Scheduling Irrigation using automatic tensiometers for pea crop

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Abstract: Recent technological advances have made soil water sensors available for efficient and automatic operation of irrigation systems. Automatic soil water sensor-based irrigation seeks to maintain a desired soil water range in the root zone that is optimal for plant growth. Automatic tensiometers were buried at 30 cm depth under the sandy soil surface of Nubaria experimental station of NRC, subjected to drip irrigation system to automatically schedule irrigation for pea crop. Soil moisture potentials 70 kPa, 75 kPa and 85 kPa, represented 3 irrigation treatments and 3 Potassium treatments 50, 75% and 100% of 100 kg $fed.^{-1}$, the officially recommended amount of Potassium fertilization for a pea crop by the ministry of agriculture in Egypt for sandy soils, were scheduled and added with the drip irrigation portions. The obtained results revealed that using soil moisture potentials 70, 75 and 85 kPa were equivalent to 85%, 75% and 60% of the field capacity of the soil, respectively. The average crop factor (Kc) was calculated for each growth stage and the water applied according to the depletion percentage for each water treatment. All the applications were adjusted on control panel which was connected to an electric valve for each treatment. Water use efficiency, productivity, growth parameters, K use efficiency were calculated for each treatment. Automatic scheduling of drip irrigation at 85% F.C. using irrometer tensioner and 75% K fertilizers led to saving 16% to 35% of supplied irrigation water compared to uncontrolled drip irrigation method, with an increase in the yield of the crop estimated by 20%.

Keywords: automatic irrigation, scheduling irrigation, automatic tensiometer, potassium fertigation, drip irrigation

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1 Introduction

Water is the most important element for social and agricultural development including, food security, industrial development, housing and urban expansion and all other aspects of human life activities. The fact that Egypt's population increasing tremendously, while the water resources of Egypt are nearly constant, reflected on the per-capita share of water which decreased from 1000 m^3 in 1990 to about 600 m^3/ individual / year in the present time, 2016. This average is far less than the individual water requirement, assigned by UN as 1000 m^3/individual/year, to be an edge for water poverty. In the light of water scarcity in Egypt, featuring to be a real big problem in the near future for Egyptian economy, water consumption, in all life activities, should be optimized and be treated as a rare and dear commodity.

Water scarcity is one of the major problems for crop production in Egypt, this is needed to reduce the consumption of water in irrigation by developing new technologies and methods that can be help full to utilize this precious input in an effective way (Abdelraouf and El Habbasha, 2014). Agriculture, being the biggest consumer of the Egyptian water resources (~85%), maximizing water use efficiency, or getting maximum productivity from the water unit, should be the main objective of irrigation management.

Automatic scheduling of drip irrigation led to saving 16% to 35% of supply, irrigation water compared to the uncontrolled drip irrigation method, with an increase in the yield of the crop estimated by 20%. Using automatic irrigation scheduling proved to be easy and doesn’t need high skills in operation and maintenance (Wahba et al., 2016).

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Avoiding moisture stresses on the plant requires providing water in time when the moisture content in the root zone depletes to a certain content of the available water capacity above the wilting point. The depletion point which requires applying water to the plant varies according to the soil, the weather and the plant type. This point can be determined by using a simple device, tensiometer, which consists of a porous ceramic cup tip connected with a plastic tube of desired length to be buried in the active root zone in order to measure the negative pressure arises from water depletion in the root zone as a result of evapo-transpiration. The readings are expressed in atmospheric pressure units displayed by an atmospheric pressure gauge attached to the upper tip of the tube. Tensiometers can be reliable for scheduling irrigation and can be connected to an automatic control system to apply water to the plant in the adjusted amount and exact time.

Many investigators found different optimum conditions for scheduling irrigation and fertilization using tensiometers under drip irrigation system. Craig (2004) defined irrigation and how much water to apply with each application. Proper irrigation timing and irrigation depth could be determined using tensiometer displaying soil moisture content measurements. Allen and Dalton (2001) proposed that tensiometers can be instrumented to provide automatic control of irrigation systems. They stated that a modification is required to allow a tensiometer to be used as is equipped with an irrigation controller. The vacuum gauge is equipped with magnet and a magnetic pick-up switch so that, when a desired and preset water tension occurs, the switch closes, starting the irrigation pump. The pump operates for a preset period of time, lowering the tensiometer reading, after which the tensiometer is again monitored until the critical water tension again occurs. Michael (2012) reported that the advantage of tensiometers compared to volumetric soil moisture sensors is that they are relatively inexpensive and the vacuum gauge can be read in the field by an irrigator. Some tensiometers have an option for connecting them to data loggers so that moisture data can be collected continuously. This can be viewable through an internet service. The data logger option increases the cost of the tensiometer but is very useful for checking that the instrument is working properly. Some higher cost tensiometers products can also automatically refill with water.

2 Materials and methods

An experiment was conducted on the sandy soil of the research station of the National Research Centre (NRC), at Nubaria Province, about 120 km south to Cairo, to study the automatic irrigation and fertigation scheduling for improvement of water productivity and potassium use efficiency and crop productivity. The study was carried out within two successive winter seasons of 2013 and 2014 on Pea crop.

Site description: Field experiments were carried out in the Experimental Farm of Agricultural Production and Research Station (APRS), National Research Centre (NRC), El Nubaria Province, Egypt, sandy soil (latitude $30^{\circ}8^{/}$ N, and longitude $30^{\circ}16^{/}$ E, and mean altitude 21 m above sea level).

Soil Characteristics:

Soil samples from 4 equal 15 cm successive depths from the soil surface down to 60 cm depth, were taken for physical and chemical analyses according to the standard methods. a- Physical properties: The soil profile is homogeneous down to 60 cm depth, showing fine sandy texture, with average components (77.6% fine sand, 8.6% coarse sand, 8.6% silt and 5.5% clay), according to the mechanical analysis, using pipette method, (Gee and Bauder, 1966). The field capacity (FC), permanent wilting point (PWP) and available water capacity (AWC) values determined for the soil are 12.0%, 4.1%, and 7.9%, respectively, (Walter and Gardener, 1986). Hydraulic (HC) of the 4 layers ranges between 6.91 and 6.17 cm h^{-1}. Bulck density equal 1.69 g cm^{-3} for all depths. Porosity (P), cm^3 voids cm^{-3} soil is 0.36. (Klute and Dirksen, 1986). b- Chemical properties: Soil pH and EC were measured in 1:2.5 soil: water suspension and in soil paste extract, respectively. The pH values for the 4 soil layers are 8.3 +/- 0.1 and EC were 0.35 +/- 0.1 dS m^{-1} for the top 3 layers and reached 0.73 dS m^{-1} in the last 45-60 cm layer. However, all the obtained figures of the analyses indicate a normal, good quality soil for cultivation. Irrigation water analysis indicated a very good quality of water with pH 7.3, EC 0.37 dS m^{-1} and SAR 4.61.

Experimental design:

The experimental design included twelve treatments: Four Irrigation Scheduling [Irrigation using automatic tensiometers were (85 % of F.C. under equivalent to soil matric potential 0.7 bar, 75 % of F.C. under equivalent to soil matric potential 0.75 bar and 60% of F.C. under equivalent to soil matric potential 0.85 bar) compared with irrigation scheduling based on Penman-Monteith equation shared the main plot and Three potassium fertigation rates under automatic irrigation scheduling were given as (50%, 75% and 100% of the officially recommended amounts (100 kg fed^{-1}) represented as sub main plot as shown in Figure1, and irrigation devices connected with wires to electrical solenoid valve, were used to operate at different levels of moisture. The ceramic tips of the tensiometers were put at 30 cm under the soil surface, the depth which represents the maximum root intensity and moisture absorption of pea root.

Automatic tensiometers:

It is an instrument to record soil moisture. The used one is Irrometer brand (Model RA). As soil moisture is depleted, a vacuum is created which is registered by the indicating needle on the gauge of the irrometer. Adjustable selector switch can be set to any desired moisture level. The Irrometer operates on the Tensiometers principle, which measures the soil water tension. Soil water tension is the Passive energy (vacuum) applied to the soil by the plant as it draws in water for nutrition. This force is measured in kilopascals (kPa) of tension range of 0-100 kPa with a high reading indicating the dry end of the scale and a low reading indicating the wet end of the scale.

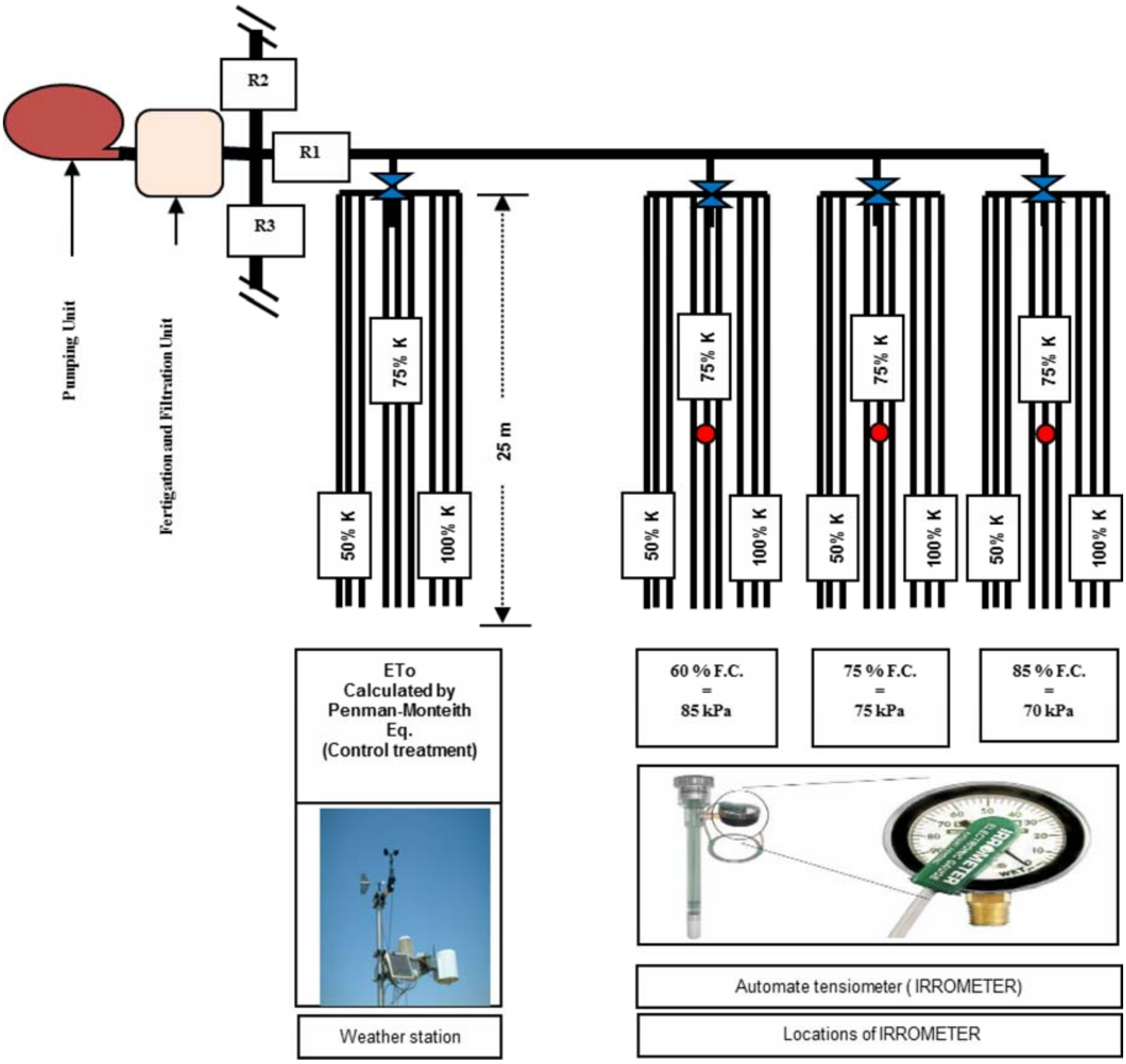


Figure 1 Layout of experimental design

Calibration of tensiometers: Figure 2 shows the relationship between the matric potential negative pressure head and the moisture content in the soil. This figure is very important in the calculation of soil moisture at different pressures and vice versa, i.e., the possibility of determining the pressure equivalent to the reading on the irrometer tube when the moisture content refers to irrigation demand. Figure 3 was used to find the pressure equal to the irrometer reading (bar). When the moisture contents were 85%, 75% and 60% of the water content at FC, the proper pressure is equal to 0.7, 0.75 and 0.85 bar) respectively. According to the experiment carried out by exposes the following Equation could be derived from Figure 2 and Figure 3), which shows the relationship between *X* pressure head (bar) and *Y* soil moisture content %

$$Y = -0.004X^2 - 0.0078x + 0.9715 \quad (1)$$

where, *X* = soil water content (%); *Y* = pressure head (bar).

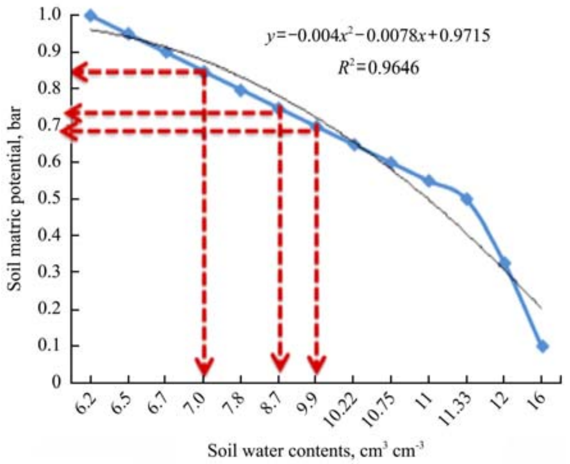


Figure 2 The relationship between soil water contents and pressure head

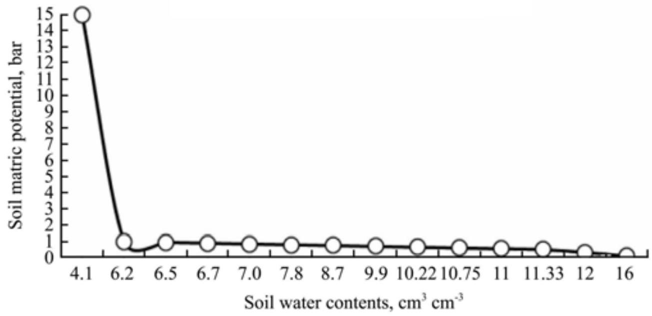


Figure 3 Determination of pressure head meeting soil water contents

Soil moisture for different FC % under tensiometer: All water application under tensiometer and the status of water in the soil were used to record the performance of the water applied to the root zone, which includes the change of volumetric water content in the soil with soil depth.

Crop coefficient under automatic tensiometer: In water levels that have been studied the application, the crop coefficient values may be affected because of the length of the growing season in light of the use of surface drip irrigation system as shown in Figure 4. These values are given a clear picture of the impact of the rate of water use throughout the seas.

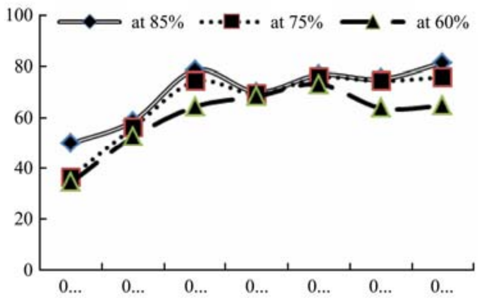


Figure 4 Applied water at different growth stages of the plant under automatic tensiometer

Pea crop and fertilization program:

Pea crop (*Pisum sativum* L) was chosen for the study, as a test crop. All the plots received the normal and recommended care steps for peas growing indicated in the instructions of the official agricultural bulletins. Pea seeds (Master B) variety was transplanted manually to each line at 10 cm distance between plant pits. The experiment was cultivated for the first growing season in 23/10/2012, repeated next year in 23/10/2013 and harvested on 21\1\2013 and 21\1\2014 respectively.

The fertilizer requirement and application rate through chemigation system for crop were carried out according to the recommended ratios for the cultivation of peas in the new land. Potassium fertilizer was added at the beginning of the fifth week of planting and the addition of K was stopped about a week before harvest. Fertilizer was added on a regular basis throughout the season by using the treatments (50%, 75% and 100%) of the recommended ratios (100 kg fed^{-1}).

Evaluation parameters:

Soil moisture: Invariably, it is due to the fact that actual soil moisture content is very different from what we thought existed, it is necessary to calibrate the tensiometer readings. Soil samples were taken at 20 cm apart from an IRROMETER and at the exact depth of the ceramic tip, using a small soil tube auger. The samples were taken to the laboratory in the soil department, Faculty of Agriculture, Ain Shams University, for Pf curve determination.

Growth parameters: Plant height, (cm), Number of pods / plant, Weight of pods / plant, (g), Dry weight of pods / plant, (g) and Total plant dry matter.

Potassium use efficiency: KUE for selected crops under Potassium treatments, (kg kg^{-1}), was computed by dividing the yield (kg fed^{-1}) / total applied potassium K, (kg fed^{-1}).

Crop yield: Yields of the different collections per plot were combined together to calculate the total green pods yield/ plot, and then total green pods yield fed^{-1}., was calculated

Water productivity: The water productivity is expressed here in kg yield per m3of water applied throughout the season. Water productivity was calculated from the next Equation (El-Shafie *et al.*, 2017).

$$\text{Water productivity (kg m}^{-1}\text{)} = \frac{\text{Marketable pods yields (kg fed}^{-1}\text{)}}{\text{Total applied irrigation water (m}^{3}\text{ fed}^{-1}\text{)}} \quad (2)$$

3 Results and Discussion

3.1 Effect of irrigation by irrometer automatic tensiometer on soil moisture distribution under water stress conditions

Soil moisture for different FC% under tensiometer: All water application under tensiometer and the status of water in the soil were used to compare the performance between the water applied. Put water in the root zone, which includes the change of volumetric water content in the soil with soil depth.

1. Volumetric soil water content at 85% of the FC

Figure 5 illustrates the variation of the volumetric soil water content with soil depth at 85 % of the FC and also, measuring the moisture content carried out every 10 days, the volumetric soil water content was lower at the top layer of the soil profile and then increased gradually to the end of the root zone.

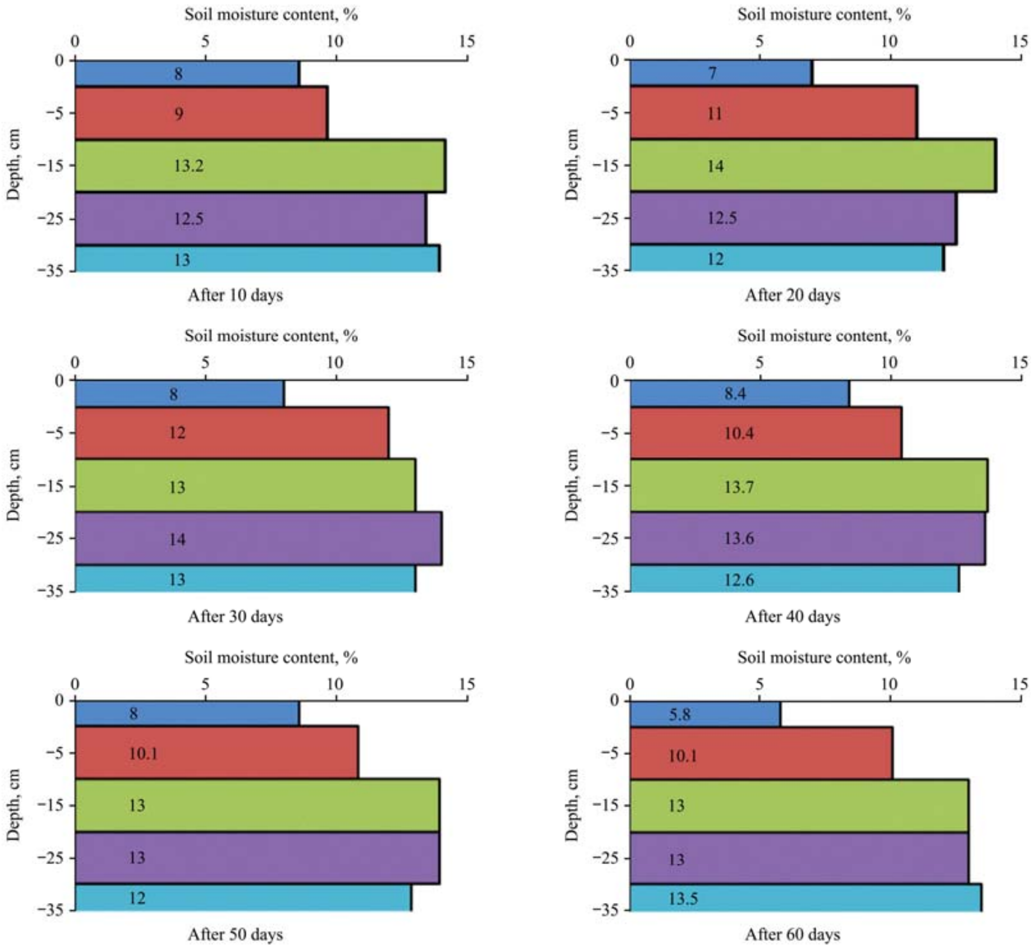


Figure 5 Soil moisture for 85% FC under automatic tensiometer

At 0-5 cm depth, the average volumetric soil water content every 10 days were 8.5%, 9%, 10%, 9.4%, 9.05% and 7.95% respectively. The water content of the soil volume in the second layer from 5-15 cm every 10 days ranges was 11.1%, 12.5%, 12.5%, 12.05%, 11.55% and 11.5% respectively. May have occurred because of this difference increased capillary action with sufficient water available at this depth. Move toward the deeper layers, volumetric water content higher values until it reached a depth of 25-35 cm at range 12%-13%.

2. Volumetric soil water content at 75% of the FC

The distribution of volumetric soil water content with soil depth at 75% of the FC is represented in Figure 6. At depths of 5-35 cm, the volumetric soil water content carried out much lower in surface layer with other layers, where about 7.4%, 4.4%, 4.2%, 4.5%, 4.3%, 3.6% and 4.2%, respectively, every 10 days from the beginning of cultivation, a depth of 0-5 cm. The water content of the soil volume in the second layer ranges 10.1%, 8.7%, 9.6%, 6.7%, 3.7%, 7.3% and 8.9% respectively, which is still higher than the first layer. At the rear of 15 to 25 cm, also at depth of 25 to 35 cm was distribution of soil moisture 12.5%.

3. Volumetric soil water content at 60% of the FC

Also, the distribution of volumetric water content in the soil with a soil depth of 60% of the FC and displayed in Figure 7. In the depths of 5-35 cm, as was the water content of the soil volumetric much lower in the surface layer from the other classes, were about 2.9%, 2.4%, 2.4%, 3.6%, 4.4%, 4.4% and 4.2%, respectively, all 10 days of the beginning of the planting, and then rolled layers to increase until to the last layer 25-35 cm, and the water content of the soil in the size of this layer about 12%.

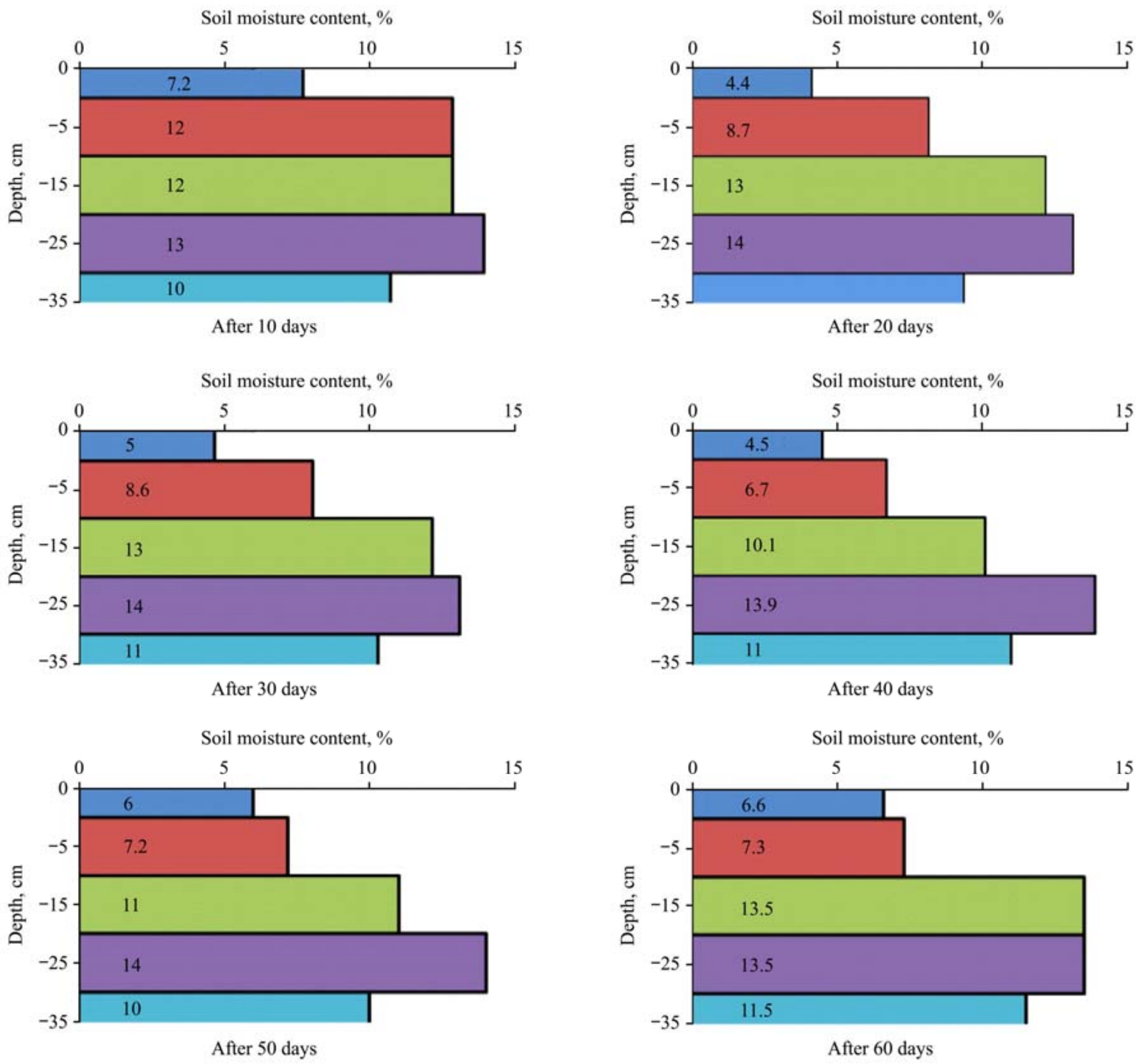


Figure 6 Soil moisture for 75% FC under automatic tensiometer

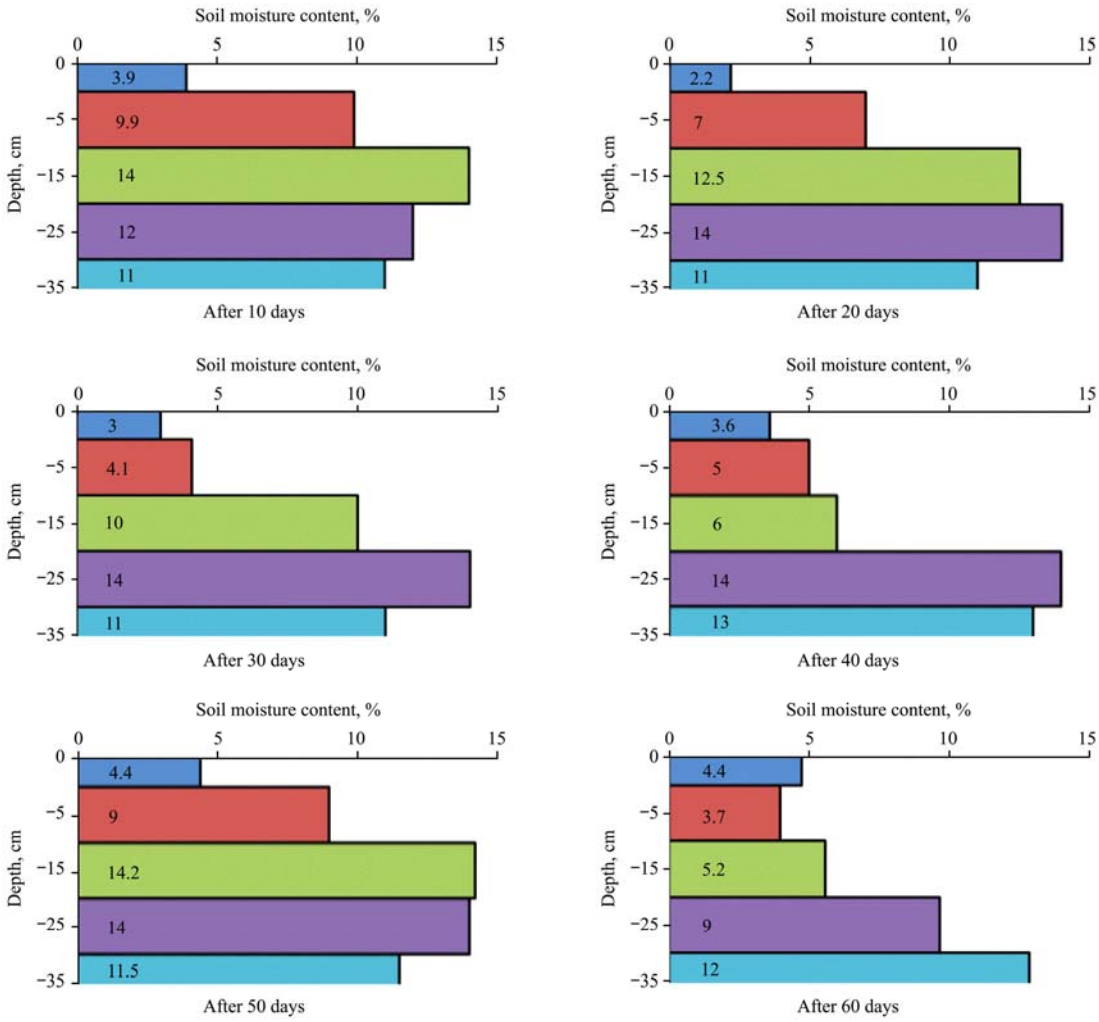


Figure 7 Soil moisture for 60% FC automatic tensiometer

3.2 Effect of irrigation by irrometer automatic tensiometer and Potassium fertigation rate on plant growth indicators:

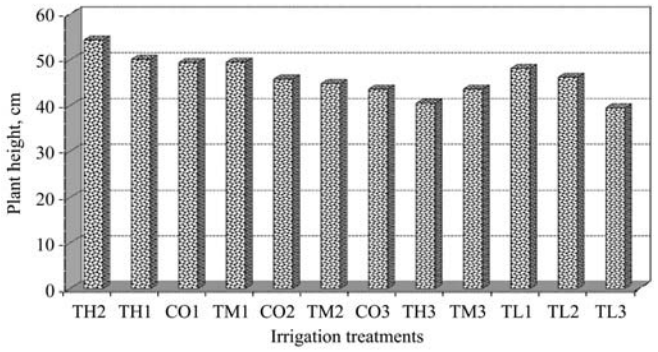
Data displayed in Figures (8 to 12) illustrate the effect of water application treatments on vegetative growth of pea (*Pisum sativum, L.*) plants as an average of both 2012-2013 and 2013-2014 experimental seasons. The effect of irrigation on the studied growth parameters: plant height, leaves area and pods no. / plant, fruit set % as well as dry matter of stems, leaves, pods and total plant were measured. The lowest values in the aforementioned characters were exhibited when plants were exposed to water stress (60% FC) at irrometer treatment.

Also, dry weight of roots showed the same trend in the both seasons.

Generally, it can be extracted that increased irrigation water applied to pea plants led to maintaining the highest moisture content in the soil which in turn favored the production of dry matter content of different plant parts, indicating the importance of the provision of water to increase plant growth. On the contrary, shortening the length of the plant and the decrease in the area of the leaves and its content of dry matter under the pressure of soil moisture can be explained by the hypothesis that the water stress caused the closure of stomata, and plant growth has affected absorption.

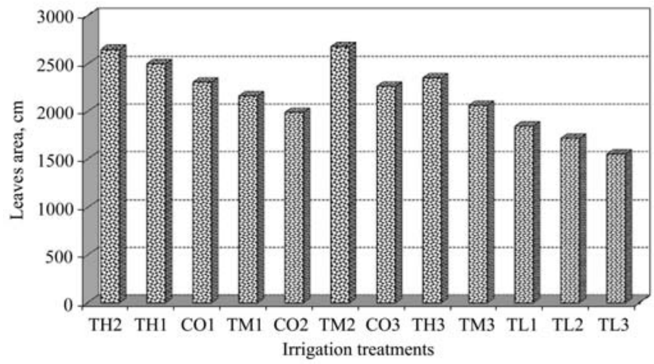
3.3 Effect of irrigation by irrometer automatic tensiometer and Potassium fertigation rate on potassium use efficiency, productivity and water productivity of pea crop

Data shown in Figures (13, 14 and 15) refer to the effect of treatments; i.e. irrometer on productivity, pod quality criteria and water productivity for both green pods and seeds yields of pea plants in growing seasons. It is clear from these figures that there were differences due to variation of irrigation rates in green pods and seeds yields fed^{-1}., and water productivity in both experimental seasons. As general, the results of all treatments concerning the productivity of pea crop have shown an increase in the yield corresponding to the increase in fertilizing rates applied in the experiment. The highest productivity has realized under the treatment TM_1 recording 3039 kg fed^{-1} (green pods), while the lowest one has been shown under the treatment TL3 giving 592 kg fed^{-1}. Figure 13, displays the yield of all treatments under the different irrigation levels. The detrimental effect of water stress on total yield of dry seeds and its components may be attributed to the reduction in vegetative growth. Besides, low soil moisture adversely affected the hormonal balance, plant development, translocation and partition of assimilates among different plant organs which in turn may negatively affect seeds yield. From the results obtained the highest water use efficiency realized with the treatment TM_1, recording 6.3 kg m^{-1}, while, the least efficiency of water occurred with the treatment TL3 recording 1.4 kg m^{-3} as shown in Figure 15.



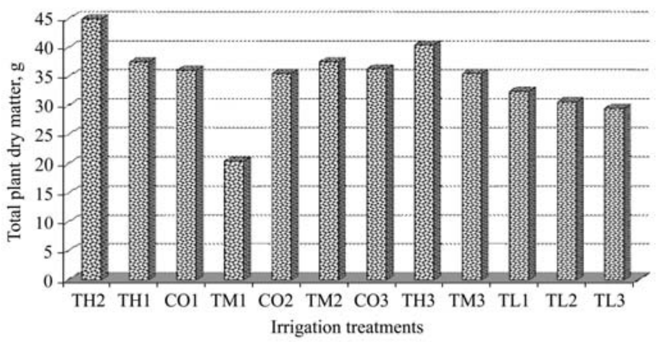
Note: CO1: 100% ETo + 100% potassium fertilizer, CO2: 100% ETo + 75% potassium fertilizer, CO3: 100% ETo + 75% potassium fertilizer, TM1: Tensiometer 75% of FC, 100% potassium fertilizer, TM2: Tensiometer 75% of FC, 75% potassium fertilizer, TM3: Tensiometer 75% of FC, 50% potassium fertilizer, TH1: Tensiometer 85% of FC, 100% potassium fertilizer, TH2: Tensiometer 85% of FC, 75% potassium fertilizer, TH3: Tensiometer 85% of FC, 50% potassium fertilizer, TL1: Tensiometer 60% of FC, 100% potassium fertilizer, TL2: Tensiometer 60% of FC, 75% potassium fertilizer, TL3: Tensiometer 60% of FC, 50% potassium fertilizer.

Figure 8 Effect of irrigation by irrometer automatic tensiometer and potassium fertigation rate on plant height of pea (cm)



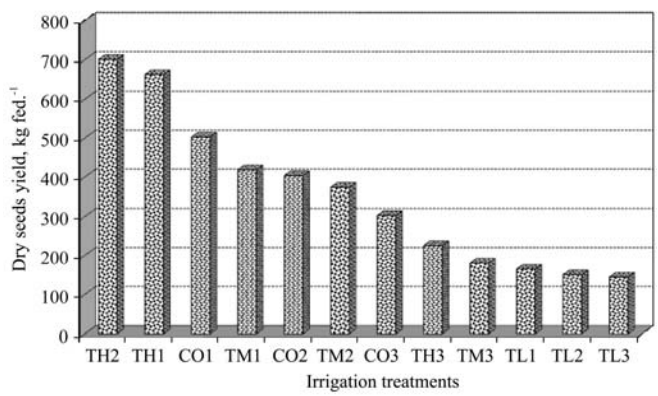
Note: CO1: 100% ETo + 100% potassium fertilizer, CO2: 100% ETo + 75% potassium fertilizer, CO3: 100% ETo + 75% potassium fertilizer, TM1: Tensiometer 75% of FC, 100% potassium fertilizer, TM2: Tensiometer 75% of FC, 75% potassium fertilizer, TM3: Tensiometer 75% of FC, 50% potassium fertilizer, TH1: Tensiometer 85% of FC, 100% potassium fertilizer, TH2: Tensiometer 85% of FC, 75% potassium fertilizer, TH3: Tensiometer 85% of FC, 50% potassium fertilizer, TL1: Tensiometer 60% of FC, 100% potassium fertilizer, TL2: Tensiometer 60% of FC, 75% potassium fertilizer, TL3: Tensiometer 60% of FC, 50% potassium fertilizer.

Figure 9 Effect of irrigation by irrometer automatic tensiometer and potassium fertigation rate on leaves area of pea plant (cm^2/plant)



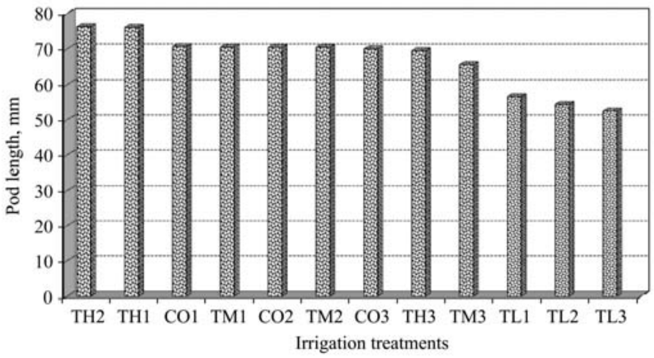
Note: CO1: 100% ETo + 100% potassium fertilizer, CO2: 100% ETo + 75% potassium fertilizer, CO3: 100% ETo + 75% potassium fertilizer, TM1: Tensiometer 75% of FC, 100% potassium fertilizer, TM2: Tensiometer 75% of FC, 75% potassium fertilizer, TM3: Tensiometer 75% of FC, 50% potassium fertilizer, TH1: Tensiometer 85% of FC, 100% potassium fertilizer, TH2: Tensiometer 85% of FC, 75% potassium fertilizer, TH3: Tensiometer 85% of FC, 50% potassium fertilizer, TL1: Tensiometer 60% of FC, 100% potassium fertilizer, TL2: Tensiometer 60% of FC, 75% potassium fertilizer, TL3: Tensiometer 60% of FC, 50% potassium fertilizer.

Figure 10 Effect of irrigation by irrometer automatic tensiometer and potassium fertigation rate on total plant dry matter of pea plant (g)



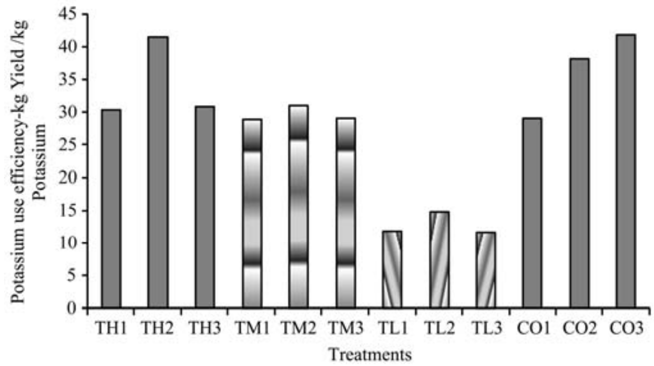
Note: CO1: 100% ETo + 100% potassium fertilizer, CO2: 100% ETo + 75% potassium fertilizer, CO3: 100% ETo + 75% potassium fertilizer, TM1: Tensiometer 75% of FC, 100% potassium fertilizer, TM2: Tensiometer 75% of FC, 75% potassium fertilizer, TM3: Tensiometer 75% of FC, 50% potassium fertilizer, TH1: Tensiometer 85% of FC, 100% potassium fertilizer, TH2: Tensiometer 85% of FC, 75% potassium fertilizer, TH3: Tensiometer 85% of FC, 50% potassium fertilizer, TL1: Tensiometer 60% of FC, 100% potassium fertilizer, TL2: Tensiometer 60% of FC, 75% potassium fertilizer, TL3: Tensiometer 60% of FC, 50% potassium fertilizer.

Figure 11 Effect of irrigation by irrometer automatic tensiometer and potassium fertigation rate on dry seeds yield (kg fed^{-1}.)



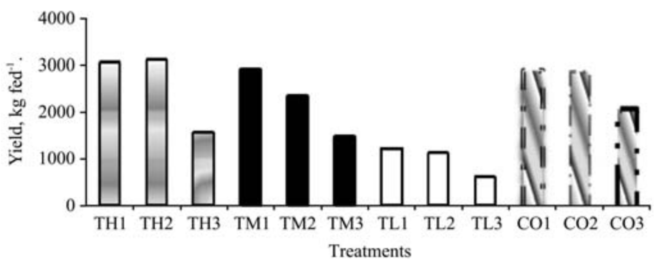
Note: CO1: 100% ETo + 100% potassium fertilizer, CO2: 100% ETo + 75% potassium fertilizer, CO3: 100% ETo + 75% potassium fertilizer, TM1: Tensiometer 75% of FC, 100% potassium fertilizer, TM2: Tensiometer 75% of FC, 75% potassium fertilizer, TM3: Tensiometer 75% of FC, 50% potassium fertilizer, TH1: Tensiometer 85% of FC, 100% potassium fertilizer, TH2: Tensiometer 85% of FC, 75% potassium fertilizer, TH3: Tensiometer 85% of FC, 50% potassium fertilizer, TL1: Tensiometer 60% of FC, 100% potassium fertilizer, TL2: Tensiometer 60% of FC, 75% potassium fertilizer, TL3: Tensiometer 60% of FC, 50% potassium fertilizer.

Figure 12 Effect of irrigation by irrometer automatic tensiometer and potassium fertigation rate on pods length (mm)



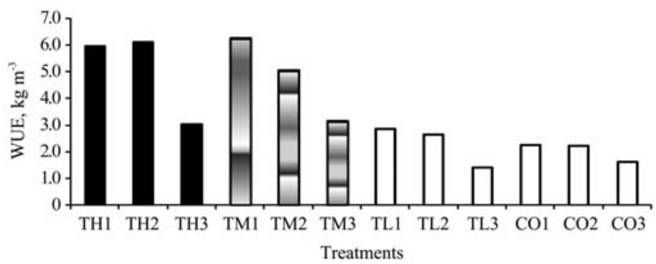
Note: CO1: 100% ETo + 100% potassium fertilizer, CO2: 100% ETo + 75% potassium fertilizer, CO3: 100% ETo + 75% potassium fertilizer, TM1: Tensiometer 75% of FC, 100% potassium fertilizer, TM2: Tensiometer 75% of FC, 75% potassium fertilizer, TM3: Tensiometer 75% of FC, 50% potassium fertilizer, TH1: Tensiometer 85% of FC, 100% potassium fertilizer, TH2: Tensiometer 85% of FC, 75% potassium fertilizer, TH3: Tensiometer 85% of FC, 50% potassium fertilizer, TL1: Tensiometer 60% of FC, 100% potassium fertilizer, TL2: Tensiometer 60% of FC, 75% potassium fertilizer, TL3: Tensiometer 60% of FC, 50% potassium fertilizer.

Figure 13 Effect of irrigation by automatic tensiometer and potassium fertigationrate on Potassium - use efficiency (kg yield kg^{-1} potassium)



Note: CO1: 100% ETo + 100% potassium fertilizer, CO2: 100% ETo + 75% potassium fertilizer, CO3: 100% ETo + 75% potassium fertilizer, TM1: Tensiometer 75% of FC, 100% potassium fertilizer, TM2: Tensiometer 75% of FC, 75% potassium fertilizer, TM3: Tensiometer 75% of FC, 50% potassium fertilizer, TH1: Tensiometer 85% of FC, 100% potassium fertilizer, TH2: Tensiometer 85% of FC, 75% potassium fertilizer, TH3: Tensiometer 85% of FC, 50% potassium fertilizer, TL1: Tensiometer 60% of FC, 100% potassium fertilizer, TL2: Tensiometer 60% of FC, 75% potassium fertilizer, TL3: Tensiometer 60% of FC, 50% potassium fertilizer.

Figure 14 Effect of irrigation by irrometer automatic tensiometer and potassium fertigation rate on crop yield (kg fed^{-1}.)



Note: CO1: 100% ETo + 100% potassium fertilizer, CO2: 100% ETo + 75% potassium fertilizer, CO3: 100% ETo + 75% potassium fertilizer, TM1: Tensiometer 75% of FC, 100% potassium fertilizer, TM2: Tensiometer 75% of FC, 75% potassium fertilizer, TM3: Tensiometer 75% of FC, 50% potassium fertilizer, TH1: Tensiometer 85% of FC, 100% potassium fertilizer, TH2: Tensiometer 85% of FC, 75% potassium fertilizer, TH3: Tensiometer 85% of FC, 50% potassium fertilizer, TL1: Tensiometer 60% of FC, 100% potassium fertilizer, TL2: Tensiometer 60% of FC, 75% potassium fertilizer, TL3: Tensiometer 60% of FC, 50% potassium fertilizer.

Figure 15 Effect of irrigation by irrometer automatic tensiometer and potassium fertigation rate on water productivity of pea (kg m^{-3})

4 Conclusion

The main results in this study can be summarised as follows: Using irrometer by different levels of moisture (85%, 75% and 60% of FC), pressure head (0.70, 0.75 and 0.85 bar). The Average Kc in the initial stage was 0.071, 0.07 and 0.05, in the mid season was 1, 0.98 and 0.98 and the end stage was 0.83, 0.73 and 0.73 respectively. In water levels that have been studied the application, the crop coefficient values may be affected because of the length of the growing season in light of the use of surface drip irrigation system. The highest productivity has realized under the treatment TM1, (Tensiometer 75% of FC, 100% potassium fertilizer) recording 3039 kg fed^{-1}. (green pods), while the lowest one has been shown under the treatment TL3, (Tensiometer 60% of FC, 50% potassium fertilizer) giving 592 kg fed^{-1}. displays the yield of all treatments under the different irrigation levels.

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