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Macro and micro nutrient status of some salt affected Vertisols of Upper Krishna Command (Karnataka)

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Abstract

Seven Vertisol profiles, occurring in the Upper Krishna Project Area of Karnataka and found to be affected with varying degrees of salinity and/or sodicity, were investigated to delineate the status of macro- and micro nutrient availability. Available nitrogen, which tended to accumulate in top two or three horizons, was low (46.0 to 162 kg ha^{-1}), while phosphorus availability was low to medium (2.0 to 13.0 kg ha^{-1}) and that of potassium was adequate (161 to 484 kg ha^{-1}). Among the micro nutrient cations, copper, manganese and iron were found in amounts well above critical limits, whereas the soils were deficient in zinc supply. The soil properties, particularly soil pH, organic carbon and degree of sodicity, influenced the availability of both macro- and micro nutrients.

Additional keywords: Available nutrient status.

Introduction

Cultivators of black cotton soils or Vertisols are generally confronted with the problem of their adverse physical properties. And, when such soils are afflicted with salinity and sodicity, the problem becomes more acute owing to reduction in their fertility status, brought about by reduced water potential, toxicity effects of various ions and high pH. In Upper Krishna Project (UKP) Command of Northern Karnataka, the Vertisols, especially those belonging to Tumkur and Kagalgomb series, have not only low infiltration rate, reduced permeability and imperfect drainage (Anonymous, 1981) but also suffer various degrees of salinity. In view of this, the present study was undertaken with the objective of evaluating the availability of macro- and micro nutrients in some representative profiles of the UKP area, so as to provide basic information for better nutrient management in these soils.

Materials and methods

Seven Vertisols profiles, suspected to be salt affected (through visual observations), were selected from different locations in UKP area, characterized by nearly level topography. Five profiles (P1 to P5), developed on granite gneiss, belong to subgroup Typic Chromusterts (Isohyperthermic), while the others (P6 and P7), originated on limestone, are Typic Pellusterts (Hyperthermic), and, respectively, belong to Tumkur and Kagalgomb series.

Soil samples, collected from six depths of each of these profiles, were air-dried and processed, and analyses for physical and chemical properties were carried out following the standard procedures (Black, 1965). For the estimation of available nitrogen, phosphorus and potassium, the methods outlined by Subbaiah and Asija (1956), Olsen *et al.* (1954) and Black (1965) were adopted, respectively, while the concentrations of micro nutrient cations, extracted using DTPA, were determined by atomic absorption spectroscopy (Lindsay & Norvell, 1978).

Results and discussion

Physical and chemical properties

The soils, having a clay content in excess of 40 per cent at all depths, are high in bulk density, low in organic carbon, moderate to strongly alkaline in reaction, high in cation exchange capacity, and have exchange sites dominated by calcium + magnesium and sodium in that order (Table 1). The soil profiles, particularly P2, P4 and P7, had exchangeable sodium percentage (ESP) values of more than 15.0, the lower limit fixed for sodic subgroups of Vertisols (Soil Survey Staff, 1994) and there was a general increase in ESP values down the profile depths, suggesting the initiation of sodiumization process (Balpande *et al.* 1996). However, considering the recent ESP limit of 6.0 (Shanmuganathan & Oades, 1983) or 5.0 (Balpande *et al.* 1996) for the Vertisols with adverse physical conditions and consequent drainage problems, all the profiles could be considered sodicity-affected. In soil water extract, Na was the dominant cation followed by Ca + Mg, while salinity was of chloride-sulphate type. Lower levels of organic carbon and higher sulphate concentration indicated the distinct possibilities of further sodification of these soils.

Table 1. Physical and chemical properties of some salt-affected Vertisols of UKP Command

Depth (cm)	Clay (%)	B.D. (Mg m^{-3})	pH (1:2.5)	ECe (dS m^{-1})	CEC (cmol (p+) kg^{-1})	ESP	Water soluble ions (Ml L^{-1})			
							Na	Ca+Mg	Cl	SO_4
P1 (Hebbal B.)										
0-15	55.2	2.58	7.9	5.4	34.8	8.7	26.9	26.4	28.5	24.6
15-30	59.5	2.63	7.8	5.3	39.2	9.4	27.3	25.8	24.0	20.2
P2 (Hebbal, K.)										
0-15	42.4	2.68	8.4	4.1	39.2	16.6	23.9	16.6	20.5	14.6
15-30	47.2	2.68	8.4	4.0	52.2	17.1	23.4	15.4	23.0	12.9
P3 (Havinal)										
0-15	44.8	2.67	7.9	6.1	34.8	9.4	30.4	30.0	28.0	30.9
15-30	47.1	2.65	8.0	5.0	38.2	15.1	26.5	22.4	31.0	16.3
P4 (ARS, Kavadimatti)										
0-15	51.9	2.70	8.5	4.2	45.2	17.8	26.0	16.2	18.5	20.0
15-30	48.7	2.70	8.6	2.2	58.3	24.2	17.8	4.2	12.5	10.8
P5 (Farmers field, Kavadimatti)										
0-15	43.1	2.74	7.5	6.4	33.1	10.5	32.2	32.0	34.5	34.8
15-30	47.7	2.71	7.8	6.2	37.4	12.2	32.6	30.0	32.0	26.4
P6 (Islampur)										
0-15	44.1	2.70	7.9	4.9	41.8	9.9	24.7	23.4	24.0	19.2
15-30	59.3	2.71	7.9	4.6	44.4	11.7	25.2	20.6	24.5	19.7
P7 (Devapur J.)										
0-15	40.3	2.59	8.4	4.1	32.2	18.9	25.4	14.0	24.0	11.3
15-30	45.1	2.65	8.6	2.4	33.3	23.2	25.2	5.2	13.0	7.8

Available nitrogen

The soils under study contained very low amounts of alkaline mineralisable N (46.0 to 162 kg/ha), which decreased with the profile depth (Table 2). The low levels may be ascribed to several factors, such as lower organic carbon, resulting from sub-optimal plant growth, high pH (Table 1) and high $CaCO_3$ content in the soil series under investigation (Nandi and Dasog, 1992), favouring higher ammonia volatilization losses, and reduced nitrification and subsided activity of N-fixing microbes (Bhardwaj, 1975).

Table 2. Available macro and micronutrient status of some salt affected Vertisols of UKP Command (Karnataka)

Depth (cm)	O.C. (%)	N	P	Available K	Zn	Fe	Mn	Cu
		<— kg/ha		—>	<—	(ppm)		—>
P1 (Hebbal B.)								
0-15	0.63	143.0	9.6	413.0	0.60	6.58	9.36	1.64
15-30	0.42	124.0	9.1	328.0	0.46	6.10	8.91	0.92
30-60	0.40	111.0	7.9	289.0	0.40	5.66	8.53	0.64
60-90	0.33	92.0	4.5	265.0	0.34	4.50	8.91	0.88
90-120	0.30	84.0	3.5	211.0	0.31	2.44	7.20	0.64
120-150	0.20	81.0	2.2	195.0	0.30	4.22	7.52	0.80
P2 (Hebbal K.)								
0-15	0.54	113.0	10.1	406.0	0.42	8.93	8.13	0.96
15-30	0.45	109.0	10.1	242.0	0.39	7.26	7.91	0.81
30-60	0.33	96.0	8.9	164.0	0.36	5.15	7.14	0.78
60-90	0.21	94.0	6.9	328.0	0.29	5.61	6.80	0.69
90-120	0.18	87.0	5.7	265.0	0.23	4.70	6.12	0.61
P3 (Havinal)								
0-15	0.36	162.0	11.1	374.0	0.51	7.39	13.40	0.80
15-30	0.21	134.0	12.8	187.0	0.48	6.77	12.91	0.75
30-60	0.16	104.0	7.1	195.0	0.36	6.21	12.15	0.70
60-90	0.15	97.0	8.2	250.0	0.31	5.76	12.06	0.71
90-120	0.10	93.0	5.4	335.0	0.29	4.50	11.51	0.63
P4 (ARS, Kavadimatti)								
0-15	0.33	102.0	5.7	356.0	0.46	8.71	9.18	1.30
15-30	0.45	95.0	4.0	20.30	0.60	7.02	8.65	0.92
30-60	0.36	81.0	3.7	218.0	0.36	6.61	7.01	0.78
60-90	0.21	72.0	2.2	273.0	0.26	5.96	7.60	0.63
90-120	0.15	65.0	6.6	226.0	0.30	5.66	7.21	0.40
P5 (Farmer's field, Kavadimatti)								
0-15	0.42	97.0	12.3	335.0	10.45	2.17	10.81	1.26
15-30	0.24	72.0	9.3	304.0	10.40	1.06	10.63	0.90
30-60	0.21	65.0	8.6	281.0	0.34	9.50	9.16	0.80
60-90	0.21	59.0	7.9	242.0	0.32	6.40	10.32	0.62
90-120	0.12	61.0	6.4	211.0	0.26	5.15	9.53	0.30
P6 (Islampur)								
0-15	0.60	138.0	6.4	413.0	0.36	5.95	8.31	2.16
15-30	0.54	121.0	5.7	390.0	0.67	5.90	8.12	1.60
30-60	0.42	97.0	4.5	320.0	0.63	4.61	7.86	1.16
60-90	0.39	93.0	4.0	398.0	0.30	4.50	7.12	1.46
90-120	0.23	96.0	8.4	161.0	0.30	6.46	7.10	1.32
P7 (Devapur J.)								
0-15	0.62	134.0	7.4	484.0	0.60	6.96	9.17	1.52
15-30	0.60	109.0	6.4	320.0	0.53	6.77	9.03	0.96
30-60	0.51	100.0	5.9	304.0	0.52	6.46	8.61	0.94
60-90	0.33	87.0	4.4	242.0	0.42	5.75	8.11	0.81
90-120	0.25	84.0	7.9	211.0	0.40	4.50	7.83	0.73

Significant positive correlation (Table 3) of available N with organic carbon (r = 0.38*) could be due to adsorption of ammoniacal N by humus complex (Kanthaliya & Bhatt, 1991), while, as found in this study, its negative association with soil pH (r= -0.55**) is well documented (Fenn & Kissel, 1973). Among the soil physical properties, available N was found related to bulk density (r= -0.67**) and porosity (r= 0.76**). These observations indicate the importance of using organic manures and crop residues, which, apart from adding nutrients, have an added advantage of improving soil physical conditions.

Table 3. Correlation coefficients

Soil property	Available Nutrients						
	N	P	K	Zn	Cu	Fe	Mn
Clay	0.13	0.16	0.02	0.04	0.04	-0.05	-0.06
Organic carbon	0.38 *	0.02	0.54 **	0.59 *	0.56 **	-0.22	-0.10
Bulk density	-0.86 **	-0.54 **	-0.56 **	-0.59 **	0.49 **	-0.52 **	-0.35 *
pH	-0.55 **	-0.37 *	-0.37 *	-0.27	-0.46 **	-0.36 *	-0.45 **
EC	-0.40 **	-0.33 *	-0.33 *	0.14	0.31 *	0.38 *	0.53 **
CEC	-0.16	-0.24	-0.24	-0.07	-0.15	-0.16	-0.36 *
ESP	-0.14	-0.26	-0.26	0.11	-0.10	-0.05	-0.27

Available phosphorus

The status of available P (Table 2) in soils was low to medium (2.2 to 12.8 kg/ha) and, as observed in Vertisols of many agro-climatic zones (Murthy, 1988), though the surface soils contain higher available P, the general inference that the salt affected soils are rich in P availability is not attested here. The deviation as shown by negative correlation (Table 3) of available P with soil pH (r= -0.37*) and ESP (r= -0.23), as well as its lower amounts could be related to higher P-fixation capacities of soils derived from granite-gneiss and limestone (ACBSR, 1984) resulting mainly due to their calcareous nature (Murthy, 1988), particularly because silt and clay sized carbonate fractions, with increased specific surface, constitute nearly 60 per cent of the total carbonates in the calcareous soils of the Tumkur and Kagalgomb series investigated (Nandi & Dasog, 1992). A nonsignificant association of available P with organic carbon (r= 0.02) signifies inorganic P fractions as the major contributors towards available P in these soils (Giridhar Krishna, 1994).

Available potassium

Unlike N and P, available K, which varied from 161 to 484 kg/ha, did not exhibit a regular depth distribution pattern (Table 2) and was not much influenced by the soil properties considered. Although its significantly positive correlation with organic carbon (r= 0.54**) (Table 3) might indicate the release of K from organic acids (Kanthaliya & Bhatt, 1991), the proposition, in the light of the fact that these soils are low in organic carbon, does not appear plausible. And, relatively higher levels of available K which are in conformity with the values obtained by Patil and Sonar (1993), could be attributed to predominance of K-rich micaceous minerals in arid region soils and their dissolution under salt-affected conditions (Pal, 1985).

Available micronutrient cations

The availability of Cu (0.22 to 2.16 ppm), Mn (6.10 to 13.45 ppm) and Fe (2.44 to 12.77 ppm) was generally well above critical limits (Table 2), while Zn was in the deficiency range (0.22 to 0.67 ppm). Relatively higher availability of Fe, Mn and Cu could be ascribed to origin of these soils from granite-gneiss and limestone (Murthy, 1988). Though these parent materials are also rich in total Zn content, its short supply could be due to high pH, presence of excess $CaCO_3$ and low organic carbon. The observation is in accordance with the inference that the alkaline calcareous soils with an inherent pH around 8.0 are responsive to Zn fertilization, inspite of their sufficient Zn reserves (Singh & Abrol, 1986).

The increase in Zn availability with organic carbon, as brought about by a significantly positive correlation between the two ($r= 0.59^{**}$) (Table 3), may be due to Zn mobilization by dispersed organic matter (Jaffery & Uren, 1983), while a similar trend for Cu could be because of formation of natural stable complexes in soil solution (Arora & Sekhon, 1981). Lack of close association of available Fe and Mn with organic carbon indicates inorganic phase as their major source (Arora & Sekhon, 1981). Among the other soil properties, soil pH influenced micronutrient availability positively, while the association pattern of the latter with physical properties suggests the beneficial role of improved soil aggregation.

Thus, it becomes imperative that the soils, which, in most cases, have sodicity well above the recently suggested critical limit (ESP = 5 or 6), exhibit characters that indicate possibilities of further sodification. While the contents of available N and P are generally low, the soils are well supplied with available K, particularly in surface layers, and among micronutrients, there appears to be a need for Zn fertilization with the availabilities of all other micro nutrient cations being adequate. Correlation studies indicate the possibilities of increasing macro- and micro nutrient availability through improvement of soil physical properties, by application of organic residues.

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