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CHARACTERIZATION OF SOIL HYDRAULIC PROPERTIES OF THE NONCALCIC BROWN SOILS

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ABSTRACT

Soil hydraulic properties are needed to address problems of irrigation, drainage, solute movement, water management and soil erosion . This study was undertaken to measure infiltration, saturated and unsaturated hydraulic conductivity, and insitu soil water retention relationship for the well drained Welikanda series of Noncalcic Brown soils (NCB) occuring in Mahaweli System B, and which has a high potential for irrigated agriculture. Hydraulic conductivity and water retention were characterized for four horizons in the soil profile. The results showed that these NCB soils have high infiltration rates and hydraulic conductivities with low water retention characteristics. Therefore these soils are easily drainable and require irrigation methods that supply water at high frequencies and low rates.

INTRODUCTION

Efficient use of water for crop production depends on an understanding of soil processes governing water movement. The processes such as entry of water into the soil, and its

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INTRODUCTION

Efficient use of water for crop production depends on an understanding of soil processes governing water movement. The processes such as entry of water into the soil, and its redistribution in the profile, flow of excess water to drains, ground water recharge and evaporation from the soil surface are examples where the rate of water movement plays a major role. The soil properties that determine these processes are collectively referred to as soil hydraulic properties (Klute and Derksen, 1986). These are mainly the hydraulic conductivity and water retention properties of soil. These properties are fundamental soil characteristics which are essential for efficient soil and water management in agricultural lands.

The NCB soil, which is an important great soil group of Sri Lanka appears in number of soil mapping units in the dry zone, and the semi dry intermediate zones (de Alwis and Panabokke, 1972) and approximately covers an area of 217,000 ha. The potential land use of this soil is high due to the availability of water for irrigated agriculture through the Mahaweli project. Therefore, there is a great need for information on insitu soil hydraulic properties for planning and management of efficient irrigation and drainage systems. The objective of this study was to characterize soil hydraulic properties of the NCB soils. This includes, infiltration, hydraulic conductivity and soil water retention relationship.

MATERIALS AND METHODS

This study was conducted at the Agricultural Research Station, Alalaganwila in the early part of 1988. An area of 25m X 10m of NCB soils was selected from the well drained Welikanda series (Maduru Oya Project Feasibility Report, 1980) for this study. The examination of the soil profile in the experimental site showed four distinct soil horizons as given in Table 1.

The soil hydraulic properties measured were cumulative and steady infiltration rates, saturated hydraulic conductivity (Ks), unsaturated hydraulic conductivity as a function of

Table 1. The soil horizons identified at the experimental site for measurement of hydraulic properties.

Horizon Designation	Depth (cm)	Textural Class	Designation used
A	0-11	Loamy Sand	Depth 1
AB	11-23	Loamy to Sandy Clay Loam	Depth 2
B1	23-50	Sandy Clay Loam	Depth 3
B2	50-90	Silty Clay Loam	Depth 4
C	>90		

volumetric water content [K(θ)] and insitu soil water retention relationship. A total of 12 infiltration runs were carried out according to a predetermined sampling grid at equal intervals in the area using double ring infiltrometer method as described by Bouwer (1986). Saturated hydraulic conductivity was estimated using the steady infiltration rate and hydraulic potential gradients at steady state for each of the four depths at the same twelve grid points (Amoozegar and Warrick, 1986). The hydraulic potential gradients were obtained by installing mercury manometer type tensiometers at the middle of each soil horizon. Unsaturated hydraulic conductivity was obtained using simplified unsteady drainage flux method as described by Green et. al (1986) for all depths at the same 12 grid points. This method involves measuring soil water content and suction profiles during the drainage cycle subsequent to infiltration.

The insitu soil water retention relationship was obtained using the volumetric moisture content and the corresponding soil water suction measurements taken at the same time during the drainage cycle for all four depths at the same 12 grid points.

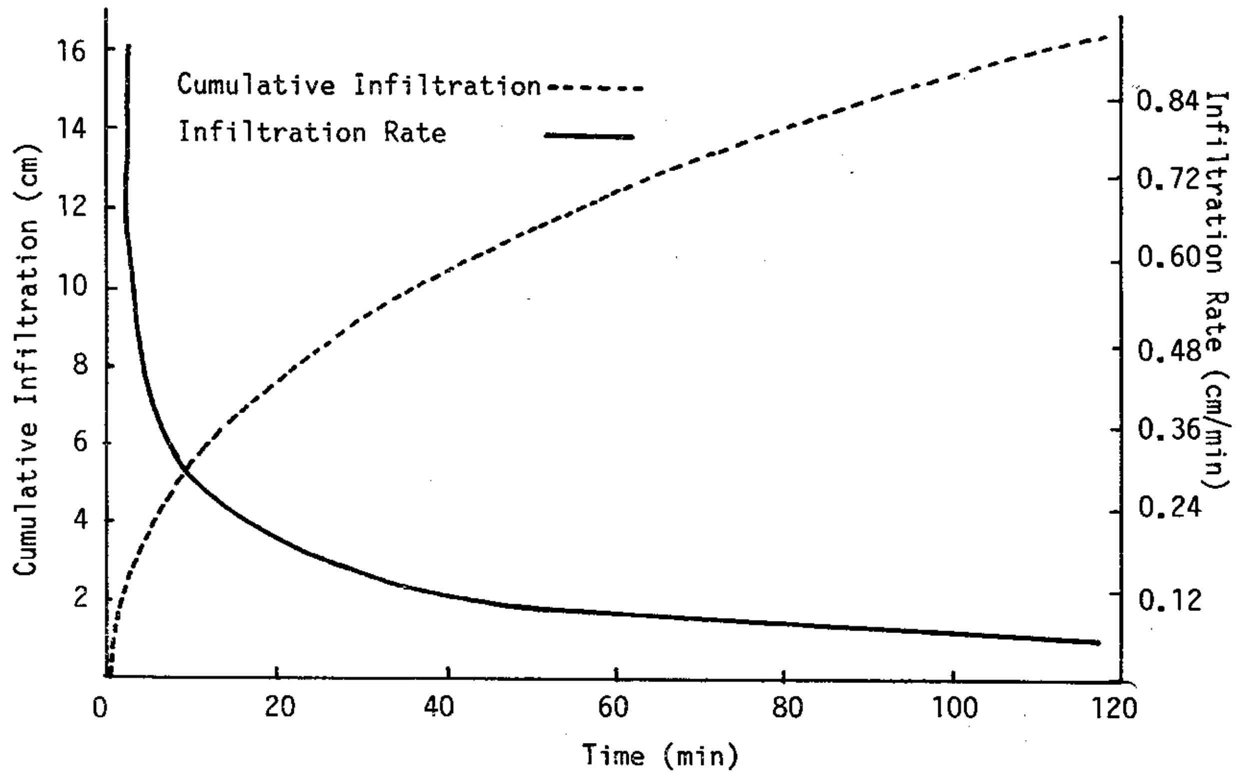

Figure 1. Cumulative and infiltration rate vs. time relationship for Non-Calcic Brown soils.

RESULTS AND DISCUSSION

Infiltration

The average cumulative infiltration and steady infiltration rate versus time curves for NCB soil are presented in Figure 1. The steady infiltration rate showed a high variability with a mean value of 7.00 cm h^{-1} within a range of 10.96 to 4.46 cm h^{-1} at 95 percent probability level. The cumulative infiltration versus time data could be summarized best by fitting them to mathematical functions reported in literature (Clemmens, 1983; Collis-George, 1977; Philip, 1957). The best fit was obtained for the empirical equation proposed by Kostiakov (Clemmens, 1983)) which is a power function as given below.

$$D = Kt^n \quad ....\quad (1)$$

Where D is Cumulative infiltration in cm.,
t is elapsed time in min.,
K and n are constants.

The mean values of parameters K and n, steady infiltration rate and the confidence intervals at 95 percent probability levels obtained using the 12 infiltration runs for NCB soil are given in Table 2. Constant n showed a value between zero and one as suggested by Heermann and Duke (1983). The parameters K and n did not show any correlation with the antecedent moisture content of the soil.

Saturated Hydraulic Conductivity (Ks)

The Ks obtained for all the four depths showed considerable variations. The average Ks for each depth and their confidence intervals at 95 percent probability levels are shown in Table 1. These results indicated that the Ks values of depth one and two were similar and considerably higher than depth three and four. Depth four showed the lowest Ks in the soil profile. This may be due to the higher clay content in depth four which

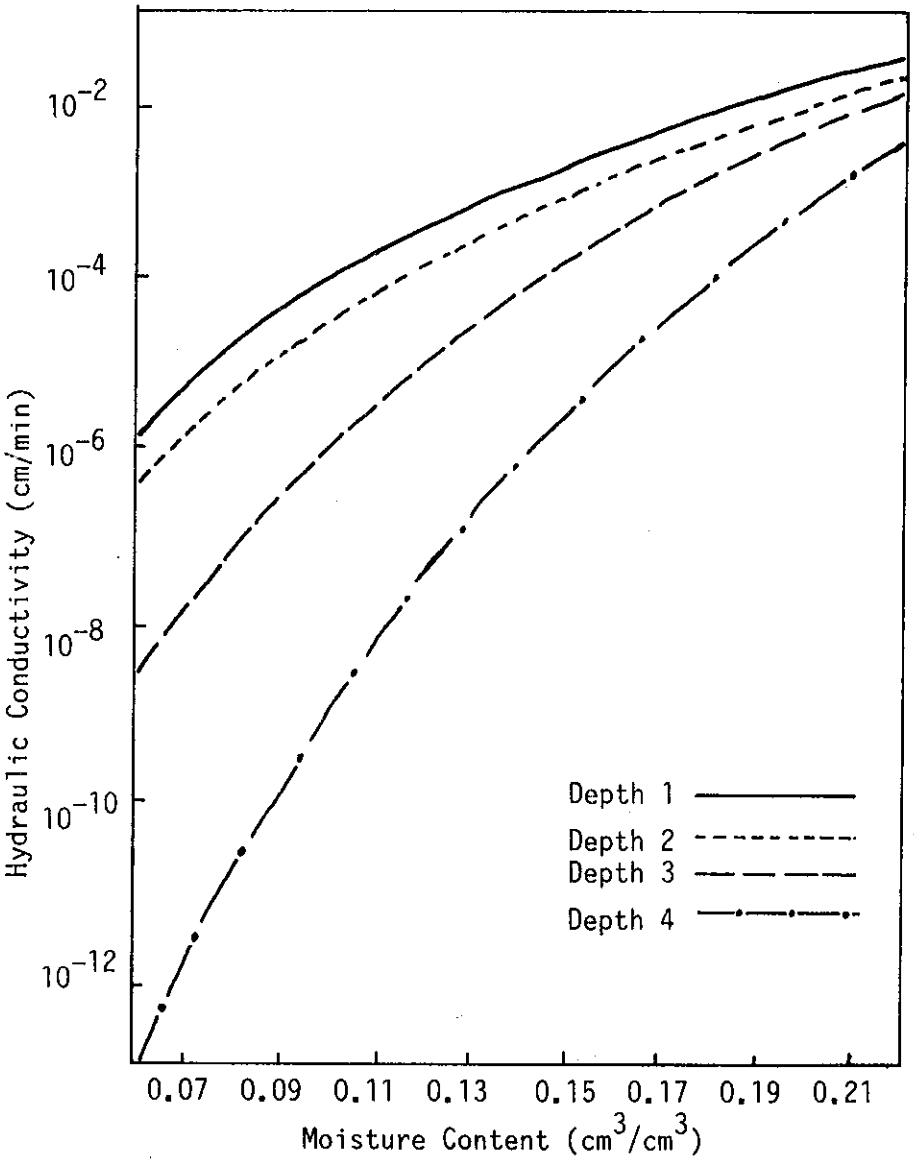

Figure 2. Unsaturated hydraulic conductivity as a function of moisture content for Non-calcic Brown soils.

Table 2. Steady infiltration rate, parameters K and n of Eq. 1 and saturated hydraulic conductivity for Noncalcic Brown soils.

Property	Mean	CI at 95% Probability
Steady infiltration rate (cm h^{-1})	7.00	10.96 -- 4.46
Parameter K	0.37	0.57 -- 0.24
Parameter n	0.43	0.45 -- 0.35
Saturated hydraulic conductivity (cm h^{-1})		
Depth 1	13.48	25.27 to 7.19
Depth 2	13.67	29.15 to 6.41
Depth 3	8.47	13.84 to 5.19
Depth 4	3.88	6.77 to 2.22

reduces the macropores contributing to restricted water flow under saturated conditions.

Unsaturated Hydraulic conductivity [$K(\theta)$]

The calculated mean $K(\theta)$ for the measured range during the drainage cycle is shown in Figure 2. It showed that throughout the range measured the $K(\theta)$ is similar for depths one and two. The $K(\theta)$ for depths three and four were lower than for depths one and two near the wet range of measurements and these discrepancies increased with decreasing water content. According to the results obtained at the dry end, depth four showed the lowest $K(\theta)$ values. This indicates that depth four can act as the impeding layer for water movement in the profile under saturated and unsaturated conditions.

Water Retention Relationship

The average field water retention relationship obtained during the drainage cycle for all the four depths for the measured range is shown in Figure 3. This showed that the water retention was highest at depth four and lowest at depth one. This was in agreement with the unsaturated hydraulic conductivity values obtained, indicating that when the water movement is rapid, less water is retained in soil and vice versa. These findings indicate that in NCB soils water retention is very low as consequence of rapid water movement due to its sandy nature. Therefore these soils are easily drained and need irrigation methods which supply water at high frequencies with less amounts.

ACKNOWLEDGMENTS

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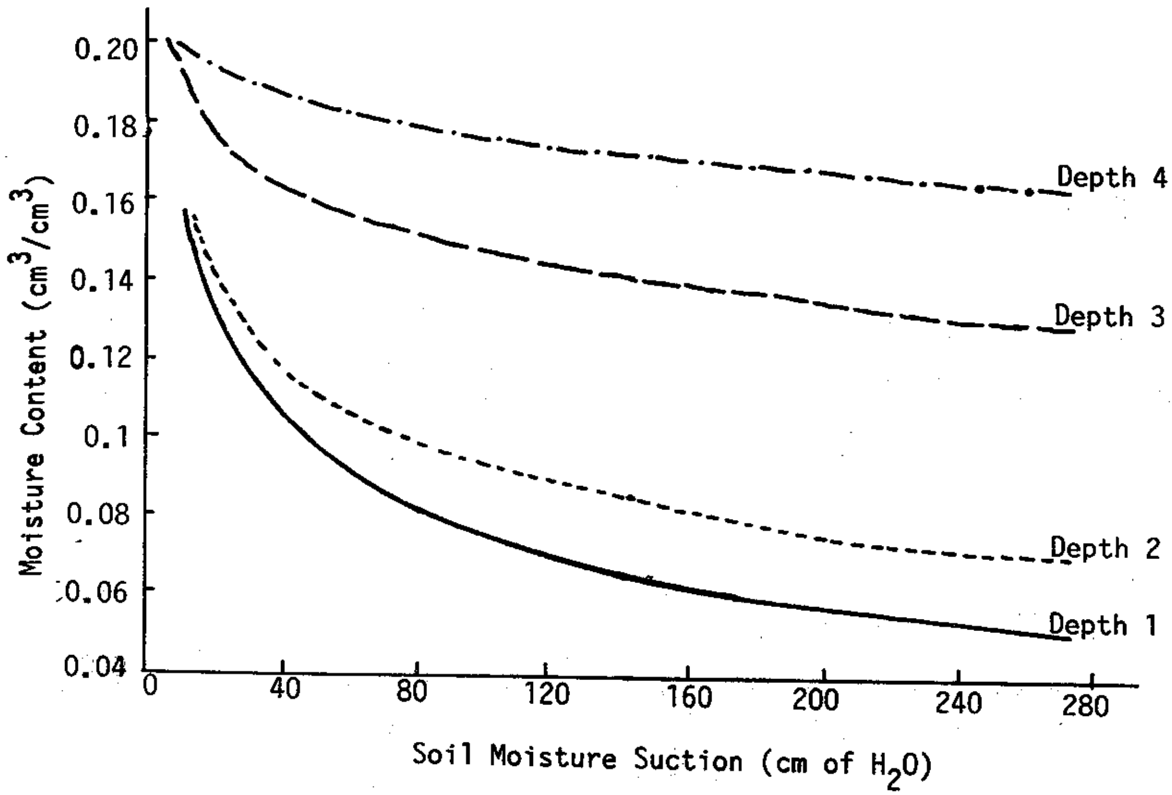

Figure 3. Field water retention relationship for Noncalcic Brown soils.

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