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Response of Green Peas to Irrigation Automatic Scheduling and Potassium Fertigation

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Abstract: Response to irrigation scheduling and potassium fertilization under drip irrigation was tested on green peas for 2 years (2012 and 2013) at the Experimental Farm of Agricultural Production and Research Station, National Research Center (NRC), (APRSNRC), El Nubaria Province, Egypt. Application of automatic irrigation was scheduled through two programmable control panel methods. The first, by using data obtained from the Central Laboratory, Agriculture, Climate, applying (CROPWAT 8 CLIMWAT 2) pre-stored software. The second, by using the daily registered data of the Automatic Meteorological Station (located in the same farm at Nubaria, provided to (CROPWAT 8) software. Potassium was applied through the drip irrigation system, equally in the twelve experimental splits. The obtained results revealed that: a clear difference is noticed between the calculated values of (CROPWAT 8) data, range 3.44 – 1.48 mm/day and (CROPWAT 8 CLIMWAT 2) data range from 3.79 - 2.03 mm /day. At the same time, the data recorded in two successive winter seasons, by the automatic meteorological station with (CROPWAT 8), showed slight differences in its values. On the other hand, water total requirements of CROPWAT 8 and CROPWAT 8 CLIMWAT 2 were 630.4 m3/fed and 707 m3/fed respectively. Data registered by the local meteorological station has proved to be the best method concerning water use efficiency and yield amount and quality. Increasing potassium fertilization rates from 50% to 100% percent (of recommended rates) increased both vegetative growth percent coverage, plant heights, both wet and dry weight of plants and net yield of pods (number of pods per plant, number of seeds per pod, average of pods, average yield of plant and total yield). Using automatic irrigation scheduling proved to be easy and doesn't need high skills in operation and maintenance.

Keywords: Automatic scheduling irrigation, Potassium fertigation and Drip irrigation.

1. Introduction

According to the constant and limited water resources in Egypt, beside the expected climate changes, threats expected to Egypt's Nile water share and the continuous increased population, therefore water should be utilized as a rare commodity. This can be achieved amongst a lot of procedures, based on maximizing irrigation water use efficiency, ie; to obtain the best productivity from water unit, adjusting water quantities given to the plant via soil moisture sensors connected to automatic control valves, which is one of the most recent methods for water control.

Many investigators found different optimum conditions for Irrigation and fertilization scheduling under drip irrigation system, [1] reported that the early- pressurized irrigation systems of the 1960's saw, also, the first irrigation controls which were predominantly electro- mechanical operated; that is, they consisted of an electrically operated timing mechanism with mechanical pins and dials which controlled the irrigation. The 1960's saw the advent of the microchip and solid-state electronic controllers which were born. Today's controllers range from inexpensive solid- state units to fully computer integrated systems. The basic principle, though, is still the same that the controllers operate irrigation schedules based on times required for operation. Automatic controllers provide an excellent tool to schedule irrigation system and in turn manage water resource and create a beautiful environment. [2]reported that automation of drip irrigation system has several advantages: Economy, saving of manual labor, increase in crop yield, conservation of energy and effective control of irrigation. [3]studied scheduling mechanism of pivot irrigation system using moisture sensors under conditions of the region (KSA). He indicated that the results proved saving about 15 % of irrigation water compared with the amount used in traditional irrigation scheduling, as well as an increase in the yield of wheat estimated by 11%. [4]studied the effect of scheduling irrigation and fertilization, using levels of potassium fertilization on the growth and productivity of the crop of green peas. The obtained results led to improving recipes for vegetative growth and yield compared to traditional methods.

The main objective of this study is to reach to the best irrigation scheduling and fertigation under drip irrigation system to improve crop productivity and water use efficiency. Green peas were the tested plant.

2. Materials and Methods

2.1 Experimental site

Field experiments were carried out at the experimental farm of agricultural production and research station(APRS,NRC), at El Nubaria Province, Egypt, (latitude 30.8667N, longitude 30.1667E, and mean altitude 21 m (a.s.l), to study the effect of automatic scheduling of irrigation on the improvement of water use efficiency and crop productivity under drip irrigation system for two successive winter seasons of 2013 and 2014. Soil particle size distribution was carried out using Pipette method after[5]. Soil moisture content at field capacity (F.C) and permanent wilting point (P.W.P) were measured according to[6]. Soil hydraulic conductivity (H.C) was determined under a constant head technique[7]. Some physical properties of the soil are presented in Table (1). Also, chemical analyses of irrigation water were carried out by using the standard methods and they are presented in Table (2).

Table (1): Some physical properties of the soil.

Depth, Cm	Particle Size distribution, %				Texture Class	θS % on weight basis			HC (cmh-1)	BD (g/cm³)	P (cm³ voids /cm³ soil)
	C. Sand	F. Sand	Silt	Clay		F.C.	P.W.P.	A.W			
0-15	8.4	77.6	8.5	5.5	**Sandy**	12.0	4.1	7.9	6.68	1.69	0.36
15-30	8.6	77.7	8.3	5.4	**Sandy**	12.0	4.1	7.9	6.84	1.69	0.36
30-45	8.5	77.5	8.8	5.2	**Sandy**	12.0	4.1	7.9	6.91	1.69	0.36
45-60	8.8	76.7	8.6	5.9	**Sandy**	12.0	4.1	7.9	6.17	1.67	0.37

Fc: Field capacity; PWP: Welting point (FC and PWP) was determined as a percentage by weight; AW: Available water; HC: Hydraulic conductivity.

Some chemical properties of the soil were measured as follows: Soil pH and EC were measured in 1:2.5 soil: water suspension and in soil paste extract, respectively. Some chemical properties of the soil are presented in Table (2).

Table (2): Some chemical properties of irrigation water.

Depth, Cm	pH 1:2.5	EC dS/m	Soluble Cations, meq/L				Soluble Anions, meq/L			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}
0-15	8.3	0.35	0.50	0.39	1.02	0.23	0	0.11	0.82	1.27
15-30	8.2	0.36	0.51	0.44	1.04	0.24	0	0.13	0.86	1.23
30-45	8.3	0.34	0.56	0.41	1.05	0.23	0	0.12	0.81	1.23
45-60	8.4	0.73	0.67	1.46	1.06	0.25	0	0.14	0.86	1.22

2.2 Irrigation system

Automatic drip irrigation system consists of the following components, Tank: Capacity of 5 m3 made of polyethylene having a float, and the tank connected to the control head with a PVC pipe diameter of 32 mm and a connector to the pump. Control head; It is located at the water inlet and consists of centrifugal electric pump (1hp), screen filter 1.5" (two tanks), venture 1", backflow prevention device, pressure gauges, control valves, flow meter and fertilizer injection pump. Main Line: It is the first line connected to the control unit to convey the water to sub main lines, the diameter of 63 mm made of the PVC. Sub main Line; The PVC, 32 mm diameter pipe attaching the group of laterals. Laterals: Made of polyethylene, 16 mm inner diameter, 28m length, feeding the incorporated drippers. The distance between two drippers was 60 cm. Irrigation Controller and Solenoid Valve. Placed above the ground.

2.3 Automatic Control System

2.3.1 Control Panel

It is a kind of 2 lines board to be programmed based on the information obtained from the CROPWAT 8 program (FAO 56), which entails the start of the irrigation cycle or disconnect it by sending some signals to run electric valves or to close it.

2.3.2 Solenoid Valve

When the system runs, the control valve via an electrical circuit raise the magnetic force generating magnetic electricity by the automated operator of the cylindrical body, which affects the pressure in the upper part, and that allows the pressure in the tube to raise the thin membrane to open the top valve.

2.4. Treatments

1. Irrigation water requirements for the pea crop were calculated according to the nearest data collected by the weather station, which was located at El - Nubaria Province that affiliated to the Central Laboratory for Agricultural Climate (C.L.A.C), Ministry of Agriculture and Land Reclamation.
2. Irrigation water requirements for peas crop were calculated according to the data of the local automatic weather station, located at El Nubaria Province that affiliated to the National Research Center (NRC).
3. Control treatment: An adjacent similar plot was cultivated with peas seeds and irrigated by drip irrigation system left to the farm administration to be irrigated and treated in their usual practice way. The water conveyed to the plot through a flow meter to measure the total quantities given to the plot. The crop measurements and yield were taken in the same way and time as that of the experimental plots.
4. Three potassium fertigation rates under automatic irrigation scheduling were given as (50, 75 and 100) % of the officially recommended amounts (100 Kg/fed) by ARC, Ministry of Agric., Cairo, Egypt.

2.5 Measurements and Calculations

1. Water and irrigation requirements
2. Crop coefficient as a function of the daily change since planting
3. Irrigation scheduling
4. Optimization of the two water and fertilizer standards

a- Standards utilize for the water unit
B- Standards utilize for the fertilizer unit

2.6 Productivity

3. Results and Discussion

3.1 Water and irrigation requirements

Data presented in Fig. 1 show the weather data elements collected from the Central Laboratory Agricultural Climate (CROPWAT 8 and CLIMWAT 2) records for the study area. Also, claimatic elements of automatic meteorological station (CROPWAT 8) assembled in the study area were recorded on a daily basis, for two successive seasons.

It is clear from the figure that the average evapotranspiration according to the (CROPWAT 8 and CLIMWAT 2) data calculated from Penman-Monteith equation range from 3.79 - 2.03 mm /day, where it was 3.44 – 1.48 mm/day for of two successive seasons using CROPWAT 8 data.

A clear difference is noticed between the calculated values of (CROPWAT 8) data and (CROPWAT 8 and CLIMWAT 2) data. In the same time, the data recorded in two successive winter seasons, by the automatic metrological station (CROPWAT 8), showed slight differences in its values.

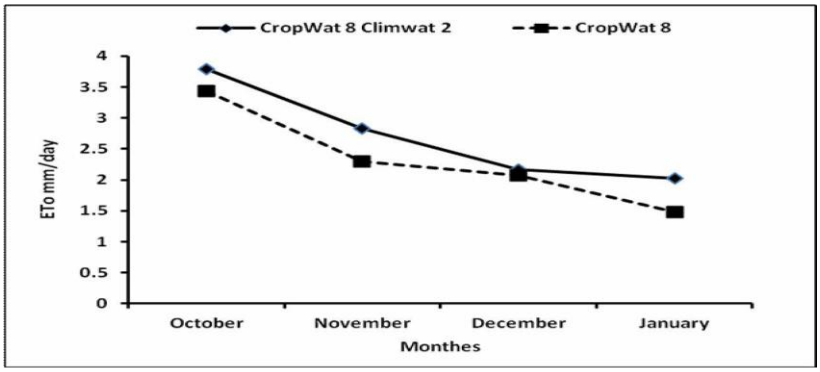

Fig. 1. Evapotranspiration for (CROPWAT 8 and CLIMWAT 2) and (CROPWAT 8).

3.2 Irrigation scheduling

3.2.1 (CROPWAT 8 and CLIMWAT 2)

All the primary data were subjected to CROPWAT 8 CLIMWAT 2 program. The irrigation scheduling process was started 3 days after the primary irrigation of cultivation. Afterwards, the irrigation was given approximately every three days, in the last half of November up to December. Afterwards, watering was provided every 5 days approx. up to the end of picking the pods.

Irrigation was panned about a week before harvest. The total water consumption was 707 m3 /fed for the whole growing season. The irrigation scheduling in terms of the number and dates of irrigations, as well as the amount of water in each irrigations were programmed on the control panel according to CROPWAT 8 and CLIM 2 outputs.The dates and quantities of each irrigation time are shown in Fig 2.

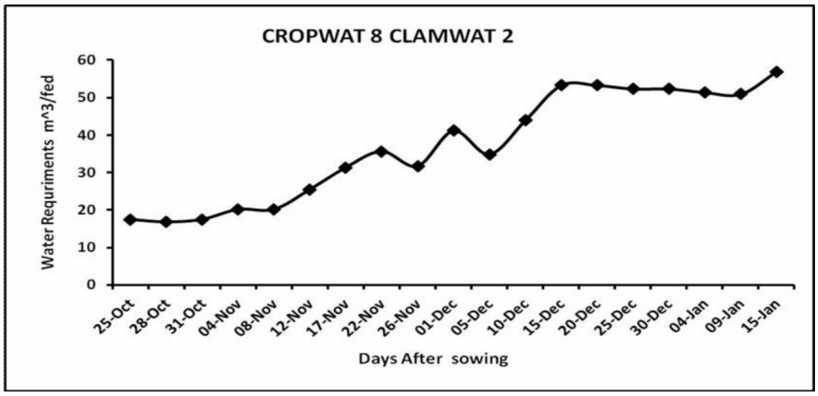

Fig. 2. Irrigation scheduling under (CROPWAT 8 CLIMWAT 2).

3.2.2 CROPWAT 8

In this experiment data were taken daily from the meteorological station located in the site. Metrological data were being received in the computer website of the station and introduced to the CROPWAT 8 software for treatment by Penman-Monteith equation. Accordingly, irrigation scheduling was being adjusted every growth period and fixed on the control panel.

Fig. 3 shows irrigation scheduling for data from the meteorological station. Irrigation scheduling has started 7 days after planting. Afterwards, irrigation scheduling was adjusted every 6 days in November and December.

Irrigation stopped about 10 days before the harvest. Daily water consumption was calculated accordig to CROPWAT 8 (630.4 m3/fed) for the whole growing season.

The average values of the data of the two seasons were used in the calculations and for producing the next curves.

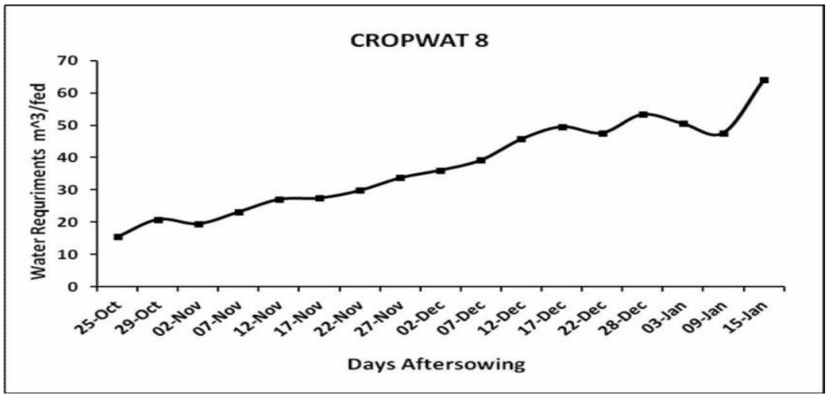

Fig. 3. Irrigation scheduling under meteorological station "First Season"

In this experiment, irrigation scheduling was carried out according to CROPWAT 8 output concerning the number of irrigations and the quantity of water in each irrigation and irrigation intervals and total water consumption all over the growing season.

3.3 Plant growth indicator

Data displayed in Figures (4 to 8) illustrate the effect of water application treatments of crop evapotraspiration (ETo) on vegetative growth of pea (Pisum sativum, L.) plants in 2012-2013 and 2013-2014 experimental seasons. It is clear from these figures that, a quite similar trend was obtained in both experimental seasons regarding the effect of irrigation on the studied growth parameters. In both seasons, plant height, leaves area and pods no. / plant, fruit set % as well as dry matter of stems, leaves, pods and total plant were significantly increased by applying water application from automatic meteorological station.

On the other hand, data indicated generally that, the medium level of water supply CROPWAT 8 CLIMWAT 2 ranked second concerning their effect on the studied growth criteria such as: Plant height, leaves area and pods no. / plant, fruit set % as well as dry matter of stems, leaves, pods and total plant.

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 lower metals from plants and plant growth has affected absorption. Also the best way to increase plant growth peas to potassium fertilizer application rate of 100% to 50% of all transactions.

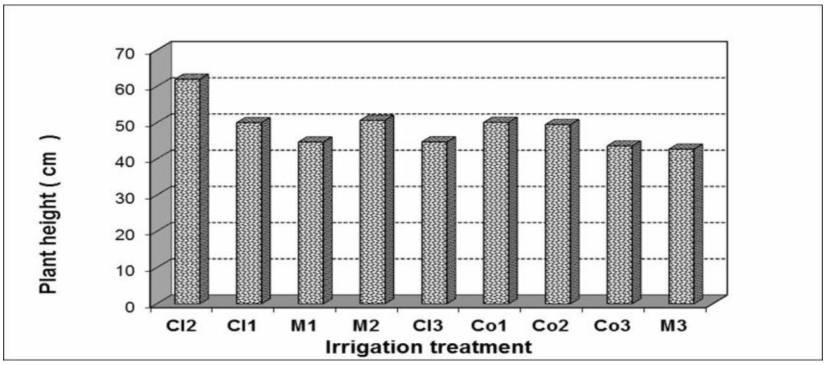

Fig. 4. Effect of irrigation treatment and fertigation treatments on plant height (cm).

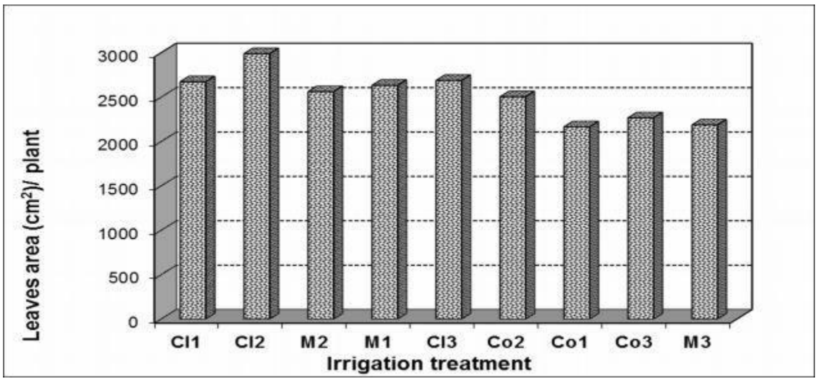

Fig. 5. Effect of irrigation treatment and fertigation treatments on leaves area (cm^2/plant).

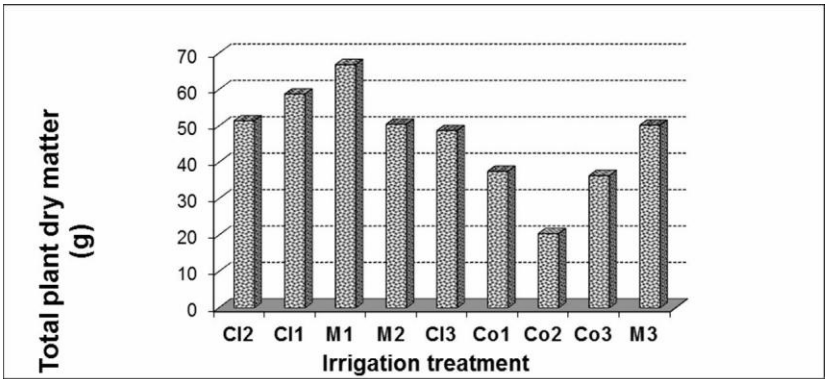

Fig. 6. Effect of irrigation treatment and fertigation treatments on total plant dry matter (g).

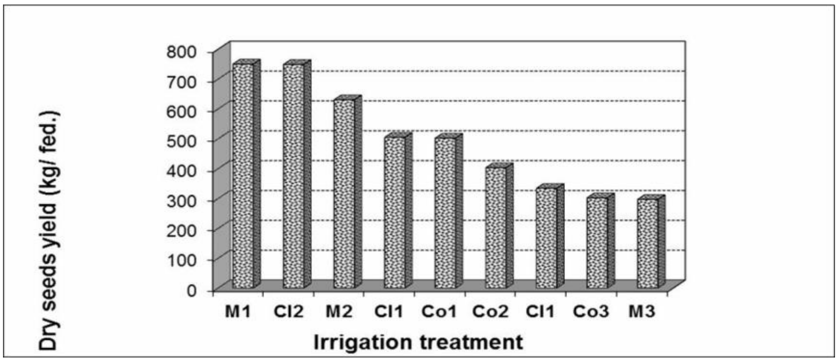

Fig. 7. Effect of irrigation treatments and fertigation treatments on dry seeds yield (kg/fed).

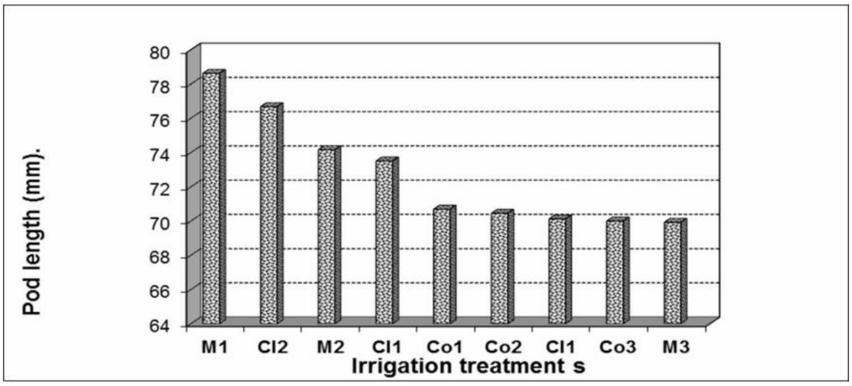

Fig. 8. Effect of irrigation treatments and fertigation treatments on pods length (mm).

Treatments keys :

M1: CROPWAT 8 under 100 % potassium fertilizer
M2: CROPWAT 8 under 75 % potassium fertilizer
M3: CROPWAT 8 under 50 % potassium fertilizer
Cl1: CROPWAT 8 CLAIMWAT 2 under 100 % potassium fertilizer
Cl2: CROPWAT 8 CLAIMWAT 2 under 75 % potassium fertilizer
Cl3: CROPWAT 8 CLAIMWAT 2 under 50 % potassium fertilizer
Co1: Control under 100%
Co2: Control under 75% **Co3:** Control under 50

3.4 Productivity, pod quality criteria and water use efficiency (WUE) and (KUE)

The data shown in Figures (9, 10 and 11) refer to the effect of treatments; i.e. CROPWAT 8, CROPWAT 8 CLIMWAT 2, control of evapotranspiration (ETo) on productivity, pod quality criteria and water use efficiency (WUE) 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., and water use efficiency (WUE) 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 M1 recording 3588 Kg/Fed (green pods), while the lowest one has been shown under the treatment M3 giving 1960 Kg/Fed. Fig., (9) 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 M1, recording 8.2 Kg/m^3, while, the least efficiency of water occurred with the treatment M3 recording 1.6 Kg/ m^3 as shown in Fig., 10.

In general, the increase in the water use efficiency was remarkable in the direction of applying the meteorological station observation treatment (recent data) compared to other treatments.

A criterion used to determine the potassium use efficiency fertilizer, was the highest efficiency for the benefit of potassium fertilizer where the treatment Cl2 and Cl3 have shown the best for KUE 75 kg/fed. As shown in Fig., 11 while the lowest KUE occurred with the treatment Tl1, where 100 kg\fed added.

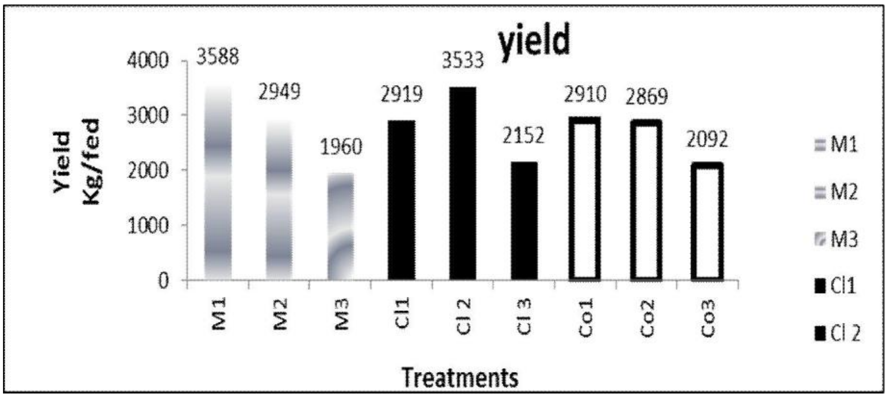

Fig. 9. Productivity under different treatments.

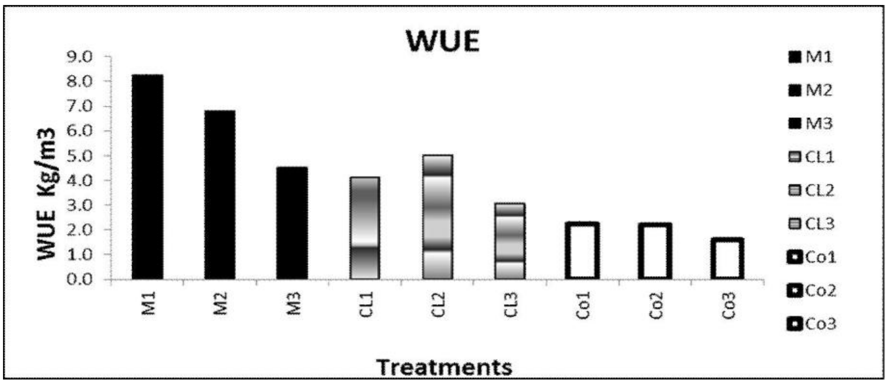

Fig. 10. Water-use efficiency (kg/m^3)

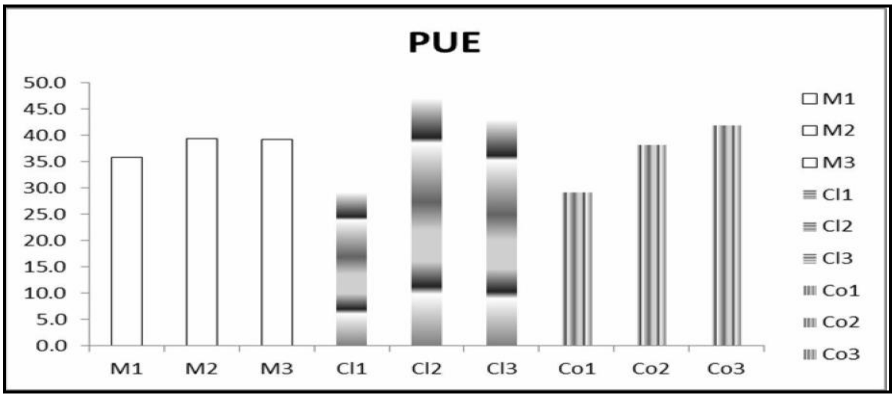

Fig. 11. Potassium use efficiency fertilizer (Kg/fed)

4. Conclusion

The obtained results could be summarized in the following:

1. 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%.
2. Scheduling irrigation using data of the meteorological station gave the best results concerning water fertilizer management.
3. The increase in the rate of K-fertilization in general from 50% to 100% officially recommended rates led to a significant increase in the yield of green pods.
4. The results of the interaction between the factors showed that the best results of pea production and water and K - fertilizer use efficiency were obtained from the addition of 100 % of recommended K fertilizer under an irrigation scheduling system using data from the meteorological station installed in the farm.
5. Increased water use efficiency under a scheduling system using meteorological station set up in the farm compared to the scheduling by other ways. While the highest values of the fertilizer use efficiency of manure treatment when 75% of the recommended rate of fertilizer.
6. The possibility of using these methods in irrigation scheduling easily, and without the need of high skills in operation and maintenance and follow-up.

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