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Assessment of Physico-Chemical Characteristics of the Soil of Lahar Block in Bhind District of Madhya Pradesh (India)

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Soil quality is one of the important factors controlling yields of the crops. Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in the context of sustainable agricultural production. Soil physico-chemical parameters are more important that control its quality. Variation in nutrient supply is a natural phenomenon and some of them may be sufficient whereas others deficient. The stagnation in crop productivity cannot be boosted without judicious use of macro and micronutrient fertilizers to overcome existing deficiencies/imbalances. The study area covers 10 villages in Lahar block of Bhind District, Madhya Pradesh. The 40 soil samples were collected from all the 10 villages keeping in view of the physiographic characteristics in different cross sections of the area. The processed soil samples were analysed for physico-chemical properties using standard procedures. The soils of the area are characterized by moderate to high pH and low to medium in organic matter content. The soils were low to medium in nitrogen, high in phosphorus and potassium, medium to high in sulphur and sufficient in calcium and magnesium. Among the micronutrient soils were noted sufficient in iron, manganese, zinc and deficient in copper.

Introduction

Soil is an important component of terrestrial ecosystem because it preserves nutrient reserves, supports many biological process (such as activities linked to nutrient cycles) and filters, keeps and transforms pollutants reducing their toxic effect. Soil quality may be affected by land use type and agriculture management practices because these may cause alteration in land productivity Soil quality is a complex and multifaceted concept defined as “the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, to maintain environmental quality and promote plants and animal health”. The quality of soil is controlled by physical, chemical and biological components of a soil and their interactions (Papendick and Parr, 1992). The concept of soil health and soil quality has consistently evolved with an increase in the understanding of soils and soil quality attributes. The deficiency of nutrients has become major constraint to productivity, stability and sustainability of soils (Chaudhari *et al.*, 2012). Soil nutrients availability depends highly on soil pH. At low pH some metallic elements like zinc and aluminum are overly abundant and highly mobile causing metal toxicity while reducing the availability of elements like calcium and phosphorus which may react to form precipitants. Adversely, at high pH elements such as magnesium and calcium tend to be abundant in the soil solution.

Soil quality encompasses many properties and processes as the structural stability of the aggregates water retention capacity of soils and capability of nutrient cycling. Of the several elements known to be essential for plant growth, macronutrients (N, P, K), Secondary nutrients (S, Ca, Mg) and micronutrients (Fe, Mn, Zn and Cu) are important soil elements that control its quality. Because of imbalanced and inadequate fertilizer are coupled with low efficiency of other inputs, the response (production) efficiency of chemical fertilizer nutrients has declined rapidly under intensive agriculture in recent years.

The results of numerous field experiments in different parts of India have, therefore indicated "fertilizer induced un-sustainability of crop productivity" (Yadav, 2003). Although widespread micronutrient deficiency has been observed in the soils of Tamil Nadu, specially the nutrient Zn deficiency (Martin, 2008), the information with respect to availability of macro and micronutrients and soil characteristics of the study area was lacking. Hence, a systematic soil analysis was proposed to delineate areas of macro and micronutrient deficiencies. In this study an attempt has been made to assess the macro and micronutrient status of 10 selected revenue villages in Lahar block of Bhind district, Madhya Pradesh, India.

Materials and Methods

Study area: Bhind district is situated in the northern part of the Madhya Pradesh and covers an area of about 4459 sq. km. It lies between N Latitude 25^o 55' and 26^o 45' and E longitude 78^o 12' and 79^o 05'. It is bounded in the North and east by Uttar Pradesh, in the south by the Gwalior and Datia districts in the west by the district Datia. Bhind district is divided into 7 tehsils and 6 blocks. It has 889 villages. Lahar tehsil is one of the seven tehsil of Bhind district, Madhya Pradesh (India). It is located in east-southern area of the district. It is located 55 Km towards South from District head quarters Bhind. Soil samples were collected randomly from each village, therefore a total of 40 samples were collected and analysed for soil parameters. The location map of the Lahar block in Bhind district Madhya Pradesh, India.

Analysis of soil physic-chemical properties: Surface soil of the farmer's field from different villages of Lahar block in Bhind district, were sampled randomly to a depth of 0-15 cm in V shape with the help of khurpi from different village of Bhind district. The Soil sample was mixed thoroughly and about a half kilogram of composite samples from farmer's field at different villages was taken for analysis. Soil sample were brought into laboratory and dried in shade at room temperature. Air dried soil samples were crushed with the help of wooden roller and sieved through 2 mm sieve. Finally dried soil samples were kept in a polythene bag for further physico-chemical analysis. Bulk Density was determined by clod method (Black, 1965). Maximum water holding capacity was measured by Piper (1966). The soil pH was determined in 1: 2.5 soil-water suspension by potentiometer method (Jackson1973). Electrical conductivity was determined extract using Conductivity Bridge and expressed as dSm^{-1} (Jackson 1973).

Organic carbon was determined by Walkley and Black (1934) Wet Oxidation method. Available macronutrients i.e. available Nitrogen (N), Phosphorus (P) and potassium (K) were estimated by the methods suggest by Subbiah and Asija (1965) and Bray and Kurtz (1945), available potassium, by the ammonium acetate method (Hanway and Heidal, 1952) as described by Jackson (1973). Available Sulphur Calcium chloride method, Chesnin and Yien (1950). Available Calcium and Magnesium Complex ometric Titration method Cheng and Bray (1951), respectively. Available Micronutrients: micronutrients Fe, Mn, Zn and Cu were determined by using DTPA extraction (Lindsay and Narvell, 1978) and by atomic absorption spectrophotometer (AAS) (Table 1).

Results and Discussion

The results of the macronutrients, secondary nutrients and micronutrients of 10 villages are given in table 2. The relative high pH of the soils might be due to the presence of high degree of base saturation. The pH, electrical conductivity, organic carbon, B.D., P.D. and Water holding capacity of the soils varied from 7.23-8.03, 0.32 to 0.82 dSm^{-1}, 0.24 to 0.49%,1.21-1.41, 2.09-2.57% and 4.42-76.55 % with a mean value of 7.68, 0.62 dSm^{-1}, 0.33% and 1.32 Mg M^{-3} 2.27 Mg M^{-3} and 44.43, respectively. On the basis of the limits suggested by Muhr *et al.*, (1963) for judging salt problems of soils, all samples (100%) were found to be less than one in electrical conductivity. The organic carbon content was low (<0.50%) in 100% soil samples. High temperature and good aeration in the soil increases the rate of oxidation of organic matter resulting reduction of organic carbon content. Available N content varied from 241.75-335.26 kg ha^{-1} with an average value of 289.36 kg ha^{-1}. On the basis of the ratings suggested by Subbiah and Asija (1956), 20% samples were low (<250 N kg ha^{-1}), 80% were medium (250 to 500 N kg ha^{-1}). This is because most of the soil nitrogen is in organic forms. Similar results were reported by Paliwal (1996). The available phosphorus content varied from 20.83 to 31.65 kg ha^{-1} with a mean value of 26.40 kg ha^{-1}. The range is considerably large which might be due to variation in soil properties *viz.*, pH, organic matter content, texture and various soil management and agronomic practices. On the basis of the limits suggested by Muhr *et al.*, (1963), no samples found low (<20 P_2O_5 kg ha^{-1}) and 100% high (20 to 50 P_2O_5 kg ha^{-1}). This might be due to the presence of more than 50% of phosphorus in organic forms and after decomposition of organic matter as humus is formed which forms complex with Al and Fe and that is a protective cover for P fixation with Al and Fe thus reduce phosphorus adsorption/ Phosphate fixation (Tisdale *et al.*, 1997).

Status of available potassium (K_2O) in the soils ranged from 300.22 to 418.30 kg ha^{-1} with an average of 355.05 kg ha^{-1}. According to limits suggested by Muhr *et al.*, (1963) 100% samples were high (>300 K_2O kg ha^{-1}) in potassium content. Status of secondary nutrient in soil range is (S, Ca, Mg) 16.58-28.68, 4.50-9.05 and 2.73-6.99, respectively. On the basis of the ratings suggested by Ramamoorthy and Bajaj (1969) 40 % were medium (10-20 kg ha^{-1} S) and 60 % high (>20 kg ha^{-1}), calcium and magnesium are found in (100%) sufficient. This might be due to creation of favourable soil environment with presence of high organic matter. Similar results were reported by Chouhan (2001). Available Fe content of these soils was ranged from 3.34 to 4.99 mg kg^{-1} with an average value of 4.09 mg kg^{-1}. 60% samples were sufficient (4.5-9.0 mg kg^{-1}) and 40% deficient iron content in soil. The available Mn content of these soils was varied from 2.25 to 2.86 mg kg^{-1} with a mean value of 2.38 mg kg^{-1}. Results suggest that 100% samples were deficient (<3.5 mg kg^{-1}) in manganese content. Zn content in soils of was ranged from 0.31 to 0.71 mg/kg with a mean value of 0.51 mg kg^{-1}. It was noted that 30% samples were deficient (<0.60 mg kg^{-1}) and 70% sample sufficient in zinc content. The available Cu content soil were ranged from 0.30 to 0.54 mg kg^{-1} with an average value 0.41 mg kg^{-1}, 20% samples were deficient (<0.60 mg kg^{-1}) and 80% sample sufficient in copper content. When compared to the other micronutrients, Mn is considerably, sufficiently present in all the samples and this result corroborate with the findings of Sharma *et al.*, (2006).

Soil nutrient index: Soil test information can be complied area wise in the form of soil test summaries which indicate the number of samples falling in the category of low, medium and high status of N, P and K, this information are used to work out from Nutrient Index (NI) or Parker Index, which in turn used to develop soil fertility map of an area.

$$NI = \frac{Nl + 2Nm + 3Nh}{Nl + Nm + Nh}$$

Where NI, Nm and Nh are the number of samples falling in the category of low, medium and high nutrient status and are given weightage of 1, 2 and 3 respectively. Considering the concept of "Soil Nutrient Index" the soil of study area were found in category of medium fertility status for nitrogen and high fertility status of phosphorus and potassium.The nutrient value index for soil of Lahar block was medium for nitrogen and Sulphur and High for Phosphorus and Potassium in given table. The value worked out from nutrient index for Nitrogen, Phosphorus and Potassium and is 1.60, 2.62 and 2.62 respectively, against the nutrient index value <1.5 for low, 1.5 to 2.5 for medium and >2.5 for high fertility status of area **(**Kumar and Shekar, 2013).

Correlation matrix: The soil pH (r= -0.540**) was found negative and significant correlation with available phosphorus and zinc. Organic carbon (r = 0.738**). Organic carbon, bulk density, EC has not significant relationship with nitrogen. Available phosphorus (r=0.383*) negatively and significantly correlated with zinc (r=-0.476*). Significant and positively correlation (r=0.378*) was found between available K and cupper and positively and non-significant calcium, magnesium and iron. Available K show significant and negative relationship with sulphur (r=-0.353*), calcium (r=-0.432*) and magnesium (r=-0319*) and negatively and non-significant relationship with iron and zinc. Jatav and Mishra (2012) have also reported the similar results in soil of Mewar region and Janjgir district of Chhattisgarh, respectively. Similar relationship was also reported by Chauhan (2001) Significant positive correlation was also found between available potassium and clay content. Available sulphur in these soil show positively and significant relationship with pH (r=0.667**).Find out similar results observed by Meena *et al.,* (2006) positive correlation (r=0.051) of organic carbon and available sulphur. The exchangeable calcium in these soil were positive and non-significant correlation with calcium (r=0.924**) negatively and non-significant iron (r=-0.230). Similar results are given by Bacchewar and Gajbhiya (2011) in soils of Latur district of Maharashtra (Table 3).

The exchangeable magnesium in this soil negatively significant correlation with calcium (r=-0.320*) and negatively non-significant manganese (r=-0.026) and copper (r=-0.288). These results were confirmatory with results obtained by Sharma *et al.*, (2003) observed significant negative correlation of calcium with organic carbon. The available Fe in this soil negatively and significant correlation with cupper (r=-0.313*). Fe in soil positive non-significant correlation with zinc (r=0.225).

Table.1 Soil physico-chemical properties (weighted mean) of study area

Sample No.	Name of villages	No. of sample collected	Moisture	BD	PD	WHC	pH	EC	OC	N	P	K	S	Ca	Mg	Fe	Mn	Zn	Cu
			(%)	(Mg m^{-3})		(%)		(dSm^{-1})	(%)	(kg ha^{-1})						(mg kg^{-1})			
S_1	Rari	4	22.83	1.42	2.44	53.64	7.95	0.65	0.24	292.05	27.25	320.18	25.03	6.46	5.20	3.85	2.27	0.46	0.39
S_2	Lapwaha	4	29.48	1.29	2.15	33.13	8.00	0.76	0.27	245.96	25.18	418.30	16.58	4.50	4.88	4.96	2.27	0.47	0.39
S_3	Achalpura	4	33.07	1.31	2.22	76.55	7.75	0.69	0.35	283.48	29.03	405.93	19.45	5.48	5.00	4.13	2.85	0.40	0.54
S_4	Rahawali	4	39.86	1.33	2.57	29.06	7.63	0.77	0.32	285.93	25.86	333.35	19.28	6.83	4.70	3.36	2.27	0.46	0.40
S_5	Barahait	4	30.71	1.31	2.32	54.13	7.55	0.58	0.32	319.86	27.51	300.22	21.90	8.75	6.99	4.96	2.82	0.71	0.32
S_6	Shikarpura	4	33.32	1.39	2.23	69.45	8.03	0.61	0.49	335.26	20.83	374.44	28.68	9.05	6.12	3.41	2.27	0.46	0.40
S_7	Katha	4	30.82	1.38	2.23	4.24	7.25	0.82	0.25	327.02	31.65	300.88	23.60	6.80	4.70	4.85	2.27	0.68	0.39
S_8	Shikari	4	39.57	1.25	2.29	36.19	7.23	0.41	0.26	272.23	29.63	406.68	19.58	6.15	3.88	3.37	2.26	0.70	0.40
S_9	Lalpura	4	23.87	1.28	2.09	38.25	7.45	0.32	0.33	290.08	23.20	347.73	24.88	5.83	2.73	3.76	2.26	0.39	0.50
S_{10}	Chhidi	4	45.38	1.21	2.17	52.66	8.00	0.61	0.42	241.75	23.85	342.82	23.10	6.13	6.46	4.85	2.27	0.45	0.37
Range			22.83-45.38	1.21-1.41	2.09-2.57	4.42-76.55	7.23-8.03	0.32-0.82	0.24-0.49	241.75-335.26	20.83-31.65	300.22-418.30	16.58-28.68	4.50-9.05	2.73-6.99	3.36-4.96	2.26-2.85	0.39-0.71	0.32-0.54
Mean			32.89	1.32	2.27	44.73	7.68	0.62	0.33	289.36	26.40	355.05	22.21	6.60	5.07	4.15	2.38	0.52	0.41

Table.2 Soil Nutrient index values of Lahar block in Bhind district of Madhya Pradesh

S. No.	Available Nutrient	NIV	Category
1	Nitrogen	1.60	Medium
2	Phosphorus	3.00	High
3	Potassium	3.00	High

Table.3 Correlation between soil physico-chemical properties of Lahar block in Bhind district of Madhya Pradesh

Soil characters	Moisture	BD	PD	WHC	pH	EC	Organic Carbon	Nitrogen	Phosphorus	Potassium	Sulphur	Calcium	Magnesium	Iron	Manganese	Zinc	Copper
Moisture	1																
BD	0.021	1															
PD	-0.132	0.149	1														
WHC	-0.001	0.305	0.017	1													
pH	0.063	0.240	-0.061	0.282	1												
EC	0.153	0.138	0.101	0.143	0.294	1											
Organic Carbon	0.159	0.111	-0.002	0.231	0.251	-0.104	1										
Nitrogen	-0.146	0.083	-0.011	0.234	-0.091	-0.142	0.188	1									
Phosphorus	0.051	-0.082	0.106	-0.078	-0.540**	0.050	-0.268	0.075	1								
Potassium	0.104	-0.216	-0.254	0.137	0.078	-0.099	-0.047	-0.218	-0.094	1							
Sulphur	-0.204	0.277	-0.031	0.210	0.049	-0.261	0.354*	0.137	-0.102	-0.353*	1						
Calcium	-0.020	0.174	0.184	0.147	0.041	-0.052	0.134	0.404**	0.069	-0.432**	0.644**	1					
Magnesium	0.056	0.151	0.072	0.185	0.087	-0.116	0.105	0.338*	0.065	-0.319*	0.667**	0.924**	1				
Iron	-0.032	0.099	-0.219	-0.019	0.144	0.250	-0.092	-0.089	0.107	-0.203	-0.241	-0.230	-0.320*	1			
Manganese	-0.054	-0.194	0.024	0.384*	-0.022	0.051	0.047	0.111	0.199	0.000	-0.174	0.100	-0.026	0.281	1		
Zinc	0.149	-0.149	0.083	-0.245	-0.476**	-0.049	-0.230	0.282	0.383*	-0.248	-0.081	0.276	0.152	0.225	0.124	1	
Copper	-0.232	-0.197	-0.165	0.321*	-0.056	-0.096	0.042	-0.061	0.038	0.378*	-0.055	-0.410**	-0.288	-0.313*	0.195	-0.562**	1

Note: '*' represents significant at 0.05 level and '**' represents significant at 0.01 level

This result was similar correlation as reported by Yadav (2008) find out that the available Fe, Mn, Zn, Cu, showed positive and significant correlation with water holding capacity. The available Mn a positive non-significant correlation with copper (r=0.195) Similar results also reported by Minakshi *et al.*, (2005) in the spatial distribution of micronutrients in soils of Patiala district. Mn is positively correlated with organic carbon (r=0.42).The available zinc content in these soils were negatively significant correlated with copper (r=-0.562**). These results were confirmatory with results obtained observed negatively correlated with EC (r= -0.096) as reported by Yadav (2011). Zn content in soil was non-significantly and negatively correlated to particle density (r=-0.165). A significant negative correlation was observed between organic carbon and available Cu and non-significant relationship with pH (r=-0.056). Significant and negative correlation bulk density (r=-0.197) and Cu content. This result was similar as reported by Minakshi *et al.*, (2005) in the spatial distribution of micronutrients in soils of Patiala district.

In conclusion, considering the concept of soil nutrient index the soils of study area were found in category of medium fertility status for nitrogen and high fertility status for phosphorus and potassium. Secondary nutrients S in found medium category, Ca and Mg found in sufficient. Zn and Mn is found in soil deficits and Fe and Cu was found in soil sufficient. The soil pH was negative significantly correlated with available phosphorus (r=-0.540**). and zinc (r=-0.476**). Available phosphorus (r=0.383*) negatively and significantly correlated with zinc (r=-0.476). A significant and positively correlation (r=0.378*) was found between available K and cupper and positively and non-significant calcium, magnesium and iron. The available Fe in this soil negatively and significant correlation with cupper (r=-0.313). The available zinc content in these soils were negatively significant correlated with copper (r=-0.562**). A significant negative correlation was observed between organic carbon and available Cu and non-significant relationship with pH (r=-0.056). The results have shown that the soil of Lahar block in Bhind district has going to start quality deterioration which requires immediate attention on sustainable soil. It is reveals from present study that, novelty of work in future organic carbon and nitrogen deficiency may be more and main cause of quality deterioration of soil, so it is recommended for study area that for sustainability that adoption of improved package of practices and integrated plant nutrition system.

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