Water Retention Characteristics of Salt Affected Soils of District Bhilwara, Rajasthan

Sharma, SS

National Bureau of Soil Survey and Land Use Planning (ICAR), Regional Centre, Udaipur- 313 001, Rajasthan, India

Abstract

Twenty six pedons at different depths of salt affected soils of Bhilwara, Rajasthan were studied for their water retention characteristics. An integrated approach of image interpretation couples with field studies was followed to delineate the salt affected soils of the district. After delineating the sites twenty six representative pedons were exposed and soil samples were collected. Weighted mean of ECe of each pedon was computed and the pedons were grouped into five categories. Water retention study was carried out at 0.033 MPa and 1.5 MPa tensions. Organic carbon; calcium carbonate; water soluble and exchangeable calcium, magnesium, sodium and potassium were also determined to correlate these with water retention characteristics of soils. Results show that with depth content of $CaCO_3$ increased whereas organic carbon decreased. Water retention characteristics are associated with texture of soil. Non-saline soil showed lowest value for PAWC and its value increases with salinity. Strongly saline soils show highest value of PAWC from S1 to S5.

Key words- Salt affected soils, calcium carbonate content, soil characteristics, water retention, Bhilwara, Rajasthan.

Introduction

Information on water retention characteristics of soil is necessary for assessing water requirement and planning of irrigation schedule for optimum crop production. The amount of soil water available for crop growth which is plant available water capacity (PAWC) is determined by the storage capacity of the soil, the ability to recharge this store by surface water application and the depth and distribution of root system. Since the information on water retention characteristics of Bhilwara district is lacking, attempt has been made in this paper to study the influence of various soil characteristics affecting water availability in salt affected soils of the district.

Experimental

The study was undertaken in Bhilwara district of Rajasthan located between 25°01'N and 25°28'N latitude and 74°01'E and 75°28'E longitude. The climate of the study area is semi-arid with mean annual rainfall of the district is 699mm and is quite erratic of which nearby 87 per cent is received during July to August. The water balance diagram shows that precipitation is greater than PET during the month of July to September, whereas PET exceeds rainfall in most of the other months. The mean annual temperature of the area is around 25.6°C, this qualifies for hyperthermic temperature region. Since the moist period is more than 90 days, this area is classified under ustic soil moisture regime and the length of growing period (LGP) of the district varies between 90 to 110 days. An integrated approach of image interpretation couples with field studies was followed to delineate the salt affected soils of the district. To demarcate areas of similar soils several auger holes and field checks were undertaken in each soil boundary and the observations for color, texture, depth etc. were recorded. On the basis of these observations representative sites were selected. After delineating the sites twenty six representative pedons were exposed and soil samples were collected, randomize for the case of comparison of results as well as to analyze constraints. Weighted mean of ECe of each pedon was computed and the pedons were grouped into five categories as suggested[1]. Physical and chemical characteristics used in the investigation are carried out as per standard procedures. Water retention at 0.033 MPa and 1.5 MPa tension was determined[2]. The PAWC was computed using the following expression-

PAWC mm/m = $\sum$ (Wmax-Wdry) BD at Wmax X HD

Where-

Wmax= Gravimetric water content at 33kPa tension

Email- shyambarnala@yahoo.com

Wdry= Gravimetric water content at 1500kPa tension

BD= Bulk density at Wmax

HD= Horizon thickness (m)

RD= Total rooting depth taken as to a depth of root limiting layer whichever is shallower

For the ease of presentation of result each pedon selected as typifying pedon from individual group of salt affected soils.

Results and Discussion

Physico-chemical characteristics

The physico-chemical characteristics of different groups show that the soils are alkaline (pH 7.66 to 8.98), calcareous (30.10 to 249.1 g kg^{-1}), and low to medium in organic carbon content (3.21 to 8.42 g kg^{-1}) (Table 1). The soil texture is sandy loam to loam in non-saline, sandy loam to clay loam in very slightly saline, sandy clay loam throughout in slightly saline, sandy clay loam to sandy clay in moderately saline and clay loam in strongly saline soils. Electrical conductivity ranged between 1.32 and 33.20 dS cm^{-1}. Content of sand, silt and clay in different pedons ranged between 25.60 to 64.13; 7.89 to 38.32; and 18.61 to 40.78%, respectively. Water soluble cations i.e. calcium, magnesium, sodium and potassium ranged between 1.6 to 87.6, 1.0 to 70.0, 10.3 to 176.0, and 0.22 to 6.0 mmol L^{-1}, respectively. Similarly exchangeable bases like calcium, magnesium, sodium, potassium, cation exchange capacity (CEC) and exchangeable sodium percentage (ESP) ranged between 5.0 to 10.9, 3.8 to 10.0, 1.5 to 5.5, 0.2 to 1.0, 12.9 to 28.4, and 7.0 to 20.2 cmol (p+)kg^{-1}, respectively. A critical examination of data suggests that the content of organic carbon and $CaCO_3$ showed reverse trend in their content with increasing depth in each pedon (Table 1). With depth content of $CaCO_3$ increased whereas organic carbon was found highest in upper layer. It was so because accumulation of plant and animal debris remains higher in upper soil layer which are the main source of organic carbon. Highest calcium carbonate content in deepest layer shows accumulation of leached ions in these layers. Content of exchangeable bases like calcium, magnesium, sodium and potassium were also remained highest in deepest layer studied which contributes highest cation exchange capacity in these layers (Table 1).

Table 1 Physico-chemical characteristics of experimental soil

Depth (cm)	Horizon	pH	ECe (dS m^{-1})	O.C.	$CaCO_3$	Sand	Silt	Clay	Water soluble(mmol L^{-1})				Exchangeable bases [cmol(p+)kg^{-1}]					
									Ca	Mg	Na	K	Ca	Mg	Na	K	CEC	ESP
P1- Non-saline soil (ECe<2.00 dS m^{-1}): Fine-loamy, mixed (cal.), hyperthermic, *Typic Halplustepts*																		
0-14	Ap	8.01	2.10	5.17	70.0	40.57	36.22	23.21	3.9	3.5	13.6	1.00	6.4	5.8	2.5	1.0	16.5	15.2
14-27	Bw1	8.00	2.00	5.17	50.0	64.13	16.45	19.42	3.0	2.4	13.1	1.20	5.2	4.3	2.2	1.0	13.8	16.0
27-47	Bw2	8.15	1.84	4.43	91.0	64.08	16.06	19.86	2.7	2.8	12.9	0.28	5.0	4.3	2.4	0.8	14.3	17.0
47-60	Ck	8.20	2.00	3.39	112.2	41.57	36.81	21.62	4.0	3.4	14.9	0.56	6.1	4.6	2.5	0.6	15.7	16.1
P2- Very slightly saline soils (ECe 2.00-4.00 dS m^{-1}): Fine-loamy, mixed hyperthermic, *Typic Calciustepts*																		
0-18	Ap	8.15	2.92	6.79	110.0	60.47	20.92	18.61	4.6	3.0	20.1	0.22	5.7	3.9	2.3	0.4	12.9	18.1
18-37	AB	8.21	2.40	6.78	100.0	59.08	21.95	18.97	3.8	2.1	16.4	0.80	5.8	3.8	2.3	0.9	13.1	17.1
37-58	Bw1	8.02	2.40	6.70	91.2	60.87	16.28	22.25	4.5	2.4	15.2	0.70	5.9	4.7	2.4	0.9	15.7	15.1
58-82	Bw2	8.10	2.68	5.28	122.1	62.62	12.78	24.60	4.9	2.4	17.3	0.70	7.0	5.7	2.8	0.9	17.2	16.4
82-120	Ck	8.20	2.68	4.52	151.0	40.87	24.51	34.62	3.7	2.0	18.7	1.00	9.1	8.8	4.2	0.9	24.0	17.4
P3- Slightly saline soils (Ece 4.00-8.00 dS m^{-1}): Fine-loamy, mixed, hyperthermic, *Typic Calciustepts*																		
0-17	A1	8.60	9.60	5.17	32.1	60.41	14.97	24.62	20.1	14.5	55.2	0.80	7.5	5.8	3.1	0.4	17.2	18.1
17-33	A2	8.98	3.08	3.39	83.0	58.40	11.43	30.17	2.7	2.1	24.8	1.00	9.2	6.5	4.3	0.4	21.3	20.2
33-55	Bw1	8.70	5.20	3.39	121.3	63.29	07.89	28.82	8.0	4.0	37.2	1.10	8.2	6.5	4.1	0.3	20.4	19.9
55-77	Bw2	8.74	7.60	3.39	152.1	62.18	09.87	29.00	13.4	11.6	50.3	0.80	7.8	5.8	3.9	0.3	21.6	18.2
77-110	Ck	8.00	4.80	3.40	175.1	60.04	10.75	29.21	9.1	8.5	28.2	1.10	8.7	7.8	2.5	0.3	20.7	12.1
P4- Moderately saline soils (Ece 8.00-16.00 dS m^{-1}): Fine-loamy, mixed (cal.), hyperthermic, *Aridic Ustorthents*																		
0-18	Ap	8.50	2.92	8.42	30.1	50.40	26.93	22.67	3.8	2.0	21.6	0.70	6.0	5.1	2.6	0.3	15.2	17.2
18-33	A2	7.90	9.64	6.05	40.2	54.68	24.51	20.81	32.8	17.2	43.5	0.80	5.8	5.1	1.5	0.5	14.0	11.0
33-45	A3	8.45	12.32	5.20	63.0	53.79	24.56	21.65	50.0	30.0	33.8	2.30	5.8	5.0	2.2	0.2	15.3	7.0
45-79	Ck1	8.63	12.32	3.39	193.2	48.62	11.66	38.72	22.7	19.3	75.8	2.20	10.8	9.2	4.9	0.2	27.1	18.3
79-105	Ck2	8.63	12.56	3.39	210.0	50.13	19.74	40.13	25.0	19.0	78.6	3.70	10.8	9.5	5.1	0.6	27.9	18.3
105-140	Ck3	8.72	13.04	3.21	249.1	47.82	11.40	40.78	30.0	13.7	83.0	2.60	10.9	10.0	5.5	0.4	28.4	19.2
P5- Strongly saline soils (Ece>16.00 dS m^{-1}): Fine, mixed, hyperthermic, *Typic Calciustepts*																		
0-19	A	7.62	33.20	7.70	57.0	30.62	38.32	31.06	87.6	62.4	176.0	6.0	8.4	7.8	2.6	0.4	20.9	12.5
19-42	Bw1	7.69	32.00	7.53	97.2	34.10	33.73	32.17	80.0	70.0	162.0	6.0	8.4	8.0	2.2	0.4	21.7	10.2
42-65	Bw2	8.00	25.20	4.01	152.1	31.08	33.24	35.68	54.3	35.7	159.0	3.40	8.7	8.2	4.4	0.4	24.7	18.0
65-90	Bw3	7.60	1.32	4.01	192.1	25.60	35.48	38.92	1.6	1.0	10.3	0.29	10.8	9.4	3.8	0.5	27.0	14.0

Table 2 Water retention characteristics of experimental soil

Depth (cm)	Horizon	Water Retention characteristics ($m^3\ m^{-3}$)				
		0.033 (MPa)	1.5 (MPa)	AWC	AWC/horizon (cm m^{-1})	PAWC per profile (mm)
P1- Non-saline soil (ECe<2.00 dS m^{-1}): Fine-loamy, mixed (cal.), hyperthermic, *Typic Halplustepts*						
0-14	Ap	0.20	0.13	0.17	2.38	82.06
14-27	Bw1	0.31	0.15	0.16	2.08	
27-47	Bw2	0.30	0.14	0.16	3.20	
47-60	Ck	0.30	0.14	0.16	2.08	
P2- Very slightly saline soils (ECe 2.00-4.00 dS m^{-1}): Fine-loamy, mixed hyperthermic, *Typic Calciustepts*						
0-18	Ap	0.28	0.20	0.08	1.44	101.6
18-37	AB	0.29	0.21	0.08	1.52	
37-58	Bw1	0.30	0.15	0.15	3.15	
58-82	Bw2	0.28	0.12	0.16	3.84	
82-120	Ck	0.32	0.20	0.12	4.56	
P3- Slightly saline soils (Ece 4.00-8.00 dS m^{-1}): Fine-loamy, mixed, hyperthermic, *Typic Calciustepts*						
0-17	A1	0.32	0.14	0.18	3.06	132.5
17-33	A2	0.36	0.13	0.23	3.68	
33-55	Bw1	0.33	0.13	0.20	4.40	
55-77	Bw2	0.32	0.20	0.12	2.64	
77-110	Ck	0.35	0.16	0.19	6.27	
P4- Moderately saline soils (Ece 8.00-16.00 dS m^{-1}): Fine-loamy, mixed (cal.), hyperthermic, *Aridic Ustorthents*						
0-18	Ap	0.32	0.13	0.19	3.42	135.2
18-33	A2	0.32	0.12	0.20	3.00	
33-45	A3	0.31	0.15	0.16	1.92	
45-79	Ck1	0.32	0.16	0.16	5.44	
79-105	Ck2	0.30	0.14	0.16	4.16	
105-140	Ck3	0.32	0.14	0.18	6.30	
P5- Strongly saline soils (Ece>16.00 dS m^{-1}): Fine, mixed, hyperthermic, *Typic Calciustepts*						
0-19	A	0.35	0.18	0.17	3.23	144.8
19-42	Bw1	0.35	0.18	0.17	3.91	
42-65	Bw2	0.36	0.17	0.19	4.37	
65-90	Bw3	0.36	0.18	0.18	4.50	

Water Retention characteristics

The water retained by soils at different tensions is shown in Table 2. Water retention characteristics varied at both the tensions and ranged between 0.20 to 0.36 and 0.12 to 0.21 $m^3 m^{-3}$ at 0.033 and 1.5 MPa tentions, respectively. The variation in moisture retention at both the tentions is mostly associated with variations in soil texture[3]. Soils with lowest sand and highest clay showed highest water retention at 0.033 MPa. Water retention is more closely related with clay content compared to sand and silt[4]. The variation in retention is relative high under low tentions and low under high tentions (Table 2). Results are in tune with previous observations[4]. Content of available water follows the trend of distribution pattern of clay. Uniform distribution of clay causes uniform distribution of available water. Non-saline soil showed lowest value for PAWC and its value increases with salinity and in general increase from S1to S5. The water storage capacity in soil is influenced by soil depth[5,6].

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