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**FACTORS AFFECTING THE BEHAVIOUR OF
MOISTURE IN SOIL AND PLANT**

By

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THESIS

**SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF**

**DOCTOR OF PHILOSOPHY
IN
AGRICULTURAL SCIENCE
(SOIL SCIENCE)**



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To My Parents



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APPROVAL SHEET

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1. INTRODUCTION

Irrigated agriculture has been practiced in arid and semi-arid regions of the world since the beginning of man's civilized history. The earliest known records of man's attempt to raise crops using artificial application of water are found in the Middle East and North Africa. The remains of wells, underground collection systems, dams, reservoirs, terraced irrigation works, catchment basins, aqueducts and conveyance channels in the Middle East all indicate that the land once supported a large population with an advanced knowledge of irrigated agriculture.

Drought and salinity are related phenomena and represent two of the most important environmental stresses influencing the productivity of agricultural systems around the World, especially in arid and semi-arid regions.

The main purpose of agriculture expansion is to increase not only land production but also the cultivated area so as to meet the increasing demand for food. In addition water is one of the most limiting factors for crop production in arid zones, and soil moisture and salinity stress play an important role in limiting plant growth. So, different kinds of irrigation water such drainage and sewage water ... etc , must be used in agriculture because of the difficulty and unavailability in obtaining a high quality or sufficient irrigation water. Besides the plant field has a slight ability to adapt or tolerate the stress, consequently it is affected by the quality

and quantity of irrigation water. So, it was necessary to search for a method to be applied to increase the plant tolerance under stress conditions. These facts justify studying the effect of soil moisture stress and salinity of irrigation water on plant growth and physiological changes in it.

The aim of this work is to study the effect of different levels of available water in soil, depletion of soil moisture and quality of irrigation water on moisture status and behaviour of plant grown in different soils. Also the investigation is extended to increase plant tolerance by reducing the transpiration process using anti-transpirant (PMA) as a trial to improve moisture status in plant leaves. This work aims also to find definite relations between moisture content and consequently, irrigation requirements of these plants. Achieving this goal will help in planning the irrigation policy for different soils and plants in the presence of different kinds of irrigation water.

2. REVIEW OF LITERATURE

2.1. Factors affecting soil moisture behaviour

The soil is a porous system containing various sizes of pores. The way in which moisture is held in soil to formulate the so-called moisture status, is used for expressing the differences in moisture behaviour or its relations to the soil **Baver et al. (1976)**.

2.1.1. Soil moisture status

When the soil moisture content is plotted against its suction, or more usually pF values, one obtains the moisture characteristic 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 gives a picture of the pore-size distribution in the soil, which reflects to a great extent the predicted behaviour of moisture in soil, **Russel (1973)**. **Brady (1984)** stated that soil moisture can be classified either on physical or biological bases. From a physical point of view, the forms of soil water are gravitational, capillary, and hygroscopic. First term means that water is in excess of the soil field capacity (0.1 - 0.3 bar). Capillary, means that water is held in the pores of capillary size and behaves according to laws governing capillarity, while hygroscopic water is that bound tightly by the soil solids at tension values greater than 31 bars.

Morsy (1976),
found a positive
and soil moisture
was negative and :

2.1.2. Soil moisture

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On the other hand, biological classification, depends on the definite relationship between soil moisture tension and its utilization by plants. Gravitational water is obviously of little use to plants and may be harmful. In contrast, moisture retained in the soil between field capacity (0.1 - 0.3 bar) and the permanent wilting percentage (15 bars) is said to be usable by plants and as such is "available water". Water held at tensions greater than 15 bars is said to be unavailable to most plants.

Gardner (1968) showed that soil moisture contents at high values of suction were affected by soil adsorption capacity, which is affected largely by soil texture. He also added that soil moisture contents at high suctions are fairly well-correlated with specific surface area of the soil.

El-Ashkar (1951) found a positive relationship between the percent of clay and soil moisture held at 15 atm. **Nielsen and Shaw (1958)** and **Bartelli and Peters (1959)** found that the correlation between soil moisture content at 15 atm and clay content was positive and highly significant, while it was negative in the case of sand fraction. **Abrol et al. (1968)** reported that silt is the major factor contributing to moisture held at 0.33 atm. in soil of semi-arid regions. They also found that soil water held at 15 atm. has a significant positive correlation with clay content. So, soil texture can be considered as the main factor which affects soil moisture behaviour.

plant roots to absorb water from the soil as well as the ability of the soil to supply and transmit water towards the root at a rate sufficient to meet transpiration requirements. These, in turn, depend on properties of the plant and properties of the soil such as hydraulic conductivity, diffusivity, matric suction and wetness relationships; and also to a considerable extent on the meteorological conditions.

From a wide view, the amount of water absorbed from soils by plants is determined by a number of plants, climatic, and soil variables. Rooting habits, basic drought tolerance and stage and rate of growth are also important plant factors. Significant climatic variables include air temperature, humidity and wind velocity and turbulence. Among the important soil characteristics influencing water availability to plants are: a. Matric and osmotic tensions, b. Soil depth and c. Soil stratification, Brady (1984).

Concerning the relationship between soil texture and soil moisture availability, Abrol *et al.* (1968), Hartmann (1974), Morsy (1976) and Elwan (1983), reported that as the soil texture tends to fineness, the value of available moisture in soil becomes greater.

Shawky and Wahdan (1985) found that the range of soil-water contents or soil matric potential between field capacity and wilting percentage can not be used as a definition of available soil water as both limits are affected by the plant factors on one hand and by the soil water properties and transpiration demand on the other hand. They also added that, most of the soil factors affect the upper limit of available water, while most of the plant factors such as, plant conditions, root habit and plant resistance to drought, mainly affect the lower limit of available water.

Sykes and Loomis (1963) stated that the permanent wilting percentage in a loamy soil varied between moisture tension of less than 10 atm with sunflower and 20 atm with maize while in a clayloam one these values were near 15 atm with sunflower and over 20 atm with maize **Sykes and Loomis (1967)** illustrated that the ability of plants to remove soil moisture before permanent wilting was significantly varied with plant species and with soil texture. Also **Hassan (1979)** indicated that water uptake by plants differed with plant species, and the highest values of water uptake were attained for plants cultivated in clay and loamy soils and the lowest ones were recorded for plants grown in sandy soil.

Shawky and Wahdan (1985), concluded that the detected wilting percentages were corresponding to matric potential ranging between < -5 to > -40 bar suction and the available water percentage indicated differences depending mainly on soil texture and plant type.

2.1.3. Soil hydraulic conductivity

The movement rate of moisture from soil to plant roots depends on the steepness of the moisture potential gradient and on the soil hydraulic conductivity, both these factors decrease rapidly as soil moisture content decreases (Kramer, 1983).

Moisture conductivity of the soil is one of the most important physical properties which plays an important role in the rate of moisture movement towards plant roots. Its values are highly affected by a number of factors, such as; soil texture, soil porosity ... etc., Zein El-Abedine et al. (1967); Fethendler et al. (1975), Omer (1977), Bhatnager et al. (1980) and Galal (1984).

Baver et al. (1976) stated that there are several characteristics of the soil moisture retention curve which affect soil moisture movement and percolation rate. First, the amount of water which is withdrawn from zero tension to that at the inflexion point on the curve appears to be closely associated with the rate of water movement. The amount of water represents the pores that have been drained and filled with air, the larger this amount, the greater is the hydraulic conductivity. Second, the tension of the inflexion point in the moisture-log tension curve seems to be closely related to hydraulic conductivity, the lower the log tension of the inflexion point, the greater is the rate of percolation. Third, in some soils, there is a tendency towards greater hydraulic conductivity as the

slope of the log tension-moisture curve from zero tension to that of the inflexion point decreases. Bishai (1966) stated that the values of the log tension of the inflexion point may be suggested as the sharp edge between the capillary and non-capillary porosity, thus the amount of water drained between the inflexion point and saturation may show great influence on water permeability. He added also that the height of the log tension of the inflexion point in the soil-moisture characteristic curve seems to extend an appreciable effect on permeability. The lower the log tension of the inflexion point, the higher is the permeability value. He also found that the light textured soil has a higher permeability value than that of the heavy textured one. This may be due to the fact that the log tension of the inflexion point is less in the light textured soil than in the heavy one which indicating that the size of the non-capillary pores is greater in the former soil than in the latter one.

When soil moisture content within the rhizosphere decreases due to plant uptake or evaporation, the remaining water becomes less available to plants. There are two primary reasons for this finding and both display a textural dependance: First, the thin moisture film around the soil particles, second, decreasing water content also causes a rapid increase in the resistance of moisture movement which limits moisture conductivity and availability, Passioura (1980 and 1981).