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Physico-chemical characteristics with enzyme activity of topsoil for farmlands management of Ajmer, Rajasthan

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ABSTRACT

Soil health is related to characteristics of soil such as fertility. The purpose of this study was to estimate the fertilization status of Ajmer farmland on different soil parameters. The soil fertilization status were influenced by soil parameters, the following parameters: sand, silt, clay content, texture, calcium carbonate, cation exchange capacity, pH, EC, OC, OM, N, P, K, Zn, Fe, Cu, Mn, B, enzyme activity of dehydrogenase, acid phosphatase and alkaline phosphatase were identified. The results were showed that soil organic carbon, nitrogen and potassium were analyzed in low range 23%, 25% and 22% respectively, in the farmland soil of Ajmer district. For 49% FLS, low concentration of iron were examined. In farmland soil, sufficient range of zinc, copper and manganese were observed but iron concentration found low for 74.21% farmland. Mean dehydrogenase activity 9.351 p Kat g-1 was assessed for FLS of Ajmer. With the helping of SFM model, imbalanced nutrient level was assessed and suggested micro-organisms to balanced soil nutrients. Soil nutrients were vital factors affecting crop production and soil fertility. These new soil information is needed to provide useful additional knowledge to policy makers, farmers and other scientist about soil like enzyme activity, nutrient concentration and soil ecology of Ajmer.

1. Introduction

Ajmer is a city in the northern Indian state of Rajasthan province. Ajmer is also known as ‘Heart of Rajasthan’ and ‘Macca of India’. Total geographical area and agricultural land of Ajmer district is 8481 km^2 and 6332.31 km^2, respectively. In this district mainly maize *(Zea mays)*, jowar *(Sorghum)*, groundnut *(Arachis hypogaea)*, moong *(Vigna radiata)*, cotton *(Gossypium)*, wheat *(Triticum)*, mustard *(Brassica)*, gram *(Cicer arietinum)*, til *(Sesamum indicum)*, pearl millet *(Pennisetum glaucum)*, cowpea *(Vigna unguiculata)*, barley *(Hordeum vulgare)* are grown. Ajmer is also famous for vegetation production like onion *(Allium cepa)*, chillies *(Capsicum annuum)*, tomato *(Solanum lycopersicum)* and cauliflower *(Brassica oleracea var. botrytis)*. The contribution of soil is wonderful on growing crop because “soil” is a critical factor which provide moisture, air, organic matter and living organisms to plant.

Soil is a live layer of earth and constitutive foundation for plant growth. The strength of soil to help sustain plants growth and consistent yields of high quality was known as soil fertility (Sihag and Prakash, 2019). Management of soil health is one main important task to improve the agricultural production. Normally, health and quality of soil was explained by physicochemical and biological parameters (Abbott and Murphy, 2003; Sinclair and De Wit, 1975; Spiertz and De Vos, 1983; Tiessen et al., 1994; Bot and Benites, 2005; Kekane et al., 2005; Herridge et al., 2008; Johnston et al., 2009; Spiertz, 2009). Soil organic matter plays important role in soil function (Henderson, 1995; Harris et al., 1996).

Soil micronutrient availability is affected by physico-chemical parameters (Sharma and Chaudhary, 2007) as electrical conductivity and pH. The soil electric conductivity affected the cation exchange capacity (CEC), soil texture, salinity, organic matter, subsoil characteristics and also affected the productivity of crop (Grisso et al., 2009). Continuous and regular cultivation of crops can affect the physical and chemical parameters of soil (Tsunekawa et al., 1997). So the analysis of soil chemical and physical parameters were essential to maintain soil quality.

Similarly, soil biological parameter also plays a crucial role in fertility of soil (Visser and Parkinson, 1992; Abbott and Murphy, 2003; Adetunji et al., 2017) because of that closely relates with nutrient cycle. Soil microbes release various soil enzymes like dehydrogenase, β-glucosidase, phosphatase, urease, catalase, protease, cellulose and phenol oxidase etc. by different enzyme reaction. The activity of these enzymes was considered as one of the potential soil fertility indexes (Ross, 1975; Pal and Chhonkar, 1981; Zantua et al., 1977; Kawaguchi et al., 1995; Baligar et al., 1999; Bergstrom et al.,1998; Jorden et al., 1995; Hojati and Nourbakhah, 2009). Basically, soil enzymes is indicator of microbial metabolism and play an essential role to catalyze many biochemical reaction and fertility at the ecosystem level (Tabatabai 1994; Kandeler 1996). In this study we have observed the activities of three enzymes, namely dehydrogenase, acid phosphatase and alkaline phosphatase in soil because these enzymes are playing important role for cycling of C, N and P in the soil and we also focused on the measurement of soil physical and chemical parameters of Ajmer district. Sustainable land management of studied district was necessary to maintain soil health and production quality which was only possible by analysis of soil fertility.

In agriculture field, different advance technologies like models were used to improve production and soil management (Sihag and Prakash, 2019). The models were successfully inform the nutrient requirement, crop production, crop performance, weather information, soil information etc. to farmers and decision makers. Modelling is an advance technique which can help for nutrient management of Ajmer soil.

Therefore, the main objective of this study is to investigate (i) physical (sand, silt, clay content, texture, calcium carbonate, cation exchange capacity) (ii) chemical (pH, electrical conductivity, organic carbon, organic matter, nitrogen, potassium, phosphorus, boron, iron, zinc, copper, manganese) and (iii) biological parameters (enzyme activity of dehydrogenase, acid and alkaline phosphatase).

2. Materials and methods

2.1. Study Area

The study area is Ajmer district (Fig. 1) is centrally located (26°03˙29˝ N, 74°46˙10˝ E to 26°21˙28˝ N, 74°37˙61˝ E) situated in center of Rajasthan province of India. It is bonded by five district as Nagaur district to north, Bhilwara district to south, Jaipur and Tonk district to east and Pali district to west. The climate of Ajmer district was semi-arid and characterized by cold-bracing winter and hot-dry summer. The mean maximum temperature was 28.81°C and minimum temperature was 12.52° C. The mean annual rainfall of the district was 529.85 mm during cropping season (Dubey et al., 2016). During the period of June to September, about 90% of the annual rainfall was received. Ajmer comes in III-A semi-arid eastern plain zone according to agro-climatic classification. The mean height from sea level, width and length of Ajmer district ranges from 280-370 mt, 110 km and 185 km, respectively.

Fig. 1. Location of study area

2.2. Soil Sampling

Soil samples were taken from the top 0 to 30 cm depth of ground level. All soil samples were separately collected in white clean polythene bags and properly marked by the help of marker. Soil drying, grinding and sieving were also involved in soil sampling. Soil samples were dried in shade at room temperature for chemical and physical parameter analysis. The soil sample was taken before the planting of plants. At this time, the effect of fertilizers and pesticides was minimum.

2.3. Physico-Chemical Parameters

Standard laboratory techniques were used to analysis attributes of the soils. Contents of soil were evaluated by international pipette method (Piper, 1950). Textural triangular method was used to analyze texture class of soil. Calcium carbonate of soil was examined by hutchinson's rapid titration method (Piper, 1950). Soil cation exchange capacity was examined with the help of 1N sodium acetate (Chapman, 1986). The pH and electrical conductivity was observed in the extract of a soil-water 1:2 solution by using pH meter and conductivity meter, respectively (Piper, 1950). Soil organic carbon was determined by wet digestion method (Walkley and Black, 1934). Soil organic matter was calculated by multiplying organic carbon content with 1.724. Nitrogen nutrient was analyzed by alkaline method (Subbiah and Asija, 1956). Available phosphorus was evaluated by $NaHCO_3$ method (Olsen et al., 1954). Soil potassium was measured by ammonium acetate and also using flame photometer (Black, 1965). Concentration of micronutrients namely as boron, zinc, copper, manganese and iron were measured by DTPA extractable method (Lindsay and Norvall, 1978). Atomic absorption spectrophotometer was used for analysis of micronutrient concentration. The soils were divided as low, medium and high range in organic carbon, phosphorus, nitrogen and potassium as suggested by Muhr et al. (1965). Micronutrient concentrations ranges were measured on the basis of critical limits suggested by Lindsay and Norvell (1978).

2.4. Biological Parameters

The activities of dehydrogenase, acid phosphatase and alkaline phosphatase were analyzed in the soil of Ajmer district with three replicate per sample. For estimation of dehydrogenase activity, TTC reduction technique was used. Air-dried 1 g soil was added with 0.1% glucose and 0.3% TCC. The solution were incubated at 37° C for 24 hours. After adding methanol, optical density was read at 485nm wavelength (Kumar et al., 2013). The acid phosphatase activity was measured by the help of p-nitrophenyl phosphate. Similarly, alkaline phosphate activity was analyzed with borax buffer at pH 9.4. Mixture was incubated at 37° C for 1 hour. After incubation calcium chloride and sodium hydroxide were added. Optical density was measured at 420 nm (Tabatabai and Bemner, 1969).

3. Result and discussion

3.1. Soil Physical Parameter Assessment

Sandy loam was more dominating texture examined for farmland soil (FLS) of Ajmer. Similar trends was observed by Jat et al. (2017) and Harisha et al. (2017). The soil of Ajmer was found in medium texture class. The content of sand, silt and clay were ranged from 71.8 to 86.2%, 6.1 to 14.9% and 5.9 to 20%, respectively. Mean value of sand, silt and clay content was observed as 76.39%, 9.96% and 13.65%, respectively. The calcium carbonate was observed from 1.1 to 20.7 percent with 6.24 percent mean concentration. In FLS, 62.54 percent soils were estimated in non-calcareous in nature as the limits classified by FAO (1973) while 37.46 percent soil of FLS was found in calcareous nature. Cation exchange capacity was varied from 3.5 to 38.7 c mol kg^{-1} with mean concentration 15.64 c mol kg^{-1}. Giri et al. (2007) obtained similar trends of cation exchange capacity and calcium carbonate for Ajmer.

3.2. Soil Chemical Parameter Assessment

Soil pH values were varied from 7.05 to 8.42 in farmland soil. Mean value 7.52 was assessed for pH exercise. In FLS, 96 % samples showed pH in normal (6.5 to 8) range and remaining

4% of FLS were showing acidic and alkaline in nature. Results from this study show some similarity in pH values to those reported by Jat et al. (2007); Pandeya and Lieth (2012); Mishra et al. (2013) and Kulloli et al. (2016). Range of electrical conductivity was observed in 0.12 to 0.45 dS m^{-1}. Mean electrical conductivity 0.33 dS m^{-1} was calculated. Similar trends were analyzed for EC by Mishra et al. (2013) and Kulloli et al. (2016). Electrical conductivity was vital component in analyzing the salinity of soil. Soil organic carbon content was varied from 0.02 to 1.04 percent with 0.62 percent mean value. Soil organic carbon was present in the medium range for 74 % of FLS and showed OC percentile between 0.5 to 0.75 %. Remaining 23% and 3% soil of Ajmer were assessed in low and high organic carbon, respectively. Pandeya and Lieth (2012); Kulloli et al. (2016) and Jat et al. (2017) obtained similar trends of organic carbon. The soil organic matter was varied from 0.03 to 1.79 % in total FLS.

The mean nitrogen concentration was measured 428 kg ha^{-1} within the range of 87 to 564 $kgha^{-1}$. The nitrogen concentration were observed in low, medium and high level for 25 %, 71 % and 4 % FLS samples **(Fig. 2)**, respectively. Nutrient nitrogen is a fundamental part of chlorophyll and control development of plant. We have found potassium concentration ranged from 52 to 882 kg ha^{-1} in farmland soil. The mean concentration of potassium 342.8 kg ha^{-1} was measured. For potassium 22 % and 62 % FLS samples **(Fig. 2)** were determined in low and medium range, respectively. In remaining 16 % FLS potassium were found high than the (>335 kg ha^{-1}) critical status given by Muhr et al. (1965). Kulloli et al. (2016) found the same trends for potassium nutrient. Nutrient potassium essential and play important role in energy metabolism, plant development, starch synthesis as well as increase plant resistance to pests and disease (Etesami et al., 2017). Soil phosphorus was varied from 4.31 to 30.28 kg ha^{-1}. The mean phosphorus concentration was observed 7.38 kg ha^{-1} in the farmland soil of Ajmer. The P concentration was found in low (<12.5 kg ha^{-1}) and medium (12.5 – 25 kg ha^{-1}) status for 49 % and 31 % FLS, respectively. Only 20% soil of FLS was analyzed above high (>25 kg ha^{-1}) range. Phosphorus is important for normal plant growth and maturity, energy storage, energy transfer. For FLS, similar trends of soil phosphorus concentrations were reported by Pandeya and Lieth (2012) and Kulloli et al. (2016). The range of different soil physical and chemical were arranged in **Table 1** and **Table 2.**

Range of zinc and iron concentration were varied from 0.62 to 0.90 ppm and 3.08 to 7.26 ppm for farmland soil of Ajmer. In FLS, the mean values of zinc and iron concentration was 0.72 ppm and 4.24 ppm calculated, respectively. The sufficient availability of zinc and iron nutrient were observed in hundred percent and 25.79 percent sample of FLS, respectively. While 74.21 percent soil of farmland soil was found in deficient (<4.5 ppm) range. Deficiency of iron are responsible for sickly yellow leaves. Micronutrient concentrations like manganese and boron were found between 3.65 to 6.78 ppm and 0.37 to 0.60 ppm by AAS. Sufficient (>1 ppm) availability of Mn was assessed in whole farmland soil samples. Micronutrient boron is necessary to maintain plant health, plant development and uptake of nutrient (K, P). The concentration of copper nutrient was found from 0.87 to 2.03 ppm in FLS. The mean concentration of copper nutrient 1.23 ppm was appeared in farmland soil. Copper nutrient was observed in sufficient range for whole FLS that mean above 0.2 ppm value. Harisha et al. (2017) obtained similar trends of copper, zinc, iron, boron and manganese nutrient.

Table 1
General physical characteristics of the FLS of Ajmer

Soil Parameter	Range
Sand (%)	71.8-86.2
Silt (%)	6.1-14.9
Clay (%)	5.9-20
Texture	Sandy loam
Texture(Class)	Medium
CEC (c mol kg^{-1})	3.5-38.7
$CaCo_3$ (%)	1.1-20.7

Table 2
General chemical characteristics of the Ajmer soil

Soil Parameters	Range
pH	7.05-8.42
EC (dSm^{-1})	0.12-0.45
OC (%)	0.02-1.04
OM(%)	0.03-1.79
N ($kgha^{-1}$)	87-564
P ($kgha^{-1}$)	4.31-30.28
K ($kgha^{-1}$)	52-882
B (ppm)	0.37-0.60
Zn (ppm)	0.62-0.90
Fe (ppm)	3.08-7.26
Cu (ppm)	0.87-2.03
Mn (ppm)	3.65-6.78

Table 3
General enzyme activity characteristics of the Ajmer soil

Soil Parameter	Range
Dehydrogenase (p Kat g^{-1})	9.102 – 9.600
Acid phosphatase (n Kat g^{-1})	1.017 – 8.426
Alkaline phosphatase (n Kat g^{-1})	1.929 – 2.168

3.3. Soil Enzyme Activity Assessment

Soil dehydrogenase (DH), alkaline phosphatase (ALP), and acid phosphatase (AP) enzyme activities varied between the different sites of Ajmer. For whole the farmland sites, the average soil DG enzyme activity was 9.351 p Kat g^{-1}. The dehydrogenase enzyme activities were ranged from 9.102 to 9.351 p Kat g^{-1}. Dehydrogenase enzyme was considered as an index of the microbiological activity of the soil (Moeskops et al., 2010). Dehydrogenase enzyme was oxidize organic matter transferring proton and electrons from substrates to acceptors. The acid phosphatase enzyme activity in farmland soil was ranged from 1.017 to 8.426 n Kat g^{-1}. The average soil acid phosphatase enzyme activity was observed 4.721 n Kat g^{-1} in FLS. For FLS, the alkaline phosphatase enzyme activity was assessed from 1.929 to 2.168 n Kat g^{-1}. The mean value of alkaline phosphatase enzyme activity was 2.048 n Kat g^{-1} observed in these soil samples. The rate of synthesis, release and stability of phosphatase was influenced by soil pH (Acosta-Martinez and Tabatabai, 2000). The activity of acid phosphatase was decreased with pH increase, while alkaline

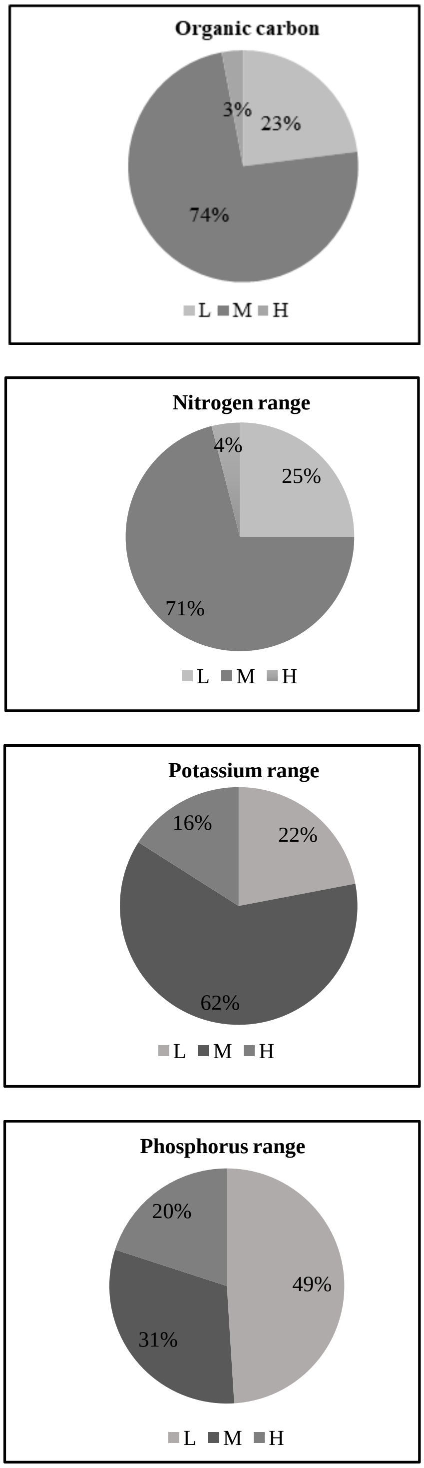

Fig. 2. Chemical parameters (organic carbon, nitrogen, phosphorus and potassium) determined in FLS of studied district

phosphatase increases (Dick et al., 2000). In farmland soil, phosphatase enzyme play an important role in phosphorus cycle. Activity of phosphatase enzyme can be used as an index of soil fertility (Makoi and Ndakidemi, 2008). The assessment of phosphatase enzyme activity was important and essential to improve crop production and soil fertility. For phosphorus stress, different agricultural management methods responsible and they also influenced the production of the phosphatase enzymes (Ndakidemi, 2006). Phosphatase enzymes were catalyze the hydrolysis of esters and anhydrides of phosphoric acid (Condron et al., 2005). The main source of phosphatase enzymes were plants and microorganisms in the soil. In the soil, phosphatase amount were varies by agricultural practices, microbial count, the extent of organic materials and minerals (Banerjee et al., 2012).

3.4. SFM Model

The SFM model (Sihag et al., 2019) was used to data analysis in this study. Different data were collected from farmland soil of Ajmer. According to model results, positive values were observed for potassium, nitrogen, phosphorus, organic carbon and iron nutrient. The means of positive sign was low availability of potassium, nitrogen, phosphorus nutrient and organic carbon present in farmland soil of Ajmer (Fig.3). While negative values indicate that means they was present excess in soil. According to data of farmland soil, deficiency was observed for pH.

['P: 8.19', 'N:193', 'K:83', 'OC:0.48', 'Fe:1.42']
['P: 6.81', 'N: 190', 'K: 49', 'OC: -0.29', 'Fe: 0.µ64']
['P: 3.85', 'N:105', 'K: 36', 'OC: -0.27']
['P: 5.04', 'N: 154', 'OC: 0.31', 'Fe: 0.18', 'pH: -0.4']
['P: 1.05', 'N: 132', 'OC: 0.24', 'Fe: 0.64', 'pH: -0.17']

Fig. 3. Results of different properties for soil by SFM model

4. Conclusion

In this paper, we presented the quantitative data of soil physicochemical and biological parameters of Ajmer district in the Rajasthan province. The objective of this study was to identify soil fertility in farmland soil of Ajmer, based on the soil properties. Fertilization status of collected soil samples were analyzed by physical parameter (sand, silt, clay, cation exchange capacity, calcium carbonate, texture), chemical parameter (pH, EC, OC, OM, N, P, K, Zn, Fe, Cu, Mn, B), and enzyme activity (dehydrogenase, acid phosphatase and alkaline phosphatase enzymes). Based on calculation, organic carbon status was found in medium range for 74 percent agricultural land. According to data, phosphorus nutrient was observed in deficiency for 49 percent for FLS of Ajmer district. The distribution of iron micronutrient was lower for 74.21% than the critical status of soil given by FAO. The medium availability of nitrogen and potassium were observed as 71% and 62% farmland soil of Ajmer. On the basis of limits of calcium carbonate given by FAO (1973) 62.54 percent farmland soil found low (<5%) and non-calcareous in nature while 37.46% FLS samples were found calcareous.

According to the computational SFM model, the deficiency of nitrogen will be reduced by Azotobator. Similarly, micro-organisms Enterobacter and Pseudomonas striata will help to improve the deficiency of phosphorus nutrient in FLS of studied district. Low availability of nutrient potassium will improved by Acidothiobacillus ferrooxidans, Paenibacillus spp., and Bacillus mucilaginosus. Investigated soil information will be useful to farmers and scientist to maintaining the fertility of Ajmer soil. The Bio-fertilizers are a better option to improve the deficiency of nutrients in soil. They are eco-friendly and directly involved in the function of soil.

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