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EFFECT OF BULK DENSITY ON SOIL WATER POTENTIAL IN MEDIUM LOAM SOIL OF AGRICULTURE

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Abstract

Based on loam soil in different design density 1.4 g/cm^3, 1.5 g/cm^3, 1.6 g/cm^3, we had done the test of the changes relationship between the soil containing water and the soil water potential, and analyzed the soil water potential trends of the loam soil in the design of different bulk density. The results show that the value of loam soil water potential is in the range of 57 to 140 kpa under the same soil containing water (gravimetric water content 12.5%) and the design of three soil bulk density, and present that the greater the soil bulk density, the smaller the soil water potential. The changing range of them is in trend of decreasing. All of these experimental studies will be benefit to choose the suitable discharge of the dripper for drip irrigation system, and make full use of the natural energy of the soil water potential, using it as the control index of irrigation system. At the same time, these results can provides a theoretical basis further for researching on the crop root zone soil moisture migration regularity and determining the optimal soil moisture environment.

Key words*: soil bulk density, soil water potential, irrigation amount, soil moisture content.*

INTRODUCTION

Soil bulk density, soil water potential are the most important soil physical indicators. During the daily management of the agricultural process, the soil experiences from dry to wet, from wet to dry alternating, and the soil bulk density changes constantly, and directly affects the final yield of the motion law of soil moisture and crop when heavy agricultural machinery and other tillage measures, for the influence of factors and soil drought and other natural factors. Soil water potential, also known as the soil negative pressure, soil matric potential, it is soil pore water by capillary interactions between soil particles and soil water and soil water mutual adsorption of a natural force, from the point of view of energy accurately characterize the soil particles of water with soil moisture available (Li Lifang, 2007; Shao Xiaomei, 2004). By filling soil, in the Brooks Corey soil water characteristic curve model based on the proposed two surface model to describe the quality of the soil water content, bulk density, and suction three variable of quantitative relationship between soil quality water content, soil water potential and soil bulk density, provide a new approach for correction variation of soil bulk density on soil hydraulic parameters influence (Shao Ming'an et al., 2007; Fu Xiaoli et al., 2008).

According to the initial moisture content is a determinant of soil water potential and analysis, it has been found that the soil initial moisture content of both moist peak front hydraulic gradient, and can influence soil aggregate encounter water disintegration of strength, and the soil infiltration characteristics have significant influence (Mu Xing Liu et al., 2012).

Li Yaogang had analysis of the different bubble root the influences of irrigation flow to soil

water potential. The test shows that the moist soil in soil water potential trends and to develop bubble irrigation emitter flow provides a theoretical basis (Li Yaogang et al., 2013). Combined with the growth condition of crop, Clark under different irrigation conditions of the effects of different soil water potential on tomato growth, analysis of soil water potential in 5 ~ -10kPa, tomato yield higher (Clark et al., 1991).

Controlling soil water potential in the application of agricultural irrigation were studied, and fully proves that the soil water potential in soil of water absorbing ability, on crop water supply situation, and pointed out that the soil water potential has become an important research direction of crop irrigation index (Dou Chaoyin et al., 2013).

All of above research results are more concentrated in the soil moisture migration, and on soil water movement in soil water potential of the research on the relationship between the less, especially without soil water potential variations under different soil bulk density in the related research.

TEST PURPOSES

The effectiveness of soil water potential directly affects the crop root system in SPAC soil moisture absorption, the soil of this type generally exist in the field of soil by soil water potential test of different soil bulk density of the real-time variation of soil water potential with soil bulk density, soil moisture, investigate the influence the soil bulk density of soil water potential, reasonable analysis of movement before and after irrigation process of soil moisture condition and soil moisture, which is convenient for controlling the soil water potential as irrigation index (Li Yalong et al., 2004), and is suitable for the emitter flow and specifications to determine the optimal soil moisture environment of crop root zone and provide a theoretical basis and relevant technical parameters (Liu Chao, 2007; Li Xingtao, 2012).

MATERIALS AND METHODS

Test materials and equipment

The soil sample of the experiment was medium loam.

The test equipment including: soil water potential sensor (MPS-2), a soil moisture sensor 5-TE, data collector EM50, electronic scales, plastic pail, sieve, cylinder, rammed earth hammer, electric drill, oven, aluminum box, thermometer et al. The EM data collector has five channels, and it can be 36000 readings for storage and data logging interval for 1 minute to 1 day; soil water potential sensor (MPS-2) using frequency domain reflectometry and the principle of thermocouple and allows for rapid determination the soil water potential range from -5 kPa to -500 kPa -500 kPa, which is high measuring accuracy, the measurement accuracy is +10% in range of -5 kPa to -100 kPa, the measurement accuracy is +25% in range interval from the -100 kPa to-500 kPa; the determination range of soil moisture sensor (5-TE) is 0~100% VWC (volumetric water content).

Methods and programs

The test was finished in soil physical and chemical properties laboratory of Farmland Irrigation Research Institute. The test method was soil column by barrel, which was made from PVC plastic pipe, and the diameter of the bottle is 15 cm. The type of PVC plastic pipe were cut into a lot of pipe sections, which length is 20 cm and covering 120 filter gauze at one of end surface of the pipe, and using a pipe hoop to fasten the barrel and the filter gauze on the periphery. Then it can form the bottom of barrel. We had made nine test barrels of soil, and number, weighting the empty barrel. Specific test programs and procedures as follows:

Selection of loam soil samples, the soil crushing, sieving, mixing, and then blended into the water content of the same initial weight. According to the normal soil bulk

density of conventional medium loam soil, the soil bulk density range is between 1.4-1.6 g/cm^3. Therefore, in order to ensure the test soil sample making feasibility and test data of the obvious contrast, we had designed three different values for the soil bulk density, which soil bulk density is 1.4 g/cm^3, 1.5 g/cm^3, 1.6 g/cm^3 respectively. According to the actual volume of the test soil barrels and the design height of soil column, we weighed soil in every test barrel by electronic scale. Then, we divided soil of every barrel into three unit saveragely and began to fill soil column in three times. During filling, every soil column was filled with three layers, which height is 5cm and evenly compacted soil between each soil layer. When the soil column was height of 10cm at the second times filling finish, we had pre laid water potential sensor, moisture sensor and negative pressure with gauge pointer at the central position of the soil column. And continued to consolidate the soil to designed bulk density till the soil column was height of 15cm at last. Then we weighed every soil sample of test soil and its barrel, calculated and checked the initial moisture content of the test soil. At the same time, we took the sample of soil into the aluminum box and test its initial water content by the method of drying test.

After the completion of soil column, we calculated the actual content of water filled into soil samples of every test soil barrel according to the difference between the soil initial containing water and designed soil containing. Then we measured respectively the needed water content of every soil barrel with a graduate, and added it into the surface of soil column. After more than four hours of water infiltrated, the potential energy between soil and water reached balance and the soil moisture content was uniform. Such as so, we could begin to test, observe data and record the soil water potential value corresponding with the soil containing water. When the test data was measured and remained to good stability, we used one of thermal equipment to heat the soil column and accelerated soil water evaporation in order to effectively change the soil moisture content. At the same time, we began to measure at regular time and record the test data of the soil water potential in a real time corresponding with a range of the soil containing water changed. We used the designed soil bulk density as the test treatment, and there were a total of 3 treatments in test, each treatment were 3 repeat. The specific test scheme is shown in Table 1, and the design of test device is shown in Figure 1.

Table 1. Test plan design table

Type of soil	Design soil bulk density (g/cm^3)	Number of test repeat
Medium loam	1.4	3
	1.5	3
	1.6	3

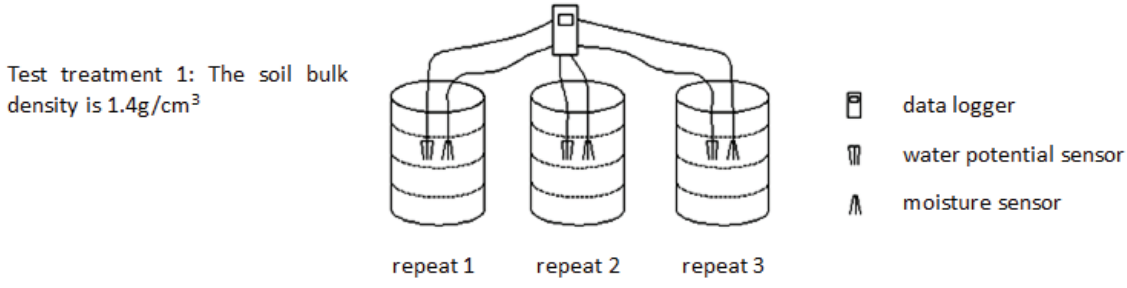

Figure 1. Design of test equipment (single treatment)

Test index

The effect of soil bulk density on soil water potential was analyzed, and the specific test indexes include: soil bulk density, soil moisture content and soil matrix potential, indoor temperature. We observed and recorded test data timing at every morning and afternoon, the test data were repeated measured at least 2 times, and determined the standard of an effective test data when the difference among all the test results in a group was not more than 2% each other.

The test data was measured at the condition of environment temperature indoor was 25℃.

RESULTS AND DISCUSSIONS

The test data was calculated and processed in the way of analyzing and counting by Excel and SPSS software, then we took the soil moisture (θ) as the abscissa and soil water potential l(P) as the ordinate. And the relationship curve between the loam soil moisture and the soil water potential was fitted by the method of data regression analysis the regression. The curve is shown in Figure 2.

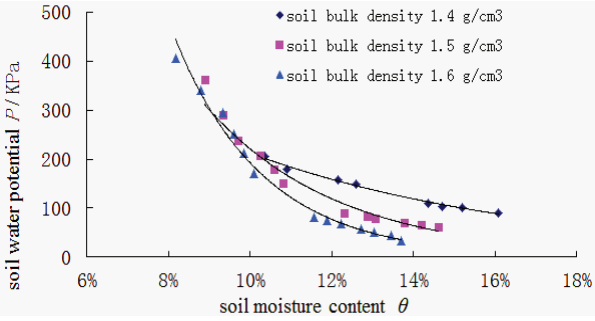

Figure 2. The relationship curve between the loam soil moisture and the soil water potential in different bulk density

After regression analysis and calculation, the relationship expression and correlation coefficient between the two variables of soil moisture content and soil water potential in different soil bulk density conditions are shown in Table 2. From the results of preliminary that: by using the form of exponential function regression, the two parameters of the loam soil moisture and the soil water potential were fitted better, and the relationship curve were accurate and meet with their data expressed.

The correlation coefficient (R) is high of above 0.95. So it is good correlation overall between them.

Table 2. Regression parameters of soil moisture content of different bulk density

Type of soil	Soil bulk density (g/cm^3)	Relational expression of P～θ	R^2
Medium loam	1.4	$P = 905.21\ e^{-14.510}$	0.9955
	1.5	$P = 4882.8\ e^{-30.950}$	0.9863
	1.6	$P = 18815\ e^{-45.810}$	0.9954

As shown in figure 2, we can see that the smaller soil bulk density of loam soil, the bigger soil moisture content change range under the conditions of the same initial weight containing content 12.5%, equal amount of water added.

There was a trend of soil water potential decreased as the soil bulk density increase. That is to say the higher soil bulk density, the soil water potential is smaller, the smaller soil bulk density, the soil water potential is greater, but the change rate of the two parameters was different obviously.

After we added the quantity of irrigation water into the soil column, there was a trend of the change range of loam soil moisture content was small as the soil bulk density increased, but the variation range of soil water potential also decreases accordingly. In other words, the higher the soil bulk density of loam, the soil moisture change interval is smaller, and the change range of loam soil water potential is smaller, but its change rate is greatly.

In addition, the change range of loam soil moisture content is smaller at condition of the test treatments of designed soil bulk density of 1.4 g/cm^3, 1.5 g/cm^3, 1.6 g/cm^3.

The change range of loam soil moisture content is between 35.56%~40.29%; but the change range of loam soil water potential is larger, between 127%~1126%. From the perspective of the soil water potential changes speed in three designed soil bulk density of 1.4 g/cm^3, 1.5 g/cm^3, 1.6 g/cm^3, the change range of loam soil water potential was more sensitive to the soil bulk density as the soil bulk density increase when the soil moisture content was in the same change range.

The loam soil bulk density was smaller, the change interval of loam soil water potential was smaller, and the effect on change speed of loam soil water potential was slower. In the range of soil gravimetric water content of 8%~18%, the change in the range of loam soil water potential

was about 120~300 kPa when the soil bulk densitywas1.4 g/cm^3; the change in the range of loam soil water potential was about 80~370 kPa when the soil bulk density was 1.5 g/cm^3; the change in the range of loam soil water potential was about 20~410 kPa when the soil bulk density was 1.6 g/cm^3. From the changes relationship of all above, there was the initial law of effect of loam soil bulk density on the soil water potential was gradually sensitive little by little as the loam soil bulk density increased.

CONCLUSIONS

By a preliminary study on the relationship between loam soil water potential and soil design density, soil moisture content and soil water potential, we had obtained some conclusions as follow:

(1) At the same type of irrigation technology and the same initial soil water content for loam soil, the soil moisture content change rate of test loam sample was about between the respective maximum 35.56%~40.31%, and the change range of soil moisture content was small as the soil bulk density increased.

(2) At the same soil water content (gravimetric water content 12.5%) conditions, the soil water potential was range of 57~140 kPa when the soil bulk density of the loam soil samples was designed to three different level, and the loam soil water potential decreased with the increase of soil bulk density.

(3) In the same change range of the soil moisture content, the change range of loam soil water potential was not obvious when the loam soil bulk density was bigger, and its change rate of loam soil water potential was gradually decreased.

(4) All the above of test results would provide a theoretical basis for making full use of the soil water potential this natural energy initially, to as a controlled index for irrigation, and further to study the crop root zone soil moisture migration regularity and determine the suitable soil moisture environment technical parameters for crop growth.

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