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Water retention characteristics of some swell-shrink soils of Chandrapur district of Maharashtra

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Abstract

The water retention characteristics of five swell-shrink soils of Chandrapur district, Maharashtra were studied. The study showed that water retentivity at 33 kPa and 1500 kPa tension was significantly and positively correlated with clay, silt+clay, CEC and exch. Ca+Mg and negatively correlated with sand content. The effect of organic carbon content on water retentivity, both at 33 kPa and 1500 kPa tension, was found non significant due to low and similar content of organic carbon in these soils. The multiple regression equations were also developed to predict water retentivity using clay content and CEC values.

Additional keywords: Plant available water capacity.

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 referred as 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 (Gardner *et al.* 1984). Since the information on water retention characteristics of soils of Chandrapur district is lacking, attempt has been made in this paper to study the influence of various soil characteristics affecting water availability in swell-shrink soils of the district.

Materials and methods

Five soils series viz. Chikali, Hirapur, Talodhi, Warwat and Pandherponi of Chandrapur district of Maharashtra were selected for this study. Soils of Chikali series are developed over basaltic plateau while the rest are on lower piedmont plains. Chikali series is mapped in Rajura tehsil and it covers nearly 0.2 per cent area of the district. Soils of Hirapur series which are extensive in Sindewahi and Mul tehsils occupy 0.7 per cent area. The soils of Talodhi series are extensive in Nagbhir, Chimur, Mul, and Chandrapur tehsils and occupy 8.7 per cent, while Warwat and Pandherponi soils which are extensive in Chimur, Bhadrawati, Warora and Rajura tehsils, occupy 0.6 and 4.1 per cent area of the district, respectively.

Horizonwise soil samples were collected from the representative profiles of each series. Particle size analysis and estimation of organic carbon, cation exchange capacity (CEC), and exch. Ca+Mg were carried out as per standard procedures. Water retention at 33 kPa and 1500 kPa tension was determined (Richards 1954). Bulk density at swelling limit (BD) was calculated using the method of Yule (1984). The equation used was: BD ($Mg\ m^{-3}$) = $0.94/(0.38 + \theta_{gl})$,

where, θ_{gl} = water content at swelling limit ($kg\ kg^{-1}$) and it was determined by the equation $\theta_{gl} = 0.006\ CEC + 0.045$ where CEC refers to cation exchange capacity (cmol (p+) kg^{-1}.)

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Table 1. Salient physical and chemical characteristics of soils

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	B.D. ($Mg\ m^{-3}$)	O.C. (%)	CEC (cmol	Exch.Ca+Mg (p+) kg^{-1})	Water content ($kg\ kg^{-1}$) 33 kPa	1500 kPa	PAWC ($m\ m^{-1}$)
Hirapur series : Fine, montmorillonitic, hyperthermic Chromic Haplusterts										
0-15	22.9	29.9	47.2	1.46	0.35	36.2	35.2	0.269	0.162	0.190
15-42	23.3	28.5	48.2	1.43	0.28	39.0	34.6	0.306	0.167	
42-71	22.0	28.0	50.0	1.41	0.28	40.0	36.3	0.329	0.182	
71-108	21.3	29.2	49.5	1.41	0.22	40.6	37.8	0.313	0.183	
Talodhi series : Fine, montmorillonitic, hyperthermic Vertic Ustochrepts										
0-13	30.7	25.0	44.3	1.49	0.49	34.0	29.8	0.262	0.127	0.206
13-35	31.5	22.3	46.2	1.49	0.49	34.0	32.0	0.287	0.151	
35-63	28.4	24.7	46.9	1.47	0.44	36.0	32.0	0.286	0.151	
63-103	27.8	24.0	48.2	1.41	0.38	40.0	37.0	0.294	0.142	
103-125	27.7	23.1	49.2	1.41	0.35	40.0	39.0	0.291	0.140	
Chikali series : Fine, montmorillonitic, hyperthermic Typic Ustochrepts										
0-18	14.3	31.0	54.7	1.28	0.51	52.0	49.6	0.392	0.200	0.127
18-51	16.6	26.5	56.9	1.28	0.41	51.6	49.2	0.400	0.203	
Warwat series : Fine, montmorillonitic, hyperthermic Chromic Haplusterts										
0-16	32.8	22.5	44.7	1.48	0.31	35.0	33.0	0.269	0.131	0.199
16-56	29.9	22.1	48.0	1.47	0.32	35.6	33.6	0.267	0.156	
56-87	23.3	24.0	52.7	1.42	0.29	39.2	35.8	0.327	0.182	
87-104	20.0	20.5	59.5	1.42	0.21	39.6	36.2	0.343	0.188	
104-144	21.3	20.5	58.2	1.43	0.21	38.4	35.0	0.254	0.192	
144-160	20.3	20.8	58.9	1.43	0.19	38.8	41.7	0.328	0.189	
Pandherponi series : Very fine, montmorillonitic, hyperthermic Chromic Haplusterts										
0-17	11.3	29.5	59.2	1.28	0.52	52.0	49.6	0.426	0.254	0.219
17-57	7.8	27.5	64.7	1.24	0.42	55.2	51.2	0.428	0.252	
57-95	8.8	27.0	64.2	1.22	0.40	57.6	53.6	0.425	0.245	
95-134	9.3	31.5	59.2	1.27	0.40	52.6	50.0	0.382	0.204	
134-160	23.5	28.0	48.5	1.35	0.36	44.8	42.0	0.313	0.168	

The plant available water capacity (PAWC) for each soil series was calculated using the following expression:

$$PAWC\ (m\ m^{-1}) = \sum_{Z=0}^{Z=RD} (W_{max} - W_{dry}).BD.D_H$$

where, W_{max} = Gravimetric water content at 33 kPa tension, W_{dry} = Gravimetric water content at 1500 kPa tension, BD = Bulk density at swelling limit, D_H = horizon thickness (m) and RD refers to total rooting depth. It is considered as 1 m or to a depth of root limiting layer, whichever is shallower.

Results and discussion

The data (Table 1) indicate considerable variation in water retentivity of the soils from one series to another and also in the same series from one horizon to another. The water content in soil at low tension (33 kPa) is almost double to that at high tension (1500 kPa). The plant available water capacity (PAWC) of these soils is relatively high indicating high amount of water storage in the profile during the crop season except in Chikali series which has low storage due to its shallow depth.

The correlation study (Table 2) indicates that water retentivity at 33 kPa and 1500 kPa tension is significantly and positively correlated with clay, silt+clay, CEC and exch. Ca+Mg and negatively correlated with sand. Thus, it suggests that amount and nature of clay have a dominant role in water retention of the soils. Similar results were reported by Velayutham and Raj (1977) and Challa and Gaikawad (1987). The positive effect of organic carbon on water retentivity of soil was, however, non-significant due to low and similar quantities of organic carbon in these soils.

Table 2. Correlation coefficients (r) between soil properties and soil water (w/w) at different tension

Soil properties	33 kPa	1500 kPa
Sand	-0.935 **	-0.939 **
Silt	0.388	0.396
Clay	0.899 **	0.899 **
Silt + clay	0.935 **	0.938 **
CEC	0.924	0.851 **
Exch. Ca + Mg	0.903 **	0.839 **
Org.C	0.192	0.078

** Significant at 1 per cent level.

The multiple regression equations obtained between water retentivity, clay and CEC in the swell-shrink soils are as follows:

33 kPa Water (kg kg^{-1}) = -0.553 + 0.00397* Clay + 0.00419* CEC (R^2 = 0.937)

1500 kPa Water (kg kg^{-1}) = -0.080 + 0.00345* Clay + 0.00186* CEC (R^2 = 0.867)

Thus, it is evident that amount and the nature of clay fraction influence water retention in cracking clay soils.

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