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Original Research Article

Physico- Chemical Properties, Available Nutrient Content and their Inter-relationship in Soils of Bhaderwah, District Doda (J&K), India

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A B S T R A C T

Composite soil samples collected from agriculture land use in temperate Bhaderwah region of district Doda in Jammu and Kashmir during the year 2016-17 were processed and analyzed in the laboratory for important physico-chemical properties and available nutrients. These soils were found to be sandy loam to clay in texture with pH, EC and OC varying from 6.06 to 8.13, 0.08 to 2.45 dS/m and 11.4 to 21.0 g/kg respectively. Content of available major nutrients *viz.* N, P, K and S varied from 224.3 to 641, 1.512 to 73.1, 46.0 to 1030.4 kg/ha and 1.42 to 100 mg/kg respectively, while that of available micronutrients *viz.* Fe, Zn and B varied from 1.0 to 33.7, 0.50 to 2.90 and 0.33 to 1.19 mg/kg respectively. Soil pH showed significant and positive correlations with available P ($r=0.47^{**}$) and K ($r=0.30^{*}$) and significant and negative correlations with available Fe ($r=-0.80^{**}$) and Zn ($r=-0.79^{**}$). EC showed significant and positive correlations with available P ($r=0.68^{**}$), K ($r=0.87^{**}$), S ($r=0.85^{**}$) and B ($r=0.61^{**}$). Soil OC showed significant and positive correlations with available N ($r=0.93^{**}$) and B ($r=0.31^{*}$). The step down regression equations indicated that about 87% of variability in available N could be attributed to OC alone. In available P and K, nearly 62% and 81% of the respective variability could be due to pH and EC together. Available S was found to be influenced by EC alone to the extent of about 72% of the total variability. pH contributed about 65% and 62% of the total variability towards available Fe and Zn in order; whereas more than 55% of variability in available B could be attributed to OC and EC together. These soils fell in high category of available P, Fe, B and medium category of available N, K, S and Zn.

Keywords

Available nutrients, Nutrient index, Pearson correlation, Physico-chemical, Regression

Introduction

The hilly district of Doda lies between $32^0 53'$ - $34^0 21'$ N latitudes and $75^0 1'$ - $76^0 47'$ E longitudes in the eastern part of Jammu and Kashmir state in the outer Himalayan range. It is bound by district Anantnag of Kashmir division on its north, district Kishtwar in the north-east, Chamba district of Himachal Pradesh in the south, district Kathua and Udhampur in south and south-west respectively and Ramban in the west. Agriculture, which is subsistence in nature with small land holdings; along with its allied sectors is the mainstay of economy for the people of this district. Major crops of the district are maize, wheat and barley, pulses (especially beans), vegetables, spices *etc.*

Average productivity of maize, paddy and wheat is 17.50, 18.00 and 17.45 quintals/ha respectively which is way behind the national yield levels. Main reason for low productivity is its being hilly, highly prone to erosion and drought with harsh climate. Bhaderwah, the temperate part of the district is characterized by relatively mild but dry summers and fairly cold, wet winters with maximum snowfall due to western disturbances. It is mostly a mono cropped zone with low production and productivity. This area is also suitable for cultivation of a variety of temperate vegetables, fruits like apple, walnut and paddy, pulses, beans *etc*. Soils, which show wide variations in different characteristics; play an important role in determining the cropping pattern and agricultural production of this area. Maintenance of proper soil fertility is an important aspect in increasing agricultural productivity in the region. Soil fertility evaluation of this region is thus, a basic decision making tool for the sustainable soil nutrient management. However, soil fertility itself depends on a number of parameters that vary spatially and temporally and are influenced by both intrinsic (soil formation factors such as soil parent material) and extrinsic factors (soil management practices, fertilization and crop rotation *etc.*) (Cambardella and Karlen, 1999). Keeping this in view, the present investigations were undertaken with the objective to study important soil properties, available nutrient status and their interdependence.

Materials and Methods

Fifty five composite soil samples were collected from agriculture land use in temperate Bhaderwah region of district Doda in Jammu and Kashmir during the year 2016-17. The samples were processed and analyzed for important physico-chemical properties like soil texture, pH, EC and OC along with available nutrients *i.e.* N, P, K, S, Fe, Zn and B using standard laboratory procedures (Jackson, 1973). Nutrient index values (NIV) were computed using the formula developed by Parker *et al.,* (1951) as modified by Motsara (2002).

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

Where,

Nl = Number of samples in low category

Nm =Number of samples in medium category

Nh = Number of samples in high category of availability

The NIV classes were categorized by comparing calculated values of NIV with the recommended levels as: Low <1.67, Medium 1.67-2.33, High >2.33.

In order to study relationship between soil physico-chemical properties and available nutrient content, Pearson correlation coefficients (r) were computed and multiple linear regression equations developed. Step down regression procedure was followed to identify soil properties exerting maximum influence on available nutrients by progressively eliminating less significant variables in the process retaining the equations with highest predictability.

Results and Discussion

Soil physico-chemical properties

Data presented in table 1 showed these soils are sandy loam to clay in texture. These are slightly acidic to moderately alkaline in reaction (pH 6.06-8.13) with most of the soils being close to neutral pH range which is considered as ideal for the availability of most of the plant nutrients. EC ranged from

0.08 to 2.45 dS/m with mean value of 0.40 dS/m. All the soils have EC value <1 dS/m (normal)except for one, having EC value of 2.45 dS/m (high), which may not be suitable for growing certain types of crops. These soils contain high to very high OC content varying from 11.4 to 21.0 g/kg with mean value of 16.2 g/kg. High level of OC is attributed to higher organic matter production coupled with temperate conditions prevailing in the area which help to accumulate and preserve organic matter due to slow rate of its decomposition.

Available nutrient content

Data presented in table 2 show available N varied from 224.30 to 641.30 kg/ha with mean value of 517.25 kg/ha. Considering 272-544 kg/ha as N sufficiency range 1.82, 67.34 and 30.94% of the studied samples fell in respective low, medium and high category (Fig. 1). High levels of available N in these soils may be due to high organic matter content. The role played by organic matter in maintenance of soil fertility in more than one ways is well established (Johnston, 1986). Available P varied from 1.51 to 73.10 kg/ha with mean value of 41.67 kg/ha. Considering 12.4-22.4 kg/ha as P sufficiency range 12.74, 5.46 and 81.90% of the studied samples belonged to respective low, medium and high category. High levels of available P in these soils may be due to application of P containing fertilizers, high OC content and favourable pH range of these soils. Available K varied from 46.00 to 1030.40 kg/ha with mean value of 262.77 kg/ha. Taking 113.3-277.5 kg/ha as K sufficiency range 12.74, 49.14 and 38.22% of the studied soils fell in low, medium and high category respectively. Sufficient available K content in these soils may be due to the presence of K rich clay minerals like illite and kaolinite besides high OC content and favourable pH. Available S ranged from 1.42 to 100.00mg/kg with mean value of 19.35 mg/kg. Considering 10-20 mg/kg as sufficiency range 52.73, 20.0 and 27.27% of the samples fell in respective low, medium and high category with respect to this nutrient.

Deficiency of available S in soils may be due to low level of S bearing minerals (Anathanarayana *et al.,* 1986) and low input of S fertilizers. Also, conditions that favour S leaching may contribute to low S levels (Patra *et al.,* 2012). Among micronutrients, available Fe varied from 1.00 to 33.70 mg/kg with mean value of17.98 mg/kg. Considering 4.5-9.0 mg/kg as sufficiency range (Lindsay and Norvell, 1978) 1.82, 10.92 and 87.36% of the studied soils belonged to low, medium and high category respectively. High Fe content in these soils may be due to the presence of Fe containing minerals and high OC content that might have protected Fe from oxidation and precipitation thereby increasing its availability (Prasad and Sakal, 1991). Available Zn varied from 0.50 to 2.90 mg/kg with mean value of 1.17 mg/kg. Considering 0.6-1.2 mg/kg as sufficiency range (Takkar and Mann, 1975)18.20, 47.32 and 34.58% of the studied soils belonged to low, medium and high category respectively. This element occurs as a contaminant in phosphatic fertilizers.

So continuous addition of chemical fertilizers, together with high OC content might have raised the levels of available Zn in these soils. Available B ranged from 0.33 to 1.19 mg/kg with mean value of 0.60 mg/kg.

Taking 0.1-0.5 mg/kg as sufficiency range for available B, 23.66 and 76.44% of the studied soils fell in medium and high category, respectively. Again, high OC content might be responsible for high available B in these soils.

Table.1 Physico-chemical properties of studied soils

	Texture	pH (1:2)	EC (dS/m)	OC (g/kg)
Range	Sandy loam - Clay	6.06-8.13	0.08-2.45	11.4-21.0
Mean	--	--	0.40	16.2

Table.2 Nutrient status, indices and fertility ratings of studied soils

Available nutrient	Range	Mean	% Samples			NIV	Fertility rating
			Low	Medium	High		
N (kg/ha)	224.30-641.30	517.25	1.82	67.34	30.94	2.29	Medium
P (kg/ha)	1.51-73.10	41.67	12.74	5.46	81.90	2.69	High
K (kg/ha)	46.00-1030.40	262.77	12.74	49.14	38.22	2.25	Medium
S (mg/kg)	1.42-100.00	19.35	52.73	20.00	27.27	1.75	Medium
Fe (mg/kg)	1.00-33.70	17.98	1.82	10.92	87.36	2.85	High
Zn (mg/kg)	0.45-2.90	1.17	18.20	47.32	34.58	2.16	Medium
B (mg/kg)	0.33-1.19	0.60	0.00	23.66	76.44	2.76	High

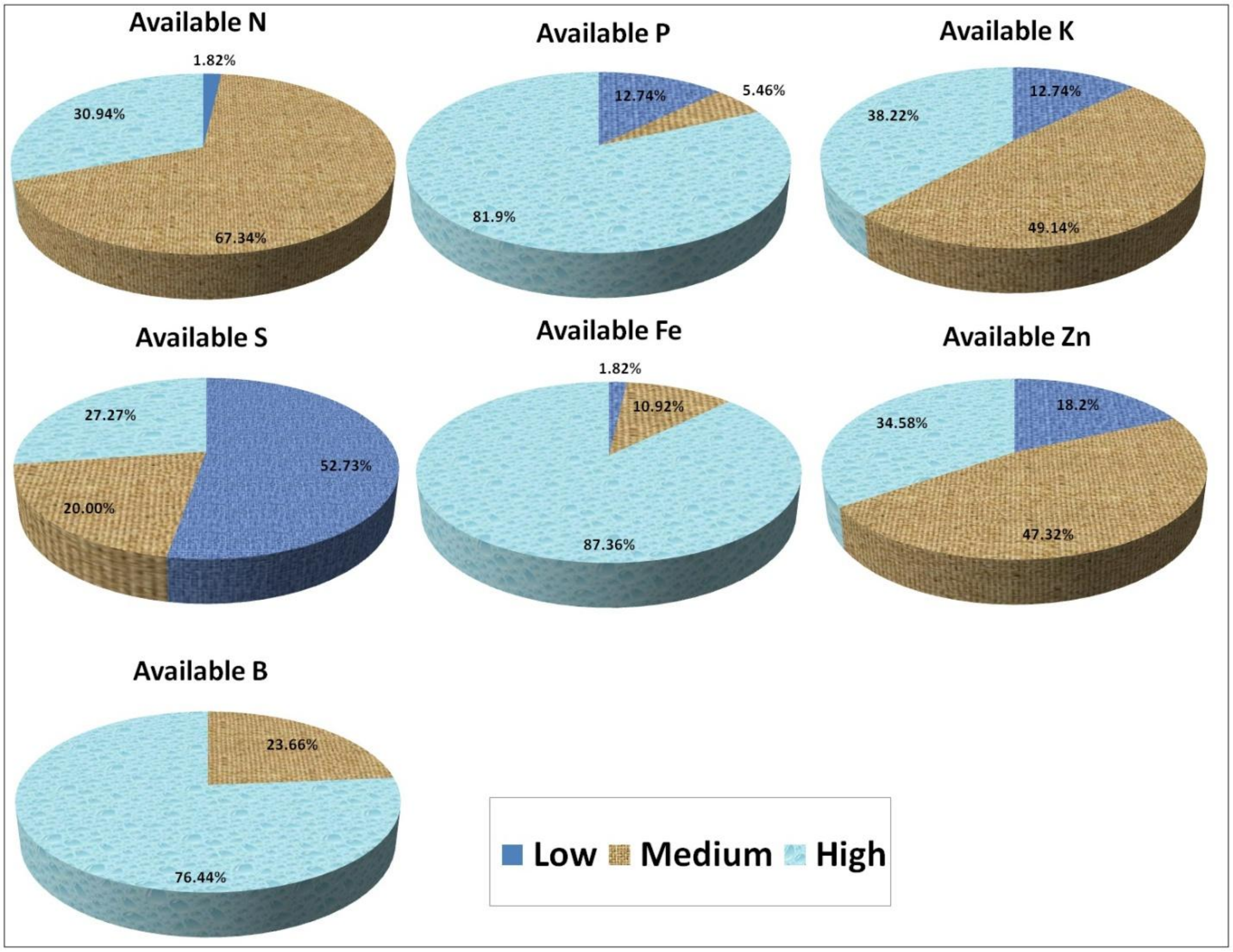
Table.3 Correlation coefficients for studied soils

pH/Av.P	0.47**	EC/Av.S	0.85**	Av.P/Av.S	0.70**
pH/Av.K	0. 30*	EC/Av.B	0.61**	Av.P/Av.Fe	-0.32*
pH/Av.Fe	-0.80**	OC/Av.N	0. 93**	Av.P/Av.Zn	-0. 48**
pH/Av.Zn	-0.79**	OC/Av.B	0.31*	Av.P/Av.B	0.43**
EC/Av.P	0.68**	Av.N/Av.B	0.35**	Av.K/Av.S	0.74**
EC/Av.K	0.87**	Av.P/Av.K	0.82**	Av.K/Av.Fe	-0. 30*
Av.K/Av.Zn	-0.36**	Av.K/Av.B	0.66**	Av.S/Av.B	0.37**
Av.Fe/Av.Zn	0.89**				
**Significant at 1% level					
*Significant at 5% level					

Table.4 Multiple linear regression equations for studied soils

Regression equation	**Predictability (R^2x100)**
Av. N = 130. 221 -6.982 pH + 7. 341 EC + 270. 153 OC** Av. N = 83.086 + 268.665 OC**	87.3 87.1
Av. P = -151. 263 + 22. 674 pH** + 43. 014 EC** + 3. 337 OC Av. P = -145.768 + 22. 683 pH** + 42.587 EC**	62.3 62.1
Av. K = -738. 349 + 85. 847 pH** + 426. 854 EC** + 114. 942 OC** Av. K = -549.082 + 86.159 pH** + 412.158 EC**	84.1 81.0
Av. S = 44.466 -5.217 pH + 53. 665 EC** -4.532 OC Av. S = -2.024 + 53. 572 EC**	73.7 72.5
Av. Fe = 127.632-14. 939 pH** -1.450 EC + 1.971 OC Av. Fe = 131.381-15.091 pH**	65.8 64.7
Av. Zn = 11. 144 -1.387pH** +0. 291 EC + 0.345 OC Av. Zn = 11. 812 -1.417 pH**	66.1 62.2
Av. B = -0. 116 + 0.028 pH + 0.285 EC** + 0.241 OC** Av. B = 0.093 + 0.288 EC** + 0.241 OC**	55.9 55.3

Fig.1 Distribution of studied soil samples in different categories of available nutrients



NI values given in table 3 further showed that these soils fell in high category of available P (NIV=2.69), Fe (NIV=2.85), B (NIV=2.76) and medium category of available N (NIV=2.29), K (NIV=2.25), S (NIV=1.75) and Zn (NIV=2.16).

Influence of soil characteristics on available nutrients

Results of correlation analysis as presented in table 3 revealed that soil pH showed significant and positive correlations with available P ($r=0.47^{**}$) and K ($r=0.30^{*}$) and significant and negative correlations with available Fe ($r=-0.80^{**}$) and Zn ($r=-0.79^{**}$). Low availability of micronutrients at higher pH may be attributed to the reduction in their solubility. These results are in conformity with the findings of Yadav and Meena (2009). EC showed significant and positive correlations with available P ($r=0.68^{**}$), K ($r=0.87^{**}$), S ($r=0.85^{**}$) and B ($r=0.61^{**}$). Soil OC was significantly and positively correlated with available N ($r=0.93^{**}$) and B ($r=0.31^{*}$). These results are in line with those of Bhat *et al.,* (2017).

Data presented in table 4 indicated that available N showed significant and positive regression coefficient (270.153**) with OC. Step down regression equations indicated that about 87% of variability in available N could be attributed to OC alone. The significant and positive correlation between OC and available N could be because of release of mineralizable N from soil organic matter in proportionate amounts (Vanilarasu and Balakrishnamurthy, 2014) and adsorption of NH_4-N by humus complexes in soil. The results are in conformity with those of Kumar *et al.*, (2014). Available P showed significant and positive regression coefficients with pH (22.674**) and EC (43.014**). Also, available K had significant, positive regression coefficients with pH (85.847**) and EC (426.854**). In available P and K, nearly 62% and 81% of the respective variability could be attributed to pH and EC together. Available S showed significant and positive regression coefficient with EC (53.665**). It was found to be influenced by EC alone to the extent of about 72% of the total variability. Available Fe and Zn had significant and negative regression coefficients with pH (-14.939** and -1.387** in order). Yadav (2011) suggested that the reduced Fe availability with increasing pH might be attributed to the conversion of Fe^{+2} to Fe^{+3} ions. The Fe^{+3} ion compounds have low solubility in solution and so are less bio available. pH contributed about 65% and 62% of the total variability towards available Fe and Zn in order. Available B had significant and positive regression coefficients with EC (0.285**) and OC (0.241**).Similar results were reported by Randhawa and Singh (1995). More than 55% of variability in available B could be attributed to OC and EC together. Great deal of heterogeneity observed in available nutrient content of studied soils might be the result of variations in intensity of soil forming factors and pedogenic processes at play during the development of these soils.

The studied soils were fine textured, rich in OC, mostly having normal EC and a pH range ideal for the availability of most of the plant nutrients. Wide variations in their fertility exist due to various intrinsic and extrinsic factors. Majority of these soils though contained medium to high amounts of available nutrients (N, P, K, Zn, Fe, and B); however S deficiencies may be expected in some of these. As such, application of S in soils testing low in this nutrient is highly likely to be responsive. At the same time, areas with excessively high levels of a nutrient equally need corrective measures in terms of proportionate reduction in fertilizer dose, in order to achieve optimum fertility levels. The results exhibited high degree of dependence of available N and B on OC; Fe and Zn on pH; P and K on both pH and EC; and that of S on EC. Thus, OC, pH and EC were identified as the main soil characteristics influencing the availability of nutrients in these soils. These can be suitably manipulated in order to combat any nutritional imbalances in these soils.

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