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Evaluations of soil Fertility Status of Available Major Nutrients (N,P & K) and Micro Nutrients (Fe, Mn, Cu & Zn) in Vertisol of Kabeerdham District of Chhattisgarh, India

Awanish Kumar*, V. N. Mishra, L. K. Srivastav, and Rakesh Banwasi
Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India
* Corresponding author : Awanish Kumar

Abstract

Grid based (GPS) surface (0-15 cm) soil samples by systematic survey were collected from 4 blocks, 84 selected villages in Kabeerdham district were 297samples identified from Vertisol. These soil samples were analyzed for N,P and K and Fe, Mn, Cu and Zn andcategorized as low medium and high as per criteria fallowed in the soil testing laboratory. Based upon the coefficient of correlation between macronutrients& micronutrient and soil properties, a significant and positive correlations observed was between soil pH and available N, P and K. Electrical conductivity exhibited significant and positive relationship with available N, P, K and organic C showed significant and positive correlation with available N and K.

Key words: fertility status, major nutrients, micro nutrients,Vertisol

Introduction

Chhattisgarh state lies between 17□46' – 24□8' N latitude and 80□15' – 84□24' E longitude. The total geographical area of the State is 136034.28 km^2 north to south and 336 km. from East to West with a total area of 1,35,194 sq. km. The use of plant nutrients in a balanced manner is the prime factor for efficient fertilizer program. Balanced nutrient use ensures high production level and helps to maintain the soil health. Chhattisgarh State has four major soils type i.e. Entisols, Inceptisols, Alfisols and Vertisols and broadly comes under red and yellow soils group. Almost all soils are deficient in nitrogen and phosphorus and medium to high in potassium.

Soil fertility is determined by the presence or absence of nutrients i.e. macro and micronutrients. Soil fertility is the inherent ability of soils to supply nutrient elements to plants. Soil fertility is related to the amount of available nutrients. Some measure it by the yield capacity, and others look it to be a function of organic matter or even soil texture. In brief, soil fertility refers to the availability status of essential macro and micro nutrients in the soil (Tisdale et.al., 1993).

In view of the finite nature of natural resources, their management in a sustained fashion has become an issue of primary concern. Sustainability of the agricultureproduction systems is the most crucial issue as our natural resources are continuingly being degraded. A system is sustainable when it improves or maintains the quality of soil, water and atmosphere. Application of chemical fertilizers has been rated as one of the most important production factor affecting the sustainability. The increasing population and food demand has forced farmers to make use of high doses of chemical fertilizers. The unscientific use of fertilizers (nutrient imbalances, incorrect amount) is a serious threat to sustainable agriculture production system.

Soil-test based fertility management is an effective tool for increasing productivity of agricultural soils that have high degree of spatial variability resulting from the combined effects of physical, chemical or biological

processes (Goovaerts, 1998). However, major constraints impede wide scale adoption of soil testing in most developing countries. In India, these include the prevalence of small holding system of farming as well as lack of infrastructural facilities for extensive soil testing (Sen et al., 2008). However, major constraints impede wide scale adoption of soil testing in most developing countries. In India, these include the prevalence of small holding systems of farming as well as lack of infrastructural facilities for extensive soil testing. Under this context, Geographic Information System (GIS)-based soil fertility mapping has appeared as a promising alternative. Soil testing provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing crop yields. Soil testing program is beneficial to formulated specific fertilizer recommendation.

Materials and Methods

The investigation to evaluate the fertility status of black soil in different village of Kabeerdham district of Chhattisgarh state. Two types of soil are present namely Alfisols and Vertisols comes under black soil. These two types soil have been taken for systematic survey under study. The information of surveyed area and other details are presented in the following sections. It is located 22.15° North latitude, 82.48° East longitude with an altitude of 280 m above the mean sea level. In Kabeerdham district the normal rainfall is 1450.0 mm and average rainfall 1241.0. The region generally experiences hot, sub humid climate, having average rainfall of 1157.1 mm. The Vertisols group of the soil covered under the different villages of the Kabeerdham district in Chhattisgarh has been taken for fertility evaluation on various aspects.

Soil samples were collected from 84 villagesfewer than 4 block of Kabeerdham district after systematic survey. Surface (0-15 cm depth) soil samples were collected from different villages. Soil samples (15 cm) were collected using soil auger and local spade with proper labels.

Analysis of Samples

Soil samples collected from the study area were dried and crushed with the help of wooden petal and passed through 2 mm sieve and then used for the determination of soil reaction, organic matter, macronutrients and micronutrients content by adopting standard laboratory methods.

Soil pH was determined by glass electrode pH meter (Jackson 1973), EC with conductivity metermethod (Jackson 1973), organic carbon by wet digestion method (Walkley and Black's rapid titration method 1934), available nitrogen was estimated by alkaline KMnO4method (Subbiah and Asija 1956), Availablephosphorus was extracted by 0.5N $NaHCO_3$ solution buffer at pH 8.5 (Olsen et al., 1954) and phosphorus in the extract was determined by ascorbic acid method (Watanabe and Olsen 1965), available potassium was extracted by shaking with neutral normal ammonium acetate for 5 minutes (Hanway & Heidel 1952) and then K in the extract was estimated by flame photometer and available micronutrients Fe, Mn, Cu, & Zn, estimated by DTPA extractable method(Lindsay & Norvell, 1978). The samples were categorized as per the rating given in Table 1.

Table 1: Limits for the soil test values for rating the soil

Classification for pH values			
Strongly acid	**Moderately acid**	**Slightly acid**	**Neutral**
<5.5	5.5-6.0	6.0-6.5	6.5-7.5
Classification for total soluble salt content (EC as dS m^{-1})			
No deleterious effect on crop	Critical for germination	Critical for salt sensitive crop	Injurious to most crops
<1.0	1.0-2.0	2.0-3.0	>3.0
parameters	**Low**	**medium**	**high**
O.C. (%)	0.25-0.50	0.50-0.75	>0.75
Av. N (kg ha^{-1})	<280	280-560	>560
Av. P (kg ha^{-1})	<12.5	12.5-25	>25
Av. K (kg ha^{-1})	<135	135-335	>335
Cu(ppm)	<0.2	0.2-0.4	>0.4
Zn(ppm)	<0.6	0.6-1.2	>1.2
Fe(ppm)	<4.5	4.5-9	>9
Mn(ppm)	<3.5	3.5-7	>7

Results and Discussion

Physico-chemical characteristics of soils:

Soil reaction (pH):

The Vertisol samples of the study area were determined for pH (Table 2) and observed in the range of 6.9-8.5 with the mean value of 7.7.

A total 297 number of soil samples were categorized for pH estimation and it was observed that nearly 32.32 %samples under neutral and 67.68% samples were categorized under saline soil (Table 3). Jibhakate et al.,(2009) Similar result were also found in soils of kotal tahsil in Nagpur district of Maharashtra, in which pH ranges from 7.1 to 8.1 as reported by).

Table 2: Salient soil properties of study area

Soil charactiristics	**Range**	**Mean**	**SD**
pH(1:2.5,Soil water)	6.9-8.5	7.7	0.3
E.C. (dSm-1)	0.01-0.57	0.22	0.10
O.C. (%)	0.21-0.89	0.54	0.17
Available N (kg ha^{-1})	100-304	193.1	45
Available P (kg ha^{-1})	2.06-20.88	8.39	3.58
Available K (kg ha^{-1})	208-821	446.2	105
Available Cu (mg kg^{-1})	0.12-5.96	2.87	1.60
Available Zn (mg kg^{-1})	0.12-2.76	0.74	0.41
Available Fe(mg kg^{-1})	1.00-43.86	8.79	10.55
Available Mn (mg kg^{-1})	2.06-30.54	5.78	5.32

Table 3: Limits for the soil test values used for rating the soil

Classification for pH values			
Acidic	Neutral	Saline	Alkaline
……	32.32%	67.68%	……
Classification for total soluble salt content (EC as dS m^{-1})			
No deleterious effect on crop	Critical for germination	Critical for salt sensitive crop	Injurious to most crops
100%	-	-	-
parameters	**Low**	**medium**	**high**
O.C. %	39.05%	46.46%	14.47%
Av. N (kg ha^{-1})	94.27%	3.73%	
Av. P (kg ha^{-1})	86.53%	13.47%	
Av. K (kg ha^{-1})		11.11%	88.89%
Cu(ppm)	0.336%	3.367%	96.29%
Zn(ppm)	44.1%	42.08%	13.8%
Fe(ppm)	52.52%	21.21%	26.26%
Mn(ppm)	52.18%	25.25%	22.55%

Salt concentration (EC)

The total soluble salt contents expressed as electrical conductivity (EC) varied from 0.01 to 0.57 dS m^{-1} with the mean value of 0.22 dS m^{-1} at 25°C(Table 2). The result have shown the EC values under normal range (<1.0dSm^{-1}). The normal EC may be ascribed to leaching of salt to lower horizons due to its light textured nature. Similar result was also found in soils of Akaltara block of Janjgir district of Chhattisgarh as described by Kunal et al., (2013).

Organic Carbon

The organic carbon (OC) analyzed in all sampled Vertisols exhibited in the range of 0.21 to 0.89 with a mean value of 0.54 (Table 2). Thus, the Vertisols of Kabeerdham is medium in OC content. Distribution of soil samples with respect to OC content indicates (Table 3) that about 39% samples had low (<0.50%) organic C, 46% in medium (0.50-0.75%) and only 14% samples had higher organic C (>0.75%). Similar result were also found in black soil group (Alfisols and Vertisoils) reported by Deepika et al., (2013). Use of almost nil tovery low amount of organic manures like farm yard manure and chemical fertilizers is imbalanced application are the main reason for poor organic C resulted in low productivity of the region. More over high temperature during summer (March to June) prevailing in the area may also be responsible for the rapid burning of organic matter, thus resulting in low organic C content of these soils. Since organic matter content is an indicator of available N status of soils, thus the soils of the area are also dominantly low in the respect their available N.

Available N

The available N content (Table 2) of Verisols ranged from 112.9 to 338.69 kg ha^{-1} with on average value of 185.16 kg ha^{-1}. The majority of the sampled area (99.10%) covering in Vertisol of Kabeerdham fall under low status (<280 kg ha^{-1}) in available N content (Table 3). Similar results were also reported by Rajeshwar et al., (2009) in the soils of Krishna district of Andhra Pradesh and Rajeshwar et al., (2009)reported that the available nitrogen content in all the pedons were low ranging from 133 to 188 kg ha^{-1} throughout the depth. Only 0.90% soil was categorized under medium (280-560 kg ha^{-1}) status. In this way, the soils samples tested were found to be deficient in N. It is quite obvious that being mobile in nature and low uptake recovery due to its losses through various mechanism like NH_3 volatilization, succeeding, denitrification, chemical and microbial fixation, leaching and runoff results inresidual/available N becomes poor in soils (De Datta and Buresh 1989).

Available P

The available P varied from 2.06 to 20.88 kg ha^{-1} with a mean value 8.39 kg ha^{-1}in Vertisols (Table 2). The study indicates that about 87% of the sampled area exhibited low and 13% under medium range of P content. Rajeshwar et al., (2009) reported that the available phosphorous content in all the pedons varied from 5.3 to 33.4 kg ha^{-1}. However, the highest available P was observed in the surface horizons and decreased regularly with depth and similar results were found Deepika and Srivastava (2013). Phosphorous is present in soil as solid phase with varying degree of solubility. When water soluble P is added to the soil, it is converted very quickly to insoluble solid phase by reacting with Ca and Mg ions. These may include calcium and partly organic matter (Cate & Olsen 1953). These reactions affect the availability of P and as a result of these reactions, a very small amount of total P is present in soil solution at any time reflected by soil testing. However, a low to medium range of soils available P under study area may be mostly affected by past fertilization, pH, organic matter content, texture and various soil management and agronomic practices Verma et al., (2005).

Available K

The results showed that the available K content (Table 2) in Vertisols ranged from 208 to 821 kg ha^{-1} with an average value 446.2 kg ha^{-1}. The data reveals that 88.89%soil samples tested were in high level of available Kand only 11.11% samples were tested under medium range (Table 3). Shukla (2011) found that the available potassium content generally medium to high and only 7.4 per cent soil samples tested low in available potassium. It ranged from 90 to 656 kg ha^{-1} (mean- 275 kg ha^{-1}), samples representing the Inceptisols, Alfisols and Vertisols of Pamgarh block in Janjgir-Champa district (C.G.). Adequate level of available K in Vertisols of the study area may be attributed to the prevalence of K-rich clay minerals like illite and kaolinite.

Relationship between soil properties and available macronutrients

Available N resulted significant positive correlation with pH as presented in (Table 4). The result indicated that available N increased with rise in pH. Similar results were reported by Kanthalia and Bhatt (1991).

Available N results significant positive correlation with organic C as presented in table 4. Most of the soil nitrogen as estimated based on the organic matter present in the soil. There is a definite relation of organic C with available N because organic matter releases the mineralizable N in a proportionate amount present in the soil. Hence, organic carbon status of the soil can predict the available N which shows positive relationship. Kumar et al. (1995) also report the identical results. Similarly organic C level also markedly affects the soil N levels and the results are in agreement with Meena et al., (2006), Kumar et al., (2009), Sharma et al., (2008), and Kanthalia and Bhatt (1991).

Available N resulted significant positive correlation with OC as represented in table 4. Similarly, OC markedly affected the soil N status and the results are in agreement with those of workers like Meena et al., (2006) and Kumar et al., (2009).

A significant and positive correlation was found between available K with pH in table. Singh and Singh (1985) reported that a significant and positive correlation between available K and pH in Beel soils of Assam. Similar results were obtained by Sharma et al., (2008), Ghosh and Mukhopadhyay (1996) in Amritsar district of Panjab. Positive non-significant correlation (r = -0.085) was also found between available P and organic carbon (Table 4). This relationship was also observed by Kumar et al., (2009).

Table 4: Correlation coefficient (r) between physico-chemical properties and available N, P and K of Vertisols of Kabeerdham District

	pH	**EC**	**OC**	**N**	**P**	**K**
pH						
EC	0.119**					
OC	0.124**	0.037				
N	0.918**	0.163**	0.597**			
P	0.596**	0.220**	0.325**	0.401**		
K	0.510**	0.334**	-0.085	0.464**	0.315**	

* and ** indicate significance of value at P =0.01 and 0.05, respectively

Conclusion

It can be concluded from the results under study that the Vertisols group of Kabeerdham district in Chhattisgarh is characterized under neutral to saline in soil reaction, soluble salt content comes under safe limit for all crops. The organic carbon level exhibited low to medium. The Vertisols of the area showed low in available N and P, high level in available K. Ingeneral, the soil samples were tested for DTPA extractable Zn, Fe and Mn was medium to low and Cu was high. Hence, the soils require attention regarding integrated nutrients management approaches and regular monitoring for soil health for better crop productivity and sustainable agriculture.

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