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Available Water Capacity of Selected Soils of Tamil Nadu

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The present study was carried out to estimate the available water capacity of 130 soil samples collected from different districts of Tamil Nadu. The samples were analysed for field capacity at 1/3 bar pressure and permanent wilting point at 15 bar pressure in Pressure Membrane Apparatus besides, organic carbon and texture (particle size). The moisture retention at field capacity ranged from 6.8 % to 57.9 % and at permanent wilting point the moisture content ranged from 2.4 % to 38.0 %. The available water capacity (moisture retained between 1/3 bar and 15 bar pressure) varied from 1.2 % to 22.6 % with a mean value of 13.5 %. The soil parameters *viz*., organic carbon, clay, silt and sand significantly influenced the field capacity of soils with a r_2 value of 0.7386. Similar effect was recorded for permanent wilting point (r_2=0.7258). Also regression equations were derived for calculating field capacity, wilting point and available water capacity from the value of organic carbon and textural constituents.

Key words: soil moisture retention, soil texture, pressure membrane apparatus.

Available water capacity (AWC) is the maximum amount of plant available water a soil can provide which is an indicator of a soils ability to retain water. It is the water held in soil between its field capacity (FC) and permanent wilting point (PWP). Available water capacity is affected by soil texture, organic matter, presence and abundance of rock fragment and soil depth.

It increases with increasing clay particles from sand to loam and silt loams. This can be related to easily measurable physical properties of soil such as bulk density, organic carbon and particle size distribution (Ravender Singh and Kundu, 2005). Coarse textured soils have lower field capacity since they are high in large pores subject to free drainage whereas fine textured soils have a greater occurrence of small pores that hold water against free drainage, resulting in a comparatively higher field capacity. Organic matter increases soil's ability to hold water, both directly and indirectly. When a soil is at field capacity, organic matter had a higher water holding capacity than mineral soils. Thus, organic matter has a positive effect in influencing the AWC of soils (Alan Olness and David Archer, 2005).

Field capacity and permanent wilting point are the moisture contents measured at 1/3 bar and 15 bar pressure, respectively. These moisture constants are measured using Pressure Plate / Membrane Apparatus. The estimation of these soil moisture constants is a costly affair and the availability of reliable data on water retention in relation to soil texture and organic carbon content for Tamil Nadu soils are few. Thus, there is a need to derive a regression equation using easily measurable soil parameters *viz.,* organic carbon, clay, silt and sand. Katterer *et al*. (2006) and Ravender Singh and Kundu (2005) developed pedotransfer function and regression function, respectively to estimate soil water content at wilting point and filed capacity from the data such as soil texture and soil organic carbon content. With this background knowledge the present study was carried out to determine the available water holding capacity of soils of different district and to establish a relationship between water retention and soil properties.

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Materials and Methods

The present study was carried out for the profile soil samples collected from various blocks of Tamil Nadu *viz*., Annur (Coimbatore), Perambalur (Perambalur), Gingee (Thiruvannamalai) and Uthangarai (Dharmapuri) during the year 2010. A total of 130 soil samples were collected, processed and analyzed for texture by International Pipette Method (Piper, 1966) and soil organic carbon by chromic acid wet digestion method (Walkley and Black, 1934). The field capacity and permanent wilting points were determined at 1/3 bar (33kPa) and 15 bar (1500kPa), respectively in Pressure Membrane Apparatus (Model: Lab0123, Make: Soil Moisture Equipment Corp., USA) available in the Department of Soil Science and Agricultural Chemistry, TNAU, Coimbatore. The soil samples were water soaked overnight in their respective porus plates and equilibrated for field capacity at 1/3 bar

and permanent wilting point at 15 bar pressure. The moisture content of equilibrated soil samples were determined by oven dry method.

Available water capacity is the amount of water held by a soil between field capacity (1/3 bar) and permanent wilting point (15 bar) and therefore can be calculated as

AWC = rfc - rpwp

Where, *rfc* is the water content at field capacity and *rpwp* is the water content at PWP

The data were statistically anlysed through correlation and multiple regression to establish a relationship among the factors and to derive the regression equation to find out the moisture retention of unknown soil samples.

Results and Discussion

The results of analysis of 130 numbers of soil samples collected from different block of Tamil Nadu are presented in Table 1. The organic carbon content varied from 0.3 to 8.8 g/kg with a mean value of 2.9 g/kg and standard deviation of 1.9. The clay content ranged from 1.4 to 66.6 per cent with a mean value of 22.9 per cent and standard deviation of 12.5. The silt content varied from 0.2 to 43.8 per cent with a mean of 9.8 per cent and standard deviation of 6.1. The sand content varied from 20.7 to 91.2 per cent with a mean value of 64.6 per cent and standard deviation of 14.3. The texture of majority of the soil samples was loamy sand, sandy loam and sandy clay loam.

The moisture retention at field capacity (1/3 bar pressure) ranged from 6.8 to 57.9 per cent with a mean value of 24.9 per cent and standard deviation of 9.8. At permanent wilting point (15 bar pressure) the values ranged from 2.4 to 38.0 per cent with a mean value of 11.4 per cent and standard deviation of 7.0. The available water capacity (moisture retention between 1/3 bar and 15 bar pressure) varied from 1.2 to 22.6 per cent with a mean value of 13.5 per cent and standard deviation of 4.4. The variation in moisture retention at two tensions (1/3

Table 1. Soil moisture retention and AWC as influenced by organic carbon (OC) and particle size distribution for 130 soil samples

Sample No	FC (%)	PWP (%)	AWC (%)	OC (g/kg)	Clay (%)	Silt (%)	Sand (%)
1	16.2	2.4	13.8	4.40	17.9	3.0	78.0
2	15.1	2.8	12.4	1.10	21.7	5.3	72.5
3	46.9	27.9	18.9	5.10	35.7	6.7	57.4
4	45.4	26.3	19.1	3.30	33.7	5.8	59.9
5	31.9	16.6	15.3	0.40	17.4	14.6	67.4
6	24.4	10.4	14.0	2.20	20.4	7.5	67.2
7	22.9	10.4	12.5	0.70	29.7	2.5	67.3
8	23.9	11.1	12.8	0.70	22.4	12.2	64.3
9	25.2	10.2	15.1	8.80	22.9	11.5	65.2
10	27.3	10.5	16.8	7.70	17.7	21.3	60.4
11	18.6	8.3	10.3	2.20	13.4	2.3	81.4
12	15.6	6.1	9.5	0.70	22.4	7.5	60.6
13	26.8	13.3	13.6	3.30	19.4	5.3	73.1
14	20.4	8.2	12.2	0.40	14.6	9.2	75.2
15	15.8	5.4	10.5	1.40	27.9	5.7	65.4
16	27.7	13.0	14.7	1.70	17.2	18.7	56.3
17	30.4	14.4	16.1	4.70	20.7	4.0	65.4
18	26.3	11.0	15.3	4.70	29.6	18.3	51.4
19	31.9	16.3	15.6	2.90	20.9	11.4	65.7
20	26.9	13.3	13.6	0.70	29.7	10.7	58.6
21	22.3	10.7	11.6	2.50	18.4	7.5	70.6
22	10.5	4.5	6.0	0.70	17.9	8.2	73.5
23	6.8	2.8	4.0	1.40	24.3	2.5	70.5
24	52.5	31.4	21.1	3.90	63.5	11.2	22.4
25	57.3	35.0	22.3	2.90	62.6	9.5	27.5
26	57.9	38.0	19.8	2.50	66.6	10.5	21.4
27	27.3	9.3	18.0	4.70	23.9	10.3	60.6
28	32.0	17.7	14.2	2.90	33.9	9.0	54.9
29	33.1	18.1	15.0	1.80	34.2	12.2	50.9
30	31.8	16.4	15.4	2.50	36.1	9.8	53.5
31	17.3	6.1	11.2	2.20	20.9	2.8	75.6
32	20.5	8.0	12.5	3.30	13.2	9.5	72.9
33	25.8	10.0	15.8	3.20	19.9	7.5	68.2
34	24.5	9.3	15.2	2.20	19.1	4.3	72.6

Sample No	FC (%)	PWP (%)	AWC (%)	OC (g/kg)	Clay (%)	Silt (%)	Sand (%)
35	22.7	8.3	14.4	1.80	11.7	5.2	77.8
36	23.8	7.7	16.2	4.00	10.1	16.5	68.2
37	31.2	9.9	21.3	4.30	19.2	20.5	60.1
38	25.7	8.0	17.8	7.20	22.2	11.9	63.2
39	24.6	10.0	14.7	7.50	24.9	10.5	59.5
40	25.4	10.4	15.0	6.50	22.9	8.8	65.1
41	25.0	10.6	14.5	3.20	20.6	6.8	65.9
42	13.8	5.1	8.7	6.80	4.2	11.5	79.3
43	16.4	6.9	9.5	2.50	13.9	8.5	72.8
44	16.3	7.6	8.8	0.40	10.9	7.8	77.7
45	12.6	6.4	6.2	1.40	5.2	7.3	83.8
46	8.3	4.0	4.2	0.40	3.8	2.7	91.2
47	11.9	5.0	6.9	2.20	5.4	4.6	83.5
48	13.1	3.4	9.7	3.60	8.4	3.8	82.5
49	19.5	10.4	9.1	2.90	14.3	5.6	75.5
50	24.9	9.3	15.5	0.90	23.4	9.2	65.7
51	30.0	21.3	8.7	2.10	24.9	12.8	58.4
52	22.0	7.4	14.5	1.20	27.4	6.3	63.4
53	19.5	7.1	12.5	1.50	20.6	13.2	61.2
54	24.2	9.3	14.9	0.60	17.9	11.3	67.0
55	27.9	12.2	15.7	6.00	15.9	6.5	72.6
56	21.3	8.7	12.6	0.30	16.2	11.5	69.8
57	15.9	4.5	11.4	5.40	10.7	6.7	79.3
58	10.9	2.7	8.2	0.30	11.2	1.0	85.7
59	24.0	10.4	13.6	3.00	26.4	7.8	63.8
60	29.2	13.7	15.6	1.20	26.9	16.5	53.4
61	28.2	13.1	15.1	1.80	30.1	10.3	54.7
62	28.3	13.2	15.0	0.30	28.7	10.0	58.1
63	23.9	10.1	13.9	1.20	30.6	0.2	63.9
64	20.7	8.7	12.0	0.90	18.7	8.2	68.2
65	17.5	8.2	9.3	0.90	9.8	11.0	76.7
66	14.9	5.2	9.7	2.70	11.6	6.2	79.4
67	20.9	10.0	11.0	1.50	18.2	5.8	72.5
68	21.0	9.7	11.3	1.80	19.1	4.0	73.9
69	14.7	6.2	8.5	0.30	18.9	2.7	78.4
70	22.1	10.6	11.5	0.30	19.4	6.3	71.4
71	28.3	12.9	15.5	8.10	29.1	14.2	56.3
72	34.7	14.8	19.9	4.50	40.9	5.7	49.9
73	32.2	12.8	19.4	3.90	30.4	18.8	50.6
74	29.9	12.1	17.8	3.90	29.4	8.7	59.4
75	29.1	11.5	17.7	3.30	36.5	7.0	56.3
76	22.6	9.1	13.5	5.90	12.9	5.3	74.8
77	19.3	7.0	12.3	1.20	15.4	6.2	76.1
78	17.2	6.1	11.1	1.80	12.9	5.8	77.0
79	28.7	9.2	19.6	1.50	19.9	5.5	68.3
80	13.9	10.9	3.0	1.80	20.6	15.0	60.7
81	11.8	3.8	8.0	2.70	8.2	7.0	82.9
82	14.8	3.8	11.0	2.40	11.1	3.8	82.9
83	14.9	5.0	9.9	1.80	13.4	8.0	76.6
84	16.4	4.9	11.5	1.50	13.9	2.7	77.4
85	11.0	5.0	6.0	2.10	8.1	8.5	79.3
86	21.0	3.0	18.0	4.60	22.9	3.0	73.1
87	8.6	3.9	4.7	3.20	11.4	3.5	84.2
88	7.6	3.4	4.1	1.10	9.1	12.8	77.8
89	17.1	7.7	9.5	5.70	19.4	4.2	71.3
90	15.0	7.2	7.8	4.30	3.7	13.0	77.7
91	17.7	6.5	11.2	3.00	14.5	7.8	76.3
92	17.3	8.1	9.2	2.90	16.2	1.2	79.0
93	43.4	23.5	19.9	3.80	37.8	17.0	43.6
94	14.3	5.5	8.8	3.20	9.9	4.7	83.5

Sample No	FC (%)	PWP (%)	AWC (%)	OC (g/kg)	Clay (%)	Silt (%)	Sand (%)
95	30.4	12.4	18.0	5.30	21.9	11.7	63.8
96	35.4	14.3	21.2	1.50	23.6	10.7	62.3
97	29.6	12.6	17.0	2.90	30.7	9.2	56.5
98	12.8	4.3	8.5	3.50	1.4	13.2	84.0
99	20.9	8.0	13.0	2.90	26.7	4.7	68.2
100	23.0	9.3	13.8	3.80	12.9	23.2	63.0
101	37.8	18.8	19.0	5.10	5.1	43.8	50.3
102	25.4	12.2	13.2	3.00	21.7	6.5	68.4
103	19.4	5.6	13.8	5.70	17.6	4.3	76.2
104	21.9	7.6	14.3	2.10	26.9	4.0	67.4
105	27.0	10.3	16.7	3.30	13.9	25.2	58.8
106	33.9	16.4	17.5	3.00	31.4	14.6	54.2
107	30.3	16.9	13.5	3.00	30.6	14.0	51.8
108	40.0	24.7	15.3	3.90	48.2	16.5	28.7
109	41.9	25.2	16.7	4.60	53.2	18.2	28.0
110	47.8	30.6	17.2	3.20	58.9	17.9	23.4
111	44.7	33.0	11.7	3.60	51.4	17.8	32.5
112	48.6	34.2	14.4	2.80	60.7	20.5	20.7
113	27.7	13.9	13.8	2.10	25.6	18.6	58.7
114	27.0	5.4	21.7	7.10	26.4	12.6	58.2
115	26.6	14.3	12.3	6.00	24.9	14.2	59.6
116	31.0	15.7	15.4	5.00	18.2	24.3	57.5
117	28.7	12.3	16.4	3.20	35.4	16.2	47.4
118	28.7	12.8	15.9	2.10	28.1	9.8	57.1
119	25.3	9.1	16.2	2.50	26.8	7.9	61.3
120	30.0	7.9	22.0	1.10	15.4	10.5	70.9
121	25.1	13.9	11.2	5.70	27.6	11.0	59.4
122	26.4	13.5	12.9	1.10	30.7	12.7	55.1
123	27.3	4.8	22.6	0.70	20.6	2.8	75.7
124	19.6	16.8	2.8	0.40	42.6	10.3	43.5
125	33.5	14.9	18.7	4.00	31.9	8.0	56.3
126	29.7	10.2	19.6	2.90	30.9	9.7	56.6
127	25.6	12.7	13.0	2.20	28.9	12.4	58.2
128	28.3	14.3	14.0	0.30	26.1	19.0	52.0
129	29.0	15.1	13.9	1.80	12.4	2.7	82.6
130	15.8	14.6	1.2	1.10	9.7	4.0	87.0
Minimum	6.8	2.4	1.2	0.3	1.4	0.2	20.7
Maximum	57.9	38.0	22.6	8.8	66.6	43.8	91.2
Mean	24.9	11.4	13.5	2.9	22.9	9.8	64.6
Standard deviation	9.8	7.0	4.4	1.9	12.5	6.1	14.3

bar and 15 bar pressure) is mostly associated with variations in soil texture. The soils with high sand content retained least amount of moisture at both tensions than soils with moderately high clay content. The results are in agreement with Walia *et al*. (1999) and Kannan (2007).

The simple correlation established among variables is presented in Table 2. In general clay established a positive and significant correlation with field capacity (r_2=0.8040), PWP (r_2=0.8122) and AWC (r_2=0.4878). Similar effect was also observed with silt particle whereas sand content had a

Table 2. Correlation between moisture retention and soil particles (n=130)

	OC	Clay	Silt	Sand
Field Capacity	0.23201**	0.8040**	0.42849**	-0.851
Permanent Wilting Point	*0.11922*	0.8122**	0.40420**	-0.843
Available Water Capacity	0.32419**	0.4878**	0.30562**	-0.543

** significant at 1% level

negative correlation with field capacity, PWP and AWC. Ravender Singh and Kundu (2005) reported that field capacity, PWP and AWC were positively influenced by silt, clay and organic carbon content while sand had negative influence. Besides, clay had a very high positive correlation with wilting point and similar findings were reported by Katterer *et al.* (2006). The presence of organic carbon positively influenced the AWC (r_2=0.3242) and this is in

Table 3. Regression co-efficient for calculating moisture constants (n=130)

Predicted property	Predictor					
	Intercept	OC (g/kg)	Clay (%)	Silt (%)	Sand (%)	r_2
Field Capacity (%)	32.87	+ 0.504	+ 0.314	+ 0.16	– 0.281	0.7386**
Permanent Wilting Point (%)	8.14	– 0.0528	+ 0.336	+ 0.2126	– 0.0981	0.7258**
Available Water Capacity (%)	24.72	+ 0.557	- 0.0213	- 0.0523	– 0.1836	0.3484**

** significant at 1% level

accordance with the findings of Hudson (1994) and Alan Olness and David Archer (2005).

The regression equation derived from the statistics calculated between field capacity, PWP, AWC and soil properties are presented in Table 3. The soil parameters *viz*., organic carbon, clay, silt and sand significantly influenced the field capacity (r_2=0.7386), PWP (r_2=0.7258) and AWC (r_2=0.3484) and similar results were reported by Manrique *et al*. (1991). The regression equation can be used for calculating field capacity, PWP and AWC from organic carbon (OC), clay, silt and sand content. Thomas Gaiser *et al.*(2000) and Saxton and Rawls (2005) derived similar regression equation for calculating field capacity, PWP and AWC from readily available variables of soil texture and organic carbon.

Thus, the results of the present investigation clearly established that there is a definite positive correlation between water retention at two pressures and clay content. The available water capacity increased with increasing organic carbon content and clay content of the soils. Also the regression equation involving organic carbon, clay, silt and sand can be used to calculate field capacity, PWP and AWC for various soils. The results will form a basis for planning soil moisture conservation and irrigation scheduling for a better crop production.

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