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Distribution of nutrients in relation to properties of salt affected soils of southern Rajasthan

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The nature of saline and sodic soils in Rajasthan is location specific (Bhargava and Raj-Kumar 2004) and accordingly limit the crop productivity. These soils contain large amount of soluble salts and/or exchangeable sodium which interfere the growth of crops. In general, the alkali soils are low in fertility (Raj-Kumar *et al.* 1995) and deficient in DTPA extractable micronutrient cations and in particular Zn and Fe (Ashokkumar and Jagdish Prasad 2010). Widespread zinc deficiency has been reported in sodic soils owing to high pH and calcareous in nature (Sharma *et al.* 1982). In sub-humid southern plain of Rajasthan (Chittorgarh, Bhilwara and Udaipur districts), the salt affected soils suffer from various degrees of sodicity. Though, efforts are being taken to ameliorate through inorganic amendments, bio-fertilizers and agronomic practices. The information on vertical distribution of macro and micro-nutrients and the factors affecting their availability particularly in Chittorgarh district is virtually lacking and hence present investigation was carried out.

Five pedons, based on marked spots on imagery (salt affected soils) were selected from different locations in sub-humid southern plain of Chittorgarh district. The district is situated between 23°32' and 25°13' north latitude and 74°12' and 75°49' east longitude and is characterized by semi-arid monsoonal climate with mean annual precipitation of 1008 mm. The sites were located in Kapasan, Rashmi and Dungla tehsils of the district. Soil samples were collected from 0-15, 15-30, 30-45, 45-60, 60-75 and 75-90 cm depths. The processed soil samples were analyzed for physical and chemical properties following the standard procedures (Richards 1954; Jackson 1973). The micronutrient cations were extracted following the procedure outlined by Lindsay and Norvell (1978).

The soils had relatively high bulk density and clay content (Table 1). The pH, EC_e and $CaCO_3$ content of the soils ranged between 8.1 to 9.7, 0.97 to 2.17 dSm^{-1} and 37.2 to 610 g kg^{-1} respectively. The organic carbon ranged from 0.42 to 6.7 g kg^{-1} and decreased with depth. The CEC of the soils ranged from 14.6 to 26.9 cmol (p+) kg^{-1} seems to be dependent on clay.

The soils had exchangeable sodium percentage (ESP) more than 15.0 (17 to 45 cmol (p+) kg^{-1}) and increased with depth, suggesting the initiation of sodiumization process (Yeresheemi *et al.* 1997) which may adversely affect the drainage (Ashokkumar and Jagdish Prasad 2010)

The alkaline mineralizable N was low (64.3 to 248.7 kg ha^{-1}) and available phosphorus was medium (6.8 to 25.0 kg ha^{-1}) and decreased with depth (Table 2). The low level may be ascribed to several factors, including low organic carbon, high pH and $CaCO_3$ content. These might have resulted in decomposition and N mineralization, favouring higher ammonia volatilization losses, reduced nitrification and subsided activity of N-fixing microbes (Bhardwaj 1975). The significant positive correlation of available N with organic carbon (Table 3) could be due to adsorption of $NH4^+$-N by humus complex (Kanthaliya and Bhatt 1991)

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Table 1. Physical and chemical properties of some salt affected soils

Depth	B.D. (Mg m^{-3})	Clay (%)	pH	EC_e (dS m^{-1})	O.C. (g kg^{-1})	$CaCO_3$ (g kg^{-1})	CEC (cmol (p^{+}) kg^{-1})	ESP (%)
P1 (Bhopalsagar) : Fine-loamy, mixed, hyperthermic Typic Calciustept								
0-15	1.53	33.9	9.1	1.51	6.68	137.0	25.3	22.5
15-30	1.54	28.8	9.3	1.47	5.17	145.0	20.6	23.7
30-45	1.56	24.7	9.3	1.9	4.60	147.0	17.4	25.6
45-60	1.57	36.8	9.3	2.12	2.90	150.0	23.8	25.7
60-75	1.56	33.8	9.4	2.03	1.82	194.0	22.9	24.9
75-90	1.58	36.9	9.4	2.14	1.52	364.0	24.4	30.0
P2 (Tana) : Fine-loamy, mixed (calcareous), hyperthermic Typic Haplustept								
0-15	1.44	30.5	8.3	3.96	7.60	37.2	18.7	17.0
15-30	1.49	32.6	8.8	1.77	6.68	45.0	21.4	17.2
30-45	1.53	27.5	9.1	1.43	6.35	62.5	17.6	18.5
45-60	1.55	34.8	9.1	1.92	5.17	67.0	18.3	23.9
60-75	1.58	37.1	9.3	1.76	3.39	92.0	20.8	30.9
75-90	1.56	41.6	9.5	2.17	1.82	310.2	26.9	31.8
P3 (Dindoli) : Fine-loamy, mixed (calcareous), hyperthermic Typic Haplustept*								
0-15	1.44	26.2	8.1	0.91	6.62	128.5	18.9	18.5
15-30	1.48	36.1	8.6	0.97	5.70	96.2	19.4	25.2
30-45	1.51	28.1	9.1	1.42	3.80	71.0	18.7	31.1
45-60	1.54	22.9	9.5	1.41	2.25	87.5	17.2	34.4
60-75	1.58	32.9	9.6	1.58	1.82	133.5	20.7	38.1
75-90	1.56	29.8	9.7	1.76	1.38	285.0	21.4	45.4
P4 (Dungla) : Fine-loamy, mixed, hyperthermic Typic Calciustept								
0-15	1.47	21.6	8.2	1.63	7.20	125.0	16.5	23.5
15-30	1.53	19.2	8.8	1.29	4.95	143.5	14.6	32.2
30-45	1.56	23.8	9.1	1.04	2.55	237.5	17.5	34.9
45-60	1.52	27.8	9.1	1.31	1.20	411.0	19.8	36.4
60-75	1.57	29.8	9.2	1.83	0.82	587.0	20.3	40.8
75-90	1.54	32.9	9.6	1.81	0.42	610.0	20.1	44.5
P5 (Idra) : Fine-loamy, mixed, hyperthermic Typic Calciustept								
0-15	1.42	28.6	8.8	2.81	3.70	63.5	20.2	28.8
15-30	1.47	26.1	9.3	1.49	2.52	156.0	19.9	35.1
30-45	1.51	31.6	9.4	1.51	1.78	172.0	21.2	38.4
45-60	1.52	33.9	9.5	1.37	1.52	181.0	21.5	40.5
60-75	1.55	32.4	9.6	1.56	1.20	187.0	21.6	42.0
75-90	1.61	35.6	9.7	1.79	0.82	190.0	22.1	41.3

* *Verma et al. (2007) proposed sodic subgroup for such soils*

Table 2. Macro and micro nutrient status of some salt affected soils

Depth	N	P	K	Zn	Fe	Mn	Cu
		(kg ha^{-1})				(mg kg^{-1})	
P1 (Bhopalsagar)							
0-15	247.2	22.5	546.3	0.68	4.28	4.98	0.77
15-30	238.4	20.0	428.1	0.6	3.95	4.75	0.70
30-45	219.4	21.1	375.6	0.58	3.86	4.61	0.54
45-60	156.7	14.9	384.4	0.53	3.53	4.35	0.43
60-75	145.7	14.8	244.6	0.46	3.38	3.99	0.37
75-90	145.4	12.4	279.5	0.33	2.97	3.64	0.34
P2 (Tana)							
0-15	348.7	25.0	253.4	0.74	2.48	4.18	1.04
15-30	319.2	24.0	445.5	0.65	2.27	3.92	0.99
30-45	247.4	19.7	384.4	0.54	2.21	2.76	0.84
45-60	279.8	20.6	340.6	0.49	1.97	3.65	0.75
60-75	186.7	17.8	366.8	0.42	1.82	3.34	0.58
75-90	180.0	16.9	410.6	0.31	1.69	3.25	0.39
P3 (Dindoli)							
0-15	280.3	17.8	384.4	0.59	3.17	5.8	0.97
15-30	257.9	25.0	366.8	0.55	2.92	5.39	0.89
30-45	228.4	23.5	401.8	0.5	2.68	4.82	0.86
45-60	148.7	19.4	358.2	0.45	2.37	4.52	0.73
60-75	156.4	17.3	375.6	0.39	1.99	4.17	0.56
75-90	131.9	13.6	411.52	0.27	1.45	3.89	0.37
P4 (Dungla)							
0-15	298.0	21.6	368.2	0.65	2.39	7.79	0.91
15-30	262.8	19.0	384.6	0.47	1.92	7.37	0.74
30-45	188.4	16.6	436.8	0.42	1.59	6.98	0.68
45-60	117.4	11.5	336.9	0.33	1.37	6.63	0.64
60-75	87.8	8.0	331.9	0.25	1.13	6.28	0.46
75-90	64.3	6.8	424.6	0.21	0.98	5.92	0.41
P5 (Idra)							
0-15	208.9	22.0	281.1	0.69	2.74	5.76	0.74
15-30	182.7	23.2	242.7	0.68	2.48	5.38	0.67
30-45	146.4	19.5	218.4	0.59	2.51	5.03	0.61
45-60	109.2	18.8	273.3	0.45	2.33	4.79	0.51
60-75	93.1	16.5	253.7	0.37	1.92	4.65	0.39
75-90	72.4	13.9	320.0	0.25	1.53	4.63	0.27

Table 3. Correlation coefficient (r) between soil properties and DTPA extractable cations

Soil properties	N	P	K	Zn	Fe	Mn	Cu
Clay	-0.27	-0.19	-0.06	-0.28	-0.11	-0.23	-0.14
Org. C	0.95**	0.74**	0.24	0.65**	0.29*	0.04	0.52**
$CaCO_3$	-0.67**	-0.87**	0.02	-0.59**	-0.49**	-0.27*	-0.59**
B.D	-0.59**	-0.58**	0.17	-0.75**	-0.22	-0.34*	-0.75**
pH	-0.80**	-0.50**	-0.09	-0.64**	-0.34*	-0.42*	-0.83**
EC	0.16	0.08	-0.32*	-0.03	0.03	-0.31*	-0.03
CEC	-0.37*	-0.26	0.03	-0.44*	-0.05	-0.63**	-0.44**
ESP	-0.86**	-0.61**	-0.21	-0.69**	-0.62**	-0.18	-0.67**

** *Significant at 1 per cent level* * *Significant at 5 per cent level*

A negative correlation of available P with pH, ESP and in particular with $CaCO_3$ indicates the higher P-fixation capacities of calcareous soils (Singh 1999). Unlike N and P, available K is high (> 218.4 kg ha^{-1}). A higher content of potassium in these soils may be attributed the greater proportion of feldspar group of minerals in arid and semi-arid region soils (Yeresheemi *et al.* 1997).

The DTPA- Cu and Mn were generally well above critical limits (Table 2), whereas, DTPA-Zn and Fe were in the deficiency range as prescribed by Arora (2002). Relatively high availability of Mn and Cu could be ascribed to their genesis from calcic-gneiss and limestone (Sehgal 1975; Chattopadhyay *et al.* 1996). Though, these parent materials are also rich in total Zn content (Singh 1999), its low availability could be assigned to high pH (r = 0.64**) and $CaCO_3$ (r = 0.59**) conducive of making the Ca-zincate. At high pH, Zn fixation increases as a result of precipitation reaction and entrapment of Zn in the interlayer wedge zones of illite (Reddy and Perkins 1974). The presence of organic matter may promote the availability of micronutrient cations, presumably by supplying complexing agents that interfere with fixation (Lodha and Baser 1971). Iron has been found as the limiting micronutrient in alkali soils due to high pH and presence of $CaCO_3$. The results indicates that all micronutrient cations show negative correlation with ESP of the soil (Table 3).

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