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INFILTRATION AND MOISTURE RETENTION OF FIVE MAJOR SOIL GROUPS OF KERALA

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A knowledge of soil water retention behaviour is essential to conduct soil water managament studies. It facilitates to understand the soil water storage and release patterns in relation to plants. Besides, information on infiltration characteristics of soil may further aid in understanding the aforesaid soil water relationships. The water retention behaviour as well as infiltrability of a soil is known to be influenced by such factors as soil texture, structure, porosity and other physico-chemical properties of soils (Lal, 1979; Collis-George and Greena, 1979; Pahad *et al.*, 1982; and Antony, 1982), In view of a lack of data available on such aspects on Kerala soils, an attempt was made to study the water retention and infiltration behaviour of five major soil groups of Kerala namely, laterite, black, red loam, riverine alluvium and costal alluvium.

Materials and Methods

Soil samples were collected at four depths, namely, 0-15, 15-30, 30-45 and 44-60 cm in each soil profile. In each soil group three sites belonging to the same series were identified for the collection of soil samples. The soil samples were brought to the laboratory, air dried and passed through 2 mm sieve before storing them in double walled plastic bags. Mechanical analysis of soils was carried out by the international pippette method (Piper, 1942), The organic matter content and cation exchange capacity (CEC) were determined by Walkley Black and ammonium acetate methods, respectively (Jackson, 1958). Soil bulk density was measured using core samples (Dakshinamurti and Gupta, 1968) whereas mean particle density of each soil sample was determined by pycnometer method (Black, 1965).

Pressure plate apparatus was employed to study the retention of water at such soil water tensions as 0.3, 3, 5 and bar. Each experiment was repeated at least thrice and the average value was assigned in each case (Richards, 1954). Infiltration studies were conducted at each location using double ring infiltrometer having 30 and 50 cm diameter of inner and outer rings, respectively (Dakshinamurti and Gupta, 1968).

Results and Discussion

The data on physico-chemical properties of soils are presented in Table 1. An appreciable variation in soil texture was observed in relation to soil groups. However, within the same soil group a uniformity in texture has been noticed. As expected, the black soils were clay in texture. The finer fraction content increased with soil depth. The data on mean particle density, bulk density

and porosity revealed a wide variation not only for the soils of different groups but also for the soils of the same group. As expected, CEC was found to be more in black soils. Organic matter content varied not only between the soil groups but also within the soil group. In all these soils the surface layers were found to be relatively rich in organic matter content.

The data on the amount of water held at various soil moisture tensions are presented in Table 2. The quantity of water held at 0.3 bar is conventionally taken as the field capacity of the soil. The field capacity was found to be maximum in the case of black soils followed by riverine alluvium, laterite, red loam and coastal alluvium soils. All soil groups gave positive correlation with clay content and field capacity (Table 4). As black and riverine soils were relatively rich in clay content, they may be expected to hold more water in comparison to other soils at 0.3 bar. Another salient feature observad was that quantity of water retained at 0.3 bar increased with soil depth. It may be explained on the basis of the fact that in most cases the content of finer fractions increased with soil depth.

The quantities ot water held at 1,3 and 5 bar also showed trends similar to those obtained for field capacity in relation to soil group and soil depth. These results amply demonstrate that black soils contain more number of smaller pores in comparison to other soils. On the other hand coastal alluvium soils retained very little water at these tensions suggesting thereby the macroscopic nature of pores in these soils.

The amount of water held at 15 bar is conventionally taken as wilting point. Again, the black soils were found to retain the highest amount of water at 15 bar followed by riverine alluvium, laterite, red loam and coastal alluvium soils. There existed a positive correlation between clay content and wilting point (Table 4). These results lend credence to the findings of Tran-Vinh-An and Nguba (1971), Borden *et al.* (1974), Warkentin (1974) Venkataraman (1976) and Antony (1982).

Available water, calculated as the difference between the quantities of water held at 0.3 and 15 bar tensions, varied widely from soil to soil (Table 2). Again, the black soils were found to be better placed in this respect. On the other hand laterite, coastal alluvium and red loam soils were found to possess an extremely poor status in this regard. Lal (1979) also reported that the available water content of highly weathered coarse textured soils of humid tropics was generally low. Similar views were also expressed earlier by De Melo (1974) De Silva *et al.* (1975) and Wahad *et al.* (1976).

Infiltration rates were found to be exceptionally higher in the case of laterite, red loam and coastal alluvium soils (Table 3). For these groups of soils, the infiltration rates varied from 5 cm/h to as high a figure as 24 cm/h. On the other hand, the black and riverine alluvium soils exhibited markedly lower values

Table 1

Physico-chemical properties of soils

Soil group (series)	Profile No.	Depth (cm)	Course sand	Fine sand	Silt (%)	Clay (%)	Bulk density (g/cm^3)	Mean particle density (g/cm^3)	Poro-sity (%)	Organic matter (%)	CEC (me/ 100g soil)
1	2	3	4	5	6	7	8	9	10	11	12
Late rite											
(Velappaya series)	I	0—15	57.8	10.8	2.4	29.0	1.69	2.77	39.10	0.54	4.32
		15-30	48.2	81.0	5.1	35.8	1.50	2.82	46.90	0.49	772
		30-45	41.9	9.6	2.0	46.5	1.63	2.84	42.60	0.27	4.68
		45—50	37.9	19.0	2.2	40.9	1.44	2.76	47.70	0.49	5.10
	II	0—15	34.3	12.4	5.0	48.3	1.54	2.82	45.40	1.20	9.33
		15-30	40.3	6.7	25	50.5	1.33	2.79	52.30	1.99	9.96
		30-45	33.6	8.6	10.2	47.6	1.33	2.75	51.60	1.06	9.25
		45—60	29.4	19.6	12.3	38.7	1.40	2.73	48.90	1.03	8.10
	III	0-15	55.7	5.5	9.3	29.5	1.60	2.65	38.20	0.59	8.76
		15-30	49.4	6.8	10.2	33.6	1.64	2.73	38.60	0.66	8.23
		30-45	43.6	6.4	5.3	44.7	1.61	2.78	42.10	0.66	6.87
		45-60	42.3	5.7	1.6	50.4	1.68	2.88	41.70	0.57	9.51

						8		10	11	12	
Black soil											
(Valiavallampathy series)	IV	0—15	20.8	8.5	17.9	52.8	1.17	2.60	55.00	1.94	45.06
		15—30	16.8	12.4	14.2	56.6	1.21	2.68	54.90	0.90	46.89
		30-45	19.0	6.3	14.4	60.3	1.17	2.62	55.30	1.18	52.28
		45—60	7.9	9.1	16.4	66.6	1.29	2.74	52.90	1.03	54.22
	V	0—15	29.4	5.1	16.5	49.0	1.32	2.61	49.49	1.63	45.99
		15—30	15.4	5.8	18.5	60.3	1.48	2.68	44.80	0.89	46.66
		30—45	14.7	3.7	13.3	69.3	1.43	2.77	48.40	0.99	51.37
		45-60	12.2	2.5	11.0	74.3	1.22	2.73	55.40	0.95	51.78
	VI	0—15	104	9.5	17.3	62.7	1.39	2.57	45.90	1.37	52.87
		15-30	10.8	10.1	14.6	64.5	1.31	2.61	49.90	0.97	52.87
		30—45	6.5	12.5	15.1	95.9	1.18	2.68	56.00	0.90	52.96
		45-60	9.8	6.9	17.2	66.1	1.08	2.79	61.30	0.89	53.09
Red loam											
(Vellayani series)	VII	0—15	45.5	16.4	4.1	34.04	1.35	2.63	48.70	0.61	3.52
		15—30	54.9	10.6	1.8	33.60	1.33	2.61	49.00	0.63	3 89
		30-45	38.7	11.2	4.1	46.0	1.35	2.65	49:70	0.59	4.15
		45—60	34.1	11.7	5.9	48.3	1.35	2.67	49.40	0.49	4.46
	VIII	0—15	45.4	12.6	5.1	33.9	1.47	3.68	45·10	0.79	3.85
		15-30	45.1	6.8	6.1	42.0	1.36	2.57	47.50	0.69	4.02
		30-45	33.5	14.8	6.1	45.6	1.33	2.62	49.20	0.50	3.22
		45-60	32.1	11.8	8.8	47.3	1.31	2.60	49.70	0.46	4.04
	IX	0-15	44.7	15.1	9.9	30.3	1.50	2.40	45.80	0.84	3.86
		15-30	29.5	16.6	5.4	48.5	1.38	2.55	45.90	0.59	4.27
		30—45	40.4	15.1	2.2	42.3	1.31	2.59	49.40	0.60	3.95
		45—60	32.5	13.9	2.8	51.1	1.34	2.68	50.00	0.63	4.27

1	2	3	4	5	6	7	8	9	10	11	12
Riverine alluvium ([illegible] series)	X	0–15	4.8	31.5	38.2	27.5	1.16	2.53	54.00	2.80	18.28
		15–30	[illegible]	35.9	39.2	[illegible]	[illegible]	2.40	[illegible]	2.34	13.27
		30–45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.47	55.80	1.78	[illegible]
		45–60	[illegible]	18.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55.10	[illegible]	[illegible]
	XI	0–15	[illegible]	[illegible]	[illegible]	27.1	1.18	[illegible]	54.80	[illegible]	[illegible]
		15–30	4.5	[illegible]	[illegible]	[illegible]	1.08	2.49	[illegible]	1.70	[illegible]
		30–45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.48	[illegible]	1.01	8.48
		45–60	4.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.50	[illegible]
	XII	0–15	[illegible]	[illegible]	[illegible]	24.[illegible]	[illegible]	2.48	[illegible]	[illegible]	5.74
		15–30	[illegible]	[illegible]	[illegible]	24.[illegible]	1.32	2.48	48.80	[illegible]	8.78
		30–45	[illegible]	[illegible]	49.8	[illegible]	1.47	[illegible]	[illegible]	1.03	15.01
		45–60	[illegible]	[illegible]	[illegible]	[illegible]	1.50	2.84	41.70	[illegible]	8.75
Coastal alluvium (Beypore series)	XIII	0–15	[illegible]	[illegible]	8.1	16.5	[illegible]	[illegible]	[illegible]	1.39	4.75
		15–30	44.4	[illegible]	[illegible]	30.1	1.30	2.40	47.80	0.81	[illegible]
		30–45	[illegible]	18.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.47	[illegible]
		45–60	[illegible]	4.1	14.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	XIV	0–15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49.80	[illegible]	[illegible]
		15–30	[illegible]	[illegible]	4.5	[illegible]	[illegible]	[illegible]	49.40	0.44	[illegible]
		30–45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47.40	[illegible]	[illegible]
		45–60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	XV	0–15	[illegible]	17.8	4.9	[illegible]	1.47	2.44	[illegible]	[illegible]	[illegible]
		15–30	[illegible]	17.2	[illegible]	[illegible]	1.41	[illegible]	[illegible]	0.41	[illegible]
		30–45	[illegible]	[illegible]	3.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		45–60	[illegible]	[illegible]	1.1	[illegible]	1.40	[illegible]	[illegible]	0.84	8.44

Table 2

Moisture retention by soil profilesamples (percentage by weight)

Soil group (series)	Profile No.	Depth (cm)	Soil moisture tension (bar)		Available water
			0.3	15	
1	2	3	4	5	6
Laterite					
(Velappaya	I	0-15	8.86	5.38	3.49
series)		15-30	13.25	8.72	4.52
		30-45	14.62	10.58	4.03
		45—60	17.24	10.85	6.39
	II	0—15	19.52	11.79	7.72
		15—30	21.38	14.34	7.03
		30-45	21.80	14.38	7.41
		45-60	21.98	15.22	6.75
	III	0—15	11.64	6.77	4.87
		15-30	14.92	8.51	6.41
		30-45	18.59	11.66	6.93
		45-60	19.04	13.06	5.98
Black					
(Valia–	IV	0-15	41 25	26.04	15.20
vallampathy		15—30	37.54	27.00	10.54
series)		30-45	40.n6	27.67	13.19
		45-60	43.16	29.10	14.06
	V	0—15	36.97	23.57	13.40
		15-30	35.99	25.02	10.90
		30—45	39.59	29.94	9.66
		45—60	44.05	27.72	16.34
	VI	0—15	40.85	26.79	14.09
		15—30	43.47	31.21	12.17
		30—45	47.45	35.52	11.93
		45—60	59.18	37.63	21.55
Red loam					
(Vellayani	VII	0-15	11.49	8.38	3.11
series)		15—30	11.80	7.65	4.15
		30-45	13.89	11.09	2.79
		45—60	17.45	13.13	4.32
	VIII	0-15	13.48	8.53	4.94
		15-30	14.13	10.32	3.81
		30-45	17.21	10.73	4.48
		45-60	18.46	13.53	4.93

1	2	3	4	5	6
	IX	0—15	12.39	8.26	4.03
		15-30	15.54	11.00	4.54
		30-45	16.26	12.71	3.56
		45—60	18.67	12.44	6.23
Riverine alluvium					
(Ponnamattom series)	X	0—15	31.89	14.74	17,15
		15—30	32 86	16.21	16.65
		30-45	32.46	15.85	16.62
		45-60	33.00	16.43	14.57
	XI	0—15	31.47	12.53	18.94
		15-30	30.93	12.35	18.58
		30—45	26.62	12.88	13.74
		45-50	30.28	16.29	13.99
	XII	0—15	17.57	9.44	8.13
		15-30	18.49	11.65	6.84
		30-45	22.81	16.55	6.26
		45-60	22.81	18.21	4.60
Coastal alluvium					
(Beypore series)	XIII	0-15	11.67	5.99	5.69
		15—30	12.45	9.83	2.62
		30—45	15.18	9.13	6.05
		45-60	13.79	9.27	4.53
	XIV	0—15	10.98	5.70	5.28
		15—30	12.47	6.81	6.66
		30—45	14.30	8.27	6.03
		45-60	12.47	8.35	4.16
	XV	0—15	10.41	4.98	5.43
		15-30	10.62	5.83	4.79
		30-45	11.75	7.00	4.74
		45—60	13.21	8.10	5.10

varying from 0.2 to 1.2 cm/h indicating thereby the less pervious nature of these soils. The high rates of infiltration in the case of laterite soils may be attributed to the presence of large quantity of gravels, sometimes even exceeding 70 per cent (Antony, 1982). Higher rates of infiltration, as observed in the present study. have also been reported for other humid tropical soils by Kamerling (1975), Wol, and Drosdoff (1976), Lal (1976) and Lal and Cummings (1979). Soil texture if also known to play a predominant role in controlling the process of infiltration. As black and riverine alluvium soils were richer in clay, they exhibited relatively low values of infiltration rates (Agrawal *et al.*, 1974).

Table 3

Steady state infiltration rate of different soil groups

Profile No.	Soil group	Location	Infiltration (cm/h)
I	Laterite	Churakkattukara	10.80
II	Laterite	Churakkattukara	4.80
III	Laterite	Churakkattukara	24.00
IV	Black	Karimannu	0.60
V	Black	Karuvapara	0.60
VI	Black	Upputhod	0.80
VII	Red loam	Vellayani	11.70
VIII	Red loam	Vellayani	7.50
IX	Red loam	Vellayani	9.60
X	Riverine alluvium	Kizhumad	0.20
XI	Riverine alluvium	Chowara	0.60
XII	Riverine alluvium	Alwaye	1.20
XIII	Coastal alluvium	Edakulam	18.00
XIV	Coastal alluvium	Edakulam	6.00
XV	Coastal alluvium	Edakulam	10.20

Table 4

Relationship of clay with porosity and moisture retention at 1/3 bar and 15 bar (Coefficient of simple correlation)

Soil groups	Porosity	Moisture retention	
		1/3 bar	15 bar
Laterite (n = 12)	0.560	0.778**	0.581*
Black (n=12)	0.158	0.444	0.540
Red loam (n=12)	0.640*	0.836**	0.870**
Riverine alluvium (n=12)	0.622*	0.763**	0.241
Coastal alluvium <n=12)	0.610*	0.719**	0.963"

* Significant at 5% level ** Significant at 1% level

Summary

Laboratory and field experiments were conducted to evaluate the soil water retention and infiltration rates, respectively, for five major soil groups of Kerala, namely, laterite, black, red loam, riverine alluvium and coastal alluvium. Black soils were found to retain more water whereas coastal alluvium retained the minimum at different soil water tensions. So, was true of their available water status_ Infiltration rates were higher in the case of coastal alluvium red loam and laterite soils. Black soils exhibited rather low values of infiltration rates.

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References

Agrawal, M. S., Agrawal, R. P. and Chaudhry, R. K. 1974. Infiltration characteristics of soils as related to soil physical properties *J. Indian Soc. Soil Sci.* 22: 285-289

Antony, P. C. 1982. *Studies on the Physical Properties of the Major Soil Groups ofKerala with Special Reference to the Effect of Salinization and Desalinization.* Ph. D. thesis submitted to the Kerala Agricultural University.

Black, C. A. (ed.) 1965. *Methods of Soil Analysis. Part I.* American Society of Agronomy, Inc. Publishers, Madison, Wisconsin. U.S,A. p. 77

Borden, R. W., Warkentin, B. P, and Coil, M. 1974. An irrigation rating for some soils in Antiqua, W. I., *Trop. Agric.* (Trinidad) 51: 501-513

Col Ms-George, N. and Greena, R.S.B. 1979. The effect of aggregate size on the infiltration behaviour of a slaking soil and its relevance to ponded irrigation. *Aust J. Soil. Res. 17:* 65-73

Dakshinamurti, C. and Gupta, R. P. 1968. *Practicals in Soil Physics.* IARI New Delhi.

De Melo, V. 1974. Agricultural aptitude of the yellow red podsolic soil, Boletin de Recursos. *Natraais de Sudane* 12: 77-89

De Silva, L. F., Dias, A.C.C.P. and De Meto, A. A. 1975. Characteristics and management properties of Oxisols in southern part of Bahia. *Revista Theobroma (Brazil)* 5 (4): 23-34

Fahad, A. A., Mielke, L. N., Flowerday, A. D. and Swartzendrubei, D. 1982. J. So/7 *Sci. Soc. Am.* 46: 377-381

Jackson, M L. 1958. So/7 *Chemical Analysis.* Prentice-Hall of India, Private Ltd, New Delhi, pp 498.

Kamerling, G. E. 1975. Studies in soil physics and agrohydrology on the young coastal plain of Surinam, South America, *De Surinaams Landbouw* **23:** 31-37

Lal, K. 1976. *Soil Erosion on an Alfisol in Western Nigeria* I.I.T.A Monograph No 1

Lal, R. 1979. Physical properties and moisture retention characteristics of some Nigerian soils. *Geoderma* 21: 209-223

Lali, R. and Cummings, D. J. 1979. Changes in soil and microclimate by forest removal. *Field Crop Res. 2:* 20-24

Piper, C. S. 1942. *Soil and Plant Analysis.* Asian Reprint. 1967, Hans. Publishers, Bombay

Richards, L. A. (Ed) 1954. *Diagnosis and Improvement of Saline and Alkali Soils.* USDA Agric. Hand Book No.60

Tran-Vinh-An and Nguba, H. 1971. Contribution of letude de lean utilie de quelques soils due Zaire, *African Soils* 16: 19-103

Venkitaraman, C. R. 1976. Nutrient status in relation to silt and clay content of some typical soils of South India. *Madras agric. J.* 64:231-254

Wahab, A., Talleyrand, H. and Lugo-Lopex, M. A. 1976. Rooting depth, growth and yield of sorghum as affected by soil water availability in an Ultisol and Oxisol. *J. Agric. Univ. P. R.* 60: 316-328

Warkentin, B. P. Physical properties related to clay minerals in soils of the Caribbean *Trop. Agric.* 51: 279-287

Wolf, J. M. and Drosdoff, M. 1976. Soil water studies in Oxisols and Ultisols and Puerto Rico. II water movement. *J. agric. Univ. P. R.* **60**: 375-385