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Analytical measurement and instrumentation for agriculture engineering

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ABSTRACT

Tensiometers are instruments that analytically used to measure the energy status (or potential) of soil water. That measurement very useful because it direct relation the ability of plants to extract water from soil. Based on this experiment, irrometer tensiometer and watermark sensors are the methods that are used reading soil water tension. Tensiometer is the only one that has direct measurement, which means it actually reads the physical forces at work in the soil while watermark sensor is indirect method of measurement soil water tension. Irrometer soil moisture measurement is equipment that is used to optimize irrigation and maximize conservation especially in agriculture sector. Irrigators often use tensiometers for irrigation scheduling because they provide direct measurements of soil moisture status and they are easily managed. In addition, tensiometers can be automated to control irrigation water applications when the soil water potential decreases to a predetermined critical value.

KEYWORDS

Analytical instrumentation;
Agriculture engineering;
Measurement technology;
Irrometer;
Watermark.

INTRODUCTION

The evidence of the Almighty of Allah could be seen via His creations such as trees, mountains, animals and the earth. In Al-Quran, eighty three verse were mentioned about agriculture and it could be a kind of our worship to the creator of all creators; Allah Subhanahuwataala and refer to Imam Nawawi on Kitab Sahih, the best work or effort for the human being is agrculture[1]. In agriculture, usually soil is measured by tensiometer which indicated soil water suction (negative pressure), which is usually expressed as tension. This suction is equivalent to the force or energy that a plant must exert to extract water from the soil. The instrument must be installed properly so that the porous tip is in good contact with the soil, ensuring that the soil-water suction is in equilibrium with the water suction in the tip. The suction force in the porous tip is transmitted through the water column inside the tube and displayed as a tension reading on the vacuum gauge. Soil-water tension is commonly expressed in units of bars or centibars. One bar is equal to 100 centibars (cb). The higher the reading is in cb (kPa), the drier your soil[2]. Unsaturated soil mechanics is often applied to geotechnical problems such as embankments, dams, pavements, foundations, landfills, slopes, nuclear waste disposals, etc. Analyzing such problems requires information about soil suction variations. This explains why significant effort has been made from all over the world on suction measurement techniques under field conditions[3,4]. presented several devices and techniques that are used for in engineering measurement. Jet fill tensiometer and small-tip tensiometer are often used to instrument soil slopes[5-7] used small-tip tensiometer to observe the desiccation of sensitive clay in field. In general, the soil suction range of these tensiometers is below 100 kPa.[8] used thermal conductivity sensor to measure higher suctions in an unsaturated swelling soil slope. The highest suction recorded reached 900 kPa. Although the suction range was enlarged using thermal conductivity sensor, hysteresis phenomenon and long time for stabilization are still the drawbacks of this technique[9] and has reported field data from three test sites where soil suction was measured using thermocouple psychrometer. The suction range for the involved soils varied from 100 kPa to 10 MPa. According to[9], the monitoring of soil suction with psychrometer technique in the near surface zone (less than 0.4 m depth) could be affected by the temperature variations. However, as[10] reported, in practice only the suction in the near surface zone varies significantly under soil-atmosphere interaction. Miniature measurement device has been widely employed in laboratory tests to measure such material[11]. It has been observed that the initial good saturation of tensiometer is essential to obtain a maximum measured suction; otherwise, the cavitation phenomenon can occur before the real soil suction is captured. Two techniques are often used to ensure a satisfactory saturation[2]: i) initial water percolation under vacuum, ii) cyclic pre-pressurization (high pressure application and cavitation under high suction).

METHODOLOGY

The instrument that we used is called Irrometer Tensiometer. It is only reflects if there is any physical forces in the soil. It is act as plant root which the moisture interact through the ceramic tips. The soil water tension outside the instrument forces the water inside to remove from it thus create tension inside the tube. Due to the tension, readings are appeared through the mechanical gauge. This instrument is very sensitive, which the ceramic tip can be broken of push too hard into the soil. Besides that, they must keep dry before want to use them, if not let them dry for a day.

Soil water tension is best monitored in the field by tensiometers or estimated indirectly by the use of electrical resistance sensors (blocks) that are placed in the soil profile at various depths. A tensiometer has a vacuum-pressure gauge mounted to the waterfilled tube to observe the soil tension measurement at any time. The unit requires the tube to be filled with water and serviced to remove any entrapped air before installation into the soil. Below is general guideline in operating irrometer which visually indicated as in figure 1;

- 0-10 Centibars = Saturated soil
- 10-30 Centibars = Soil is adequately wet (except coarse sands, which are beginning to lose water)
- 30-60 Centibars = Usual range for irrigation (most soils)
- 60-100 Centibars = Usual range for irrigation in heavy clay
- 100-200 Centibars = Soil is becoming dangerously dry for maximum production. Proceed with caution!

Experimental set-up

Figure 2,3,4 and 5 shows the experimental set-up for this study. The detail oeration as per following steps;

A hole is drove in the ground with the standard ½ inches pipe. The standard ½ inches pipe will make a hole for an exact fit. The irrometer's is inserted in the hole, leaving at least 1 inches of the space between

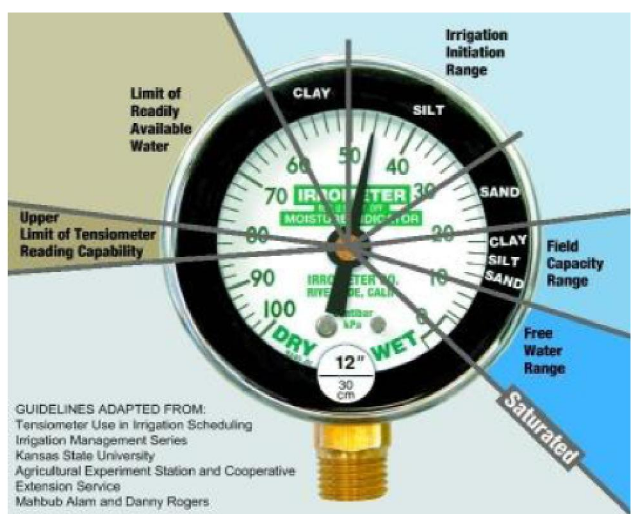

Figure 1 : Operating irrometer guide for measurement[2].

bottom of the gauge and ground surface.

The irrometer is filled with a diluted solution of irrometer fluid. Fill to the circle of reservoir. Tap top of the irrometer with your palm to remove any air lock. Take the vacuum pump and extract air from the instruments by pulling a vacuum of 80 to 85kPa.

The pump is left on the instrument for 10 to 15 seconds to allow air to rise and then release vacuum gently.Refill the fluid if necessary and replace cap until stopper comes in contact with bottom of the reservoir, then, continue tightening for ¼ turn only. The reading is taken every 1o minutes for 3 hours.

RESULTS AND DISCUSSION

TABLE 1 and 2 shows the result of soil moisture on two different reading. Based on this experiment, irrometer tensiometer and watermark sensor are the methods that are used reading soil water tension. Tensiometer is the only one that has direct measurement, which means it actually reads the physical forces at work in the soil while watermark sensor is indirect method of measurement soil water tension. Irrometer soil moisture measurement is equipment that is used to optimize irrigation and maximize conservation especially in agriculture sector. Tensiometric measurement is the physical force actually holding water in the soil, measured in Centribars (or kPa) of soil water tension. Irrometer soil moisture measurement is based on the tensiometric method, because of the fact that the amount of water is not as important as how difficult it is for the plant to extract it from the soil. Soil water tension (or metric potential) has to be overcome for the plant to move water in to its root system.

Figure 2 : The location of measure of moisture at kusza farm

Figure 3 : Make a hole to insert irrometer using specific puncher (as indicated)

Figure 4 : Vacuum (as indicated) the bubble to avoid air lock

Figure 5 : Then left and take reading of soil moisture for every 10 minutes.

Moreover, based on the reading recorded as in figure 6, the soil is stated as clay which it is in the range of field capacity. Field capacity means that the gravity has pulled all the water from the largest pores. The smallest pores hold the water against gravity, while the larger pores are filled with air. This is the optimal condition for crop development which is the water is held at a force that is easily overcome by the uptake power of the roots, whereas at the same time the soil is sufficiently ventilated

TABLE 1: Irrometer reading (kPa) against time taken (minutes)

Time (min)	Irrometer reading (kPa)
10	0.0
20	2.0
30	2.0
40	2.0
50	2.0
60	2.0
70	3.0
80	3.5
90	3.5
100	3.7
110	3.8
120	3.8
130	3.8
140	3.8
150	3.8

TABLE 2 : Second irrometer reading (kPa) against time taken (minutes)

Minutes	Reading, kPa
10	20
20	20
30	20
40	20
50	18
60	18
70	18
80	18
90 > 120	18

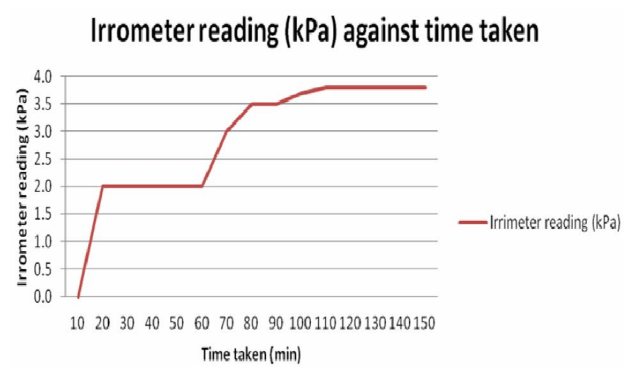

Figure 6 : Irrometer reading (kPa) against time taken (minutes)

to enable the roots to breath.

Watermark sensor is another method for reading the soil water tension but it needs to calibrate first. The watermark is designed to be a permanent sensor, placed in the soil to be monitored and "read" as often as necessary with a portable or stationary device. Internally installed gypsum provides some buffering for the effect of salinity levels normally found in irrigated agricultural crops and lands. A graph of readings over time is plotting to makes it easier to see the trends, thereby making interpretation simpler. A slow increase means the soil is drying out slowly but a big jump means the soil is losing water very rapidly. By analyzing such trends in the readings, it will determine when to irrigate. The result from the graph shown that the irrometer reading is at 0 – 10 kPa and increasing against time which mean that soil is saturated soil and plant root extracting the water with the time but there is an error occurred during the experiment. This is due to, before experiment, the soil is irrigate with water and still wet during experiment occurred. The wet soil will affect the reading of the irrometer due to there are present high amount of water in the soil and surrounding plant root[8,9]. Thus, the irrometer tensiometer measuring of soil tension tells how forceful water is being pulled out from the sensor to the soil[11]. These instruments also tell how hard plant roots to draw adequate water from the soil. By using 2-3 different depths at each monitoring station gives a complete picture of water movement and location in the soils.

The shallow sensor shows a rapidly increasing reading, but the deep sensor shows adequate moisture. This shows that the moisture is different in soil profile. If the deep sensor also shows a dry condition, then a longer irrigation cycle is needed to fully re-wet the entire root zone. The readings that are taken after an irrigation or rainfall event will show the exactly how effective that water application was.

CONCLUSION

As the conclusion, the moisture content can be determined by irrometer tensiometer which also gives precise results. The results can be in short time which can make the work easier. Based on above, the soil is clay type which is very suitable for certain type of crops which can stand in soil that can retain water in long time. Different depth of sensor will tell the soil moisture at different level in soil profile. Thus, the reading will tell how fast the crop is extracting water (how fast the soil is drying out) and warn in advance of needed of irrigations.

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