), MSWC and FYM as per the treatment were mixed thoroughly in each pot. Initially 8 healthy seeds of sorghum were sown into each pot at a depth of 5 cm. Remaining dose of nitrogen (25 kg of N ha⁻¹) was top dressed in each pot at 30 DAS. Treatment-wise sorghum plants were taken and tagged at harvest. These samples were air dried and grinded in a stainless steel grinder to avoid any contamination. The processed samples were preserved in polyethylene bags for further analysis. The soil was loamy sand in texture and normal with respect to pH (7.8) and EC (0.14 dS m⁻¹) with low in organic carbon (0.35%), medium in available P₂O₅ (35.84 kg ha⁻¹) and high in available K₂O (237.6 kg ha⁻¹). In MSWC nutrient composition is 1.10% N, 1.0% P and 0.86% K and N, P and K content in FYM is 0.49, 0.38 and 0.43%. The result revealed that application of 15.0 t MSWC ha⁻¹ registered significantly higher plant height at 25 DAS (94.72 cm) and at harvest (189.2 cm). The green yield (198 g pot⁻¹) and dry yield (58.41 g pot⁻¹) of sorghum were significantly higher under application of MSWC @ 15.0 t ha⁻¹, which at par with T7 and T10. Similarly, the content of Fe (965.77 mg kg⁻¹), Mn (65.67 mg kg⁻¹), Zn (67.33 mg kg⁻¹) and Cu (11.47 mg kg⁻¹) in fodder sorghum were significantly increased with treatment T₄ (15 t MSWC ha⁻¹) over control (T₁) and also increased of Fe (56.42 mg pot⁻¹), Mn (3.84 mg pot⁻¹), Zn (3.93 mg pot⁻¹) and Cu (0.67 mg pot⁻¹) uptake by crop with same treatment.
Effect of Boron and Cutting Management in Seed Production of Lucerne

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Augmentation in the productivity as well as quality of forage crops is the need of present demand. Lucerne is one of the important winter sown green forage crop called “Green gold of forage crops” as it is rich in proteins (18-22%), amino acids and vitamin ‘A’. It is one of the most widely adoptable crop due to its high palatability, nutritious, rich in protein and mineral constituents, excellent growth habit and quick regrowth after cutting. Boron requirement of lucerne is comparatively higher than of other field crops. Foliar application of boron to lucerne helps pollen germination, water soluble sugars, number of seeds per pod and seeds per inflorescence. Well cutting management may affect the yield components, such as no. of tillers, pod per plant number of seed per pods, thereby affecting grain yield. Adopting appropriate agronomic practices will helps to increase quantity and quality of seed, therefore it is necessary to work out the optimum requirement of boron and appropriate cutting schedule for Lucerne. Keeping this in view the experiment was laid out in a randomized block design (factorial) comprising of 4 levels of boron (0, 0.02, 0.04 and 0.06%) and 4 cutting management (C1: Last cut at 3rd week of February, C2: Last cut at 4th week of February, C3: Last cut at 1st week of March, C4: Last cut at 2nd week of March) replicated thrice during rabi season of 2015-16 and 2016-17 at the Main Forage Research Station Farm of Anand Agricultural University, Anand. The experimental results revealed that the last cut of green forage at 3rd or 4th week of February and leave for seed production, followed by foliar spray of 0.02% boron at flower initiation stage and 2nd spray at 10 days after 1st spray along with all recommended practices resulted into maximum seed yield and net return.
Enhancing Yield, Quality and Uptake of *Kharif* Groundnut (*Arachis hypogaea* L.) by Potassic Fertilizer Management in *Entisol*

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A field experiment was conducted at Post Graduate Research Farm, College of Agriculture, Kolhapur during *kharif* season of 2016 to evaluate yield and quality of *kharif* groundnut (*Arachis hypogaea* L.) in *Entisol* with different sources and levels of potassium (K). The soil of the experimental site was sandy clay loam in texture and had pH 7.6 containing organic carbon %, available N, P₂O₅ and K₂O i.e., 0.45, 150.25, 21.37, and 252.75 kg ha⁻¹ and S 10.35 mg kg⁻¹, respectively. The treatments comprised of five levels of K viz., 0, 10, 20, 30 and 40 kg ha⁻¹ K₂O and four sources of K viz., muriate of potash (MOP), sulphate of potash (SOP), bagasse ash and schoenite, each with 25 and 50 kg ha⁻¹ N and P₂O₅, respectively, as basal dose. The experiment was laid out in a factorial randomized block design with three replications. Significantly highest dry pod (3.2 t ha⁻¹), kernel (2.2 t ha⁻¹) and haulm yields (3.9 t ha⁻¹) were recorded by application of 40 kg ha⁻¹ K₂O, and among the sources, the corresponding highest yields (2.7, 1.9 and 3.7 t ha⁻¹), respectively were recorded with SOP. Significantly highest oil yield was recorded by application of 40 kg ha⁻¹ K₂O (1.0 t ha⁻¹) and SOP (0.9 t ha⁻¹) among the levels and sources of K, respectively. The interaction effect between levels and sources of K was non-significant in relation to oil yield. The shelling percentage was not affected by the levels and sources of potassium. The nutrient uptake of groundnut increased significantly with increase in levels of potassium and the highest total uptake of N, P, K, Ca, S and B (130.1, 19.8, 82.5, 56.9 and 18.4 kg ha⁻¹ and 44.5 g ha⁻¹, respectively) were recorded for 40 kg ha⁻¹ K₂O. Among the sources, the highest uptake of total N (114.3 kg ha⁻¹), Ca (53.2 kg ha⁻¹) and S (15.6 kg ha⁻¹) was recorded for SOP, while that for total P (17.9 kg ha⁻¹) K (75.5 kg ha⁻¹) and B (42.8 g ha⁻¹) was observed for MOP being at par with SOP. The effect of different levels and sources of potassium and their interactions were did not affect the pH, electrical conductivity (EC), organic carbon, per cent calcium carbonate equivalent and available N, P, K, S and exchangeable Ca and Mg of soil after harvest of groundnut.
Balance Fertilization for Improving Potato Crop Productivity and Soil Fertility in Upper Gangetic Plain zone

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Potato (Solanum tuberosum L.) is the world's fourth important food crop after wheat, rice and maize because of its higher yield potential along with high nutritive value. Uttar Pradesh is leading potato growing state followed by West Bengal, Bihar and Punjab. Western Uttar Pradesh is highly advanced in terms of agriculture. The cropping intensity of the zone is above 150%. In this intensively cultivated zone, fertilizer use is unbalanced for preferential use of N on the cost of other nutrients. Literature revealed that farmers fertilizer use is skewed towards N in this zone. On the other hand, phosphorus application was sub-optimal and nutrients like K, S and Zn are largely ignored, resulting in deficiencies of these nutrients. Balanced nutrition is not only for plants but it is essential for the human and animal health especially Zn and Fe are important nutrients for both humans and plants. Attainable yield of crops under farmers’ fertilizer practices in the area vary with inherent soil fertility level, crop residue, organic materials input, rate of applications, rate, method and schedule of fertilizer application, and variation in nutrient requirements by cultivars etc. In contrast, one standard recommendation of plant nutrients are exists in the area. Drastic changes in crop cultivars and other agronomic management has witnessed during this period. This leads to inefficient use of added nutrients as application rates do not consider the spatial variability in nutrient requirements among the fields. SSNM has been proposed as an approach to tailor fertilizer application to match field-specific needs of crops to improve productivity and profitability.

To prove the importance of balanced fertilization on potato crop productivity and soil fertility, demonstrations were conducted at farmers field village Gijhauri, Bulandshahar with 4 nutrient management options: (1) Farmer fertilizer practice (FFP), (2) Farmer fertilizer practice (FFP) + Potassium (3) State fertilizer recommendation (SR) and (4) SSNM

Potato tuber yield during 2014 and 2015 was significantly affected by different on-farm trial treatments. Application of nutrients according to farmer fertilizer practice resulted significantly reduction in potato tuber yield during both the years. Adoption of SSNM yielded 16.4, 8.0 and 11.6 percent higher tuber yield than FFP, FFP+K and SR, respectively during 2014, similarly the increment during 2015 was 15.6, 8.3 and 10.6 percent. Inclusion of potassium over FFP resulted in 7.8 and 6.7 percent higher tuber yield during 2014 and 2015, respectively. Inclusions of different nutrients in accordance to SSNM pakage like potassium, sulphur, zinc and boron over FFP as well as SR have resulted in an improvement in crop yields and maintenance of soil health. Balance fertilization is essentially required for the sustenance of intensive cropping system and sustainability of soil health.
Assessment of Soil Fertility Constraints Using Spatial Mapping in Kultali block of Coastal Sundarbans, West Bengal

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Accurately characterizing the spatial variability of soil fertility parameters is critical for the rational development and increasing the agricultural productivity in the coastal Sundarban region of West Bengal. Seventy five surface soil samples (0-25 cms) were sampled in Kultali block of 24 Pgs(S) district, West Bengal covering 234.21 sq kms. The sampling was performed by using cadastral maps in conjunction with GPS system. The soil reaction, salinity and nutrient maps were prepared by Inverse Distance Weighted (IDW) spatial interpolation method using ArcGIS Ver. 10 software. Soils were dominantly silty clay loam in texture (61.63%TGA), with moderately acidic soil classes (pH< 5.5) occupying 22.44% of TGA, while the extremely acidic soils with pH < 4.5 is observed in a sizeable 14.10% area of the block. Higher saturated electrical conductivity (ECe) values >8 dS m⁻¹ is observed in 20% of TGA while soils with ECe values between 4 to 8 dS m⁻¹ occupies 16.8% of TGA. On an average, organic C of the studied area was medium to high in nature with a mean value of 0.9%. Soils were low in available nitrogen (< 280 kg ha⁻¹) in about 41% of TGA and low in available P (<45 kg ha⁻¹) in 61% TGA. The DTPA extractable Zn status is also deficient (<0.6 ppm) in 38% of TGA. Higher availability status of K, Mn, Cu, Fe and S were found in such soils. Nutrient Index values for all the studied plant nutrients were generated. These values revealed that area is medium in available N; low in available P and Zn necessitating its incorporation through external inputs but the native supply of available K, S and micronutrients are much pronounced. From the correlation study it is observed that pH was negatively correlated with organic carbon (r = -0.513; p<0.01) and positively with available P (r = 0.231; p <0.05). The ECe values showed a negative correlation (r = -0.255; p <0.05) with Av N and was positively correlated with Av Zn (r = 0.252 ; p <0.05).The organic carbon content also showed positive correlation with Av Cu (r=0.470; p<0.05), Av Fe (r=0.401; p<0.05) and Av S content (r=0.293; p<0.05) of the soils in the block.
Effect of Sources and Levels of Sulphur on Green Pod Yield of Summer Cowpea (Vigna unguiculata L. Walp) under Middle Gujarat Conditions

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A field experiment was carried out on loamy sand soil at Bidi Tobacco Research Station Farm, Anand Agricultural University, Anand to study the effect of sources and levels of sulphur on green pod yield of summer cowpea (Vigna unguiculata L. Walp) under middle Gujarat conditions” during summer season of 2013-14. Plant height recorded at 60 DAS and at final picking, number of branches plant$^{-1}$, leaf area index at 30 and 60 DAS, number of green pods plant$^{-1}$, length of pod, number of seeds pod$^{-1}$, total green pod yield, dry stover yield and dry weight of root nodules plant$^{-1}$ were significantly altered due to application of sulphur in vegetable cowpea. Potential production and profit from cowpea variety Anand Vegetable Cowpea-1 could be secured by applying sulphur @ 20-30 kg S ha$^{-1}$ through Gypsum, Bentonite or Elemental sulphur in summer season under middle Gujarat conditions.
Soil Test Based Fertilizer Prescriptions Equation for Specific Targeted Yield of Bt Cotton in Vertisols of Telangana

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Field experiments were conducted for three years on Bt Cotton during kharif season in black soils at Agricultural Research Institute, Rajendranagar, Hyderabad to develop soil test based fertilizer recommendations for attaining yield targets of 2.5 t ha\(^{-1}\) and 3.0 t ha\(^{-1}\) under IPNS. Data was generated on nutrient uptake, N, P & K requirement, percent contribution of N, P & K from soil, fertilizer and vermicompost and fertilizer prescription equation for different Bt Cotton production levels of 2.5 t ha\(^{-1}\) and 3.0 t ha\(^{-1}\) were calibrated. The basic data was transformed into simple workable fertilizer prescription equations for calculating fertilizer doses based on initial soil test values by the procedures laid by Ramamoorthy et al. (1967). Based on the study, the estimates of nutrient requirements (kg) for obtaining 1 quintal Bt seed cotton yield were found to be 2.55 for N, 0.22 for P and 1.03 for K. The nutrient contribution from soil, fertilizer and vermicompost was found to be 13.98, 29.46 and 2.65 for N, 10.61, 13.20 and 2.49 for P and 6.03, 21.75 and 20.37 for K respectively. The best response yard stick (kg output kg\(^{-1}\) input) was found to be 6.64 based on target yield coefficients and this equation is used for adaptability. In medium nutrient status (P and K), the saving of fertilizer in terms of phosphorus was 23 kg and potassium 8 kg per hectare over the recommended dose of fertilizer for a target of 25q ha\(^{-1}\). The fertilizer prescriptions equation, thus developed are as follows: Nitrogen fertilizer FN= 8.66 T-0.47SN-0.09VC N, Phosphorus fertilizer FP=1.69T-0.80SP-0.19VC P and Potassium fertilizer FK=4.72T-0.28SK-0.94VC K where T is the target yield in q ha\(^{-1}\), SN, SP & SK are the initial soil test values of available N, P & K and VC N, P & K are the N, P & K contents in vermicompost.
A column study experiment conducted to study the effect of application of different levels (0, 1, 2, 4, 6, 8 and 10 tonne ha\(^{-1}\)) of bagasse ash on physico-chemical properties of soil, during the year 2017, at the Department of soil science and agricultural chemistry, MPKV, Rahuri. The experiment laid out in Completely Randomized Design (CRD) with seven treatments and three replications in inceptisol soil. The seven treatments \textit{viz}; bagasse ash @ 0, 1, 2, 4, 6, 8 and 10 t ha\(^{-1}\) was applied in column study. The bagasse ash was characterized and found strongly alkaline due to the pH (9.71). The results of this investigation revealed that the physical properties such as bulk density decreased (1.26 Mg m\(^{-3}\)) while field capacity (40%), PWP (20.26%), aggregate stability (57.88%), hydraulic conductivity (1.26 cm h\(^{-1}\)) were significantly improved due to addition of increased quantity of bagasse ash. In case of chemical properties the significantly increased in soil pH(8.28), Ec (0.36 dS m\(^{-1}\)), organic carbon (0.79%), calcium carbonate (8.66%) and CEC (55.20 Cmol (p\(^{+}\)) Kg\(^{-1}\)) were observed mostly in each 0-15 cm depth as compared to 15-30 cm, 30-45 cm, and 45-60 cm due to application of bagasse ash. The bagasse ash application also increased concentration of anions HCO\(_3\)\(^{-}\) (7.73 meL\(^{-1}\)), SO\(_4\)\(^{2-}\) (2.67 meL\(^{-1}\)), Cl\(^{-}\) (8 meL\(^{-1}\)) and cations Ca\(^{2+}\) (7.7 meL\(^{-1}\)), Mg\(^{2+}\) (1.36 me L\(^{-1}\)), Na\(^{+}\) (0.88 meL\(^{-1}\)), K\(^{+}\) (2.94 meL\(^{-1}\)) of saturation paste extract of soil. The leachate analysis showed higher values of cations and anions in 30 days leachate analysis than 60 days leachate analysis.
Response of Garlic to Micronutrients Application in Medium Black Calcareous Soils of Saurashtra Region of Gujarat

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A field experiment was conducted on medium black calcareous soil of Vegetable Research Farm, Junagadh Agricultural University, Junagadh, Gujarat, during 2014-15 and 2015-16 to study the response of garlic to multi-micronutrients formulation mixture fertilizers in medium black calcareous soils. The results revealed that higher bulb (6712, 5762 and 6237 kg ha⁻¹) and dry leaves (1370, 1181 and 1275 kg ha⁻¹) yields in year 2014-15, 2015-16 and pooled results, respectively, as well as Fe, Mn, Zn and Cu uptake by bulb and dry leaves of garlic were registered with soil application of FeSO₄ @ 15 kg ha⁻¹ and ZnSO₄ @ 8 kg ha⁻¹ as per soil test value (STV), follow by soil application of multi-micronutrients Grade-V @ 40 kg ha⁻¹ and foliar multi-micronutrients supplementation through 1.0% spray of multi-micronutrient formulation Grade-IV having Fe-4.0%, Mn-0.1%, Zn-5.0%, Cu-0.5% and B-0.5% at 60, 75 and 90 days after sowing (DAS). These all the treatment were statistically at par with each other but significantly superior over control. Significantly higher value of bulb height (2.3 cm), plant height (26.5 cm), No of cloves per bulb (10.9) and bulb girth (1.9 cm) were also recorded with soil application of FeSO₄ @ 15 kg ha⁻¹ and ZnSO₄ @ 8 kg ha⁻¹ as per soil test value (STV), follow by foliar application of multi-micronutrient mixture Grade IV.
Effect of Different Levels and Time of Potassium Fertilization on *Kharif* Groundnut in Medium Black Calcareous Soils of Saurashtra Region of Gujarat

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A field experiment was conducted during four *kharif* seasons (2010 to 2013) at main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, to study the effect of different levels and time of potassium fertilization on yield, quality and nutrients uptake by *kharif* groundnut. The treatments comprise of four levels of potassium viz; 0, 25, 50 and 75 kg ha⁻¹ as basal and three levels viz; 25, 50 and 75 kg ha⁻¹ in two split (1/2 as basal and 1/2 at 30 days after sowing). The results revealed that the average pod as well as haulm yield of *kharif* groundnut was significantly influenced by different potassium treatments. The significantly higher pod (1.5 t ha⁻¹) and haulm (3.7 t ha⁻¹) yield were recorded with application of K₂O @ 50 kg ha⁻¹ in two split. Increase in groundnut pod yield to the tune of 34 per cent over control. The shelling percentage and oil content in kernel was significantly affected by different potassium treatments. The maximum shelling percentage and oil content was recorded with potassium application @ 50 kg ha⁻¹ as basal. Significantly the higher N and S uptake by pod and N, P, K and S uptake by haulm were recorded with application of K₂O @ 50 kg ha⁻¹ in two split. While, application of K₂O @ 75 kg ha⁻¹ as basal significantly increased P and K uptake by pod.
Status of DTPA-extractable Micronutrients in Inceptisols of Mirzapur

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Micronutrients are inevitable elements in the production of quality food crops by its various enzymatic as well as metabolic functions in the plants. This reflects in terms of significant increase in yield and quality of the crops. Thus its application in deficient areas is recommended to increase the productivity as well as sustainability in the region. Since last few years unbalanced use of nutrient fertilization giving poor yields of the crop in eastern Uttar Pradesh by the farmers which results in the poor health of crop and human beings as well. Viewing above facts 51 representative surface (0-15 cm) soil samples were collected from Gangpur and Bhawanipur villages of Mirzapur district to evaluate the micronutrient status of the region. Mirzapur lies 25° 8' 1.3164'' N and 82° 33' 51.9480'' E with elevation of 87 m in Vindhyan zone of eastern Uttar Pradesh. The soil samples were air dried, processed and passed through a 2 mm sieve in the soil processing lab of the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, BHU, Varanasi. Micronutrients viz. Fe, Mn, Cu and Zn were analyzed using standard methods by Atomic Absorption Spectrophotometer (AAS) in the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, BHU, Varanasi. The range (mean) values of DTPA-extractable available Fe, Mn, Cu and Zn were 16.20 to 43.60 (24.16), 1.02 to 6.46 (2.95), 0.44 to 3.17 (1.56), and 0.50 to 1.80 (0.75) in Gangpur; 13.20 to 35.60 (22.79), 0.70 to 7.00 (3.45), 0.38 to 1.72 (1.23) and 0.52 to 1.14 (0.73) mg kg\(^{-1}\) soil in Bhawanipur village. In general, DTPA extractable micronutrients (Zn, Fe, Mn and Cu) were found sufficient. Results revealed the sufficiency of all the micronutrients in the selected region but giving an indication to maintain such levels in future also.
Effect of Zinc and Boron on Growth and Yield of Foxtail Millet Grown in Alisols of Karnataka

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A field experiment was conducted in KVK at Bidaregudikaval village, Tiptur taluk, Tumkur district of Karnataka in soil which was deficient in DTPA extractable zinc and hot water soluble boron, to study the effect of zinc and boron on growth and yield of foxtail millet. The experiment was laid out in RCBD design comprising 18 treatments replicated thrice. The results revealed that significantly higher grain and straw yield (1.7 and 2.6 t ha⁻¹), Significantly higher nutrient content and uptake of N, P, Ca, Mg, Zn, Cu and B crude protein (9.47%) and crude fibre (9.19%) by foxtail millet was recorded in treatment which received fertilizers application of 40 kg N ha⁻¹, 40 kg P₂O₅ ha⁻¹, 30 kg K₂O ha⁻¹, ZnSO₄ @ 12.5 kg ha⁻¹ and Borax @ 5 kg ha⁻¹ combined with application of farm yard manure at 6.5 t ha⁻¹ as compared to RDF (40: 40: 30 N: P₂O₅: K₂O kg ha⁻¹). The results of the present study evidently concluded that the application of 40: 40: 30 kg N: P₂O₅: K₂O ha⁻¹, ZnSO₄ @ 12.5 kg ha⁻¹ and Borax @ 5 kg ha⁻¹ along with FYM at 6.5 t ha⁻¹ under rainfed condition is beneficial for getting higher yield of foxtail millet as well as higher benefit cost ratio (2.96) as compared to the RDF (40: 40: 30 kg N: P₂O₅: K₂O ha⁻¹) in zinc and boron deficient soils of Tumkur district of Karnataka.
Effect of Different Nutrient Management on Yield and Quality of Maize Grown in Soils of Indo-Gangetic Plain

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A field experiment was conducted to study the effect of various nutrient management on yield and quality of maize (cv. Azad Uttam) grown at Crop Research Farm of Nawabganj of C.S. Azad University of Agriculture and Technology, Uttar Pradesh during 2015-16 and 2016-17. Treatments used for present investigation were control, 100% NPK (120:60:60 kg ha⁻¹), 100% NPK+S, 100% NPK+Zn, 100%NPK+S+Zn, 125% NPK, 125% NPK+S, 125% NPK+Zn, 125% NPK+S+Zn and 150% NPK. Results indicated that treatment comprising 125% NPK+S+Zn gave the highest grain yield (3.2 t ha⁻¹) as compared to that in control (1.5 t ha⁻¹). Plant height, number of cobs per plant, cob length and grain test weight of maize were found to be highest under treatment comprising 125% NPK+S+Zn. Nutrient uptake by maize was also increased significantly under this treatment. The treatment of 125% NPK gave 20% higher grain yield over 100% NPK, whereas 150% NPK resulted in 7% higher grain yield over 125% NPK. Application of Zn (5 kg ha⁻¹) along with 100 and 125% NPK resulted in increase in grain yield by 15% and 7%, respectively, over application of 100 and 125% NPK alone. Addition of S+Zn along with 100 and 125% of NPK was found to increase the grain yield by 30% and 23% respectively, over application of 100 and 125% NPK alone. Significantly higher values of oil (224 kg ha⁻¹) and protein (253 kg ha⁻¹) contents in maize grain were recorded under treatment comprising 125% NPK+S+Zn as compared to that under control. Therefore, integrated use of both macro and micro nutrient could enhance the grain yield and quality of maize grown in the study area.
Micronutrient Status of Soils under Rice-wheat Cropping System in Submountaneous Region of Punjab

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Rice-wheat system is predominant cropping system followed by farmers, of Punjab state and it is a nutrients exhaustive system. The soil productivity under this system is evaluated on the basis of natural soil fertility and to have great nutritional value in crops is a subject of intense debate in the present scenario. Therefore, balanced fertilization with macro and micronutrients in plant nutrition is very important as far as high yielding crops and high quality products are concerned. The main objective of nutrient management should be balanced fertilization which means the application of all the plant nutrients in sufficient amounts, appropriate forms and ratios to maximize yield within the context of eco-friendly and long-term production. Balance among nutrients in the plant may be more critical than actual amounts, so taking care of the major nutrients is not enough for maximum yields. Though micronutrients are required in traces but they are as important as are macronutrients as they play pivotal role in plant growth. As there is a synergistic relationship between availability of Mn and Fe, Zn and P, and Ca, Mg, K, and N with the result the basic understanding of the micronutrients is important. Generally, studies on micronutrients status of soils in submountaneous region of Punjab are not much more due to less prevalence of their deficiency symptoms. Therefore, the information on soil micronutrient status of soils in submountaneous region of Punjab is limited. Keeping these facts in view, the present study was undertaken to have knowledge about the micronutrient status of district Gurdaspur having rice-wheat as the predominant cropping system.

The research study was conducted during 2015-16 in district Gurdaspur, which is north-western district of Punjab in North India situated between 32º02'01.35" N and 75º24'26.73" E and at an altitude of 285 M. The average annual rainfall of the area varies from 800mm to 1500mm with wide variations. About 80% of total rainfall is received in 3 months from mid June to mid September. Soils of the district are alluvial in nature with varied soil types; sandy loam to silty clay loam. Majority of the soils are clay loam to silty clay loam showing more nutrient retentive capacity. Rice-wheat is the predominating cropping system in the district. A total of 220 soil samples (0-15 cm) were collected randomly from farmers’ fields of the district with the help of auger. The soil samples were mixed thoroughly, sieved through a 2mm sieve and analyzed in the laboratory using DTPA extraction method. The concentrations of Zn, Cu, Fe and Mn were determined using atomic absorption spectrophotometer (Varaian AAS FS 240 Model).

The results of our investigation showed that among the collected soil samples DTPA extractable Zn ranged from 0.18 to 4.68, Cu ranged from 0.16 to 11.1, Mn ranged from 0.90 to 23.2, and Fe ranged from 2.10 to 39.9 mg kg⁻¹. Results indicated that 37.7%, 13.6%, 3.2% and 1.4% soil samples were deficient in Mn, Zn, Fe and Cu, respectively. The soil Zn deficiency is probably due to the application of P fertilizer which was applied continuously in all seasons in the region. Zinc uptake efficiency can be increased with the higher levels of Fe²⁺, Cu²⁺, and Mn²⁺ in soil. Results further revealed the extent of Zn, Cu, Fe and Mn deficiencies are due to continuous intensive and monotonous cropping pattern followed by farmers of this district which led to the micronutrient deficiencies in the soils. Therefore, there is a need of various management options to ameliorate Zn, Cu, Fe and Mn deficiencies and their inclusion in nutrient management programme to overcome nutritional imbalances and improve crop productivity.
Crop Yields and Soil Properties as affected by Integrated Use of Organic and Inorganic Inputs in Wheat-fodder Maize Cropping Sequence

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A two year field study was conducted to evaluate the effect of two organics, farmyard manure and vermicompost each at three rates (0, 5, 10 t ha⁻¹ and 0, 1, 2 t ha⁻¹, respectively) along with two levels of mineral fertilizer (75% and 100% of recommended dose) on crops yields and soil properties under a wheat-fodder maize cropping sequence. The experimental was conducted at Forage Research Station, Anand Agricultural University, Anand with factorial RBD design.

The results of two year study showed that incorporation of either farmyard manure at 10 t ha⁻¹ and/or vermicompost at 2 t ha⁻¹ with mineral fertilizers substantially increased the yields of wheat and the succeeding fodder maize crop as direct and residual effect, respectively. The magnitude of increase in total wheat yield was of 26 and 11%, respectively with farmyard manure at 10 t ha⁻¹ and vermicompost at 2 t ha⁻¹ over the control as a direct effect. Similarly, green fodder yields also increased by 13 and 11% with farmyard manure and vermicompost at their higher levels compared with no organic application as a residual effect.

The results also showed that soil amended with farmyard manure had a higher available soil nutrient status, especially organic carbon, TMBC, available N and some of micronutrients. Soil microbial biomass carbon was enhanced as both a direct and residual effect with the addition of farmyard manure followed by vermicompost and mineral fertilizer treatments and also by combined addition of manure with either vermicompost or mineral fertilizer. Farmyard manure increased the availability of soil macro- and micronutrients, whereas vermicompost influenced only the availability of micronutrients at wheat harvest. A residual effect of farmyard manure and mineral fertilizers was found for beneficial for available N. Meanwhile, the residual status of micronutrients in the soil was either maintained or significantly improved due to organic amendments (Mn and Zn with farmyard manure; Fe and Zn with vermicompost). The integrated effect of farmyard manure and vermicompost at a higher level benefited the next crop by increasing the yield of fodder maize and improving the availability of P and available nutrients in soil. Addition of vermicompost also improved soil organic carbon, Fe and Zn availability.

Hence, 2 t ha⁻¹ of vermicompost have a similar potential of 10 t ha⁻¹ farmyard manure, and addition of either along with a moderate rate of mineral fertilizers (i.e. 75% of RD) could effectively benefit wheat–fodder maize yield and improve soil health.

Thus, the overall results indicated that the integrated effect of organics with mineral fertilizer significantly improve the crop yields in wheat as a direct effect and fodder maize as a residual effect as well as the soil properties at the end of the cropping sequence. Integration of organics with mineral fertilizer thus minimize the load of chemical fertilizers and thereby reduce the load of metals in soil.
Gabion Based Filtration System to Address the Dual Purpose of Urban Sewage Management and Safe Irrigation

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Municipal sewage in India (62000 million litre daily) assumes greater significance in view of increased fresh water scarcity and lesser allocation of water for agriculture in future. Sewage treatment capacity is insufficient. Thus, above 40000 mld of untreated urban sewage is discharged polluting the environment. There is severe management issues with the urban sewage. Treatment of all the sewage in India (100%) is still distant. Since, centralised treatment systems are costly, land occupying and have technical constraints also. Decentralised and differential sewage treatment systems have better potential. On the other hand, urban sewage is a huge resource in terms of nutritional richness and perpetual availability. Peri-urban farmers in India use untreated sewage for irrigation since long to grow a variety of crops specially vegetables. Reports of heavy metals exceeding safe limits in vegetables and infections are recurrent. Neither the ban on untreated sewage irrigation is forthcoming nor has feasibility. In this context, a gabion based sewage treatment system was designed. A prototype had been developed and tested for it’s efficiency. The performance of the prototype system has been very encouraging in reducing pollutant loads in wastewater. The system has been installed in a drain at Chandrasekharpur, Bhubaneswar and monitored. 30% reduced BOD, 70% reduced suspended solids were observed in treated sewage water. The heavy metal concentrations were reduced to below permissible limits (Cd 0.01, Cr 0.10, Ni 0.2 mg l⁻¹) in the treated sewage. The authors discuss the design, performance and experience of the system in this paper.
Screening of Rice Genotypes for Tolerance to Soil Acidity and Related Nutritional Constraints in Rainfed Medium Low Lands

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A field experiment was conducted in the experimental farm of Zonal Agricultural Research Station, Dumka, Birsa Agricultural University, Ranchi, Jharkhand during Kharif 2017 to evaluate location specific genotypes for tolerance to soil acidity and related nutrient constraints in rainfed medium low lands. The experimental findings have been interpreted in terms of grain yield, crop response (%) to lime, lime use efficiency (LUE), P and K–uptake by the crop. The experiment was laid out in Split plot design in which fertilizer levels (two) [NPK (RD) i.e., @ (100:50:25) kg ha−1 and NPK (RD) + lime @3q ha−1] were taken as the main plot and rice vars. (thirteen) as the sub-plots. It was found that the grain yield and nutrient uptake (P & K) by the crop were significantly influenced by lime (irrespective of vars.) and genotype differences (irrespective of lime levels). Significantly higher grain yield (51.55 q ha−1), P-uptake (15.78 kg ha−1) and K-uptake (17.75kg ha−1) were recorded with (NPK + Lime) (irrespective of vars.). The highest crop response to lime (26.2%) and lime use efficiency (4.55 kg grain kg−1 lime) were recorded with HRI 197, whereas the maximum increase in P-uptake (20.0%) and K-uptake (32.3%) were obtained with DRR-44 and DRR-42, respectively.
Nutrients (N, P and K) Balance Under Different Resource Conservation Technologies in Transplanted and Direct Seeded Rice

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Nutrient budgeting is a useful tool in determining present and future productivity of agricultural land as well as undesirable effects of nutrient mining and environmental pollution. Nutrient (N, P, and K) managements are strongly linked to energy and food production, but excess nutrient causes environmental pollution. Balances of N, P, and K were calculated for six (6) resource conservation technologies along with conventional control under direct seeded and transplanted conditions in a rice-green gram system taking into consideration the inputs through inorganic fertilizer, green manure, leguminous fixation, non-leguminous fixation, crop residues, rain and irrigation water and outputs through crop uptake and losses through leaching, volatilization and denitrification. Inorganic fertilizer was the dominant source of N, P and K inputs in all the resource conservation treatments and the removals was mostly by crops harvesting in both dry and wet seasons. There were positive balances of N for direct seeded (61.3-98.2 kg ha⁻¹) and for transplanted (48.7-85.0 kg ha⁻¹). Highest N balance under direct seeded could be achieved under green manuring + customized leaf colour chart (GM+CLCC) and it was 37.6% more than the conventional practice, whereas under transplanted condition, N balance was highest under residue retention and it account 42.7% more than conventional practice. Similarly, there were also positive balances of P, for direct seeded (37.3-46.8 kg ha⁻¹) and for transplanted (34.8-42.0 kg ha⁻¹). Highest P balance under direct seeded could be achieved under both GM+CLCC-N and brown manuring (BM) and it was 11.5% more than conventional practice, whereas under transplanted condition P balance was highest under residue incorporation and it account 14.5% more than conventional practice. Potassium balance under direct seeded ranged from 7.2 to 30.7 kg ha⁻¹ and the highest balance recorded under zero tillage, whereas under transplanted condition it ranged from 0.5 to 44.5 kg ha⁻¹ and the highest value was found under residue incorporation treatment. The study identified the best treatment for nutrient resource conservation to sustain yield and also to predict environmental degradation due to imbalanced fertilizer use.
Nutrient Content, Uptake and Quality of Wheat (*Triticum aestivum* L.) as Influenced by Lateral Spacings of Drip and Nitrogen Levels

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A field experiment was carried out during *rabi* season of the year 2015-2016 at the Regional Research Station farm, Anand Agricultural University, Anand, Gujarat with main objectives to find out the effect of lateral spacing of drip and nitrogen on yield, N and P content and uptake as well as protein content of wheat and to study the effect of lateral spacing of drip and nitrogen on nutrient status of soil after harvest of wheat crop. The soil was sandy clay with bulk density 1.43 Mg m⁻³, EC 0.24 dS m⁻¹ and soil pH 7.7, low in available N (237 kg ha⁻¹), medium in available P₂O₅ (50.34 kg ha⁻¹) and K₂O (347 kg ha⁻¹). The experiment was laid out in split-plot design with four replications and eight treatment combinations with four lateral spacings (drip at 60, 80 and 120 cm and conventional method) and two levels of nitrogen (100% RDN and 75% RDN). Irrigation schedules were relegated as main plot treatments and two nitrogen levels were allotted as sub-plot treatments. Irrigations were applied @ 1.0 ADFPE through drip irrigation. Laterals with emitters of 4 lph discharge capacity were installed the distance between two emitters was 37.5 cm. The daily pan evaporation values were measured with the help of USWB class ‘A’ open pan evaporimeter.

The results indicated that treatment of lateral spacing showed significant influence on grain as well as straw yield of wheat. Similar trend was observed in case of N and P content in grain and straw and also for protein content in grains. Varying lateral spacings exerted a significant influence on available soil N status but not on soil P₂O₅. The effect of varying nitrogen levels was non-significant on grain yield and straw yield. Effect was significant on N content in grains and straw but non-significant on P and K in grain and also for P and K in straw. It was found significant on protein content of the grains where, significantly higher protein content was recorded under 100% RDN over 75% RDN. Similarly, P₂O₅ and K₂O in soil after harvest of the crop were not influenced significantly by the different nitrogen levels but it significantly influenced soil available N.
Potentiality of Land Uses in Restoration of Degraded Sodic Land and Improvement of Organic C Pools in Northwest India

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We studied five land-uses namely Jamun (Syzygium cumini) Eucalyptus (Eucalyptus tereticornis) Mesquite (Prosopis cineraria) Prosopis juliflora and pasture (Sporobolus marginatus and Desmostachya bipinnata) situated at Saraswati Range, Kurukshetra, Haryana, India to evaluate changes in soil physico-chemical properties such as pH¹:², EC¹:², pH₄pH of saturation paste ECₑECₑ of aqueous saturation paste extract exchangeable sodium per cent (ESP CaCO₃ content, very labile, oxidizable organic carbon and inorganic carbon up to a depth of 100 cm. Results showed that soils under Prosopis cineraria recorded higher pH¹:² (10.94) and pH₄ (10.24) at 40-60 and 80-100 cm soil depth, respectively. Eucalyptus showed lowest pH¹:² and pH₄ throughout the depth than others. Highest (9.54 dS m⁻¹) and lowest ECₑ (2.03 dS m⁻¹) was observed under Prosopis juliflora and pasture at 0-20 cm soil depth, respectively. ECₑ was 2.25 times higher than EC¹:² irrespective of land uses. Irrespective of land uses and soil depth, Prosopis cineraria recorded highest ESP. Except 0-20 cm soil depth, Eucalyptus showed lowest ESP in all the soil depth than other land uses. Jamun showed highest CaCO₃ as well as inorganic carbon in all the soil depths. Highest oxidizable organic carbon was observed under Eucalyptus (7.11 g kg⁻¹) followed by Jamun (4.81 g kg⁻¹), Prosopis juliflora (4.04 g kg⁻¹), Prosopis cineraria (3.98 g kg⁻¹) and pasture (3.71 g kg⁻¹) at 0-20 cm soil depth. Very labile carbon also followed similar trend. Among the land uses Eucalyptus showed maximum potential in reduction of soil sodicity. Type of land use significantly influences physico-chemical properties of sodic land and need to be considered while formulating their reclamation management strategies.
Standardization of Fertigation Scheduling to Kinnow Mandarin in Hot Arid Region of Western Rajasthan

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A field experiment on scheduling of drip fertigation to kinnow mandarin was conducted in sandy soils of research farm of Central Institute for Arid Horticulture, Bikaner. Twelve treatments comprised of eleven fertilizer schedules along with control (No inorganic fertilizer) through drip system with three replications in randomized block design were deployed in ten year old kinnow mandarin fruit crop. The soil of the experimental block is sandy containing 86.0 per cent sand content, 8.0 percent silt and 6.0 percent clay content and low in organic carbon (0.04%), medium in available phosphorus (12 kg ha⁻¹) and high content of available potassium (186 kg ha⁻¹). The infiltration rate of the soil is very high. The solid water soluble fertilizers having the different grades of N, P and K were used for fertigation the crop. The fertigation was carried out from the month of March to November at weekly interval basis. The petiole analysis was carried out from the leaf samples collected from the month of August and fruit yield was recorded at the harvest. The data revealed the fruit yield was significantly changed with fertigation scheduling and highest fruit yield (23.5 t ha⁻¹) was obtained with the fertigation schedule i.e. 30, 60 and 20% of N, P and K from month March to June, 50, 40 and 40% of N, P and K from July to September and 20 and 40 percent N and K of recommended dose (1200 g N, 500 P and 750 g K) from October to November month were applied and minimum fruit yield (40 q ha⁻¹) was obtained in control treatment where no inorganic fertilizers were given. Data pertains to leaf petiole analysis also revealed that maximum content of N (1.68%), P (0.18%) and K (1.45%) were estimated in above said fertigation schedule and minimum N, P and K contents were recorded in control treatments. Thus present study revealed that fertigation schedule which provides nutrients to the crop as per the crop need boost the crop health and their yield potential.
Evaluation of Maize Genotype under Organic Crop Management Practices in Rainfed Ecosystem of Vertisols

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There is a worldwide awareness about organic production systems concerning human health. Organic agriculture is a holistic production management system which promotes and enhances the agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of on-farm inputs, taking into account that regional conditions require locally adapted systems. Under low productivity zones, crop yields either remain similar or increase during transition period from conventional to organic production system. Maize (Zea mays L.) is the third important cereal crop in the world after wheat and rice with respect to area and production. India is the fifth largest producer of maize in the world, contributing 3% of the global production and produced 26.3 million tonnes from 9.90 million ha area with an average yield of 2.7 t ha⁻¹ of maize during 2017-18. Quality parameters of food grains are generally controlled genetically but agricultural practices, like fertilizer management, irrigation, tillage operations, besides climatic and edaphic factors also influence the produce quality. Hence, an attempt was made to screen out 12 maize genotypes that can perform in terms of better productivity and nutritional quality under organic management practices. The study was undertaken at ICAR-Indian Institute of Soil Science, Bhopal in a randomized block design with three replications during 2014 to 2017 with organic nutrient management practice. Recommended N based manure was done in the form of cow dung manure + poultry manure + vermicompost (1/3rd proportion from each organic). Results of the study revealed that among the genotype of maize Kanchan 101 out performed in yield followed by Proagro 4212, Pratap-6 and JM-216, respectively. Seed yield of Kanchan variety was found significantly higher than others. Protein, ash and tryptophan content in maize grain was influenced significantly among various genotypes. The higher values of protein (10.04%) and tryptophan (0.91 g 16⁻¹ G N.) were recorded in proagro-4212. Proagro 4212 registered the maximum seed protein content of 10.04 (%) which was significantly superior over others. However ash and tryptophan content in maize grains did not varied significantly among the genotypes of maize. The significant variation for seed yield and seed protein content among the genotypes examined in this study indicates that there is need for breeding high yielding maize cultivars suitable to perform under organic farming in the future.
Impact of Soil Salinity on Crop Production and Monetary Losses in Gujarat


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Land degradation caused by salinity is a major impediment to productive utilization of land resources for crop production in arid and semi-arid regions of the State. Saline soils having electrical conductivity of saturation extract (ECe) is more than 4 dS m⁻¹, occupy an area of about 1.68 Mha in Gujarat, which is distributed in five regions of the Gujarat State showing the highest extent of saline soils in Kutch region (608000 ha), followed by Saurashtra (433840), North (328180 ha), Central (204160 ha) and South (104000 ha) and assumed paramount importance as demands for food and feed continue to increase at unprecedented rates, while the agricultural land base needed for production is shrinking. The population density of the state is 258 persons per square kilometer. Gujarat is the tenth greatest state with respect to population in India. From a little figure of 50.7 million 2001, the number of people in the state has touched 67.3 million in 2017 which indicates that the population is developing at a yearly rate of about 2.0 percent. At country level the projections of increase in demand by the end of 2050 for food commodities suggest that the demand for food grains will grow by about 50 per cent and the rise in demands for fruits, vegetables and animal products will be 100% to 300%. The existing barren and low productive salt affected lands could be used effectively to augment the food production by using different interventions/technologies for management of these salt affected lands. No systematic study is available on salinity induced losses at the State level i.e. in Gujarat. In the present paper it was estimated the production and monetary losses in crops caused by salinity in Gujarat. The estimation was done by using crop production loss estimation method. According to this estimation, Gujarat State loses annually 2.73 million tones of agricultural production valued at rupees 49.14 billion due to salinity only. The result of the study showed that share of cash crops (cotton, sugarcane) in the total production losses was highest (44.58%) followed by cereals (33.44%), oilseeds (19.16%) and pulses (2.38%), where as in case of monetary loses, the oilseed contributed highest monetary loses of Rs. 20.49 billion followed by cash crops (Rs. 14.15 billion), cereals (Rs. 12.41 billion) and pulses (Rs. 2.08 billion). For getting optimum production from saline area of Gujarat, the region wise reclamation and management option suggested. These area cultivation of salt tolerant varieties and use sub-surface drainage in Central Gujarat and North Gujarat, cultivating salt tolerant varieties, horticultural species and use sub-surface drainage in South Gujarat and Saurashtra and cultivating salt tolerant varieties and alternative land use in Kutch region.

Saline soils of the State deserve immediate attention and need to be reclaimed/managed to minimize the losses by adoption of suitable location specific soil reclamation/management techniques along with proper crop management practices. Reclamation and management of saline soils will definitely bring a significant improvement in socio-economic conditions and livelihood security of resource-poor farmers living in the State.
Evaluation of Composts as Mixture with Lime and Ash for Nutrition of Tomato After Winter Rice

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A field experiment was carried out at Assam Agricultural University, Jorhat, Assam research farm to evaluate the growth and yield of tomato (Lycopersicon esculentum Mill.), variety - Avinash, and soil fertility status after harvest of the crop. Seven treatments were evaluated comprising recommended doses (75:26.2:50 kg ha-1 N:P:K) of fertilizers (RDF) and 10 t ha-1 farmyard manure (FYM), ½RDF as mixture with vermicompost (1 t ha-1), vermicompost 1 t ha-1 or farmyard manure (FYM) 2.5 t ha-1 mixed with quick lime (CaO) powder (10 kg ha-1) and wood ash (1 kg ha-1), vermicompost 1 t ha-1 or FYM 2.5 t ha-1 mixed with quick lime powder (20 kg ha-1) and wood ash (2 kg ha-1), keeping an unfertilized plot as control. The treatments were replicated thrice in a randomized block design with individual plot size of 3.0 m x 2.7 m on a sandy loam soil with pH 5.5, organic carbon 7.2 g kg-1, available N 246.2 kg ha-1, P 8.2 kg ha-1, K 166.5 kg ha-1, NH4-N 41.8 mg kg-1 and NO3-N 18.3 mg kg-1. Twenty five days old seedlings of tomato were planted on 10th January in 2015 and 13th January in 2016 at a uniform spacing of 30 cm between plants and 50 cm between the rows. Application of FYM 2.5 t ha-1 mixed with quick lime powder 20 kg ha-1 and wood ash 2 kg ha-1 produced significantly higher fruit yield of tomato over rest of the treatments. Recommended practice of nutrient management was at par with vermicompost-lime-ash (1000-10-1 kg ha-1) and FYM-lime-ash (2500-10-1 kg ha-1) mixtures. The lowest fruit yield of tomato was recorded in the unfertilized plot and was at par with vermicompost-lime-ash (1000-10-1 kg ha-1) mixture. The available N content after harvest of tomato was not affected by the treatments. The available P and K contents were significantly higher in fertilized plots compared to the control plot, but without any statistical difference among them after harvest of the crop. The soil pH and concentrations of nutrients significantly differed 1t 30 and 60 days after planting of tomato due to application of FYM-lime-ash mixture, irrespective of doses. The FYM-lime-ash (2500-10-1 kg ha-1) mixture performed at par with recommended practice in terms of fruit yield and better in B:C ratio when evaluated in farmer’s field.
Variations in Soil Properties Under Multipurpose Tree Species in Hot Arid Rajasthan

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Tree plantation is known to bring changes in edaphic, micro-climate, floral and other components of ecosystem recovery process through bio-recycling of mineral elements, micro-climate modification, changes in vegetation composition etc. Inclusion of tree species in agricultural systems can also optimize the nutrient recycling and have positive effects on soil physical and chemical properties. Under trees considerable amount of nutrients are incorporated into soil through litter fall and it's recycling which in turn improve the nutrient reserve of the soils. Tree species like Prosopis cineraria, Tecomela undulata and Acacia senegal due to their drought hardiness, resistance to inhospitable climate and assured economic returns are considered excellent for arid land conditions. These tree species can be grown on soils having poor fertility, moisture deficit and high soil temperature. The present paper discusses effect of these tree species on the physico-chemical properties of soils under arid environment. The plantations of Acacia senegal and Prosopis cineraria were even aged, while that of Tecomella undulata was relatively young. The soils had an overall status of OC, P and K as low (<0.50%), low to medium (8.2-15.7 kg ha⁻¹), medium to high (276-498 kg ha⁻¹), respectively. There was improvement in water holding capacity and decrease in surface soils bulk density under these tree species when compared to control field (bare field without any plantation/vegetation). Slight decrease in pH of the soils under these tree species was noticed, whereas changes in EC were not appreciable. Significant improvement in soil organic carbon (0.12 to 0.27%), available phosphorus (9.7 to 13.36 kg ha⁻¹) and Potassium (336 to 393 kg ha⁻¹) was found under these tree species compared to control field. The content of Fe, Mn, Zn and Cu was 15, 31, 101 and 86 per cent higher under these tree species than the control field. The amount of nutrients returned to the soils through litter fall followed the order of Ca>K>Mg>P>Fe>Mn>Zn>Cu under tree species and variation in the amount of nutrient returned to the soils among the different tree species and control field explained by the quantity of litter production and its chemical composition. Available nutrient content both were significantly correlated with SOC content which is mainly due to increase in the available exchange sites for nutrients and increase in the formation of clay humus complexes.
Agronomic Biofortification of Wheat Grain with Zinc through Zinc Fertilization in Northern India

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Wheat provides a fifth of humanity’s food. India produces 13% of wheat production in world. Currently 36.5% of Indian soils suffer from Zn deficiency which might further escalate to 51.2% if soils under marginal deficiencies are brought under intensive cultivation. Zinc deficiency in soils does not only reduce crop productivity, but it also leads to low-Zn food causing human malnutrition. The problem is global; however, it is more acute in India as billions of people suffer from Zn malnutrition. To biofortify wheat grain with Zn through Zn fertilization. Effectiveness of wheat (Triticum aestivum L.) crop to be biofortified through foliar applications of ZnSO₄⋅7H₂O at boot and milk stages and basal Zn application at the time of sowing was investigated under field conditions at 25 sites across UP, HP, Pb and Haryana states of Northern India. The concentration of Zn in harvested whole grains was determined by AAS. Foliar spray of Zn fertilizer increased grain Zn concentration from 48 to 94% and 32 to 139% over no Zn across all sites during 2014-15 and 2015-16, respectively. A pooled cluster analysis data showed significant mean increase in grain Zn concentration with foliar spray of Zn (35.2 mg kg⁻¹) than with no Zn (18.9 mg kg⁻¹). Grain yield of wheat varied across years and among the selected field locations. Soil Zn addition gave higher grain yield followed by foliar Zn as compared to no Zn treatment. Foliar spray of Zn produced the highest agronomic efficiency, Zn use efficiency apparent recovery of Zn and utilization efficiency as compared to soil Zn application. The present field study clearly showed that wheat grain can be very easily bio-fortified by nearly two-fold by foliar application of Zn fertilizers. A novel and low cost fastest approach of agronomic biofortification of wheat grain with Zn was validated. This agricultural intervention strengthens the links between agricultural research and nutrition.
Role of Manganese Biofortification on Growth and Yield of Wheat

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Wheat is one of the most important staple food in the world. Wheat (*Triticum aestivum* L.) is originated from South West Asia, belongs to the family *Gramineae*. It’s value in human diet is in both as a source of carbohydrates and protein. It provides approximately 20 per cent of total calories for human. Wheat grain contains 12.2 per cent protein, which is more than other cereals. Manganese is essential for photosynthesis, carbohydrate formation, sugar formation and chlorophyll formation. Manganese materials are easily remobilized and leached by precipitation and often accumulate in sub-soil layers. So, increase the productivity of wheat, nutrient management is one of the most important factor. Asset this, field experiment was carried out at micronutrient project (ICAR) farm to study the effect of soil application of Mn besides their scheduled foliar application at different concentrations with the perspective of Biofortification of wheat with Mn. The field experiment was taken with ten treatments and four replication under randomized block design. The results showed that external supplementation of Mn in wheat through Foliar MnSO4 were found effective in increasing grain, straw and root yield over their soil application MnSO4. Soil + foliar application of Mn also proved to be significance higher over its both individual applications. The study further indicated that enrichment of wheat grain yield with Mn was best accomplished by soil application of Mn at 20 kg MnSO4 ha-1 followed by its three foliar sprays at 0.5% caused substantial increase in its uptake by wheat. Similarly, the straw yield and root biomass were higher by its soil + foliar application i.e. 20 kg MnSO4 ha-1 + three foliar spray at 0.5% of MnSO4.
Improvement in Zinc Delivery for Wheat Crop Employing Engineered Nanoparticles

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Nano materials can be used in producing more soluble and diffusible sources of Zn fertilizers. Higher specific surface area and reactivity of ZnO-NPs compared to bulky ZnO may improve Zn solubility, diffusion in soil and hence better Zn availability to plants. 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. To evaluate the effectiveness of different concentrations of ZnO-NPs on plant growth attributes, grain yield and final Zn levels in wheat crop compared with conventional delivery of Zn. Solution culture and greenhouse experiments were carried out to study the impact of ZnO-NPs with a mean particle size of 30 nm on wheat plant growth traits, Zn concentration and yield. For comparative study, different concentrations of ZnO-NPs were used as compared to conventional ZnSO₄·7H₂O (10 mg kg⁻¹) fertilizer and control (no Zn). The highest root and shoot length, dry weight and grain yield was recorded with the application of nanoscale ZnO at 2.5 mg kg⁻¹ which shows higher growth and yield differed from that of ZnSO₄ and control thus confirming better interaction between nanoparticles and rhizosphere. The highest germination percentage of 94 was observed when the wheat seeds were treated with the nanoscale ZnO at 200 mg kg⁻¹ respectively; and it was significantly more than that of control and ZnSO₄. Higher doses of ZnO nanoparticle had negatively influenced the plant growth and yield parameters. The delivery of Zn through ZnO-NPs resulted in positive effect on seed germination, root and shoot growth, seedling vigour index, number of tillers, had higher chlorophyll content, Zn concentration and grain yield. Application of ZnO-NPs supplied Zn, had higher use efficiency, better plant growth and significantly improved the yield. Delivery of Zn nutrient through ZnO nanoparticles in right dose and of the right size could be effective and beneficial in enhancing the growth and yield attributes of wheat crop. There is a possibility of reducing dose of Zn using nanostructured fertilizer like ZnO-NPs.
Effect of Grey Water Irrigation and Soil Application of Lignite Humic Acid on the Performance of Radish

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A pot experiment was conducted to establish the effect of grey water irrigation and humic acid application on the yield and nutrient uptake by radish. The experimental soil analyzed sandy loam texture, pH 7.2, EC 0.19 dS m⁻¹, CEC 15.6[c mol(p⁺) kg⁻¹], low in organic matter 4.9 g kg⁻¹, available N(123.0 mg kg⁻¹), available P (4.5 mg kg⁻¹) and medium in available K (90 mg kg⁻¹). Calculated quantities of NPK were supplied though urea, superphosphate and muriate potash so as to supply a uniform N: P: K dose of 50:30:50 kg ha⁻¹. The treatments consisted of two types of irrigation water viz, bore well water and grey water and four levels of lignite humic acid (0, 15, 30, 45 mg kg⁻¹). The LHA extracted from Neyveli lignite was used for this experiment. The LHA was applied as K-humate by dissolving calculated quantity of LHA in 0.1N KOH to the respective pots. Each treatment was replicated six times. Radish var. Pusa Chetki was grown as test crop. Four plants in each pot were maintained and allowed to grow up to maturity and, harvested at 45 DAS. Growth and yield parameters were recorded at appropriate stages of crop growth. The soil samples collected at harvest were analyzed for available NPK and S, exchangeable Ca and Mg, DTPA extractable Fe, Mn, Zn and Cu as well as DTPA extractable heavy metals namely Cr, Pb, Ni and Cd. The post-harvest soil samples were also analysed for fecal Coliforms. Soil application of LHA @45mg kg⁻¹ to grey water irrigated plants increased the tuber and leaf yield to the tune of 123.89 and 180.28 per cent. Soil application of LHA to grey water irrigated plants increased the uptake of N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and reduced the uptake of Cr, Pb, Ni and Cd by radish.
Performance of Cotton Cultivars Grown in Soils Irrigated with Saline Water

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Crops and their cultivars differ considerably in their ability to tolerate salinity. Except at germination stage, cotton in general, can tolerate excessive salts during its different growth stages. Therefore, the present investigation was conducted to test the performance of three cotton cultivars in soils irrigated with different levels of salinity at the experimental farm, Punjab Agricultural University, Ludhiana from 2015-2017. The field soil was loamy sand (Typic Ustochrept) having pH (1:2 soil and water) 8.02 and organic carbon 2.8 g C kg⁻¹. Five levels of saline water (EC0, 3, 6, 9, 12 dS m⁻¹) were used for irrigating three cotton cultivars (LH-2076, Ankur 3028 and RCH 650) during the trial period. Each treatment was replicated thrice in a completely randomized design. The results revealed that increasing salinity of irrigation water significantly increased soil pH and EC in all three years of experimentation. Electrical conductivity of soil under highest level of saline water irrigation (EC12 dS m⁻¹) was found to be 7-8 times more as compared to where non-saline water was applied. Yield parameters were adversely impacted due to elevated salinity levels of irrigation water. Pooled over three years, among different cultivars of cotton, the maximum cotton yield was produced by Ankur 3028 (20.94 q ha⁻¹) even at highest level of saline water (EC12 dS m⁻¹) whereas lower cotton yields were recorded for RCH-650 and LH-2076 (15.31 q ha⁻¹ and 14.34 q ha⁻¹) respectively. The results suggested that performance of Ankur 3028 was better at all levels of applied saline irrigation water compared to other cultivars grown over a period of three years.
Effect of Cyclic Use of Sodic and Canal Water for Irrigation - Development of Soil Quality Indices

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Anthropogenic reductions in soil health, and of individual components of soil quality, are a pressing ecological concern. Soil quality as influenced by cyclic use of sodic and non-sodic canal water for irrigation was studied in a 16-year long term cotton-wheat experiment. The treatments were irrigation with CW, irrigation with SW (residual sodium carbonate (RSC10 me L⁻¹) and different combinations of CW and SW applied in a cyclic mode starting with CW or SW. Soil quality index (SQI) computed on the basis of scores assigned to 20 variables and principal component score based on 14 variables revealed that CW irrigation was the best in terms of achieving better soil quality while irrigation with SW resulted in the minimum soil quality. Cyclic irrigation treatments with 2CW (2CW:SW; SW:2CW) significantly improved soil quality followed by treatments with one CW and one SW alternated in a cycle (CW:SW; SW:CW). Minimum improvement in soil quality over SW alone treatment occurred in 2SW treatment (CW: 2SW; 2SW:CW). Soil quality index and principal component score were significantly correlated with wheat yield and explained 81 and 72% variation in yield, respectively. Crop productivity was as adequately explained by either soil ESP or SAR only (82%) and by soil pH or OC (~73%). Principal component analysis revealed that soil pH, ESP and SAR were the most promising indicators of soil quality and crop productivity in a sodic environment created due to cyclic use of canal water and sodic water for irrigation in cotton-wheat rotation in NW India.
Effect of Fertigation in Soybean Productivity

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A field experiment was conducted to study the effect of fertigation in soybean productivity during kharif, 2016 and 2017 at Tribal Research cum Training Centre, Anand Agricultural University, Devgadhbaria, Dist. Dahod. Seven treatments (T1: Fertigation at flowering (50% RDF) as basal + 50% RDF through fertigation; T2: Fertigation at pod initiation (50% RDF as basal + 50% RDF through fertigation); T3: Fertigation at seed filling (50% RDF as basal + 50% RDF through fertigation; T4: Irrigation at flowering (RDF as basal); T5: Irrigation at pod initiation (RDF as basal; T6: Irrigation at seed filling (RDF as basal) and T7: Flat sowing (RDF as basal). The application of RDF as basal and irrigation at flowering, pod initiation and seed filling stages increased the soybean yield to the tune of 25.89%, 12.99% and 10.57% as compared to irrigation and RDF as basal, respectively. When 50% RDF as basal and 50% as fertigation at flowering, pod initiation and seed filling stage further enhanced the seed yield to the extent of 32.26%, 15.86% and 12.90% over RDF, respectively. The fertigation system produced 3.30% higher yield than irrigation system (averaged over treatments). When comparing the fertigation and irrigation system, fertigation at flowering (5.05%). Fertigation at pod initiation (2.53%) and fertigation at seed filling (2.21%) produced higher yield than irrigation.

Harvest index, branches/plant and seed index remained at par due to different treatments. Fertigation at flowering produced maximum dry matter at different stages, CGR, RGR, straw yield, RUE net returns and B:C ratio and nutrient exhaustive. Fertigation at seed filling stage possesses the higher values of dry matter and CGR at all the stages. The highest nutrient uptake was with fertigation at seed filling stage.
Growth and Yield Response of Basmati Rice to Soil and Foliar Zinc Application

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Rice is an important staple food crop which is satisfying human daily calorie intake and zinc (Zn) deficiency is a vital factor that determines rice production. Keeping in view this, a field study was conducted at research farm of Regional Research Station, Gurdaspur, Punjab Agricultural University, Ludhiana during Kharif 2016 to evaluate the effect of zinc fertilization on growth and yield response of Basmati rice under zinc deficient and sufficient site. The experiment was conducted in a split plot design, keeping two rice varieties as main-plot treatments and seven zinc fertilization treatments viz, T1- control, T2 - 3.12 kg Zn ha⁻¹, T3 - 6.25 kg Zn ha⁻¹, T4 - 12.5 kg Zn ha⁻¹, T5 - 25 kg Zn ha⁻¹, T6 - soil application of Zn @ 6.25 kg ha⁻¹ through ZnSO₄·7H₂O + 0.5% foliar spray of ZnSO₄·7H₂O at pre-anthesis stage, T7 - soil application of Zn @ 6.25 kg ha⁻¹ through ZnSO₄·7H₂O + 0.5% foliar spray of ZnSO₄·7H₂O at pre-anthesis stage + 0.5% foliar spray of ZnSO₄·7H₂O at post-anthesis stage in sub-plots with three replications. Among the growth parameters plant height, effective tillers per plant and panicle length increased with increasing Zn levels at both the sites whereas test weight (1000 grain weight) showed significant increase with increasing zinc levels in zinc deficient site and non-significant increase in zinc sufficient site. Pusa Basmati 1121 recorded higher grain yield than Punjab Basmati-2 whereas higher straw yield was obtained for Punjab Basmati-2 at both the sites. An increase of 26% and 9.4% in grain yield of basmati rice with zinc fertilization over control was noticed in zinc deficient and sufficient site. A non-significant increase in grain and straw yield was there in zinc sufficient site with increasing Zn levels might be due to enough inherent Zn availability in Zn-sufficient site for metabolic and growth processes. Maximum grain and straw yield was recorded in treatment where 25 kg Zn ha⁻¹ was applied whereas significant increase was found in treatment where 3.12 kg Zn ha⁻¹ (T2) was applied followed by 6.25 kg Zn ha⁻¹ (T3) and 12.5 kg Zn ha⁻¹ (T4) with grain yield of 29.61 q ha⁻¹, 31.51 q ha⁻¹ and 33.59 q ha⁻¹, respectively. Grain and straw yield in soil plus foliar applications (T6 and T7) did not differ much than soil applied Zn treatment of 12.5 kg Zn ha⁻¹ (T4). Thus, zinc application alone or combined application of zinc through basal and foliar can lead to better growth and higher grain yields of basmati rice especially in zinc deficient areas.
Effect of Soil Application of Fe and Zn on Yield of Two Rice Varieties

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An investigation entitled “Effect of soil application of Fe and Zn on yield and quality of two rice varieties” was carried out during kharif, 2014 at Department of Natural Resources Management, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari. The present pot trial consisting of 20 treatment combinations involving two varieties (V1: GNR-4, V2: IET-23833) and ten micronutrient levels (M0:- Control, M1:- 2.50 mg Fe kg$^{-1}$, M2:- 5.00 mg Fe kg$^{-1}$, M3:- 7.50 mg Fe kg$^{-1}$, M4:- 10.00 mg Fe kg$^{-1}$, M5:- 1.25 mg Zn kg$^{-1}$, M6:- 2.50 mg Zn kg$^{-1}$, M7:- 3.75 mg Zn kg$^{-1}$, M8:- 5.00 mg Zn kg$^{-1}$, M9:- Grade 5 @ 12.0 mg kg$^{-1}$) was conducted in FCRD with three repetitions. The experimental results revealed that variety V 2 (IET-23833) performed significantly superior over V 1 (GNR-4) with respect to growth parameters viz., plant height (126.9 cm), number of tillers hill$^{-1}$ (15.67) and number of effective tillers hill$^{-1}$ (14.33) as well as 1000 grain weight (20.7 g) at harvest of rice crop. However, variety V 1 recorded 52.9 and 32.5 per cent higher grain (84.1 g pot$^{-1}$) and straw (88.4 g pot$^{-1}$) yields, respectively, as compared to variety V 2. Among the micronutrient levels, treatment M 7 (3.75 mg Zn kg$^{-1}$) recorded 8.19, 7.98 and 6.30 per cent more plant height than control (M0) at 60 DAT, 90 DAT and at harvest, respectively. Whereas, the treatment receiving 7.5 mg Fe kg$^{-1}$ (M3) recorded significantly more number of tillers hill$^{-1}$ (16.17) and number of effective tiller hill$^{-1}$ (14.83) at harvest of rice. However, all the growth parameters remained at par with majority of the treatments receiving micronutrient. Among the micronutrient treatments, M3 produced significantly higher grain and straw yields of rice i.e., 73.5 and 80.8 g pot$^{-1}$, respectively in comparison to control (64.2 and 73.3 g pot$^{-1}$), but it was at par with treatments M5, M6, M8 and M7. As compared to control, the extent of increase in grain yield with micronutrients treatments M2, M3, M4, M5, M6 and M7 was 12.1, 14.4, 10.9, 8.8, 11.0 and 9.5 per cent, respectively. Hence, it was appear that variety GNR-4 was found superior with respect to grain and straw yields of rice.
Effect of Soil Application of Fe and Zn on Nutrient Content and Uptake by Two Rice Varieties

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An investigation entitled “Effect of soil application of Fe and Zn on nutrient content and uptake by two rice varieties” was carried out during kharif, 2014 at Department of Natural Resources Management, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari. The present pot trial consisting of 20 treatment combinations involving two varieties (V1: GNR-4, V2: IET-23833) and ten micronutrient levels (M0:- Control, M1:- 2.50 mg Fe kg⁻¹, M2:- 5.00 mg Fe kg⁻¹, M3:- 7.50 mg Fe kg⁻¹, M4:- 10.00 mg Fe kg⁻¹, M5:- 1.25 mg Zn kg⁻¹, M6:- 2.50 mg Zn kg⁻¹, M7:- 3.75 mg Zn kg⁻¹, M8:- 5.00 mg Zn kg⁻¹, M9:- Grade 5 @ 12.0 mg kg⁻¹) was conducted in FCRD with three repetitions. The experimental results revealed that variety V2 recorded significantly higher content of Ca (0.211%), Fe (136.5 mg kg⁻¹), Mn (22.5 mg kg⁻¹) and Zn (78.2 mg kg⁻¹) in grains as compared to variety V1 with an exception of P (0.18%) which was significantly higher in V1. In case of straw portion also, significantly more content of P, Ca, Zn and Cu was recorded in variety V2 than V1, but it was not true for Mg, Fe and Mn content. As far as micronutrient levels are concerned, application of either Fe (M1 to M4) or Zn (M5 to M8) significantly increased the N, P, Fe and Zn content in all parts (grain, straw and root) of rice as compared to control. With respect to nutrient uptake, significantly higher uptake of N, P, K, Ca, Mg, Fe, Mn and Cu by grain and straw was registered in variety V1, while variety V2 registered significantly higher uptake of Zn by both grain and straw of rice. Further, most of the treatments receiving Fe and Zn, removed significantly higher amount of all the determined nutrients from soil, as indicated in higher content in grain and straw of rice as compared to control.
SQI Assessment for Alternate Cropping Sequence in PAP Command Area of Tamil Nadu

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Considering the water scarcity and higher cost of cultivation, when an existing cropping sequence cannot be followed for upcoming years and its continuous adoption may lead to deterioration of soil quality, a soil quality assessment is required and an index is to be developed to select an alternate cropping sequence in order to effectively utilize the natural resources and also to stabilize the productivity and sustainability of soil health. With this view, for assessing the soil quality and selecting alternate cropping sequence to the existing rice - rice - green manure cropping sequence to the Parambikulam Aliyar command area (1.74 lakh ha) situated in Annamalai’s range of Pollachi hills in Coimbatore district the present investigation was taken up.

To study these objectives, a field experiment was carried out at Coconut Research Station, Aliyar nagar, Pollachi (Tk.), Coimbatore (Dt.), Tamil Nadu during 2016-2017 with seven alternate cropping sequences viz., Rice - Sunflower (T1), Rice - Sesame (T2), Rice - Black gram (T3), Rice - Castor (T4), Rice - Maize (T5), Rice - Onion (T6) and Rice - Groundnut (T7) in Randomized Block Design with three replications. Rice was chosen as kharif season crop and for second season (rabi), the sequential crops were cultivated and the post harvest soils were collected for evolving the soil quality index. A positive impact on fertility value (soil physical, chemical and biological properties) of the soil was registered in T4 followed by T7 and T5 cropping sequences. The SQI was evolved for seven cropping sequences and the higher SQI registered in Rice - Castor (T4) followed by Rice - Groundnut (T7) and Rice - maize (T5) cropping sequences which were on par. From the results of the present investigation, considering the quantity of water consumption, economic yield, soil quality sustainability and B:C ratio, the best alternative cropping sequence recommended for Parambikulam Aliyar command area is in the order of Rice - Castor/Rice - Groundnut/Rice - Maize cropping sequences.
Impact of Rice Establishment Methods, Tillage and Rice Straw Management Practices on DTPA-extractable Micronutrient Cations Under Rice-wheat Cropping System

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Puddling in rice and intensive tillage in wheat are known to cause deterioration of soil structure and decrease in permeability in the subsurface layer and thereby adversely affecting the availability of nutrients as well as productivity of rice-wheat system. Zero tillage with rice residue retained on soil surface improve overall soil physical and chemical health through replenishing soil organic matter which lead to increase in availability of macro and micronutrients (Zn, Cu, Fe and Mn) and help to support sustainable rice-wheat system. The knowledge of different conditions under which the micronutrient cations (Zn, Cu, Fe and Mn) become available to plants is very important. Therefore, the present investigation was planned with the prime objective to estimate the effect of different tillage practices and rice establishment methods on DTPA-extractable micronutrient cations under rice-wheat system.

The present study was carried out under an on-going field experiment at Department of Soil Science, Punjab Agricultural University, Ludhiana in split plot design with three replications. The soil of experimental field was loamy sand in texture, taxonomically classified as Typic Ustrochrept. The experiment comprised of twelve treatment combinations. The main plots consisted of four rice establishment methods viz. direct seeded rice under zero tillage (DSR-ZT), conventional tillage (DSR-CT), reduced tillage (DSR-RT) and puddled transplanted rice (PTR) and three subplots in wheat viz. conventional tillage without rice straw (CTW-R), zero tillage without rice straw (ZTW-R) and zero tillage with rice straw (ZTW+R). In this study, soil samples were collected from each treatment with auger, processed in the laboratory and analyzed for different chemical pools of micronutrients using sequential extraction procedure. The concentration of DTPA-extractable micronutrients (Zn, Cu, Fe and Mn) was determined with atomic absorption spectrophotometer (Varian AAS FS 240 Model).

Among the different tillage practices in wheat, DTPA-extractable Zn was found to be significantly higher in ZTW+R as compared to ZTW-R. Santiago et al (2008) reported that availability of DTPA-extractable Zn were higher under ZT with crop residues as compared to CT.DTPA-extractable Fe and Mn were found higher under PTR as compared to DSR-RT, DSR-ZT and DSR-CT, whereas the DTPA-extractable Zn was found lower under PTR and higher under DSR-RT. The DTPA-Cu did not showed significant effect under main plot treatments during both the years. The DTPA-extractable Zn, Cu and Fe content found to decrease with increase in soil depth, however, the DTPA-extractable Mn content showed increase with increase in soil depth. Under tillage and rice straw management practices in wheat, ZTW+R found as the better treatment as it increased the availability of DTPA-extractable micronutrient cations (Zn, Cu, Fe and Mn) as compared to ZTW-R and CTW-R. Prasad et al (2010) found that incorporation of residue both rice and wheat significantly increased DTPA-extractable micronutrients content in surface (0-15 cm) soil due to build up in organic carbon in soil.
Enrichment of Wheat (*Triticum aestivum* L.) and Rice (*Oryza sativa* L.) Grains with Zn and Fe Through Ferti-fortification

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Agricultural research, during the last four decades, has largely been focused on increasing food production to meet the food needs of the escalating population. The green revolution ushered by the adoption of intensive agriculture using modern agricultural techniques together with the introduction of fertilizer responsive high yielding crop varieties, however, brought in its wake the micronutrient malnutrition in humans, particularly with respect to zinc (Zn) and iron (Fe). At present, the people are not starving in great number from energy deprivation but are becoming more malnourished day by day. Micronutrient malnutrition particularly that of Zn and Fe, is presently of alarming proportions in many developing nations. The use of the modern cereal cropping systems in many developing nations has given rise to decreased per capita production of foods having higher micronutrient density. This has resulted in lower availability of micronutrient-rich food in many regions of the world. More than two billion people in the world are suffering from sub-clinical deficiencies of Zn and Fe because of the low contents of these micronutrients in their diet that includes cereals like wheat and rice grains. Tackling the problem of micronutrient malnutrition to human health is the serious challenge for the scientists in the new millennium. The genetic manipulation can be an alternative to supplementation and/or fortification. Breeders have been making efforts on this front but there have been no specific studies on enriching the grains of cereals with Fe and Zn through exogenous application of these micronutrients to the concerned crops.

The present investigation was therefore, taken up to study the effect of foliar applied Zn (0.5%) and Fe (0.5%) on the productivity of different wheat varieties and their enrichment in wheat grains. To fulfill the objective that foliar applied Zn and Fe is better option for enrichment of wheat grains, a field experiment was conducted in Department of Soils, PAU, Ludhiana for two consecutive years (2013-14 to 2014-15). The soil of the field was loamy sand (*Typic Ustochrept*) having pH 7.8 and EC 0.12 dSm⁻¹. Also the soils were low in organic carbon (0.34%) and available nitrogen (252 kg ha⁻¹) but medium in Available phosphorus (15.8 kg ha⁻¹) and available potassium (184 kg ha⁻¹). The research was carried out with a prime objective to enrich wheat grains with Zn and Fe through their foliar application. Five wheat varieties *viz.* PDW 274, PDW 291, PBW 343, PBW 502 and PBW 550 were selected for experimental study. These include both durum and aestivum varieties. Four foliar sprays @ 0.5 per cent each of Zn and Fe were applied at different stages of wheat growth starting from maximum tillering, flower initiation, milk and dough stages. Similarly, paddy nursery was sown in the first week of May. The 45 days old paddy seedlings were transplanted in the field. Five cultivars of paddy *viz.* PR 113, PR 114, PR 115, PR 116 and PAU 201, were transplanted in second week of June. A basal dose of 120, 30 and 30 kg ha⁻¹ N, P₂O₅ and K₂O respectively was applied through urea, diammonium phosphate and muriate of potash on soil test basis. The treatments were controls for zinc (- Zn) and iron (- Fe) and three foliar sprays each of 0.5% zinc sulphate (+Zn) and ferrous sulphate solution (+Fe). Three foliar sprays of Zn and Fe were applied at different growth stages starting from maximum tillering stage and before and after the flower initiation stages. The first spray of Zn and Fe was applied at maximum tillering stage whereas, the second and third sprays were made before and after flower initiation stages, respectively.
For estimation of micronutrients (Zn and Fe) content in grain, 0.5 g grain sample was digested using diacid mixture (HNO₃:HClO₄:: 4:1) as per method. After proper dilution with double distilled water, the micronutrient content in digested materials was estimated by using an atomic absorption spectrophotometer (AAS). The experiment was designed in a randomized block design.

In field experiments conducted on wheat and rice cereal crops from 2007-2010 at Research Farm of Punjab Agricultural University, Ludhiana showed that increase in Zn and Fe content of their grains was minimum with their soil application compared with foliar application. Ferti-fortification of wheat and rice grains with Zn and Fe is better way to increase their concentration in grains. The results of wheat and rice crops reported that ferti-fortification of Zn and Fe was even more effective than their application to soil environment in providing the Zn and Fe for transport to wheat and rice grains indicating that ferti-fortification with Zn and Fe in cereal crops can be effective in increasing Zn and Fe concentration in their grains. This research paper will explore the possibilities of enhancement of Zn and Fe concentrations in rice and wheat grains through ferti-fortification.

Foliar application of Zn and Fe significantly increased the grains yield of wheat grains varying from 2.5-5.1%. Irrespective of durum or aestivum varieties, the results of the study indicated that 17.3-38.8% enrichment with Zn and 13.1-30.3% of Fe is possible through foliar application of inorganic sources of Zn (ZnSO₄.2H₂O) and Fe (FeSO₄.2H₂O) respectively. The data further showed that foliar application each of Zn and Fe @ 0.5 per cent at different stages of wheat growth significantly increased the grain yield and concentration of Zn and Fe in grains. Foliar application of 0.5% each of Zn and Fe separately at different stages of wheat growth significantly increased the grain yield of wheat and the maximum grain yield of 63.1 q ha⁻¹ (PBW 550) and 62.5 q ha⁻¹ (PBW 343) were reported with Zn were 8.2 and 4.3 per cent higher than control, respectively. On the other hand, four foliar application of Fe increased the grain yield up to 61.4 q ha⁻¹ (PBW 343) and 60.6 q ha⁻¹ (PBW 550) which were 2.5 and 2.2 per cent higher than control, respectively. The uptake of Zn and Fe micronutrients increased significantly with foliar application of Zn and Fe over control. All the wheat varieties showed significant increase in Zn and Fe concentrations over control.

Ferti-fortification of paddy with Zn and Fe played a pivotal role in enhancing their content in five cultivars of paddy. All the five cultivars of paddy viz. PR 113, PR 114, PR 115, PR 116 and PAU 201 recorded an increase over control in paddy, Zn and Fe accumulation in paddy (with husk) and brown rice (without husk), and their uptake with foliar application of Zn and Fe. Ferti-fortification of paddy with 0.5% foliar sprays of Zn and Fe resulted in 7.0 and 8.6 per cent increase in paddy yield respectively, over control. Foliar application of 0.5% Fe significantly increased the yield of paddy cultivars varying from 6.9-10.3 per cent. Irrespective of cultivars, the results of the present study indicated that 30.8-44.8 per cent increase in Zn concentration and 22.3-38.2 per cent of Fe concentration is achievable through foliar application of inorganic sources of Zn (ZnSO₄.7H₂O) and Fe (FeSO₄.7H₂O), respectively. The data further showed that foliar application of 0.5% Fe significantly increased the Fe content of husk and its maximum content was reported in cultivar PAU 201 (432 mg kg⁻¹) with an average increase of 378 mg kg⁻¹). Brown rice can accumulate higher Zn (47 mg kg⁻¹) than its husk (29 mg kg⁻¹) whereas, paddy husk can translocate higher Fe (378 mg kg⁻¹) than brown rice (24 mg kg⁻¹). Our results reported that the paddy husk could retain 16 times more Fe than its brown rice (without husk) whereas, brown rice had 1.6 times more Zn than its husk part.
Interactive Effects of Saline and Sodic Water Irrigation and Crop Residue Incorporation on Soil Biochemical Properties under Rice-wheat Cropping System

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Soil degradation resulting from salinity and sodicity is a major environmental constraint with severe negative impacts on soil fertility and agricultural productivity. A long term field experiment was carried out to study interactive effects for saline/sodic irrigation in rice and crop residue incorporation in wheat in a split plot design on soil biochemical properties in a rice-wheat cropping system. Soil samples were collected from two soil layers (0-5 cm and 5-10 cm) after the harvest of wheat crop for soil physico-chemical and soil biochemical properties. The results showed that sodic + gypsum (SW3) decreased pH, EC and SAR and increased oxidisable soil organic carbon, available phosphorus, dehydrogenase and alkaline phosphatise activity in both soil layers as compared with sodic (SW2) and saline (SW4) water irrigation. Irrespective of water quality, incorporation of crop residues resulted in decreased pH, EC and SAR and increased oxidisable soil organic carbon, available phosphorus, dehydrogenase and alkaline phosphatise activity in both soil layers. The order of change observed was rice + wheat residues > rice residue > wheat residue > without residue. The results of the present study indicated that soil biochemical properties could be used as potential soil health indicators in water quality and incorporation of crop residue treatments under rice-wheat system.
Assessment of Groundwater Quality of Chittorgarh District of Rajasthan

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A survey was conducted during pre monsoon season of the year 2017 in Chittorgarh district of Rajasthan to assess the groundwater quality and it was found that the well depth of groundwater varied from 7.00 m bgl to 30.20 m bgl with an average value of 16.69 m bgl whereas groundwater levels of Chittorgarh district varied from 3 m bgl to 25 m bgl with an average value of 12.34 m bgl. TDS of groundwater of Chittorgarh district varied from 110 to 2920 ppm with a mean value of 600 ppm. pH of groundwater varied from 7.00 to 9.40 with mean value of 7.70 whereas the electrical conductivity of groundwater varied from 0.17 to 4.56 dSm⁻¹ with a mean value of 0.94. Based on the electrical conductivity of groundwater 1.49% groundwater sample falls under low salinity class (C₁), 44.03% samples falls under medium salinity class (C₂), 50.00% groundwater samples falls under high salinity class (C₃) and 4.48% falls under very high salinity class (C₄). Concentration of cations: Ca²⁺, Mg²⁺, Na⁺ and K⁺ were found 0.20 to 6.20, 0.60 to 7.20, 0.25 to 28.52 and 0.10 to 3.60 meqL⁻¹, respectively. The concentration of anions (CO₃²⁻, HCO₃⁻, Cl⁻ and SO₄²⁻) were 0.00 to 4.80, 0.40 to 12.20, 1.00 to 24.00 and 0.15 to 4.50 meqL⁻¹. RSC of groundwater varied from nil to 5.20 meqL⁻¹ with a mean value of 1.48 meqL⁻¹. Based on RSC value of the groundwater 91.79% groundwater samples fall under normal water category. Sodium Adsorption Ratio (SAR) of groundwater water ranged between 0.18 to 12.92 with mean value of 3.37. Based on SAR value of the groundwater 94.78% groundwater samples falls under low sodium category of water. Hence, it is concluded that the nature of groundwater of Chittorgarh district is Na-Mg-Ca & Cl-HCO₃-SO₄ type and the possible dominant salt in groundwater is sodium chloride. Groundwater quality maps were prepared which may be useful for policy maker or planners for easy illustration and decision making.
Studies on Salinity Tolerance in Castor 
(Ricinus communis L.)

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Castor (Ricinus communis L.) (commonly known as Erand in Hindi) is an important non-edible oilseed crop of Euphorbiaceae family commercially grown in the semi arid and arid regions of Gujarat and Rajasthan. Oil content in castor seed varies from 45% to 51%, whereas castor cake/meal serves primarily as an organic fertilizer. The productivity of castor in India is highest in the world while Gujarat among Indian states. There is great scope of area expansion of castor in the coastal and salt affected areas of Gujarat vis-à-vis India. With aiming the select the suitable genotype which can tolerate salt content, a laboratory study was conducted at Castor Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar (Distt. Banaskantha) Gujarat. The soil selected for the experimental was sandy loam in texture; pH 7.3 (1:2.5); EC 0.21 dSm⁻¹; OC 0.18%. The salinity levels were raised to 4 dSm⁻¹ and 8 dSm⁻¹ as per method suggested by Central Soil Salinity Research Institute, Karnal. Twenty seeds of 50 genotypes were germinated in suitable size (60 cm x 45 cm) plastic trays. The seeds were allowed to germinate. The germination % were recorded at 10 days of experimentation and No seed was germinated after this period. The plant height was measured at 15 days of the experimentations.

Genotype 109, 114, 124, 126, 136, 137 could germinate under all salinity levels (upto 8 dSm⁻¹). The reduction in plant height was found minimum in genotype 126. Considering plant performance after germination, genotypes 114 and 136 are better.
Screening of Different Rice (*Oryza sativa* L.) Genotypes for Iron Efficiency

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Rice (*Oryza sativa* L.) is a most important food staple and energy source of more than half the world population. Iron (Fe) deficiency is the most common nutritional disorder in the globe affecting between 2 to 5 billion people. It is an important micronutrient which is essential for cellular growth and differentiation, oxygen binding, transport and storage, enzymatic reactions, immune function, cognitive function, mental and physical growth etc in human body. Therefore, it is necessary to identify the Fe efficient genotype having higher Fe concentration and their bioavailability in grain for improving the Fe intake in populations dependent on rice as a staple food. In order to evaluate Fe efficiency of rice genotypes, field experiment was conducted at Anand Agricultural University, Anand. Twenty eight diverse rice genotypes were evaluated in the field at three Fe levels viz. low (no fertilizer Fe), medium (10 kg Fe ha\(^{-1}\) soil application through iron sulphate) and high (20 kg Fe ha\(^{-1}\) soil applied through iron sulphate + three foliar sprays of 0.5% iron sulphate). Relative grain yield i.e. Fe efficiency index varied from 65.7 to 109% and relative grain Fe uptake i.e. Fe efficiency varied from 59.4 to 104% with a mean value of 89.7 and 79.4% respectively. Cultivar Swarna was having the highest Fe efficiency index as well as Fe efficiency. Based on grain yield and Fe efficiency, the genotypes were classified as efficient and responsive (Swarna, SLR-51214 and GR-13), efficient and nonresponsive (GR-11, GR-12, GR-3 and Ashoka), inefficient and responsive (Lalkad, Gurjari Palkhali-203 and GR-101) and inefficient and nonresponsive (GR-9, GR-102, AAUDR-1 and K- Kamod). The efficient and responsive genotypes are most desirable as they would yield more with higher Fe content under low Fe and also respond better to Fe additions.
Effect of Poor Quality Irrigation Water and Crop Residue Incorporation on Chemical Properties and Potassium Dynamics of the Soil

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The present research was conducted to study the influence of poor quality water irrigation and crop residue incorporation on physico-chemical properties and potassium dynamics of the soil. The long-term experiment (Since, 2006) had 16 treatments involving four irrigation water qualities; canal water irrigation (SW1), sodic water (SW2), sodic water plus gypsum (SW3) and saline water (SW4) and four crop residue regimes involving application of wheat straw @ 6 t ha\(^{-1}\) to rice crop (T1), rice straw @ 6 t ha\(^{-1}\) to wheat crop (T2), both rice and wheat straw @ 6 t ha\(^{-1}\) each (T3) and the unamended control (T4). Irrigation with sodic (SW2) and saline (SW4) water significantly increased soil pH, EC, soluble salts, sodium adsorption ratio (SAR), exchangeable sodium percentage (ESP) while application of gypsum with sodic water decreased pH, SAR and ESP in soil after wheat harvest in 2016-17. Saline and sodic water irrigation lowered all the potassium (K) fractions viz. water soluble K (WSK), exchangeable K (ExK), non-exchangeable K (NEK) in the soils, whereas application of crop residues increased these K fractions. The magnitude of increase in K fractions was more when both rice and wheat residues were incorporated (T3) in the respective seasons significantly increased all the K fractions over the unamended control (T4). The water soluble K and ExK decreased with depth while NEK and total K increased with soil depth. The study showed that the adverse effects of saline and sodic irrigation on K fertility can be effectively managed by incorporation of crop residues.
Effect of Soil and Foliar Application of Micronutrients on Growth, Yield and Nutrients Uptake by Tomato

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A field experiment was conducted on Typic Haplustert soils of Vegetable Research Farm, Junagadh Agricultural University, Junagadh, Gujarat, during 2013 to 2016 (Three years), to study the efficacy of multi-micronutrients formulation mixture fertilizers in improving crop production of tomato. The results revealed that the mean fruits (20.32 t ha⁻¹) and stalk (15.6 kg ha⁻¹) yields as well as Fe, Mn, Zn and Cu uptake by fruits and stalk of tomato were increased significantly due to soil application of FeSO₄ @ 15 kg ha⁻¹ and ZnSO₄ @ 8 kg ha⁻¹ as per soil test value (STV), follow by foliar multi-micronutrients supplementation through 1.0% spray of multi-micronutrients mixture Grade-IV having Fe-4.0%, Mn-0.1%, Zn-5.0%, Cu-0.5% and B-0.5% at 45, 60 and 75 days after sowing and which were statistically at par with each other but, significantly superior over control. The magnitude of increased in fruit yield were 26.0 and 20.9% owing to soil application of FeSO₄ @ 15 kg ha⁻¹ + ZnSO₄ @ 8 kg ha⁻¹ and foliar application of micronutrients mixture Grade-IV @ 1.0% at 45, 60 and 75 days after sowing over control, respectively. Significantly higher value of fruit length (5.4 cm), plant height (67.0 cm), No of fruits per plant (41.8), plant fruit girth (8.1 cm) and fruit weight (53.0 g) were also recorded with soil application of FeSO₄ @ 15 kg ha⁻¹ and ZnSO₄ @ 8 kg ha⁻¹ as per soil test value (STV), follow by foliar application of multi-micronutrients mixture Grade IV. The soil application of multi-micronutrients mixture as per STV or foliar spray 1.0% grade-IV were found beneficial and economical for increasing okra yield.

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Despite conservation agriculture (CA) is promoted as a climate resilient technology, limited information is available on its impacts on N storage within soil aggregates vis a vis global warming potential (GWP) under tropical agro-ecosystems. Hence, this study assessed the effects of a medium-term (5-years) CA on total soil N (TSN) changes in bulk soils and aggregates, N2O emission, GWP and greenhouse gas (GHG) intensity under maize (Zea mays L.) wheat (Triticum aestivum L.) system on the Indo-Gangetic Plain. Results revealed that the soils under permananet board bed with residue (PBB+R) has 37 and 9% more macroaggregate-and microaggregate-associated N concentrations in topsoil (0-5 cm layer) than conventional tillage (CT; 248 and 299 kg N ha⁻¹). However, topsoil aggregation and aggregate-associated N contents of permanent narrow bed with residue (PNB+R) and zero tillage with residue (ZT+R) were similar to CT plots. In the maize-wheat cropping system, N2O emission was ~21% and ~17% higher in soils with PNB+R and PBB+R, respectively, than CT. The N2O fluxes following each split application of mineral fertilization were significantly higher in soils under ZT than CT. The CO2 emission was significantly lower in the ZT plots than CT in both crops. Furthermore, the CO2 emission was significantly higher under all residue retained plots in both crops. Highest CO2 emissions were observed in PNB+R plots. The dehydrogenase and fluorescein diacetate activities and TSN, microbial biomass N, NO3-N and NH4-N concentrations were also highest in PBB+R plots in topsoil. The topsoil dehydrogenase activity was significantly correlated (r = 0.426, n = 21, p<0.05) with CO2 emission and with N2O emission (r = 0.770, n = 21, P<0.01) during wheat (2014-15). However, topsoil FDA activities and MBN concentrations were only significantly correlated with N2O emission in wheat. Overall, in the maize-wheat system, the GWP and GHG intensities in the CT, PBB+R and ZT+R plots were similar. Thus, PBB+R practice is a better management alternative for soil N improvement (and a reduced fertilizer N dose could be adopted in future) than CT. That practice also had ~22% greater crop productivity in the maize-wheat cropping and similar GHG intensity to CT plots.
GHG Emissions and Carbon Crediting in Crop + Hortipastoral + Livestock Integrated Farming Systems under Irrigated Dry Conditions of Telangana

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Studies on green house gas emissions were carried out during 2017-18 in an established integrated farming systems unit developed for small and marginal farmers under Irrigated dry situations and evaluated under AICRP-IFS since 2011-12 by integrating field and fodder crops, horticulture and animal components in 1 ha area. The crop component in 0.7 ha, includes arable cropping systems viz., rice-groundnut, maize-groundnut, maize + pigeonpea-sunhemp and pigeonpea + sweetcorn-bajra, Bt cotton + greengram-fodder sorghum and cereal fodder block in 0.1 ha. The horticulture component (0.2 ha) included a fruit crop guava with under storey hedge lucerne. The Livestock component has 2 desi cows (Gir), 10 + 2 goats (Osmanabadi) and a supplementary unit of 200 poultry birds (Aseel). Complementary units Vermicomposting and composting were included for residue recycling in the system.

Emissions of green house gases from crop land under various cropping systems in IFS unit during kharif and rabi seasons indicated that a total of 2.148 kg nitrous oxide was emitted from the cropping unit. Maximum emissions of nitrous oxide per annum were recorded in rice-groundnut cropping system (0.455 kg N₂O) and were followed by fodder block (0.378 kg N₂O). Lowest quantities of emissions were observed in Pigeon pea + Sweet corn-bajra system (0.237 kg N₂O or 78.4 kg CO₂ eq). From rice crop about 32.4 kg of methane emissions were recorded. In terms of CO₂ equivalence a total of 1346 kg CO₂ was recorded from 9000 sq.m area. Inclusion of leguminous crops in the system resulted lower emissions than other cereal or millet crops.

From the livestock unit due to enteric fermentation 167.8 kg of methane emissions were recorded and maximum enteric emissions were observed in goatery unit with 19 goats (95 kg). Due to manure production 19.07 kg of methane emissions and 9.38 kg nitrous oxide emissions were observed. In terms of CO₂ equivalence a total of 6830.6 kg was recorded from livestock unit. Nearly 51.6% emissions were accountable to enteric fermentation (3523.8 kg CO₂ eq.). The data on carbon crediting indicated that there was more of sink (27608 CO₂-e(kg)) through biomass production, agroforestry and soil organic carbon sequestration than the emissions (8487.23 CO₂-e(kg)) from crops, livestock and energy use etc. This higher sink is making the system carbon negative and environmentally safe.
An Examination of Yield and Trade-offs among CO$_2$, CH$_4$ and N$_2$O Emissions from Direct Seeded Rice Paddy Fields under Soil Water Potential based Water Management

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Increased concentration of greenhouse gases (GHGs) such as CO$_2$, CH$_4$ and N$_2$O alter the energy balance of the atmospheric system, which leads to subsequent climate change. We conducted a two year field experiment for water management based on tensiometric measurement of soil water potential (SWP) in order to quantify temporal and seasonal variation in GHGs emissions and their trade off relationship at five levels of SWPs viz. SWP 1 (-20 kPa), SWP 2 (-30 kPa), SWP 3 (-40 kPa), SWP 4 (-50 kPa) and SWP 5 (-60 kPa), in addition to the traditional practice of growing flooded rice (CF). Measurements of CH$_4$ and N$_2$O emission during the growing period was done using manual closed chamber-gas chromatograph and the CO$_2$ emission was measured using an infrared CO$_2$ analyzer. Seasonal CH$_4$ emission was decreased by 30-60.2% at different SWPs based irrigation schedule as compared to CF. In contrary, there was an increase in emission of CO$_2$ and N$_2$O by 12.9-26.6% and 16.3-22.1% respectively at SWPs 1 and 2; however a significant decrease in emissions of these gases were observed at higher SWPs (SWP 3 to 5). There was water saving of 41.1% and statistically at par grain yield with CF under SWP 2. We observed that SWP 2 maintain yield, save water and reduce CH$_4$ emission; whereas due to trade-offs among the three GHG, there was no significant reduction in global warming potential (GWP) as compared with CF. We also found a significant regression relationship between seasonal GHGs emission and soil Eh, pH, EC and temperature. Thus, it can be concluded that among the irrigation scheduling strategies evaluated in this study, -30 kPa SWP treatment could be a potential option for maintaining rice yield, increasing water productivity and mitigating CH$_4$ emission without any significant change in GWP from direct seeded paddy fields. However, further studies are needed to identify suitable management practices for reducing CO$_2$ and N$_2$O emissions under -30 kPa SWP in order to reduce the overall GWP.
Supplementing Macronutrients through Treated Wastewater Irrigation in Peri-urban Agriculture

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Presently Indian agriculture is affirmed to meet the challenge of doubling farmers' income by 2022 from the base year 2016-17. Other than improving land and water productivity two factors that play an important role in farmers' income one is market that decide the cost of the output of agriculture and the other one is the cost incurred on input used for cultivation. By lowering the input cost through minimising the wastage and by recycling the wastes, farmers can increase their income and improve their livelihood. Recurring inputs mainly comprised of seed, fertilizers, irrigation, pesticides and labour among which average share of fertiliser cost to total cost of cultivation is about 20 percent. In 2015-16 total consumption of fertilizers in India was 267.3 lakh tons at the ratio of N: P: K (nitrogen: phosphorous: potassium) as 7.2:2.9:1 and an amount Rs. 13984.93 crores was spent to import N, P & K fertilizers. Other than crop residues, municipal wastewater contains considerable amount of NO₃-N (nitrate-nitrogen), NH₄-N (ammonium-nitrogen), PO₄-P (phosphate-phosphorous) and K (potassium) that can be judiciously used to supplement N, P and K fertilizers. In peri-urban areas farmers use municipal and wastewater for irrigation because of its nutritional value. Studies conducted on municipal wastewater revealed that Patia drain of Bhubaneswar contained NH₄-N, NO₃-N, PO₄-P and K in the range of 4.5-5.0, 0.08 to 0.17, 0.1 to 0.3 and 0.37 to 0.42 me L⁻¹. Patia drain in Bhubaneswar collects wastewater from households, hospitals, small scale industries, schools, Infocity and found to be a suitable site for wastewater with all possible combination of contaminants in urban wastewater. Samples collected from Daya river where all the drains of Bhubaneswar is discharged as well as receives the return flow from the cultivated lands contained NH₄-N, NO₃-N, PO₄-P and K in the range of 0.99 to 3.03, 1.4 to 4.1, 0.003 to 1.04 and 0.06 to 4.42 me L⁻¹. It has been observed that the nutrient content in the surface water was higher during rabi season when it is comparatively dry and no rainfall. About 62000 mld of municipal wastewater is generated in India which can be a potential source not only for water as well as for macro nutrients if the contaminants can be reduced. An online hybrid online filter has been developed that can reduce the sediment, microbial and heavy metal load in the wastewater and retain the macronutrients for necessary supplement. In-situ filtration system to treat wastewater for its use in agriculture may be one of the resource conversion technology that will help to utilise waste by the farmers to minimise input cost a step forward to double the income by 2022.
Assessment of Trace Metals Content in Edible Part of Plants and Potential Health Risk for Human Health

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Assessment of heavy/trace metals in foods and awareness among the peoples is an important task for nutritionists, environmentalists and scientists because consumption of foods containing heavy/trace metals is one of the main ways by which these elements enter in the human body and deposited, overlapping noble minerals and cause an array of diseases. The present study aimed to investigate the concentration of different metals in agricultural soil and also in edible part of plants grown on same soils for notice the possible health risks to human body through food chain transfer. Under investigation forty two edible plant parts of different standing crops in the field and side by side soil samples (0.0-15.0 cm) were collected from Bokaro district, Jharkhand during January-February 2018 under the project of “AICRP on Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants (ICAR)”, Ranchi Centre. The contents of Fe, Mn, Zn and Cu ranged from 5.11 to 29.14 (13.37 mg kg⁻¹), 0.74 to 7.92 (2.79 mg kg⁻¹), 1.35 to 8.50 (4.03 mg kg⁻¹), 0.24 to 1.37 (0.80 mg kg⁻¹), in the other hand content of heavy metal viz., Pb, Ni and Co found in the range of 0.32 to 1.21 (0.67 mg kg⁻¹), 0.10 to 1.70 (0.63 mg kg⁻¹) and 0.47 to 6.72 (2.47 mg kg⁻¹), respectively in edible part of different crops in Bokaro district. Considering the contamination level given by WHO/FAO content of Zn, Cu, Fe, Mn, Pb, Ni and Co in soil is lower than the observed prescribe limit of contamination. Intake of metals (Zn, Cu, Fe, Mn, Pb, Ni and Co) in human body through plant also was found within the permissible limit as recommended by WHO, Food and Nutritional Board and US EPA. The Health Risk Index (HRI), on the basis of metals (Zn, Cu, Fe, Mn, Pb, Ni and Co) concentration in all edible part of plants were found <1.0, can be considered safe with no risk to human health. Results also advocated that if farmers used 200g fresh mixed edible part of plant per day in their diet, even then it does not fulfill the recommended nutrition. A wider gap in recommended and supplement amount of Zn, Cu, Mn and Fe was found in dietary allowance per day for people living in rural areas in Bokaro district. Therefore, agronomical and genetically approaches should be adopted for increase the transfer factors of essential micronutrients for human health and also to restrict the uptake of toxic metal in plant.
Assessment of Fluoride Concentration in Groundwater of Amaravathi River basin, Tamilnadu, India

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Water is one of the most important natural assets and plays a vital role for all living organisms and plants to survive in this world. Safe drinking water is the primary need of every human being. Fresh water has become a scarce commodity due to over exploitation and pollution of water.

The main source of fluoride in ground water is fluoride-bearing rocks, possessing rock bearing minerals that contribute to toxicity of domestic water. Also the content in ground water is a function of many factors such as availability and solubility of fluoride minerals, velocity of flowing water, pH, temperature and concentrations of calcium & bicarbonate ions in water. Among the water quality parameters, fluoride ion exhibits unique properties as its concentration in optimum dose in drinking water is advantageous to health and if the concentration exceeds the limit, this affects the health. Therefore, an attempt is made to analyze the water for fluoride content in the drinking water in some villages of Kundadam block of Tiruppur District of Tamilnadu State, India.

Fluoride in drinking water has both positive and negative effects on human health. Small concentration of F⁻ is essential for normal mineralization of bones and the formation of dental enamel. However, the excess concentration F⁻ in groundwater causes adverse impact on human health. A fluoride concentration of 1 ppm (1 mg L⁻¹) in potable water is essential for healthy teeth and bones. However, at higher concentrations (>1.5 ppm), it has adverse effects such as causing dental and skeletal fluorosis. Fluorosis is one of the major health risks faced by people in India. This may be due to consumption of more fluoride through drinking water. As same water is being used for irrigation purpose, fluoride can also enter into the food chain and finally reach human beings. In the present study, water samples from 20 revenue villages of Kundadam Block, Tiruppur District, Tamilnadu state were analyzed for fluoride content. Ground water samples were collected in 49 locations and analysed for various parameters including Fluoride. Out of which 4 locations were found to contain more than permissible level (>1.5 mg L⁻¹) of fluoride in drinking water and 37 locations were contain minimum required quantity of fluoride in water to prevent dental caries and the remaining locations were not affected. From the study, it was observed that Kundadam block of Tiruppur district in Tamil Nadu is moderately fluoride endemic. About 26 per cent of the locations in this block have fluoride level more than the prescribed permissible limit in drinking water.
Micro, Secondary and Pollutant Elements Status in Geo-referenced Soils of Bokaro District of Jharkhand

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Fertility status of soil that are of relevance in the present day context of keeping pace with the productivity-driven production goal of the country’s agricultural sector. The role of balanced plant nutrition is well established to attain the target of production goal and consequently supplement of nutrition in animal and human being. Appropriate management of plant nutrients is largely governed the fertility status of soil and its translocation in plant. To consider these aspects, current study was carried out to assess the status of available micro, secondary and pollutant elements in soil of Bokaro district, Jharkhand (subzone IV of VII ACZ, India). Total 325 geo-referenced surface (0.0-15.0 cm) soil samples were collected randomly from nine blocks of the district (Lat. 23°33′03.2″ to 23°51′35.5″, Log. 85°00′29.9″ to 86°59′42.0″ and Alt. 132 to 384 msl) during January-March 2018 under the project of “All India Coordinated Research Project on Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants (ICAR)”, Ranchi Centre. Soils were strongly acidic to moderately alkaline in reaction (pH 4.01-8.66) with low electrical conductivity (0.02 to 1.56 dS m⁻¹) and organic carbon content varied from very low (0.08 g kg⁻¹) to high (15.16 g kg⁻¹) status with their mean values of 5.69 (pH), 0.23 (EC) and 7.09 g kg⁻¹, respectively. Micronutrients i.e., Fe, Mn, Zn, Cu and B content were varied from 13.78 to 64.60, 4.48 to 46.60, 0.08 to 4.66, 0.02 to 7.80 and 0.14 to 4.87 mg kg⁻¹ with their mean values of 42.47, 22.56, 2.09, 1.69 and 0.95 mg kg⁻¹, respectively. Iron, Mn, Zn, Cu and B content were well sufficient except available Zn and B. Zinc deficiency was observed about 39.35% [2.77% acute deficiency (≤0.3 mg kg⁻¹); 10.77% deficiency (0.3-≤0.6 mg kg⁻¹); 25.85% marginally deficiency (0.6-≤0.9 mg kg⁻¹)] soil samples of the district and reflected initiation of emerging deficiency in red and lateritic soils, while deficiency of boron has reached at alarming stage and 55.69% [1.85% acute deficiency (≤0.2 mg kg⁻¹); 22.15% deficiency (0.2-≤0.5 mg kg⁻¹); 31.69% marginally deficiency (0.5-≤0.7 mg kg⁻¹)] soils suffering from B deficiency in the district. In case of secondary nutrient like sulphur (S) content in soil was observed varied from 0.52 to 77.67 mg kg⁻¹ with its mean value 20.62 mg kg⁻¹ and about 80.93 per cent [28.62% acute deficiency (≤10.0 mg kg⁻¹); 35.69% deficiency (10.0-≤20.0 mg kg⁻¹); 16.62% marginally deficiency (20.0-≤30.0 mg kg⁻¹)] soils were found deficient of sulphur. On the other hand, heavy metals i.e., Pb, Ni, Co and Cd content range between 0.24-5.23, 0.04-3.82, 0.16-3.96 and 0.02-0.34 mg kg⁻¹ with their mean values of 1.69, 1.44, 1.17 and 0.15 mg kg⁻¹ respectively. As per considering the safe limit of Pb (20 mg kg⁻¹), Ni (10 mg kg⁻¹), Co (20 mg kg⁻¹) and Cd (3 mg kg⁻¹) in soil all the heavy metals have available below the safe limit and no risk for cultivation land and sustainable crop productions. Hence, deficiencies of Zn, B and S are most common in Bokaro district soils. Therefore, for successful and profitable crop production maintaining soil and plant health immediate need to give more attention to supply Zn, B and S fertilizers at village level and create awareness to use these fertilizers in judicious and scientific way among the farmers. In organic matter concern farmers of the Bokaro district should be encouraged to apply organic matters along with the balance use of fertilizers for optimum yield potential.
Enhancing efficacy of phytoextraction of Zinc, Cadmium and Lead in contaminated soil

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In phyto-extraction slow removal rate of metals by plant is the main constraint in the way of making effective use of this green technique in managing contaminated site. Hence, an attempt has been made to study the effect of selected organic and inorganic amendments on enhancing efficacy of phytoextraction of Zn, Cd and Pb in contaminated soil using Indian mustard (\textit{Brassica juncea} cv. Pusa Vijay) as a test crop. Results indicated a significant redistribution of metal from non-labile to labile pool in soil as a result of application of different amendments. Substantial increase in intensity factor of metals in solution was also recorded in amended soil. Metal concentration in soil solution as extracted by \textit{rhizon} sampler ranged from 47.5 to 1138 µg L\textsuperscript{-1} for Zn, 3.78 to 88.1 µg L\textsuperscript{-1} for Cd and 1.19 to 66.3 µg L\textsuperscript{-1} for Pb. Tremendous increase in free ion activity of Zn, Cd and Pb in Baker soil test extract was recorded in amended soil as compared to control, where no amendment was added. Cadmium uptake by shoot of mustard was enhanced to the extent of 125, 62.5, 175, 175 and 212\% in green manure, EDTA, S+S oxidizing bacteria, metal solubilizing bacteria and green manure + metal solubilizing bacteria treated soil, respectively over control. More or less, similar enhancement in Pb and Zn uptake was observed in amended soils. Conjoint application of green manure and metal solubilizing bacteria proved to be the most efficient in enhancing the Zn, Cd and Pb uptake by mustard, which could be an effective option for enhancing solubility of metals in soil \textit{vis-a-vis} hastening phytoextraction from practical point of view. An effective option of disposal of metal contaminated plant material after phytoextraction is yet to be evolved.
Semi-Surface Horizontal Flow Constructed Wetland Treatment of Domestic Sewage Effluent: Effect on Soil Nitrogen Transformations

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An experiment was conducted at the Main Agricultural Research Station, Dharwad, Karnataka during January to May, 2014 to study the effect of irrigation with treated domestic sewage effluent coupled with fertilizer levels on soil nitrogen dynamics both temporally and spatially. The treatment of domestic sewage water was carried out using a semi-surface horizontal flow constructed wetland. For treating the domestic sewage effluent, the domestic sewage of the University campus was converged at one point, allowed to undergo sedimentation in the inlet tank and passed though constructed wetland system made using locally available bedding materials like bricks and charcoal to target higher treatment efficiency.

The nitrogen fractions studied were ammoniacal, nitrate, organic and total nitrogen. For treating the domestic sewage effluent, the domestic sewage of the University campus was converged at one point, allowed to undergo sedimentation in the inlet tank and passed though constructed wetland system made by using locally available bedding materials like brick pieces and charcoal to target higher treatment efficiency. The water samples were collected from the inlet and outlet of the system at 7 days interval and characterized for its quality. The soil samples were collected 30 and 60 days after transplanting and at harvest of test crop and assessed for various nitrogen forms as per standard procedures.

Among the inorganic fractions of N analysed, ammoniacal N was the dominant form irrespective of the sources of irrigation water. Ammoniacal, nitrate, organic and total nitrogen concentrations were tending to reduce down the depth. Nitrate nitrogen content in the plots receiving treated sewage effluent was more than other sources of irrigation water throughout the experimental period. At 30 DAT, the surface soil irrigated with treated sewage effluent recorded nitrate nitrogen content of 35.78 mg kg⁻¹. Organic and total nitrogen content in the sewage irrigated plots were significantly superior over groundwater irrigated plots. Total nitrogen content in the untreated sewage effluent irrigated plots in the surface and subsurface soils were 1006 and 739 mg kg⁻¹ respectively at 30 DAT which was far higher than that at 60 DAT and at harvest.
Effect of Cadmium Spiking on Performance of Basmati Rice Varieties in a Sandy Loam Soil

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Cadmium accumulation in soil is hazardous because its high quantity can decrease crop production and quality by affecting nutrient uptake and inhibition of growth and all plant processes. This may pose risk of bioaccumulation in the plant and food chain. Cadmium is particularly hazardous pollutant due to high toxicity and solubility in water. In most of the Asian countries, where rice is grown extensively and is a staple crop, the rice fields get contaminated with runoff from waste piles of mines and some major ways of metal addition into rice soils are agronomic management interventions like use of metal rich insecticides, phosphatic fertilizers and application of waste water and sludge in the paddy fields. Basmati rice (*Oryza sativa* var Bas) is an important staple food in the human diet of south Asia. In India about 12 -16 lac tonnes of basmati rice is produced every year and only one-third of it is consumed in the country and the remaining two-third is exported. Heavy metal content higher than maximum permissible levels of basmati rice may lead to health disorders in humans particularly in tropical countries and poses a risk of rejection from the importing countries as higher accumulation of toxic heavy metals in basmati grown in contaminated soils.

A screenhouse study was conducted to investigate the effect of cadmium spiking on performance of basmati rice varieties in a sandy loam soil. The results of the screenhouse experiments on six basmati rice varieties (Basmati 370, Basmati 386, Pusa Basmati 1121, Punjab Basmati 2, Punjab Basmati 3, Pusa Basmati 1509) and spiking the soil with Cd upto100 mg kg⁻¹ soil resulted in an increased mean DTPA-Cd content from 0.15 mg kg⁻¹ soil in control to 37.93 mg kg⁻¹ at the highest metal spiking levels. A significant decrease in dry matter yield of root, straw, husk and grain of all six basmati rice varieties was observed with increase in levels of metal spiking. At the highest level of Cd spiking, maximum grain yield was observed in Pusa Basmati 1509 and the minimum was observed under Basmati 386. The mean grain yield decreased from 25.89 in control to 10.35 g pot⁻¹ at 100 mg Cd Kg⁻¹ soil spiking rate. The metal accumulation pattern with respect to the varieties followed the same trend and maximum accumulation was observed in Basmati 386 and minimum in Pusa Basmati 1509. Metal spiking increased the accumulation of Cd in root, straw, husk and grain in the order of roots>>straw>>husk>grain. The mean grain metal concentration in basmati rice varieties was found to be higher than maximum permissible limit of FSSAI beyond 25 mg kg⁻¹ of Cd.
Efficiency of Heavy Metal Removal by Different Seasonal Flowering Plants in Contaminated Soil

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The present study was undertaken to know the efficiency of different flowering plants for their heavy metals extraction capacity in a process of phyto-remediation. The investigation was carried out in micro-plots at Micronutrient Project (ICAR), B.A. College of Agriculture, AAU, Anand. The contaminated soils from Vatwa-Nawagam area was utilized in the micro plots with three levels of heavy metals loading. The external addition of heavy metals mixture for Low (L-HM i.e. initial content in soil), Medium (M-HM i.e. Cd-10, Ni, Cu, Cr and Pb-100 mg kg⁻¹ soil each) and High (H-HM i.e. double of M-HM) were tested. The soil was incubated for one month and then after four different flowering plants [Marigold (MG), Gaillardia (GL), Balsam (BL) and Bataniya (BT)] were grown to study their effect on plant growth and extraction of heavy metals as direct effect in first season (kharif; 2007) and residual effect (Winter, 2008) with FCRD2 design. The objective of study was to evaluate the selected flowering plant species for their capacity to extract heavy metals from contaminated soil. The findings indicated that survival of plants and growth was adversely affected more under direct effect compared to residual effect. Amongst the flower plants, maximum survival was noted in Marigold (89%) in first season (under direct effect) and Gaillardia (98%) in second season (under residual effect) at low level of heavy metals. The Bataniya gave maximum survival in both the seasons at medium level of heavy metals loading. The maximum yield of flower, leaf and stem was recorded in Marigold and Gaillardia due to direct and residual effect, respectively; while root of Bataniya recorded more dry weight than other flowering plants in both the seasons. In general, the Marigold recorded maximum total biomass yield.

Marigold recorded the highest heavy metal removal under direct effect among all the flowering plants. Further, maximum removal of Cd, Ni and Pb was recorded by Marigold and Gaillardia due to high level of direct and residual effect of heavy metals, respectively. The percentage of removal of Cr by Marigold over Balsam was higher by 24%, which was least removed heavy metal amongst the other heavy metals. It was clearly noticed that maximum removal of all heavy metals was recorded through flower part of Marigold followed by root, leaf and stem parts of Bataniya as a direct effect. The Ni was removed maximum by Gaillardia while Marigold removed maximum Cr. The Gaillardia plant removed Cr and Cd more than any other plants. In general, the overall results indicated that the removal of heavy metals by different parts of plants followed the order as: for Cu - FlowerMG > StemMG > RootBT > LeafBT; for Cd - FlowerMG > StemBT > RootMG > LeafBT; for Ni - FlowerMG > StemBT > RootBT > LeafGL; for Cr - FlowerMG > RootBT > StemMG > LeafBT; and for Pb - FlowerMG > RootBL > LeafBT > StemMG. The overall removal of the different heavy metals by the flower plants followed the order as: for Marigold Cu > Ni > Pb > Cr > Cd; for Balsam Ni > Cu > Pb > Cr > Cd; for Bataniya Ni > Cu > Pb > Cr > Cd and for Gaillardia Ni > Cu > Pb > Cr > Cd. The phyto-extraction capacity of different flowering plants in removing of sum of total all the heavy metals (Cu+Cd+Pb+Ni+Cr) on absolute quantity basis was in the order as: Marigold > Balsam > Bataniya > Gaillardia.
Dynamics of Metal and Metalloid in Sludge Treated and Zn Smelter Effluent Irrigated Soils

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Disposal of sewage sludge to agricultural land has been considered as one of the most practically feasible ways of the waste management. Land application of sewage sludge is becoming popular day by day due to possibility of recycling valuable components such as organic carbon and other plant nutrients. However, its applications to agricultural land mainly limited by the presence of trace toxic metal and metalloid. Hence, present study was conducted with the objectives of to study the effect of sludge application on some selected soil properties, and to assess the availability of metals in sludge treated and polluted soils using rice as test crop. For this purpose, two bulk surface 0-15 cm soil samples were collected each from experimental farm of IARI, New Delhi (Typic Haplustept) and zinc smelter polluted area (Debari, Rajasthan, Typic Haplustept). Sludge samples were collected from Okhla treatment plant located in Delhi. Graded doses of sludge (0, 10, 20, 30, 40 and 50 g per kg soil) were added to IARI soil. Application of sludge reduced the pH by 0.76 units, while increased EC, organic carbon and cation exchange capacity in IARI soil by 0.69 dS m⁻¹, 0.65% and 6.9 cmol (p⁺) kg⁻¹, respectively over control at the highest rate of sludge addition. Similarly available N, P and K content in sludge treated IARI soil (50 g kg⁻¹) were increased by 65, 10.5 and 45 mg kg⁻¹. DTPA extractable trace element content in sludge treated soil was elevated by 11.1 mg kg⁻¹ for Zn, 2.36 mg kg⁻¹ for Cu, 18.9 mg kg⁻¹ for Fe, 16.1 mg kg⁻¹ for Mn, 28.2 µg kg⁻¹ for Cd, 0.78 mg kg⁻¹ for Pb and 166 µg kg⁻¹ for Ni. Zinc smelter effluent irrigated soil showed extraordinarily high level of both total and extractable trace elements, particularly Zn, Cd and Pb. Rice grain was found to contain Zn, Cu, Fe, Mn, Cd, Pb, Ni and As in the range of 25.3-38.4 mg kg⁻¹, 3.26-6.53 mg kg⁻¹, 9.28-19.5 mg kg⁻¹, 11.5-19.8 mg kg⁻¹, 8.67-28.6 µg kg⁻¹, 134-595 µg kg⁻¹ and 39.9-90.7 µg kg⁻¹, respectively. Risk assessment for intake of metals and metalloid through consumption of rice by human indicated that application of sludge should be restricted up to 20 g kg⁻¹ (equivalent to 40 t ha⁻¹) and smelter contaminated soil is unfit for rice cultivation.
Effect of Lime, Compost and Microbial Inoculants on removal of Cadmium and Lead removal by Mustard and Maize in Trace Metal Contaminated Soil of Jharkhand

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Contamination of trace metals refers to their anthropogenic accumulation, which may or may not inflict any harm to the system or organism. Pollution is the worst example of contamination where irreversible toxicity-damage has already occurred due to buildup of the toxic substances in the system. Jharkhand has several coal mines. The Damodar river basin is a repository of approximately 46 per cent of the Indian coal reserves. Due to extensive coal mining and rapid growth of industries, soil and water resources have been badly contaminated. Besides mining, coal-based industries like coal washeries, coke oven plant, coal fired thermal power plant, steel plants and other related industries in the region are responsible for degradation of environmental quality. Keeping this in view, a Farmers’ field trial was conducted at Patratu (Ramgarh, Jharkhand) to study the effect of lime, compost, plant growth promoting rhizobacteria and arbuscular mycorrhizal fungi for remediation of high trace metal levels in mustard maize cropping system.

Results reveal that microbial inoculants with or without vermicompost increased the trace metal removal, however, vermicompost alone decreased the removal. Vermicompost, lime and lime + vermicompost significantly reduced the total Cd uptake by mustard and maize. Inoculation with *Glomus mossae* resulted in elevated level of Cd in mustard and maize plants. Total trace metal content in soil was significantly reduced by microbial inoculation alone or that in combination with vermicompost. However, DTPA-extractable trace metals decreased with addition of amendments as well as inoculation of microbes. *Glomus mossae* was most effective in remediating the trace metals under this study, the total metal content reduced effectively by their inoculation alone while inoculation along with vermicompost resulted in reducing the DTPA-extractable fraction, more effectively. The extent of reduction in total Cd and Pb after harvest of both crops was 6 to 26 and 5 to 12 per cent, respectively over control. However, the corresponding values observed for DTPA extractable Cd and Pb was 53 to 65 and 20 to 32 per cent over control in microbial inoculation and 46 to 47 and 14 to 17 per cent in case of amendments.
Sequential Impact of Minerals on Soil-Plant-Animal Continuum in Trans-Gangetic Plains in South-Western Haryana

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In order to study the soil-plant-animal continuum (SPAC), the soil fodder (n=45 each); feed and animal hair (n=38 each); animal milk (n=35); blood serum of cattle (n=27) and human blood serum samples (n=39) were collected from village Rawal was district Hisar (Haryana). The selection of farmers was done on the socio-economic survey, which was carried out before conducting this study. The relationships between soil and plant with animal hair and milk, blood serum of animal and human for different minerals were studied. The samples were analyzed for their physico-chemical properties, phosphorus and micronutrient (Zn, Cu, Fe and Mn). Among the micro nutrient status in soil, plant and feed samples, the maximum deficiency of Fe (18.9%) in soil, Zn (4.4%) in plant and Cu (0.7%) was observed. However, 10.8%, 2.1% and 1.5% of samples in soil, plant and feed were found deficient in P, respectively. Results revealed that a highly significant (p<0.01) positive correlation for Zn (0.38) in soil-plant, for Cu (0.48, 0.55) in soil-plant and soil-hair was observed.
Prospective of Legacy Soil Phosphorus into Sustainable Nutrient Management Strategies

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Legacy soil phosphorus (P) is the secondary accumulation by virtue of continuous use of fertilizers and manures in agricultural production systems. It is widely evidenced for low efficiency of P fertilizer use (10-25%) in many agricultural production systems. A huge potential as secondary P source is bestowed in many soils globally which can suffice the P requirement of plants and could be able to substitute external P supply through fertilizers and manures to a large extent. The efficient use of P in agriculture is of utmost priority for sustainable crop production in many soils, as well as to safeguard the quality of surface waters and conserve resources of phosphate rock. In contrary to the common belief, the efficiency of P use is high even up to 80% and more when assessed in a farming system taking into account the residual P from previous applications over an adequate period of time using the balance method. It implies that the previously applied P has significant contribution in periodical P use efficiency of a farming system in a given soil.

In order to exploit the legacy soil P, adequate research efforts has to be needed including characterization of residual soil P like quantity, distribution and accessibility, crop management options, rate of accumulation/decline by the cropping system etc. This information may signify the fate of legacy soil P as P nutrition of plants in different agricultural production systems. The holistic system approach integrating precision farming, efficient plant types, engineered microbes etc. for nutrient management considerably utilized the legacy soil P for plant nutrition. Further the customized targeted applications of fertilizer P may also be included to optimize the crop yields where legacy P cannot fully meet the crop demands. The present review shows that it is possible to identify a critical level of soil P in a particular soil and farming system. Recovery of periodically added P and use of current P inputs has to be taken into account to reach and maintain the critical P level in a given soil and farming system. Hence development, implementation, and evaluation of strategies for reaching and maintaining the critical level of soil P on different soils and farming systems may achieve high P use efficiency extensively.
Research and Extension Experiences on Organic Farming

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The history of Indian agriculture shows that most of its farming community relies on traditional methods and ecological agriculture such as “agnihotra” and “panchagavya” the farming systems based on ancient techniques for soil and animal management. The farmers’ knowledge of ecological systems, environment and their conventional wisdom has to play more roles in making organic farming more sustainable. Status of organic farming showed the rapid growth of organic farming as well as consumer’s preferences for organic products. Gujarat state has wide variety of soils, climate, cropping patterns and extent of water availability and its quality. It is therefore implicit that each and every situation arising out of various combinations of the factors above would provide separate technological inputs for organic farming. Keeping the facts and benefits of the organic farming, Navsari Agricultural University (NAU) has already started organic farming over a span of 10 hectares land of organic farm at NAU, Navsari from 2005 by using organic input like bio-compost, vermicompost, cakes, green manuring etc. in combination with bio-fertilizers and some innovative formulation or liquid manures (Panchgavya, Jivamrut, Amritpani, Cow urine, Vermiwash and Banana pseudostem sap). In this farm, NAU has standardized different agronomic practices viz. crop rotation, cover crop, green manuring, crop diversity, etc. for the improvement of natural resources. Due to the different organic interventions, the physical, chemical and biological properties of the soil are improved; quality of the produce enhanced as well as sustained yield was obtained. Organic farm has been certified through APEDA accredited organic certification agency since eight years. The research, extension and transfer of technology on organic farming are the major activity of organic farming cell of the University. The organic farming unit is carrying out research as well extension activities on organic farming by including innovative techniques.
Building Capacities of Women Farmers through Better Farming Practices for Rural Prosperity

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Though women comprise 50-60 percent of farm labour, they are not respected as farmers in India. However, women are important contributors to agricultural growth.

In 2013, K+S kali GmbH partnered with S.M. Sehgal Foundation to start the Unnat Krishi (improved agriculture) project in Alwar district of Rajasthan, India. A baseline assessment before starting showed 97 percent of women in farm families had average land holdings of 0.2 to 0.4 ha¹. The project aimed to educate women farmers to produce more from the same land footprints using an improved package of practices (better varieties, adequate seed rate, balanced fertilization) along with field demonstrations, field days, exposure visits, and communication tools.

For demonstrations, two plots (improved farming practices = demo vs. farmer’s practice = FP) of half bigha (1.8 ha⁻¹) each were laid out side on same piece of land and all inputs for cultivation were provided. FP was not pre-defined, but farmers could act at will. In order to show the impact of balanced fertilisation, variety and seed rate were kept uniform in both plots. Nutrient management for the demo plot was based on soil test-based recommendations, supplemented by potash, sulphur, zinc and boron (only in mustard). Two junior agronomist were deployed to ensure implementation of the recommendations throughout the season.

For sustainability, each beneficiary put 60 percent cost of inputs received (seed varieties, fertilizers) into a revolving fund for inputs and services after the project’s completion. In three years (2013-16), 635 women farmers benefited directly from the project, and more than 2,000 benefited indirectly. Using improved farming practices, the average yield (of 3 years) of pearl millet and mustard demo plots as compared to farmer’s practice increased by 0.6 t ha⁻¹ (32.7%) and 0.4 t ha⁻¹ (23.6%) respectively. This yield gap in demo plot and farmer practice was maintained throughout the project duration. Contrary to the popular notion, employing more balanced nutrient management did not change production costs substantially. In fact, cultivation costs were reduced by INR 965 ha⁻¹ in mustard, while they increased by INR 1,965 ha⁻¹ in pearl millet merely due to reduced and increased P application, respectively. The positive yield response attributed to additional gross income of INR 10,554 and INR 5,801 per hectare for mustard and pearl millet, respectively.

A qualitative assessment revealed that small percentage of women are now looked upon by male farmers for their knowledge about fertilizers, seeds, and other farm inputs. Increased productivity and reduced cultivation costs have increased their farm income. However, the biggest challenge is to convince male decision maker to adopt the newly acquired knowledge income. Indeed, the continuous/stable yield improvement over the project duration of here years indicates that the rate of adoption is only marginal. As the decision making in the rural households is male dominated, these women have very little influence in participating and influencing the decisions regarding their farms.