

वार्षिक प्रतिवेदन
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भारतीय मृदा विज्ञान संस्थान
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2. EXECUTIVE SUMMARY

Soil Fertility Evaluation and Database

- District-wise nutrient database was developed. The nutrient availability per hectare of cultivated area was computed from different sources viz., farmyard manure, compost, green manure, and chemical fertilizers. The animal census data of 2003 was used in computing the manure availability from cattle and buffalo. The total availability of manure N, crop residue N, and Green manure N is 1.42, 0.216, and 0.112 mt, respectively. The total consumption of fertilizer N is 14.47 mt. This means around 10% of total N consumption is presently met by organic manures. Around 15% of P need is met by organic sources, whereas the values for K are more encouraging. Around 60% of K consumption is met by organic sources. The district-wise consumption of N, P and K, as well as the losses of N, and K were also computed. Some districts mainly in central India are spotted where nutrient budget need to be looked into and more nutrient input need to be given. The district-wise maps representing above information were prepared using GIS. A database in MS Access has been created from where the required information for a particular district can be retrieved.

Improving Input Use Efficiency

- The efficiency of urea coated with urease inhibitor (UI) and nitrification inhibitor (NI) was evaluated in comparison to plain urea in wheat. At 100% recommended rate of N, UI-NI coated urea produced 12% higher wheat grain yield compared to plain urea, whereas, UI coated urea produced 7% higher grain yield as compared to plain urea. Nitrogen use efficiency in wheat was measured in terms of Apparent Recovery of applied N. When applied at 100% rate, the apparent recovery of applied N was 64% with UI-NI coated urea, 53% with UI coated urea against only 42% recovery of applied N as plain urea. The apparent recovery of applied N as UI-NI coated urea was 20% higher than the recovery of N from plain urea.
- Zeolites are porous crystals with the ability to exchange ions and catalyze reactions. They can be used as carriers and/or medium of nutrients. The N release kinetics was studied in a Vertisol inoculated with a natural zeolite over a period of 28 days in an incubation study. Addition of zeolite delayed the N release from the soil-zeolite system. Addition of zeolite to soil also reduced soil urease activity.
- Allwin wonder and Allwin top (patented products) are under the specialty fertilizer mixtures. A study conducted to study their efficacy on Maize indicated that application of Allwin wonder and Allwin top as separate doses along with 100% of recommended fertilizer dose increased yield of maize only to a marginal extent. However, the combination of Allwin wonder and Allwin top half of the dose used for their individual application along with 100% of recommended fertilizer dose increased maize yield up to 10% compared to the application of chemical fertilizers alone.
- Amongst the different nano rock phosphate particles, SRP II (110 nm) recorded the highest dry matter yield of soybean crop. The other plant parameters like, plant height, root length, root volume, root dry matter weight were all improved due to application of rock phosphate nano particle. By Double Stage Froth Flotation Process heavy metal concentration in the rock phosphate can be minimized up to certain level. Complete removal of heavy metals from rock phosphate is not possible by this method. The biomass yield of soybean crop harvested after 60 days of sowing was higher in nano rock phosphate applied soil in comparison to micron sized rock phosphate.

Monitoring Long Term Productivity, Soil Quality and Resilience

- Soil quality studies in on-going 37 year old long-term experiment indicated that microbial biomass nitrogen, plant-available water content, microbial biomass carbon, saturated hydraulic conductivity and dehydrogenase activity were found very important indicators in Alfisols at Palampur. In Alfisols of Ranchi, higher values of SQI and sustainability index were obtained with balanced and integrated nutrient supply system.
- In Vertisols of Akola, sustainability yield index (SYI) for sorghum and wheat was very high in 150% NPK (sorghum 0.384; wheat 0.417) and NPK + FYM (sorghum 0.378; wheat 0.397). Integration of NPK with FYM application maintained higher SQI and SYI reflecting better physical, chemical and biological health of soil. The role of microbial biomass C and N found to be overall important in making the soil quality functional.
- A field experiment was carried out to screen the indicators of soil quality of the districts Vidisha and Sehore. The master indicators explained 43.7% and 52.3% of the yield in Vidisha and Sehore, respectively. The SQI value of Sehore district ranged from 1.31 to 3.92 (with mean value of 2.57) whereas the SQI value in Vidisha varied from 1-4 (with mean value 2.19). The optimum and threshold level of oxidizable C were 9.72 and 5.14 g/kg soil in Sehore district and 13.07 and 3.23 g/kg were the values for the same in Vidisha district.
- An investigation on “Microbial Resilience of Degraded Soils under Copper Stress” was undertaken to understand the microbial resilience capacity of degraded soils under copper stress. The incubation studies revealed that Cu stress showed significant reduction in acid phosphatase, alkaline phosphatase, DHA and MBC over the control (without Cu stress). Among the various treatments, application of Charcoal + FYM showed greater recovery in DHA and MBC at the end of 12 weeks after Cu stress application, followed by FYM, Charcoal and control in Nagda soil (Saline) and Pithampur soil (Sodic).

During the period under report, field investigation was carried out on 10 farmers' fields (5 each from Sehore and Vidisha) from Kharif season of 2010, to study the soil resilience after imposing treatments with graded levels of hardwood charcoal (0, 5.4, 10.8 and 16.2 t/ha). There was marked improvement in Soybean yield due to charcoal application and the yield improvement was more pronounced in soil having low SQI value. In Sehore district, the mean yield of Soybean increased from 1621 kg/ha to 1818, 2005 and 2143 kg/ha due to 5.4, 10.8 and 16.2 t/ha charcoal addition where as in Vidisha district, the mean yield increased from 1636 kg/ha to 1724, 2000 and 2169 kg/ha due to 5.4, 10.8 and 16.2 t/ha charcoal addition, respectively. Thus the results showed that application of graded levels of bio-char resulted in yield improvement by 13.76, 25.25 and 35.54% over the treatment receiving no charcoal in Sehore district and by 5.82, 25.84 and 38.20%, respectively in Vidisha district. The results further suggested that soils with low SQI values were more resilient to external application of charcoal. The possible reasons attributed to this effect could be i) the N availability in soil is decreased due to high C:N ratio of the charcoal, ii) the availability of nutrients is higher due to increase in cation and anion retention capacity of the soil and iii) enhanced mycorrhizal infection.

Managing Soil Physical Environment

- No-tillage (NT) significantly reduced the bypass loss of water by 40% compared to conventional tillage (CT) beyond 60 cm soil depth due to lesser crack width and intensity. Soil resistance to penetration was more in CT compared to NT. Per cent water stable aggregates significantly improved in NT at 0-5 and 5-15 cm soil depth compared to CT. The profile distribution of SOC showed that maximum SOC was found at 15-30 cm soil depth in CT and 5-15 cm in NT. It was observed that the microbial activities were increased with increasing level of organic matter application. The soil microbial biomass carbon was relatively greater in NT plots (556.8 mg/kg)

as compared to CT (369 mg/kg). Whereas the other parameters such as soil respiration, FDA and Dehydrogenase (DHA) were at par between conventional tillage and No-tillage plots.

- In a long-term tillage experiment, after ten cropping cycles of soybean, variations in N levels significantly influenced the bulk density (BD) of the top 15 cm soil, while below 15 cm depth the BD difference among the treatments were not significant. The BD at 0-7.5 cm depth was minimal in reduced tillage (1.20 Mg/m^3) while the maximum value was recorded (1.30 Mg/m^3) under conventional tillage. The cumulative infiltration up to 300 minutes was significantly higher in no tillage, mould board tillage treatments compared with the reduced and conventional tillage treatments. Cumulative infiltration recorded at 100%N and 150%N level was also significantly higher than that at 50%N level.
- Broadband vegetation indices viz. normalized difference vegetation index (NDVI), green-NDVI, and narrow-band vegetation indices viz. normalized difference red edge (NDRE) calculated from the spectral reflectance of maize crop (cv. Kanchan101) recorded at important growth stages was used for prediction of leaf area index and biomass of the crop at different growth stages. The results showed that the NDVI is a good predictor for the leaf area index (LAI) and biomass of maize at the initial stages. GNDVI was found to be a better predictor for LAI and biomass than NDVI during full vegetation stages. However, hyper-spectral vegetative indices NDRE was found to predict LAI more accurately ($R^2 = 0.65$) than both the NDVI and G-NDVI.
- In a long-term tillage experiment, weed density (monocot as well as dicot weeds) were the least in the mould board (MB) plough treatments and the highest in the conventional tillage (CT) treatments. The reduced tillage (RT) and no-till (NT) treatments had fewer monocot weeds than the CT because of the use of pre-emergence herbicides. The dicot weed density in the RT and NT plots was greater than the CT during 30 days after sowing whereas the differences were not significant in the later stages of crop growth. Weed seed stratification in the 20-30 cm soil depth followed the trend as: MB > CT = RT > NT. Type of tillage implement and cultivation techniques significantly impact weed seed stratification in soil as soil disturbance regimes are related to seed distribution, burial, viability and seed emergence. No-tillage systems retain sizeable quantity of weed seeds in the surface soil, whereas with soil inversion caused by mould board ploughing, weed seeds tend to distribute uniformly over the soil depth.

Monitoring Soil Chemical Parameters

- The concentration of total and extractable copper in acid soils of India varied widely. Extracted soil Cu by different extractants was well correlated with each other. Contribution of soil organic carbon towards total and extractable Cu was significant.
- Application of 1 kg Zn/ha either through Micromac (a new formulation of zinc fertilizer in the form of zinc polyphosphate) or zinc sulphate monohydrate were found statistically at par with respect to grain yield of maize in a Vertisol.
- The concentration of hot water soluble boron of 0.51 mg/kg soil was recorded as critical value of boron in neutral to alkaline soils of Punjab whereas, critical value of 29.2 mg B kg⁻¹ dry matter at 45 days growth of toria in those soils was recorded.

Improving Soil Biological Condition

- The higher concentrations of active C pools such as soil microbial biomass carbon (SMBC), water soluble carbon (WSC) and acid hydrolysable carbohydrates (AHC) were observed in NPK+ FYM treated plots in Vertisol under soybean –wheat rotation at Jabalpur.

- The (POM-C) particulate organic matter fraction (% of TOC) decreased substantially from 20 -36.9 % at 60% WHC, and 2-8.6% under submerged condition. Similar trend was observed for acid hydrolysable carbohydrates indicating that active and slow pool of carbon are the sensitive pool to change with moisture and temperature.
- C-mineralization rate increased with increase in temperature from 25 to 45°C with soil moisture of 60% WHC as compared to submerged condition in all fertilizer and manure treatments during 90 days period of incubation. C-efflux was greater during April-May and July-August. However at day time it was relatively lower than evening.

Microbial Diversity and Biofertilizers

- Studies on genetic diversity of *rhizobia* of 20 major legumes initiated. 830 *rhizobial* strains isolated and tested for nodulation. Groundnut and Soybean *rhizobia* authenticated by *nif* and *nod* gene detection.
- Soil genomics analysis of organically farmed and pesticide polluted soils initiated. 50 clonal libraries of 16s r DNA and *nif* H genes for each soil sequenced and analyzed phylogenetically.
- *Azotobacter*, *Azospirillum* and PSB tolerant to high temperature and matric stress and performing well under drought stress identified.
- Biofertilizers (*Azospirillum*, PSB) improved yield of aerobic rice by 20-40% in Tamilnadu.
- Enriched mycostraw along with PGPR and cyanobacteria inoculation in farmers' field saved nitrogen and phosphorus significantly and improved rice yields by 15-32% in Bihar.
- A single medium formulated for *Rhizobium*, PSB and *Pseudomonas fluorescens* for preparation of liquid inoculants. Liquid inoculants gave highly promising results (+15% yield increase) with maize and pigeonpea in Alfisols reducing fertilizer requirement by 25-50%.
- PGPR- *Bacillus licheniformis* application improved plant health and yield of apple. PGPR *Bacillus sp.* was highly promising for capsicum and Chrysanthemum.
- Transfer of Biofertilizer Technology to tribal districts of Orissa gave significant improvement in yield of pulses. In the North-East, biofertilizer enriched compost technology transferred through KVK's gave highly promising results in sali rice, boro rice, toria and jute.
- A complete database of the most promising PGPR (50) and rhizobia (58) for growth promotion of soybean, chickpea and wheat in Vertisols was prepared. 15 elite PGPR strains increased the soybean yield by 18% and 10 elite rhizobial strains increased the grain yield of soybean by 15% in Vertisol field.
- Based on 16s r DNA analysis, 23 PGPR identified and gene sequences deposited with NCBI. Early report of *Lysinibacillus fusiformis* as PGPR. New report of *Dyella marens* is as PGPR. First isolation of *Staphylococcus succinus* from soil.
- 5 PGPR were antagonistic to all three pathogenic fungi studied viz., *Fusarium oxysporium*, *Sclerotium rolfsii* and *Rhizoctonia bataticola*. Based on 16s r DNA homology these were identified as *Bacillus amyloliquefaciens*, *B. subtilis* (3 no.) and *B. licheniformis*. They showed early promise for checking Fusarium wilt in 'sick plots' in Vertisol field.

- 10 oligotrophic bacteria from rhizosphere soils and composts identified that could survive in double distilled water for one year. They belonged mostly to *Bacillus* sp. were as effective as other PGPR for soybean, chickpea and wheat in Vertisols.
- Diversity analysis of chickpea rhizobia in Vertisols showed that they fell into 3 clusters at 54 % level of similarity. Diversity analysis based on utilization of carbohydrate sources was more discriminatory as compared to intrinsic antibiotic resistance (IAR). The most effective strains (83%) fell in the major cluster.
- The chickpea growing soils of M.P. had sufficient population of native rhizobia (MPN 1600- 4100 cells/g soil) showing the need for identifying competitive strains from among the local isolates.
- Three effective rhizobial strains identified for chickpea in Vertisols that can increase yields by 25-40% and fix 32-52 kg/ha of additional N over native rhizobia.
- Inoculation of Rhizobium and PGPR resulted in significant increase in nodulation and yield of chickpea along with improved soil health as evident from increased population of free living, heterotrophic N fixers and acid phosphatase activity in soil.
- Microbial mediated bioreduction of terminal electron acceptors in tropical soils of long term agroecosystem are affected by the type and dose of fertilizer application. Inorganic fertilizers applied alone and/or with organic amendments regulate the microbial metabolic processes differentially under anaerobiosis.

Biofortification

- An experiment was conducted for Zn biofortification of 15 varieties each of sorghum and finger millet crops. Overall, the Zn foliar application found to be superior in terms of plant height, photosynthetic pigments, nitrate reductase activities, and root volume. Further, the pre-flowering stages are more responsive than the post-flowering stages in both the crops. Among the two crops, the finger millet seems to be more sensitive than the sorghum.

Amelioration of Contaminated Soils

- Long term application of NPK+FYM moderated the soil reaction (pH) of Jabalpur LTFE centre and pH was maintained at 7.44. The recorded EC value in the soil of LTFE did not show any significant change irrespective of treatment and depth. All the enzymatic activities like acid phosphatase, alkaline phosphatase, FDA etc. showed the highest activity in surface horizon of the soil treated with 100% NPK + FYM.
- Among different varieties of tuberose, Prajwal tolerates up to the highest level of Cr i.e., 200 mg kg⁻¹ soil while the varieties like Shringar and Mexican single tolerate up to 50 mg kg⁻¹ soil.
- Cr affected tuberose plant by delaying the seedling emergence. Cr up to 10 mg kg⁻¹ soil didn't affect but at 25, 50, 100 and 200 mg kg⁻¹ soil delayed emergence significantly resulting in stunted growth. Among the three varieties, the variety Prajwal recorded the highest total dry weight and the highest photosynthesis rate than Shringar and Mexican single varieties. The data on the partitioning of Cr in different plant parts revealed that the highest concentration of Cr was found in roots followed by shoot and flower.
- A study was conducted to investigate the effect of treated and/or untreated effluents coming from textile industries in up-stream and down-stream of Bandi River, Pali (Rajasthan) on soil and groundwater bodies. Groundwater from downstream villages was highly saline and had high Na as compared to upstream villages.

Copper, Pb, Cr and As concentrations in groundwater of several downstream villages were above the permissible level for drinking water. The soils cultivated by using contaminated well waters developed high salinity.

- A study was conducted to investigate the effect of acidic industrial effluent generated by industries of Korba city (Chhattisgarh) on soil quality of agricultural land in nearby Kharmora village. Water samples from several locations had high Cd and Cr content, beyond the permissible level for drinking water. Soils irrigated with effluent were highly acidic, saline and contained high amount of heavy metals Cr and Cu.

Recycling and Rational Usage of Different Waste in Agricultural Soils

- A study was conducted to determine screening levels of Cd, Cr, Cu, Ni, Pb, and Zn for a susceptible soil amended with municipal solid waste compost following a widely recommended soil test procedure involving the extraction of these heavy metals with a dilute calcium chloride solution. Soil test screening levels were determined through three different approaches, namely, 'phytotoxicity', 'food contamination,' and 'soil microbial activity diminution'. The lowest values of these soil test screening levels of the heavy metals determined by three different approaches were considered to be protective for all target organisms and were found to be: 0.003 mg kg⁻¹ Cd, 0.052 mg kg⁻¹ Cr, 0.637 mg kg⁻¹ Cu, 0.022 mg kg⁻¹ Ni, 0.008 mg kg⁻¹ Pb, and 3.800 mg kg⁻¹ Zn.
- Study was carried out to quantify the limits of Cd, Cr, Cu, Ni, Pb, and Zn levels permissible in soil, which would help in protecting animals, plants, and microorganisms. Maximal protective concentration limits of these metals were determined in the soil through three different approaches, namely, 'phytotoxicity', 'food contamination,' and 'soil microbial activity diminution'. Considering the lowest values of these maximal permissible soil concentrations of the heavy metals determined by three different approaches to be protective for all target organisms, these levels were found to be: 392 mg kg⁻¹ Zn, 179 mg kg⁻¹ Cu, 0.34 mg kg⁻¹ Cd, 81 mg kg⁻¹ Pb, 30.7 mg kg⁻¹ Ni, and 31 mg kg⁻¹ Cr.

Organic Farming

- Application of 100 % NPK along with FYM not only resulted in improvement in the nutritional quality such as protein, tryptophan (amino-acid) and nutritionally important microelements in wheat grains but also improved the 100-grain weight of wheat in both the LTFE wheat grain samples.
- Organic farming practices recorded the highest soybean seed yield which was 22.4% higher than the inorganic management practices. The incessant rains and cloudy weather aggravated the insect problem and there was a drastic reduction in over all soybean yield in the year 2010.
- Nutritional quality constituents' viz. protein and oil contents were better in the organic farming practices than inorganic management practices but was at par with integrated nutrient management. However, total ash, methionine and tryptophan contents in seeds were not affected significantly among the nutrient management practices.
- There was higher available N and K under soybean-wheat cropping system when Panchagavya, Biodynamic preparations and organic manures were applied together, while under maize + cowpea-gram system, application of panchagavya preparations with organic manures registered higher post harvest soil N content.

Crop Adaptability to Climate Change

- Land use largely determines the potential for soil organic carbon storage and ultimately C sequestration in soil. The forest land use system having the maximum amount of soil organic carbon mineralized significantly more of native soil organic carbon in comparison to other land use systems. Soil carbon mineralization followed direct relationship with initial soil carbon content. Residue carbon mineralization in soil was observed to be the function of soil initial carbon content, microbial biomass, carbon in labile pool and prevalence of substrate specific soil heterotrophs.
- Among the 10 soybean varieties, most of them are very much sensitive to the sudden change in soil moisture and atmospheric temperature. But all the varieties in the first sowing plots thrived well compared to the second sowing plots. It was found that those short duration varieties surviving better by utilizing the soil moisture and giving good yield. As the time of sowing extended the available moisture in the soil will be less to support the proper plant growth under non-irrigated condition and this may lead to drastic decrease in the yield.

On-farm Research and Impact Assessment

- The assessment of qualitative parameters for categorizing different degrees of soil quality to enhance the soil health and productivity based on soil physical, biological and chemical properties involving simple, low cost, farmer-friendly methods, in participatory way was conducted. Total 12 parameters of soil quality assessment comprising of soil physical, biological and chemical parameters were determined in selected farmer's fields using low cost farmer friendly tools. The weighted average values of three parameters as assessed in the field, organic manure based farming was in 'Good' category of soil health followed by integrated farming system that recorded 'Fair' category overall.

