International Journal of Agricultural Sciences
Volume **11** | Issue 2 | June, 2015 | 307-315 ■ e ISSN-0976-5670
DOI:10.15740/HAS/IJAS/11.2/307-315
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RESEARCH PAPER

Water retention characteristics of red lateritic soils, red soils and black soils of Tamil Nadu in relation to soil texture

RAJESHWAR MALAVATH* AND S.MANI[1]
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, HYDERABAD (TELANGANA) INDIA (Email : rajeshoct31naik@gmail.com)

Abstract : The present study was carried out to estimate the available water capacity of 246 soil samples collected from red lateritic soils of Dryland Agricultural Research Station, Chettinad, native red soils and application of transported black soils over the red native soils of Maize Research Station, Vagarai and black soils of Cotton Research Station, Veppanthattai of Tamil Nadu. The soils were analyzed for field capacity at 1/3 bar (33kpa) pressure and permanent wilting point at 15 bar (1500kPa) pressure in pressure plate apparatus besides, organic carbon and particle size distribution (soil texture) in surface and subsurface soils. In red lateritic soils the moisture retention at field capacity ranged from 13.2 to 20.5 and 13.8 to22.5 per cent, at permanent wilting point ranged from 5.4 to 10.9 and 4.9-11.6 per cent and available water capacity (moisture retained between 1/3 bar and 15 bar pressure) varied from 4.3 to 13.3 and 4.9 to 13.7 per cent. The moisture retention of application of transported black soils over native red soils varied from 29.2-30.4 and 19.8-22.7 per cent, at permanent wilting capacity varied from 14.8-16.9 and 7.6-9.2 per cent and the available water capacity varied from 13.6-15.5 and 11.9-14.1 per cent. The moisture retention of native red soils at field capacity varied from 16.2-19.4 and 16.2-18.5 per cent, at permanent wilting capacity varied from 5.4-7.6 and 4.9-7.8 per cent and the available water capacity varied from 10.2-11.6 and 11.3-11.9 per cent. The moisture retention of black soils at field capacity ranged from 30.8 to 39.7 and 32.4 to 40.8 per cent, at permanent wilting point 15.3 per cent to 22.9 and 16.9-24.6 per cent. The available water capacity varied from 13.5 per cent to 18.5 and 13.8-18.4 per cent in both the surface and sub-surface soils, respectively. The sub-surface soils of transported black soils over native red soils have high moisture retention capacity than native sub-surface soils. The available water capacity and maximum water holding capacity in all the soils were in the order of black soils>transported black soils over the native red soils> red soils > red lateritic soils. The soil parameters *viz.*, organic carbon, sand silt and clay significantly influenced the field capacity of soils. The transported black soils over native red soils is beneficial for retaining the more soil moisture for sustaining crop growth particularly in rainfed situations under changing climate.

Key Words : Water retention characteristics, Red lateritic soils, Red soils, Transported black soils over the red soils, Black soils soil texture, Pressure membrane apparatus

View Point Article : Malavath, Rajeshwar and Mani, S. (2015). Water retention characteristics of red lateritic soils, red soils and black soils of Tamil Nadu in relation to soil texture. *Internat. J. agric. Sci.*, **11** (2) : 307-315.

Article History : Received : 24.12.2014; **Revised :** 26.05.2015; **Accepted :** 31.05.2015

*** Author for correspondence (Present Address) :** Acharya N.G Ranga Agricultural University A.P Water Management Project, Agricultural Research Station., Garikapadu, KRISHNA (A.P.) INDIA

[1]Department of Soil Science and Agricultural Chemistry, Agricultural College and Research Institute, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

INTRODUCTION

Soil is a valuable resource that supports plant life, and water is an essential component of this system. Management decisions concerning types of crops to plant, plant populations, irrigation scheduling, and the amount of nitrogen fertilizer to apply depend on the amount of moisture that is available to the crop throughout the growing season. The spaces that exist between soil particles, called pores, provide for the passage and for retention of gasses and moisture within the soil profile. The soils ability to retain water is strongly related to particle size; water molecules hold more tightly to the fine particles of a clay soil than to coarser particles of a sandy soil, so clays generally retain more water (Leeper and Uren, 1993). Conversely, sands provide easier passage or transmission of water through the profile. Clay type, organic content and soil structure also influence soil water retention (Charman and Murphy, 1978). Organic matter increases soils 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 (Olness and Archer, 2005). The maximum amount of water that a given soil can retain is called field capacity, whereas a soil so dry that plants cannot liberate the remaining moisture from the soil particles is said to be at wilting point (Leeper and Uren, 1993). Available water is that which the plants can utilise from the soil within the range of field capacity and wilting point. Water-holding capacity is controlled primarily by soil texture and organic matter. Soils with smaller particles (silt and clay) have a larger surface area than those with larger sand particles, and a large surface area allows a soil to hold more water. In other words, a soil with a high percentage of silt and clay particles, which describes fine soil, has a higher water-holding capacity.

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 red lateritic soils, red soils, transported black soils over red soils and black soils is very meagre. Keeping this in view, a detailed field wise study was taken up with an objective to estimate soil moisture dynamics at filed capacity and wilting point of red lateritic soils of Dryland Agricultural Research Station, Chettinad, native red soils and application of transported black soils over the red native soils of Maize Research Station, Vagarai and black soils of cotton.

MATERIAL AND METHODS

In order to study the detail field wise water retention characteristics in relation to soil particles of the surface and sub surface soils, the total of 123 surface and 123 subsurface soil samples were collected from Dryland Agricultural Research Station, Chettinad, Sivaganga district, Maize Research Station, Vagarai, Dindigul district and Cotton Research Station, Veppanthattai, Perambalur district of Tamil Nadu during the year 2011-12. Five to six pits were dug for each sample in every field. From each pit sample was collected at a depth of 0-15 cm and 15-30 cm. A composite sample of about 1kg was taken through mixing of representative soil samples. The soil samples were air-dried in shade, processed and screened through a 2 mm sieve. After sieving all the samples were packed in the polythene bags for analysis.

Methods used for analysis :

The soil samples representing each of the fields were characterized for important physical, physico-chemical properties using standard procedures. Particle size analysis was done according to International Pipette method (Piper, 1966), bulk density (Blake and Hartze, 1986), water holding capacity (Sankaram, 1966), organic carbon (Walkley and Black, 1934). The field capacity and permanent wilting points were determined at 1/3 bar (33 kPa) and 15 bar (1500 kPa), respectively in pressure membrane apparatus (Model: Lab0123. Make: Soil Moisture Equipment Corp., USA) as described by Richards (1954). The soil samples were water soaked overnight in their respective porus ceramic 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. The data were statistically analyzed through correlation.

RESULTS AND DISCUSSION

The collected soil samples of each research station differed due to textural variation and soil types and the station wise result in detail was discussed.

Water retention characteristics of red lateritic soils:

A total of 144 numbers of surface and subsurface soil samples collected from Dryland Agricultural

Research Station, Chettinad, Sivaganga district are presented in Table 1. The clay, silt and sand contents in the soils varied from 17.9-31.7, 3.5-10.5 and 60.6-76.8 per cent in surface soils and 18.1-33.0, 4.2-11.5 and 59.1-74.4 per cent in sub surface soil, respectively. The clay content was more in sub surface soils than surface soils might be due to the mobilization and translocation of clay. The bulk density values ranged from 1.27 to 1.39 Mgm^{-3} in surface soils and in sub surface soils the values varied from 1.32 to 1.41 Mgm^{-3}. The bulk density values in surface soil were low when compared to sub surface samples. Lower bulk density values of surface soil might be due to loose, porous and organic matter content. The maximum water holding capacity of surface and sub surface soil ranged from 9.35 to 32.85 per cent and 11.98-36.35 per cent, respectively. These differences were due to the variation in the depth and clay, silt and organic carbon content.

The moisture retention at field capacity (33kpa) varied from 13.2-20.5 and 13.8-22.5 per cent and at permanent wilting capacity (1500kpa) varied from 5.4 to 10.9 and 4.9 to 11.6 per cent, respectively in both the surface and sub surface soils. The available water capacity varied from 4.3-13.3 and 4.9 to13.7 per cent in both the surface and sub surface soils. Increasing trends in available water capacity were observed in subsurface soils caused by an increase in clay in subsurface soils. This variation is attributed to the textural changes in the soils. The soils of C block showed higher water retention as it contained more amount of clay. Soils of B block of the 'research station revealed the low content of water at field capacity due to considerable amount of sand content in it. The soils with high sand content retained least amount of moisture at both tensions than soils with moderately high clay content might be due to the red laterite soils being dominated by kaolinite clay with small surface area, retained lower amount of water at different soil water suctions. The results are in agreement with Walia *et al*. (1999). The organic carbon content ranged from 3.0 to 6.8 g kg^{-1} and 1.2 to 5.4 g kg^{-1} in surface soil and subsurface soil, respectively. Higher organic carbon content was recorded in surface samples as compared

Table 1: Physical characteristics of surface and sub surface soils of DARS, Chettinad

Block	Number of soil samples	Depth (cm)	Particle size distribution (%)			B.D ($Mg\ m^{-3}$)	Water retention ($kg\ kg^{-1}$)		Available water (AWC)	MWHC (%)	OC ($g\ kg^{-1}$)
			Sand	Silt	Clay		33 kpa	1500 kpa			
A	22	0-15	71.5-76.8	3.5-7.9	18.0-21.9	1.32-1.38	13.8-17.4	5.4-8.8	5.7-9.5	11.35-21.36	3.6-6.0
			(74.5)	(5.5)	(20.0)	(1.34)	(15.1)	(7.37)	(7.7)	(16.4)	(5.2)
	22	15-30	63.8-73.0	4.2-8.1	21.2-28.5	1.33-1.41	14.2-17.8	4.9-9.2	5.8-10.7	11.98-23.81	1.8-4.7
			(69.1)	(5.8)	(25.1)	(1.35)	(15.9)	(7.6)	(8.3)	(17.8)	(3.3)
B	8	0-15	73.2-76.2	4.2-7.1	18.4-19.9	1.36-1.39	13.3-16.6	6.4-8.8	4.3-8.8	9.35-19.1	4.2-5.7
			(74.7)	(6.1)	(19.2)	(1.37)	(14.8)	(7.4)	(7.4)	(15.0)	(4.9)
	8	15-30	68.6-71.6	5.4-7.7	20.0-23.9	1.38-1.42	13.8-17.1	6.6-9.8	4.9-9.1	13.35-20.35	2.4-3.9
			(71.1)	(6.6)	(22.3)	(1.39)	(15.2)	(8.3)	(6.9)	(16.6)	(3.1)
C	20	0-15	60.6-72.1	4.3-9.5	24.0-31.7	1.27-1.35	13.9-20.5	5.9-9.4	7.2-13.3	15.1-32.85	4.3-6.7
			(66.3)	(6.34)	(27.3)	(1.32)	(17.8)	(8.0)	(10.1)	(26.8)	(5.7)
	20	15-30	59.1-68.7	4.5-8.2	27.9-33.0	1.32-1.36	17.4-22.5	7.6-9.9	9.2-13.7	25.1-36.35	2.8-4.6
			(63.8)	(6.6)	(29.6)	(1.34)	(20.1)	(8.8)	(11.3)	(30.3)	(3.9)
D	14	0-15	65.4-73.2	4.3-10.5	17.9-28.5	1.31-1.35	13.2-15.5	7.4-10.9	5.5-10.0	14.35-27.1	3.0-6.0
			(70.3)	(7.0)	(22.6)	(1.32)	(15.2)	(8.0)	(7.0)	(19.5)	(5.0)
	14	15-30	62.1-71.8	5.5-11.5	18.6-30.3	1.33-1.37	15.2-19.1	6.5-11.6	7.2-12.8	20.1-34.1	1.2-4.6
			(67.6)	(8.0)	(24.7)	(1.34)	(16.8)	(8.5)	(8.8)	(24.2)	(2.6)
E	8	0-15	71.1-75.3	4.9-9.1	17.8-22.4	1.31-1.35	13.3-15.5	7.8-10.4	5.1-7.1	12.85-19.78	4.5-6.8
			(73.8)	(6.3)	(19.8)	(1.32)	(14.7)	(8.4)	(6.3)	(16.9)	(5.5)
	8	15-30	63.3-74.4	5.2-9.5	18.1-30.4	1.33-1.37	15.8-17.4	7.6-9.6	7.0-9.4	19.6-25.6	1.6-5.4
			(68.1)	(6.9)	(25.0)	(1.34)	(17.0)	(8.7)	(8.3)	(22.0)	(3.6)
Ovearal range		0-15	60.6-76.8	3.5-10.5	17.9-31.7	1.32-1.41	13.2-20.5	5.4-10.9	4.3-13.3	9.35-32.85	3.0-6.8
Mean			(71.9)	(6.2)	(21.8)	(1.33)	(15.5)	(7.8)	(7.7)	(18.9)	(5.26)
Ovearal range		15-30	59.1-74.4	4.2-11.5	18.1-33.0	1.27-1.39	13.8-22.5	4.9-11.6	4.9-13.7	11.98-36.35	1.2-5.4
Mean			(67.9)	(6.8)	(25.3)	(1.35)	(17.0)	(8.4)	(8.7)	(22.2)	(3.3)

to subsurface samples. The simple correlation established among variables is presented in Table 2. The clay content positively correlated with organic carbon, water retention at field capacity, available water content and maximum water holding capacity (r = 0.291*,0.729**0.682**and 0.823**) whereas sand was negatively correlated with silt, clay, organic carbon, water retention at field capacity, available water content and maximum water holding capacity (r = -0.382**, -0.933**,-0.253*-0.648*,-0.621* and -0.792*), respectively, similar was reported by Singh and Kundu (2005) 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).

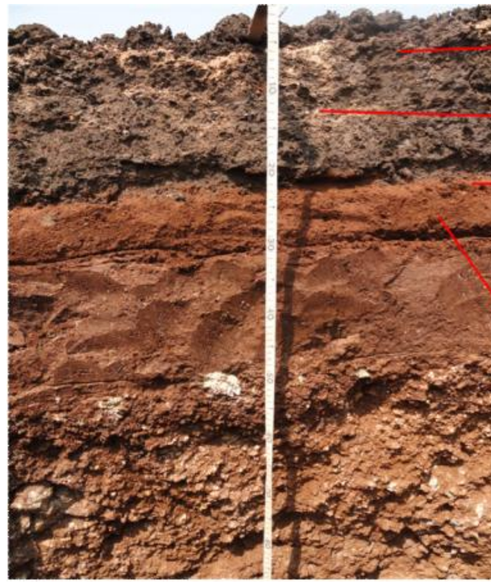

Fig. 1 : Transported black soils over native red soils (10.56978°N, 77.56141°E)

Water retention characteristics of application of transported black soils over the red soils :

The research station has total number of 13 fields. Among that 9 numbers fields such as A_2, A_3, A_4, A_5, A_6, B_3, B_4, B_5 and B_6 are fully filled with transported black soils at the rate of 390 tones ha^{-1}over native red soils at average depth of 20 cm during the year 2007 (Fig. 1). Thus, the upper 20 cm depth of soils became transported black soil layer and native red soil became subsurface layer. The applied black soils have more than 65 per cent clay and silt particles. It is mainly applied for improving soil moisture conservation and water holding capacity for better root growth and crop establishment. A total of 18 numbers of surface (9) and subsurface (9) soil samples collected from transported black soils over red soils at a depth of 0-15 and 15-30 cm are presented in Table 3. The clay, silt and sand contents of the transported black soils over native red soils varied from 44.5-50.9, 17.8-19.3 and 31.0-36.2 per cent in surface soils and 21.1-25.8, 14.2-15.9 and 58.6-64.4 per cent in subsurface soil, respectively. The clay content was more in surface soils than subsurface soils due to application of black soils over native red soils. The bulk density values ranged from 1.45-1.50 Mgm^{-3} in surface soils and in subsurface soils the values varied from 1.47-1.51 Mgm^{-3}. The bulk density values in surface soil were low when compared to sub surface samples. Lower bulk density values of surface soil might be due to clay and organic matter content. The maximum water holding capacity of surface and sub surface soils ranged from 47.48-50.36 per cent and 32.5-36.5 per cent, respectively. The organic carbon content ranged from 4.7-5.6 g kg^{-1} and 3.4-4.6g kg^{-1} in surface soil and subsurface soil, respectively. Higher organic carbon content was recorded in surface samples as compared to subsurface samples could be attributed to the addition of farm yard manure

Table 2: Correlation between soil properties and water retention characteristics of DARS, Chettinad

	Sand	Silt	Clay	OC	BD	33 kpa (F.C)	1500 kpa (W.P)	AWC	MWHC
Sand	1.00	-0.382**	-0.933**	-0.253*	0.384**	-0.648**	-0.159	-0.621**	-0.792**
Silt		1.00	0.030	-0.035	-0.276*	-0.042	-0.036	-0.006	0.115
Clay			1.00	0.291*	-0.309**	0.729**	0.180	0.682**	0.823**
OC				1.00	-0.051	0.216	0.031	0.177	0.255*
BD					1.00	-0.191	-0.250*	-0.081	-0.284*
33 kpa						1.00	0.336**	0.814**	0.838**
1500 kpa							1.00	-0.170	0.041
AWC								1.00	0.879**
MW.H.C									1.00

* and ** indicates significance of values at P=0.01 and P=0.05, respectively

and plant residues to surface horizons than in the lower horizons (Rajeshwar *et al*., 2009).

The moisture retention at field capacity (33kpa) varied from 29.2-30.4 and 19.8-22.7 per cent and at permanent wilting capacity (1500kpa) varied from 14.8-16.9 and 7.6-9.2 per cent, respectively in both the surface and sub surface soils. The available water capacity varied from 13.6-15.5 and 11.9-14.1 per cent. The maximum water holding capacity of surface and subsurface soil ranged from 47.48-50.36 per cent and 32.5-36.5 per cent, respectively. The surface soils have the more available water capacity than subsurface soil owed to addition of clay containing transported black soils. The clay content was positively correlated with organic carbon, water retention at field capacity, available water content and maximum water holding capacity (r = 0.834**,0.987**, 0.953**and 0.960**) whereas sand was negatively correlated with silt, clay, organic carbon, water retention at field capacity, available water content and maximum water holding capacity (r = -0.947**, -

Table 3: Physical characteristics and organic carbon status of transported black soils over native red soils of MRS Vagarai

Field	Depth (cm)	Sand	Silt	Clay	B.D (Mg m^{-3})	Water retention ($kg\ kg^{-1}$) 33 kpa	Water retention ($kg\ kg^{-1}$) 1500 kpa	AWC (%)	MWHC (%)	OC ($g\ kg^{-1}$)
A_2	0-15	33.0	18.3	48.7	1.50	30	15.9	14.1	47.48	5.4
	15-30	59.9	15.9	24.2	1.50	19.8	7.6	12.2	32.45	3.9
A_3	0-15	36.2	19.3	44.5	1.46	30.3	14.8	15.5	48.66	5.0
	15-30	59.7	15.6	24.7	1.47	20.4	8.5	11.9	32.78	4.0
A_4	0-15	33.8	17.9	48.3	1.47	29.9	16.3	13.6	48.48	4.7
	15-30	58.6	15.9	25.5	1.48	21.5	8.4	13.1	33.88	3.8
A_5	0-15	30.8	18.7	50.5	1.48	29.2	15.3	13.9	48.34	5.1
	15-30	60.0	14.2	25.8	1.47	21.3	8.8	12.5	33.35	4.3
A_6	0-15	33.6	18.6	47.8	1.46	30.6	16.9	13.7	47.61	4.7
	15-30	61.0	14.7	24.3	1.50	21.4	9.2	12.2	31.54	4.3
B_3	0-15	34.0	19.8	46.2	1.46	29.4	15.6	13.8	47.66	5.4
	15-30	61.8	15.2	23.0	1.48	22.7	8.6	14.1	38.67	3.4
B_4	0-15	35.6	17.8	46.6	1.46	30.4	16.8	13.6	47.19	5.4
	15-30	61.6	14.8	23.6	1.49	21.4	9	12.4	33.68	3.9
B_5	0-15	31.0	18.1	50.9	1.46	30.9	16.2	14.7	49.09	5.5
	15-30	64.4	14.5	21.1	1.51	20.8	7.9	12.9	34.48	4.6
B_6	0-15	32.4	19.2	48.4	1.45	30.4	15.6	14.8	50.36	5.6
	15-30	63.2	14.8	22.0	1.49	21.7	8.2	13.5	36.55	4.6
Range	0-15	31.0-36.2	17.8-19.3	44.5-50.9	1.45-1.50	29.2-30.4	14.8-16.9	13.6-15.5	47.48-50.36	4.7-5.6
Mean		33.4	18.6	48.0	1.47	30.1	15.9	14.18	48.3	5.2
Range	15-30	58.6-64.4	14.2-15.9	21.1-25.8	1.47-1.51	19.8-22.7	7.6-9.2	11.9-14.1	32.5-36.5	3.4-4.6
Mean		61.1	15.1	23.8	1.49	21.2	8.46	12.75	34.2	4.1

Table 4: Correlation between soil properties and water retention characteristics of transported black soils over native red soils of MRS, Vagarai

	Sand	Silt	Clay	BD	33 kpa (F.C)	1500 kpa (W.P)	AWC	MWHC	OC
Sand	1.00	-0.947**	-0.999**	0.623**	-0.988**	-0.989**	-0.958**	-0.963**	-0.831**
Silt		1.00	0.930**	-0.637**	0.935**	0.926**	0.933**	0.924**	0.763**
Clay			1.00	-0.615**	0.987**	0.990**	0.953**	0.960**	0.834**
BD				1.00	-0.628**	-0.623**	-0.623**	-0.635**	-0.446
33kpa					1.00	0.996**	0.980**	0.982**	0.841**
1500kpa						1.00	0.960**	0.967**	0.838**
AWC							1.00	0.990**	0.825**
MWHC								1.00	0.814**
OC									1.00

** indicate significance of value at P=0.05

0.999**, -0.831**, -0.988**, -0.958** and -0.831*), respectively (Table 4) might be due to high surface area of clay colloids and presence of exchangeable cations and had significant negative correlation with porespace it might be due to very less air spaces between the particles.

Water retention characteristics of native red soils:

The native red soils (4 No's) fields of MRS, Vagarai such as A_1, A_7, B_1 and B_5 were not filled with transported black soils. A total of 8 numbers of surface (4) and subsurface (4) soil samples were collected from native red soils. The clay, silt and sand contents in the native red soils varied from 17.4-19.6, 12.5-15.2 and 65.2-69.2 per cent in surface soils and 19.8-21.4, 12.6-14.2 and 66.0-66.5 per cent in subsurface soil, respectively presented in Table 5. The clay content was more in sub surface soils than surface soils might be due to the mobilization and translocation of clay. The bulk density values ranged from 1.43-1.47 Mgm^{-3} in surface soils and in subsurface soils the values varied from 1.47-1.51 Mgm^{-3}. The bulk density values in surface soil were low when compared to sub surface samples. The maximum water holding capacity of surface and sub surface soils ranged from 28.24-29.94 per cent and 31.1-31.7 per cent, respectively. The organic carbon content ranged from 3.0-4.1 g kg^{-1} and 2.6-3.9g kg^{-1} in surface soil and subsurface soil, respectively. Higher organic carbon content was recorded in surface samples as compared to subsurface samples. The moisture retention at field capacity (33kpa) varied from 16.2-19.4 and 16.2-18.5 per cent and at permanent wilting capacity (1500 kpa) varied from 5.4-7.6 and 4.9-7.8 per cent, respectively in both the surface and sub surface soils. The available water capacity varied from 10.2-11.6 and11.3-11.9 per cent. The correlation of native red soils among the various soil properties reveal that the clay content positively correlated with organic carbon, water retention at field capacity, available water content and maximum water holding capacity (r = 0.267, 0.229,201 and 0.487) but not significant, respectively (Table 6). The sand content had negative correlation with silt, clay, water retention at field

Table 5: Physical characteristics and organic carbon status of native red soils of MRS, Vagarai

Field	Depth (cm)	Sand	Silt	Clay	B.D (Mg m^{-3})	Water retention (kg kg^{-1})		AWC	MWHC (%)	OC (g kg^{-1})
						33 kpa	1500 kpa			
A_1	0-15	65.2	15.2	19.6	1.43	17.8	7.6	10.2	28.24	4.1
	15-30	66.0	12.6	21.4	1.49	19.4	7.8	11.6	31.21	3.9
A_7 to A_9	0-15	69.2	12.5	18.3	1.47	16.2	5.4	10.8	28.76	3.1
	15-30	66.5	13.2	20.3	1.51	16.2	4.9	11.3	30.11	2.9
B_1	0-15	68.8	13.8	17.4	1.44	18.5	6.9	11.6	29.94	3.1
	15-30	66.0	14.2	19.8	1.48	18.4	6.5	11.9	31.73	3.3
B_2	0-15	67.8	13.4	18.8	1.44	18.1	6.9	11.2	29.88	3
	15-30	66.4	13.3	20.3	1.47	17.9	6.2	11.7	30.87	2.6
Range	0-15	65.2-69.2	12.5-15.2	17.4-19.6	1.43-1.47	16.2-18.5	5.4-7.6	10.2-11.6	28.2-29.9	3.0-4.1
Mean		67.7	13.7	18.5	1.44	17.7	6.7	10.9	29.2	3.3
Range	15-30	66.0-66.5	12.6-14.2	19.8-21.4	1.47-1.51	16.2-19.4	4.9-7.8	11.3-11.9	31.1-31.7	2.6-3.9
Mean		66.2	13.3	20.5	1.49	17.9	6.4	11.6	31.0	3.1

Table 6: Correlation between soil properties and water retention characteristics of native red soils of MRS, Vagarai

	Sand	Silt	Clay	BD	33 kpa (F.C)	1500 kpa (W.P)	AWC	MWHC	OC
Sand	1.00	-0.487	-0.797*	-0.201	-0.310	-0.362	0.035	-0.274	-0.481
Silt		1.00	-0.139	-0.564	0.178	0.390	-0.349	-0.255	0.404
Clay			1.00	0.618*	0.229	0.141	0.201	0.487	0.267
BD				1.00	-0.258	-0.539	0.459	0.541	-0.228
33kpa					1.00	0.866**	0.430	0.520	0.412
1500kpa						1.00	-.079	0.057	0.712*
AWC							1.00	0.934**	-0.463
MWHC								1.00	-0.238
OC									1.00

* and ** indicate significance of values at p=0.01 and P=0.05, respectively

Table 7: Physical characteristics of surface and sub surface soils of CRS, Veppanthattai

Block	Number of soil samples	Depth (cm)	Particle size distribution (%)			B.D ($Mg\ m^{-3}$)	Pore space (%)	Water retention ($kg\ kg^{-1}$)		Available water (AWC)	W.H.C (%)	OC ($g\ kg^{-1}$)
			Total sand	Silt	Clay			33 kpa	1500 kpa			
Northern	4	0-15	18.5-20.5	17.8-19.6	60.6-62.3	1.45-1.49	35.1-36.2	32.3-37.9	16.9-21.4	14.7-16.7	46.2-46.2	5.7-6.5
			19.6	18.7	61.6	1.47	35.6	35.2	19.7	15.5	46.7	6.1
	4	15-30	19.3-20.8	16.3-18.1	62.6-62.9	1.48-1.51	24.9-26.4	35.4-37.9	18.6-21.1	16.2-17.8	48.7-52.4	2.7-3.7
			19.7	17.6	62.7	1.49	25.6	36.6	19.7	16.9	50.4	3.2
Western	5	0-15	20.1-23.9	16.1-19.5	58.1-61.5	1.42-1.49	34.9-36.9	30.9-38.4	15.3-22.9	14.4-15.6	43.2-46.8	5.3-6.4
			22.2	17.9	59.9	1.45	35.8	34.4	19.3	15.1	45.3	5.9
	5	15-30	18.7-22.3	16.4-17.8	60.2-63.8	1.47-1.53	23.5-25.8	32.8-40.5	16.9-24.4	15.5-16.1	46.5-48.3	2.2-3.2
			20.2	17.3	62.5	1.49	24.4	36.6	20.7	15.8	47.5	2.5
Southern	2	0-15	20.5-26.3	14.4-18.9	59.3-60.6	1.47-1.49	33.5-37.2	32.8-34.4	18.5-19.3	14.3-15.1	42.9-45.4	5.0-5.2
			23.4	16.6	60.0	1.48	35.3	33.6	18.9	14.7	44.1	5.1
	2	15-30	20.5-22.0	15.3-16.4	61.6-64.2	1.49-1.51	23.2-25.8	35.6-35.8	18.8-20.4	15.4-16.8	46.3-50.4	1.7-1.9
			21.3	15.8	62.9	1.50	24.5	35.7	19.6	16.1	48.35	1.8
Central	14	0-15	19.7-23.1	15.3-19.1	59.2-61.9	1.41-1.53	24.9-36.9	30.8-36.2	16.3-22.4	13.5-15.7	41.2-46.8	4.6-6.3
			21.5	17.7	60.7	1.45	33.7	32.97	18.5	14.5	43.5	5.2
	14	15-30	18.7-23.4	14.4-17.2	61.5-65.1	1.45-1.53	23.2-27.8	32.4-40.5	17.9-24.6	13.8-17.5	42.3-52.6	1.8-3.4
			21.0	16.1	63.0	1.49	24.7	35.09	19.8	15.1	45.6	2.4
Eastern	13	0-15	18.0-22.8	16.9-18.3	59.6-64.1	1.43-1.53	32.5-34.6	34.9-39.7	18.4-23.4	15.4-18.1	46.1-52.3	3.7-6.6
			20.5	17.5	62.1	1.46	33.4	37.0	20.5	16.4	48.9	5.2
	13	15-30	19.6-22.8	13.2-15.8	62.9-67.2	1.46-1.55	21.6-24.4	36.9-40.8	20.4-22.6	15.9-18.4	47.3-54.2	2.2-3.7
			21.0	14.6	64.3	1.50	23.4	38.4	21.3	17.1	50.9	2.7
Ovearal range		0-15	18.0-26.3	14.4-19.6	58.1-64.1	1.41-1.53	24.9-37.2	30.8-39.7	15.3-22.9	13.5-18.1	41.2-52.3	3.7-6.6
Ovearal mean			21.2	17.7	61.1	1.45	34.2	34.8	19.4	15.3	45.9	5.4
		15-30	18.7-23.4	13.2-18.1	60.2-67.2	1.45-1.55	21.6-27.8	32.4-40.8	16.9-24.6	13.8-18.4	42.3-54.2	1.7-3.7
			20.8	15.9	63.4	1.50	24.2	36.5	20.4	16.1	48.3	2.6

capacity, permanent wilting point, available water content and maximum water holding capacity and organic carbon and positive correlation with porespace might be due to size of the particles are the large and have low surface area.

The result reveals that the subsurface soils of transported black soils over native soils have high moisture retention capacity than native subsurface soils due to high deposition black soils as top layer leads the translocation of clay in lower depth which is having high clay content. The higher bulk density and moisture retention at field capacity, at permanent wilting point and available water capacity were more in application of transported black soils over native red soils which may be due to high smectite clay content, more CEC and more exchangeable cations, similar findings were reported by Hirekurubar *et al.* (1991).

Water retention characteristics black soils :

A total of 76 numbers of surface and subsurface soil samples collected from cotton Research Station, Veppanthattai at a depth of 0-15 and 15-30 cm are presented in Table 7. The clay, silt and sand content ranged from 58.1 to 64.1, 14.4 to 19.6 and 18.0 to 26.3 per cent in surface soils and 60.2 to 67.2, 13.2 to 18.1 and 18.7 to 23.4 per cent subsurface soils, respectively. Clay is more or less uniformly distributed within the surface and subsurface soils. The low proportion of sand and silt in these soils might be related to the parent material in which the soils develop. The bulk density values ranged from 1.41 to 1.53 Mgm^{-3} in surface soils. In subsurface soils the values varied from 1.45 to 1.55 $Mg\ m^{-3}$. The maximum water holding capacity of surface and sub surface soil ranged from 41.2 to 52.3 per cent and 42.3 to 54.2 per cent, respectively. The organic carbon content ranged from 3.7-6.6 g kg^{-1} and 1.7-3.7 g kg^{-1} in surface soil and subsurface soil, respectively. Higher organic carbon content was recorded in surface samples as compared to subsurface samples. The moisture content at field capacity (33kpa) varied from 30.8 to 39.7 and 32.4 to 40.8 per cent, at permanent wilting capacity (1500 kpa) varied from 15.3 to 22.9 and 16.9 to 24.6 per cent. The available water capacity varied from 13.5-18.1 and 13.8-18.4 per cent, respectively in both the surface and subsurface soils. The higher bulk density and moisture retention at 33kpa and 1500 kPa, available water capacity were more in black soils being dominated by smectite clay with large surface area, retained higher amount of water at different soil water suctions (Hirekurubar *et al*., 1991). Correlation studies among physical properties and organic carbon of black soils revealed that the sand was negatively correlated with silt, clay, water retention at field capacity, available water content and maximum water holding capacity (r =-0.292*, -0.586**, -0.315**, - 0.275*, -0.233* and -0.271*), respectively (Table 8). The clay content was positively correlated with bulk density, water retention at field capacity, wilting point, available water content and maximum water holding capacity (r=0.353**, 0.546**, 0.471**, 0.414** and 0.456**) and it was negatively correlated with organic carbon, and pore space (r=-0.577** and -0.65**) might be due to high surface area of clay colloids and presence of exchangeable cations and had significant negative correlation with porespace might be due to very less air spaces between the particles.

Conclusion :

The moisture retention at field capacity (33 kpa), permanent wilting point (1500 kpa) and available water capacity were high in black soils followed by the application of transported black soils over the native red

Table 8: Correlation between soil physical properties and organic carbon of CRS, Veppanthattai

	Sand	Silt	Clay	B.D	OC	33 kpa (F.C)	1500 kpa (W.P)	AWC	W.H.C
Sand	1.00	-0.292*	-0.586**	-0.037	0.042	-0.315**	-0.275*	-0.233*	-0.271*
Silt		1.00	-0.604**	-0.380**	0.640**	-0.335**	-0.285*	-0.260*	-0.272*
Clay			1.00	0.353**	-0.577**	0.546**	0.471**	0.414**	0.456**
B.D				1.00	-0.542**	0.337**	0.245*	0.327**	0.355**
OC					1.00	-0.314**	-0.239*	-0.288*	-0.308**
33 kpa						1.00	0.895**	0.706**	0.695**
1500 kpa							1.00	0.315**	0.309**
AWC								1.00	0.986**
W.H.C %)									1.00

FC- Field capacity, WP- Wilting point, AWC-Available water content, MWHC-Maximum water holding capacity, OC- Organic carbon; * and ** indicates significance of values at P=0.05 and P=0.01, respectively soils due to high smectite clay content. In the subsurface layer transported black soils have more moisture retention than the native surface and subsurface red soils. The soils with high sand content retained least amount of moisture at both tensions than soils with high clay content might be due to the red soils and red laterite soils being dominated by kaolinite clay with small surface area, retained lower amount of water at different soil water suctions. The application of black soils over native red soils is beneficial for retaining the high soil moisture for sustaining crop growth particularly in rainfed situations under changing climate.

Acknowledgement :

The authors are thankful to authorities of Tamil Nadu Agricultural University, Coimbatore for their technical support during the course of investigation.

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