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CHARACTERIZATION OF SOIL MOISTURE RETENTION RELATIONSHIP IN NON-CALCIC BROWN SOILS (HAPLUSTALFS)

RANJITH B. MAPA and W. L. BODHINAYAKE

Department of Soil Science, Faculty of Agriculture, University of Peradeniya

ABSTRACT

The soil moisture retention relationship is useful in obtaining field capacity, permanent wilting point (PWP), available water, aeration capacity and pore size distribution which are important physical parameters used in soil moisture studies. This relationship was characterized for the Non-calcic brown (NCB) soils using undisturbed soil core samples obtained from four major horizons. Field capacity and PWP increased with depth and showed a positive relationship with clay content and the surface horizon showed significantly less available water than the subsurface horizons. The subsurface horizons did not show any significant differences in available water as the increase in field capacity was similar to the increase in PWP. When the soil water depletion from field capacity was computed, 70% of available water was lost before reaching 100 kPa (1 bar). This indicates that the readily available moisture for NCB soils is likely to be 70% of the total available water. Thus total readily available water in NCB soils would be 54 mm per 90 cm of soil. When the pore size distribution was estimated using water retention results, all the four major horizons showed aeration capacities exceeding 10% indicating no drainage problems in this soil when the water table is at a considerable depth.

KEY WORDS : Available Water, Non-calcic brown soils, Porosity

INTRODUCTION

The soil water retention relationship is a function relating a capacity factor, which is the water content (volumetric or gravimetric) to an intensity factor, the energy state of soil water (Klute, 1986). This functional relationship which was first proposed by Buckingham (1907) is identified in literature by various names including soil moisture retention curve, release curve, characteristic curve, sorption — desorption curve and moisture suction relationship. This is a fundamental soil characteristic used to obtain soil moisture parameters such as field capacity, permanent wilting point (PWP) and available water. According to Cassel and Nielsen (1986) water retention varies from soil to soil and indeed from soil horizon to soil horizon.

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As this curve shows the progressive decrease of soil water with increased suction it is also extensively used to estimate aeration capacity and pore size distribution of soils (Danielson and Sutherland, 1986).

The water retention relationship depends mainly on soil texture, structure and organic matter content. The organic matter considerably affect the water retention by its hydrophyllic nature and indirectly by modification of soil structure (Hillel, 1972).

The soil water retention relationship could be obtained by using pressure plate apparatus in the laboratory (Klute, 1986) or by using tensiometers and soil water content measurements in the field (Bruce and Luxmoore, 1986). The laboratory methods have the added advantage of obtaining this relationship for the entire suction range of interest (from saturation to PWP) and soil cores could be used to obtain samples of relatively undisturbed structure.

The Non-calcic brown soils (NCB) is an important great soil group in Sri Lanka and covers about 217,000 ha (Amarasiri, 1987). According to soil Taxonomy (USDA, 1975) these soils are classified as Haplustalf great group (De Alwis and Panabokke, 1972). These soils usually occur in a complex pattern together with several other great soil groups. The agricultural potential of these soils is high due to the availability of irrigation facilities from the Mahaweli River Diversion Project. The NCB soils have been divided into upland and lowland categories on the basis of natural internal drainage, where the upland soil series are named as Maduru and Welikanda, and the lowland soil series as Galwewa and Boattewewa (Maduru Oya Project Feasibility Report, 1980). The well-drained Maduru and Welikanda series are already used for irrigated agriculture and there is a great need for characterization of soil properties useful for planning and managing irrigation efficiently.

The objective of this study was to characterize the soil water retention relationship and pore size distribution for the Welikanda series of NCB soil.

MATERIALS AND METHODS

This experiment was conducted at the Regional Agricultural Research Centre, Aralaganwila in the Mahaweli System B area during yala 1988 on the Welikanda series of NCB soils. The examination of soil profile at experimental site showed four distinct soil horizons namely A, AB, B1 and B2 corresponding to 0—11, 11—23, 23—50 and 50—90 cm depths respectively. Four undisturbed soil core samples of 5.2 cm in diameter and 3.0 cm in height were obtained from the middle of each horizon using a core sampler. The core samples were wrapped in polythene to prevent drying and transported to the laboratory. Prior to the water retention measurement excess soil on each end of the soil core was carefully trimmed to be on level with the brass core. A cheese cloth was attached to one end using a rubber band to facilitate repeated weighing of samples.

Samples were saturated and water retention measurements were made using a standard pressure plate apparatus as described by Klute (1986) for 13 suction intervals ranging from 2 kPa to 1500 kPa. When the outflow ceased indicating that the soil was at equilibrium with water at the applied suction, cores were weighed to calculate water loss between each suction increment. The samples were oven-dried and weighed after the final pressure step of 1500 kPa. The gravimetric water contents at each suction level were calculated and converted to volumetric water contents using the appropriate bulk densities. The average volumetric water contents were plotted against applied suction to obtain the soil water retention relationship for all four soil horizons. Total porosity was obtained using the bulk density and particle density (Danielson and Sutherland, 1986). Total porosity was used as the volumetric water content at saturation corresponding to zero suction value. Pores which could not hold water at 10 kPa (diameter 0.03 mm) were estimated as macropores and rest as micropores. The textural analysis of the samples was carried out using the hydrometer method for a subsample from each horizon.

RESULTS AND DISCUSSION

The sand, silt and clay percentages, textural class and bulk density for the major horizons in NCB soil at the experimental site are given in Table 1. The soil showed a very coarse texture and the bulk density of the B2 horizon was higher than the layers above.

The water retention relationship for all four horizons of the NCB soil is shown in Fig. 1. Field capacity, PWP and available water which are important soil moisture parameters were obtained from the water retention relationship and are listed in Table 2. Field capacity was estimated as the soil water content at 10 kPa as proposed by Landon (1984) for coarse-textured soils. The PWP was estimated as the soil water content at 1500 kPa. The difference between the field capacity and PWP will indicate the available water capacity for plant use. The field capacity and PWP increased with depth and was positively correlated with the clay content. Many workers (Salter and Williams, 1965; Hillel, 1972) have reported that the field capacity and PWP increase when soils become finer in texture. These field capacity and PWP values are higher than those reported by the Land Use Division of the Irrigation Department, Colombo (Unpublished data, 1979) where disturbed and sieved samples were used in contrast to the undisturbed soil cores used in this study. Results obtained from core samples are better approximations of *in situ* conditions than those obtained from disturbed and sieved samples.

When available water capacity was estimated A horizon showed significantly lower values than the other three horizons. Horizons AB, B1 and B2 did not show any significant differences in available water capacity probably due to the similarity in texture (Table 1). When a weighted average was used the 90 cm deep NCB soil profile showed 71.5 mm of available water. Table 3 shows the amount of available water as a percentage of total available water for selected suction increments starting from field capacity. It showed that on a weighted average basis 70% of the available water from the soil profile was depleted before reaching 100 kPa (1 bar) suction. Therefore readily available moisture is likely to be 70% of the total available moisture for NCB soils (Table 2). Joshua (1988) observed a similar trend in Reddish Brown Earth soils and confirmed this fact in field experiments. Thus total readily available water in NCB soils would be 53.6 mm per 90 cm of soil depth.

The total porosity, microporosity and macroporosity for the major horizons of NCB soils are shown in Fig. 2. Horizon B2 showed lower total porosity than the other horizons. Macroporosity was highest for horizon A and decreased with depth. Macropores drain under the influence of gravity and will form the basis for aeration capacity of soils. As all the horizons show an aeration capacity greater than the limiting value of 10% (Landon, 1980) these soils will not have any drainage problems during the high rainfall periods. There will be no necessity to have any surface drainage for quick disposal of water for these soils. Since these soils are predominantly sandy they have high saturated hydraulic conductivities (Mapa and Bodhinayake,

1988) and no drainage or salinity problem will occur if the water table is at considerable depth. Microporosity was lower than macroporocity in A, AB and B1 horizons having less water retention. In the B2 horizon amount of micropores was greater than macropores and this horizon held a considerable amount of water. This shows that when the soil profile is heterogeneous owing to textural changes with depth there is a need to characterize soil water retention for each major horizon.

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Table 1. Soil texture and bulk densities for the major horizons of NCB soil at experimental site

Horizon	*Depth (cm)*	*Sand%*	*Silt%*	*Clay%*	*Textural Class*	*Bulk Density* (Mg/M^3)
A	0—11	93.7	4.1	2.2	Sand	1.66
AB	11—23	87.8	7.7	4.5	Loamy Sand	1.69
B1	23—50	89.8	4.7	5.5	Loamy Sand	1.65
B2	50—90	84.2	7.6	8.2	Loamy Sand	1.73

Table 2. Soil moisture parameters obtained from the water retention relationship for NCB soils

Parameter	*Volumetric Moisture (%)*			
	Horizons			
	A	*AB*	*B1*	*B2*
Field Capacity (10kPa)	14.74	17.11	18.19	19.16
PWP (1500 kPa)	4.64	5.82	6.59	7.81
Available Water	10.10	11.29	11.60	11.35
Readily Available Water (70% of Available Water)	7.07	7.90	8.12	7.95

Table 3. Depletion of available water as a percentage of total available water at selected suction increments for NCB soils

Suction Increment (kPa)	*Depletion (%)*			
	Horizons			
	A	*AB*	*B1*	*B2*
10 — 15	19.02	22.11	26.06	18.97
10 — 20	31.51	33.19	37.69	29.66
10 — 37	47.06	48.07	53.10	45.19
10 — 50	58.40	59.13	61.25	56.21
10 — 100	70.48	69.16	73.97	68.32
10 — 300	83.30	85.81	88.02	85.84
10 — 500	93.77	94.12	94.52	94.16
10 — 1000	98.44	98.27	97.92	99.33
10 — 1500	100.00	100.00	100.00	100.00

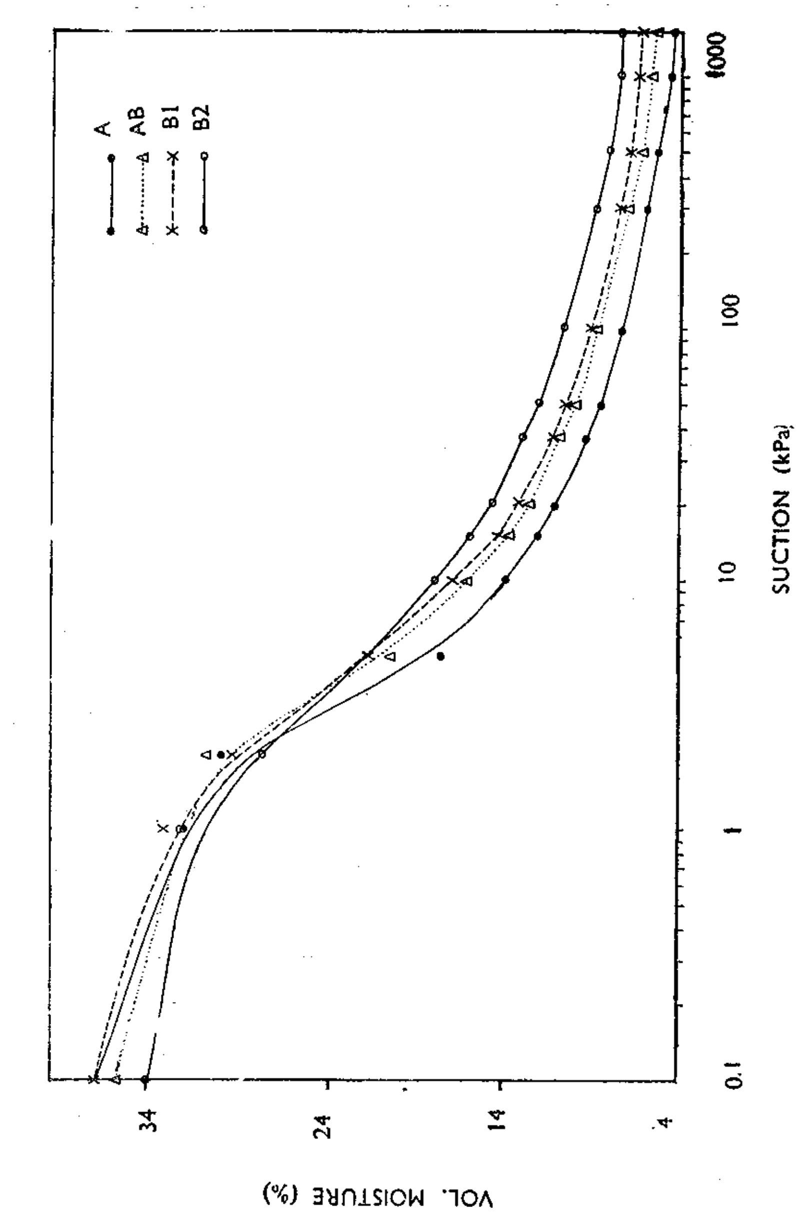

Fig. 1. Soil water retention relationship for major horizons of Non-calcic brown soils.

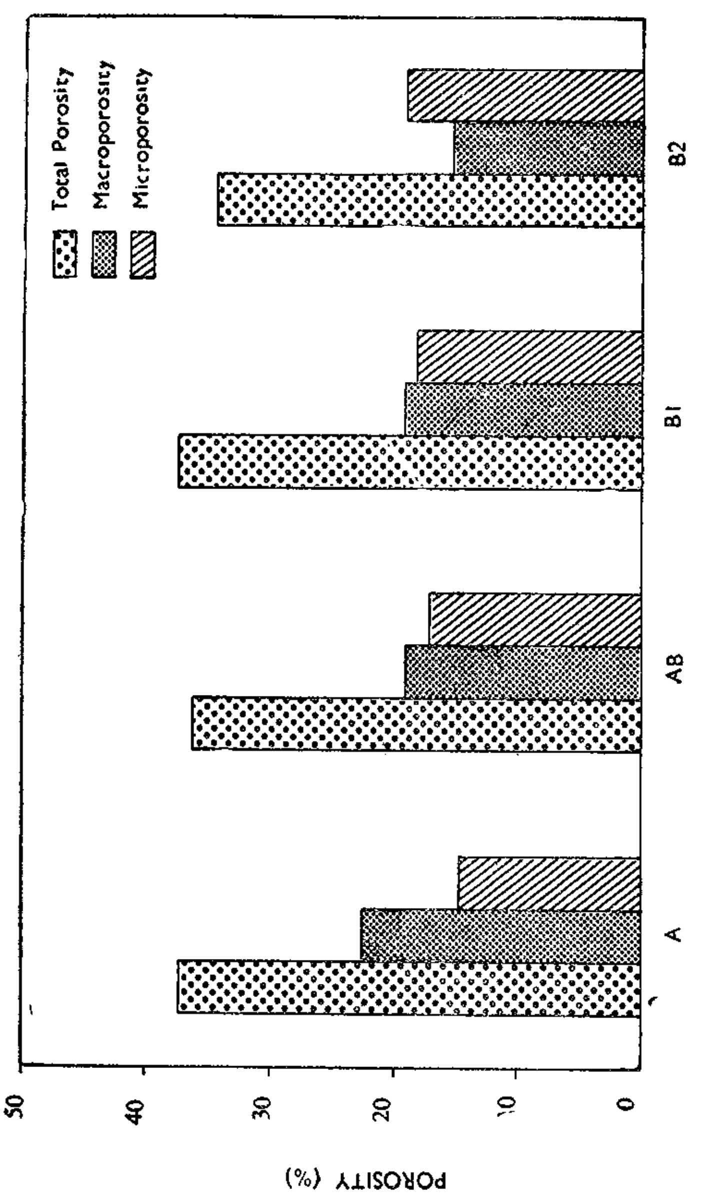

Fig. 2. Total porosity, macroporosity and microporosity for the major horizons of Non-calcic brown soils.