STUDIES ON THE MOISTURE CHARACTERISTICS OF THE EGYPTIAN SOILS

By

Moroy Mostafa Moroy

B. Sc. Agric. "SOIL Science" 1962

THESIS

SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF SCIENCE

in

SOILS

FACULTY OF AGRICULTURE
UNIVERSITY OF AIN SHAMS

1976

APPROVAL SHEET

Name : Morsy Mostafa Morsy

Title : Studies On the Moisture Characteristics of the Egyptian Soils.

Thesis has been approved by :

Date : / /19[illegible]

بسم الله الرحمن الرحيم

A C K N O L E D G M E N T

The author wishes to express his deepest gratitude and thanks to Prof. Dr. H. Hamdi, Prof. of soils, to Prof. Dr. S. Y. Metwally, Head of the Soils Dept., Faculty of Agriculture, University of Ain Shams, to Prof. Dr. A. G. Abdel Samie, Vice president of the Academic of Science and Technology and to Dr. M. Talha, Associate Professor of the Soils Dept., Faculty of Agriculture, University of Ain-Shams, for the supervision, valuable guidance, and helpful suggestions.

Sincere thanks are also extended to the authorities of the National Research Center to the facilities which made the excution of this work possible.

CONTENTS

I. INTRODUCTION

The cultivated land in Egypt is the most valuable source for the national income which depends mainly on Nile-water. In Egypt, most of the cultivated soils depend on Nile water which in turn is limited even after the construction of the high Dam. The high Dam increased the water available for irrigation. However, the necessity to husband and manage the Nile water resource effeciently on sustained Scientific basis are of the most vital tasks. The application of the optimum amount of water to obtain the highest yield of crop is of enormous importance. To determine the water requirements, the soil moisture characteristics must be known. Soil moisture characteristics directly or indirectly affect soil air, temperature, composition of water. Pore size percentage and distribution affects the movement of water into and within the soil both are functions of pore size distribution as well as the moisture storing capacity in soils and the amount of available water to plants

Therefore, the aim of the present study is to determine the moisture characteristics of some Egyptian soil and their relation to some chemical and physical properties. For this purpose, representative twelve profiles from the Delta region varying in texture, salinity and alkalinity were chosen, sampled and analysed for the following characteristics, a) general physical and chemical properties, b) soil moisture curves c) pore-size distribution and d) aggregate stability. The correlations of both texture and structure to soil moisture characteristics were evaluated.

II. REVIEW OF LITERATURE

2.1. Moisture characteristics curves definition

The soil is a porous system contains various size of pores. The way in which water is held in soils to formulate the so-called moisture constants is used for expressing differences in the water-relation of soils (Baver, 1956).

When the moisture content of a soil is plotted against its suction, or more usually pF values, one obtains the moisture characterstic curve of the investigated soil. The suction is inversely proportional to the effective radius of the pores containing the air-water menisci. The slope of the moisture characteristic curve plotted against the suction gives a picture of the pore-size distribution in the soil (Russell, 1973). Briggs (1897) showed that the retention of soil moisture would be dependent upon the number and size of the capillary spaces. Briggs and Mclane (1907) developed the moisture equivalent as an expression of the ability of a soil to hold water under a centrifugal force 1000 times that of gravity. The wilting coefficient was introduced by Briggs and Shantz (1912) to express that moisture content of the soil at which plant permenantly wilt. To determine the attraction of the soil at any given point for water the term (Capillary potential) was suggested by Buckingham (1907) and Gardner (1922) who defined it as the work required to move unit mass of water from a point where the potential is zero to the point in question. There are various methods for determining the soil moisture potential. The most important methods which may be employed are water distribution in long columns (Buckingham, 1907), moisture absorption by seeds (Shull, 1916), vapour pressure (Puri, [illegible]), freezing point depression and dilatometer (Bouyoucos, 1936), water distribution under centrifugal force (Russell and Richard, 1936), and water distribution under tension in conjunction with porous clay cell (Richard 1947, 1949a, 1949b).

1.2. The relation of moisture retention to texture

The soil is a disperse system characterized by the large amount of surface per unit mass. It is well known that clay particles have the greatest surface area per unit volume. Water is disturbed over the surface of the soil particles and throughout the pore system. The finer textured soils have greater percentages of total colloidal matter, greater total pore space, much greater adsorption surfaces and hence retain greater percentages of moisture. El-Ashkar (195[illegible]) showed the positive correlation between permanent wilting percentage and the below

2 μ fraction. The subfraction laying between the size limits of 0.25 μ and 0.10 μ has the highest positive correlation. Mitwally (1953) found a significant positive correlation between the clay content and the single values which deal with water absorption. Nielson (1958) estimated an equation for determining the field capacity and wilting percentage from known soil clay percentage. He found that the correlation of the 15 atmosphere percentage with the clay content of a soil, was highly significant, but with the silt fraction it was not significant and the 15 atmosphere was not found to be linear with clay content.

However, Bartelli (1959) showed that clay content is positively correlated with moisture percentage at 1/3 and 15 atm. Stieven (1966) reported that the saturation percentage (S.P.) was closely related to the mechanical constituents of a soil where the following equations were obtained.

$$S.P. = 573.72 - 4.54\ clay\% - 5.40\%\ silt - 5.56\%\ sand \pm 1.89$$

$$S.P. = 35.16 + 0.87\ clay\% - 0.16\ sand\% \pm 6.93$$

Winkler (1970) showed that the tension at which water ceased to be available to plants were one, three and fifteen atmospheres for the podzolised soil, the planosol and the gley soil, respectively. Gavrik (1973) pointed out a regression equation describing the relations between the mechanical composition of the soil and the moisture parameters. He found that the correlation coefficients were of the order 0.6* to 0.9** Anderson (1973) found that significant correlation between moisture constant and mechanical composition in the swedish soils. Hartmann (1973) showed that in the Beljekiam soils, the field capacity was found to correspond to pF 2 for sand, loamy sand and clayey sand and to pF 2.54 for sandy loam and light sandy loam soils.

The available water is determined by the difference between field capacity (1/3 atm.) and wilting percentage (15 atm.). Wilcox (1941), Jamison (1956), and Lund (1959) found that sand percentages had a negative correlation with available moisture. Mentioned investigators in addition to Bartelli (1959) concluded that silt particles were of primary importance in controlling available moisture in soil, and that as the former increased, the latter also increased.

Lund (1959) showed that there was no correlation between clay content and available moisture, while Jamison (1956) found the same correlation to be negative. Petersen (1968) proved that the lowest values of available water is with the sand-rich coarse textured soil classes, while these values increased in clay rich fine textured soil classes. Coarse textured soils had low available moisture because they had pores too large to retain much moisture as indicated by their low moisture content at 1/3 atm. As texture became finer, available water increased because more pores were present with dimensions favourable for holding available water for plant use. However, as soil texture became increasingly finer, available moisture decreased because more water was retained by the increased surface area and points of contact which harbor water as films held at high tension. In general, as soil texture became finer, wilting percentage and field capacity increased. However, wilting percentage, increased at a greater rate for the finer textured classes of soil resulting in the greatest available water in the medium textured classes. These relationships were similar to the theoritical values reported by Buckman and Brady (1965).

[illegible] (19[illegible]) made a quantitative assessment of the effect of the proportion of sand, silt, clay and organic matter on the available water capacities (A.W.C). He found that the A.W.C. of a soil was negatively correlated with percentage of coarse sand and positively correlated with the percentage of international fine sand (or American silt) and organic matter. He and used a regression equation to estimate the A.W.C. of a soil from the mechanical analysis data, the following equation was obtained :

A.W.C. (in./Ft)= 1.50-0.0120 coarse sand%+0.0123 international fine sand% + 0.302 organic carbon %.

Petersen (1968) found that the silt in the very fine clay soils had a negative influence because the silt particles were surrounded by clay and were not present in great enough proportions to aggregate and form pores. He showed also that the the field capacity was highly correlated with the available water but the wilting percentage showed either no correlation or was negatively correlated.

Zawadzki (1970) found that the retention at pF 2.0 initially increased quickly with an increase in the silt+clay fraction and then slowly to reach 30% at 75% silt+clay. At pF 4.2 water retention increased first slowly and then quickly to reach 30 % at 75% silt+clay. Thus, the potential available water retention increased quickly to 25% at 30% silt+clay and then decreased slowly at 15% at 75% silt+clay.

2.3. Moisture retention as related to soil structure

Baver ([illegible]) defined soil structure as "the arrangement of primary (sand, silt, or clay fraction) and the secondary (aggregate) particles into a certain structural pattern. Complementary to this arrangement of the solid phase of the soil was the configuration of the non-solid (liquid and gaseous) phase which determined the size distribution and arrangement of soil pore space. Soil structure was of great importance of crop production. The term soil structure might be used to cover a group of properties largely concerned with the pore size distribution in the soil. The coarser pores controlled the spaces into which roots could grow, the permeability of the soil to rain or irrigation water, and the aeration of the soil when wetted but well-drained. The medium size pores affected the water supply to the roots and the finest pores the ease of cultivation of the soil. The fundamental problems in soil structure management were, therefore, concerned with the creation of structural pores, and their stabilization when formed. Pure clay mineral particles were plate-shaped and carried a negative charge on their surface, but the electrical conditions on their broken edges were less well characterized and might consist of both positive and negative charges. When clay particles in a dilute suspension flocculated, they sticked together to form an open floccutate, that was the particles form the [illegible] into an open network by joining up edge to edge or edge to face (McEwan, 195[illegible]).

The non-capillary porosity of the surface soil was a very dynamic property. It changed with weather conditions and the frequency of tillage. Tillage operations usually increased the total porosity and non-capillary pores of a compact soil. The impact of rain dropped on a granular well-aereated soil tended to disperse the soil particles and caused a compaction of the immediate surface accompanied by a decrease in porosity, especially the larger or non-capillary pores, which Wollny (1889) was the first to show how great this decrease in non-capillary porosity could be. His data showed that the total porosity of the unprotected soil averaged only about 6 percent less than that of the protected one, while the non-capillary porosity was about 31 percent less. Thus, it was important to stress that the most serious effect of the deterioration of the structure of the surface soil was the decrease in the non-capillary pores, this decrease was responsible for poorer aeration, reduced bacterial activity, and a lower infilteration capacity for precipitated water. The non-capillary pores increased by cracking due to shrinkage, by the roots of vegetation, and by the burrows of the animal life in the soil Wollny ([illegible]) showed that earth-worm burrows raised the non-capillary pores of loam soil from 8.9 to 31.1 percent. Soil aggregation affected most of the physical properties of the