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EFFECT OF WATER MANAGEMENT BY DRIP IRRIGATION AUTOMATION CONTROLLER SYSTEM ON FABA BEAN PRODUCTION UNDER WATER DEFICIT

Mansour, H. A.*, Sabreen, Kh. Pibars, M. Abd El-Hady and Ebtisam I. Eldardiry

Water Relations and Field Irrigation Dept., Agricultural Division & National Research Center, Egypt.

ABSTRACT: Field experiments were carried out at the Agricultural Research and Production Station, NRC, El-Nubaria district, Egypt during the winter season of 2012 and 2013 growing seasons in a sandy soil with Faba bean (*Vica Faba* L.G461) under automation controller drip irrigation system, to study the effect of water deficit (50, 75, and 100 % FC, field capacities) and compost tea additions (100 and 50 liter/fed) on faba bean yield, water and fertilizers use efficiency (WUE, FUE). The obtained results showed that the faba bean yield, WUE and FUE were superior by using compost tea (100 liters/fed and100 % FC) while the lowest values results were attained after using 50 liters/fed compost tea and 50 % FC. It could be concluded that the biggest added amount of compost tea 100 liters/fed impacted positively on Faba bean plants because they contain more amount of macro and micro nutrients and it helps save water under sandy soil conditions. Faba bean plants avoid the water stress under 100 % FC but adversely affected by water stress under FC (50 and 75%).

Key words: Drip irrigation, Automation, Water deficit, Compost tea, Faba bean, WUE, FUE.

1. INTRODUCTION:

Drip irrigation has advantages over conventional systems of irrigation as an efficient means of applying water; especially where water amounts are limited. So water could be saved and both crop quantity and quality could be increased. Several issues have emerged concerning the adaptation of the drip technology [1]. The agriculture sector is developing rapidly, albeit under severe climatic conditions. Rapid development and uses of modern information technology and use of computers could greatly facilitate further development of the sector. Irrigation management is a tool whereby timely application of water can improve irrigation efficiencies and ultimately yields [2]. An automated management of greenhouse brings about precise control needed to provide the most proper condition for plant growth. The five most important parameters to consider when creating drip irrigation are humidity, temperature, ground water, carbon dioxide, light intensity [3]. Compost applications are a commonly used practice in agriculture; however the concept of compost tea is becoming increasingly popular amendment in organic agriculture, which is simply a liquid solution form of compost that has been soaked in water [4]. Research has documented that compost tea suppress diseases in organic systems. Although undocumented, compost teas are also thought to increase not only aggregate stability, but also the microbial activity in the soil, especially under sandy soils. Other benefits of compost tea are the stimulation of root and vegetative growth and increased and higher quality yields [5].

To improve water use efficiency WUE, integrative measures should aim to optimize cultivar selection and agronomic practices. [6] Mentioned that the fertilizer use efficiency (FUE) of corn was increased by application of nitrogen. [7] Carried out a field trial to identify the effective irrigation treatments (50, 75 and 100% of the soil, water holding capacity) in the presence of different levels of P_2O_5 and K_2O fertilizers on seed yield and yield component of faba bean. He found that the highest plant vigor was at watering up to 75% in the presence of 100 and 200 kg ha^{-1} of P_2O_5 and K_2O, respectively. [8] And [9] reported that the increases in both water use efficiency and water utilization efficiency were maximum under drip irrigation system, followed by the low head bubbler irrigation system. The relationships between crop yield and water use has been a major focus of agricultural research in arid and semi-arid regions and have been reviewed previously [10]. Also water-yield relationship has been investigated using different methods of limited water applications and programs [11].

The objectives of this research work by were studying the effect of drip irrigation managed by the automation controller system, compost tea application under water deficit on faba bean yield, water and fertilizers use efficiency.

2. MATERIAL AND METHODS

Experiments were conducted at the Agricultural Research Station, El-Nubaria district, Egypt, National Research Centre, (latitude of 30o30\ N and longitude of 30o20\ E) during the winter season of 2012 and 2013. The experimental plots used in these 2012 and 2013 studies were located in organic transition field, to which no inorganic fertilizers or pesticides had been applied, and the plots had been continuously covered using a crop rotation.

Faba bean (*Vica Faba*) variety (G461), was planted in the last week of October 2012 and the growing season lasted 150 days. Under automation controller drip irrigation system, three irrigation rates of the following: 50, 75, and 100 % of water content at field capacities. Two compost tea additions: 100 and 50 liters/fed injected into the irrigation system. Compost tea was applied to soil under dripper lines (lateral) about 50 cm width before initiation the experiment and before planting. Recommended doses of the normal fertilizers (N, P and K) were added according Agricultural Extension.

Ground water is the source of irrigation and the values of EC, pH and SAR were 0.36 dSm^{-1}, 7.3 and 1.14 meq^{-1}, respectively. The soil is loamy sand in texture, pH tends to be slightly alkaline (8.3) and soil EC (1:5) was 0.42 dS m^{-1} and determined according to [12]. Soil moisture content at field capacity and permanent wilting point were 14.5, and 4.2 % on a weight basis, respectively and measured after [13].

The automation controller system component:

The automation controller system consists of moisture sensors, temperature sensors, signal conditioning circuit, digital to analog converter, LCD Module, relay driver, solenoid control valves, etc. The important parameters to be measured for automation of the irrigation system are soil moisture and temperature. The entire field is first divided into small sections such that each section should contain one moisture sensor and a temperature sensor. RTD like PT100 can be used as a temperature sensor while Tensiometers that continuously monitor soil water status, useful for practical irrigation scheduling, and are extensively used on high-value cash crops where low water tension is desirable, can be used as the moisture sensor to detect moisture contents of soil (Fig. 2). These sensors are buried in the ground at the required depth. Once the soil has reached the desired moisture level the sensors send a signal to the micro controller to turn off the relays, which control the valves of drip irrigation systems used [14] and [15].

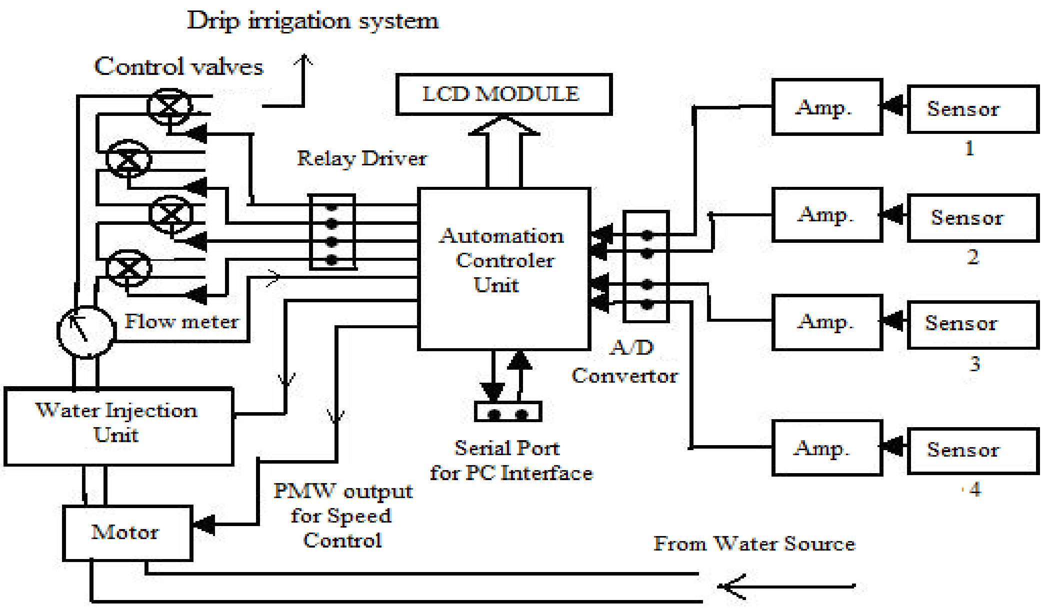

Fig. (1) Automation controller unit

Statistical analysis:

Trial data were subjected to the analysis of variance appropriate to the experimental design to evaluate the effects of treatments on the yield and yield components snap bean [16]. MSTAT-C was used to conduct the analysis of variance. Least significant differences were used for means separation at the 0.05 probability level.

3. RESULTS AND DISCUSSION

Distribution uniformity of the automation controller drip irrigation system:

The main purpose to use tensiometer is to eliminate applying too little or too much water in an untimely manner can result in yield reductions. Over irrigation waste water, costs money to pump, and may leach nutrients beyond the root zone.

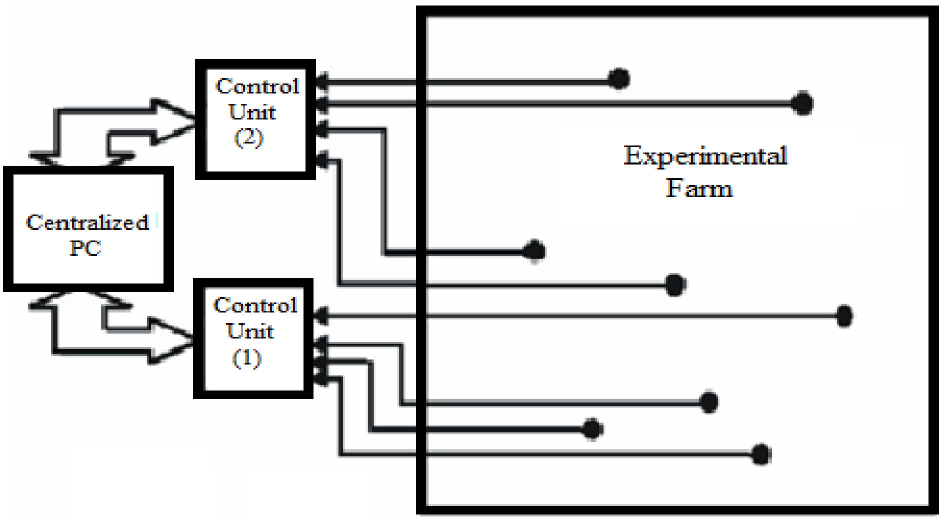

Fig. (2) Applied in Field

Distribution uniformity is a scale for known the validation of automation controller drip irrigation system for its application in the experimental work. This scale estimates the homogeneity of irrigation water distribution. Data in (Table 1) includes the volume of receiving water through 20 cans, which were put below randomized 20 drippers.

Table 1. Data for estimating distribution uniformity for automation controller drip irrigation system.

Cans number	Water volume (l/h)	Cans number	Water volume (l/h)
1	0.24	11	0.26
2	0.24	12	0.27
3	0.25	13	0.28
4	0.25	14	0.28
5	0.25	15	0.28
6	0.25	16	0.28
7	0.25	17	0.28
8	0.26	18	0.29
9	0.26	19	0.29
10	0.26	20	0.29

Operating time of this test was 5 minutes, Average of the lowest quarter = 0.246 (l/h) and average of receiving water = 0.272 (l/h) and distribution uniformity were shown on Fig. 3. Emission uniformity of automation controller drip irrigation system under study was high (90.44 %) this indicates the water distribution has positively affected. So, the decision to irrigate should be based upon an estimate of crop and soil water status, coupled with some soil moisture and economic return. The irrigation management holds account the requirements out of water for the crops. We developed at the time of a national research program a computer system for control and supervision of the drip irrigation [3]. Faba bean Yield and water use efficiency:

Concerning faba bean yield under drip irrigation, automation controller system, when using compost tea 50 liters/fed (Table 2 and Fig. 1) Grain yield production was the highest value (2070 liters/fed) by using FC 100 %, followed by FC 75% irrigation treatments (1550 liters/fed). The lowest value (970 liters/fed) was achieved under FC 50% irrigation treatment. There was a significant difference at the 1% level in faba bean yield among study's irrigation treatments. Compost tea 50 liter/fed as shows (Table 2 and Fig. 1) (FC 100%) treatment of faba bean yield was the highest value (2360 liters/fed), followed by under (FC 75%) value (1620 liters/fed). While the lowest value (1030 liters/fed) was obtained under (FC 50%). There were significant differences at the 1% level in faba bean yield between any two field capacities treatments.

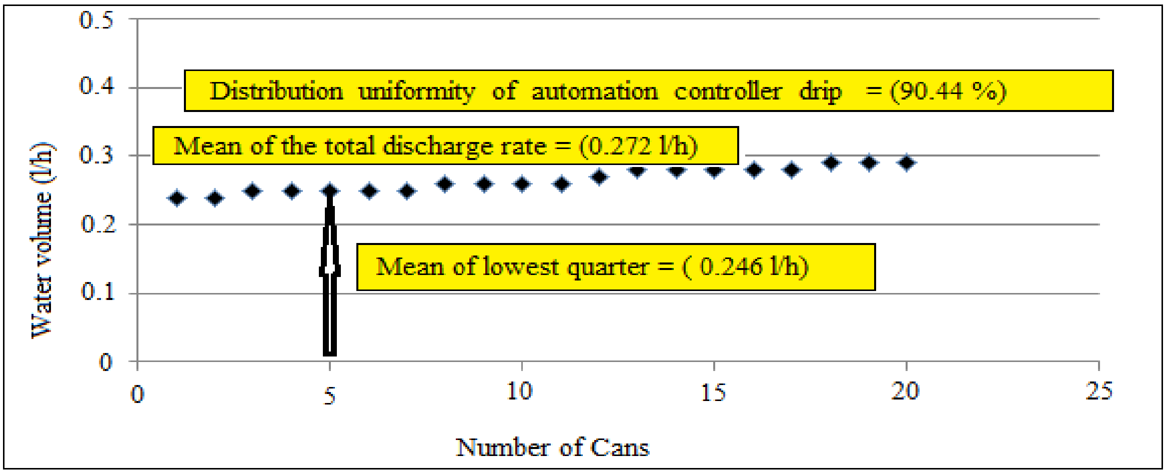

Fig. (3). Distribution uniformity of the automation controller drip irrigation system.

The highest and lowest values of corn yield were 2360 liters/fed (100 liter composts tea/fed; 100 % irrigation treatment) and 970 kg fed (50 liter compost tea/fed; 50 % irrigation treatment), respectively. While compost tea 100 liters/fed has a preemptive effect to increase corn yield by about 9 % compared with 50 liter/fed. Regardless compost tea effect, increasing amount of water in soil, increase corn yield by 40, 122 and 59 % comparing irrigation treatment, 100 % FC with 75 and 50 % and 75% FC with 50 %, respectively.

Regarding to the irrigation treatments, water consumed were calculated relative to water content in soil at field capacity, so the change in WUE attributed mainly to response corn plants to irrigation water added. WUE was improved by about 11% by increasing compost tea from 50 to 100 liters/fed (by doubling compost tea amount), whereas the same increase percentage was attained among irrigation treatments in both compost treatments (Table 2). Mostly WUE values at 50 liter compost tea/fed are lower than the 100 liter compost tea. The maximum and minimum values of WUE were resulted 2.23 kg /m^3 (100 liter composts tea/fed; 100 % irrigation treatment) and 1.83 kg/m^3 (50 liter composts tea/fed; 50 % irrigation treatment), respectively. In general, this study revealed that under deficit irrigation suffered greater yield loss than the normal irrigation treatment. This is in accordance with the results obtained by [17] that reported increasing plant demand under deficit irrigation could reduce the yield. This suggests that greater precautions need to be taken when using low irrigation water quantity for the production in areas where water is a limiting factor. This is in line with the results obtained from [18] which reported that drip irrigation at lowest irrigation level with normal planting produced a significantly higher corn yield. This might be attributed to the existence of higher competition between the plants for water than the normal planting method.

Differences between any two field capacities treatments were significant at the 1 % level except (compost tea 50 liters/fed with 100 % FC) X (compost tea 100 liters/fed with 75 %FC) and (compost tea 50 liters/fed with 75 % FC) X (compost tea 100 liters/fed with 50 %FC). Interactions were significant at the 1 % level. The increase in WUE under compost tea 100 liters/fed were 14.0, 4.5 and 6.2 % in comparison with compost tea 50 liters/fed under 100, 75, and 50 % irrigation treatments, respectively.

These results attributed to faba bean plants that avoid the water stress under 100 % FC but adversely affected by water stress under 50 % irrigation treatment. The highest amount of compost tea 100 liters / fed impacted positively on faba bean plants because they contain more amount of macro and micro nutrients and it helps save water with sandy soil through its content from colloidal materials. Compost teas have been also found to increase crop yields and produce quality [4].

One can see that soil texture greatly influences water availability. Sandy soil can quickly be recharged with soil moisture, but is unable to hold as much water as the soils with heavier textures. As texture becomes heavier, the wilting point increases because fine soils with narrow pore spacing hold water more tightly than soils with wide pore spacing.

Soil ability to retain more water is controlled primarily by soil texture and organic matter. Soils with smaller particles have a larger surface area than those with larger sand particles (sandy soils), and a large surface area allows a soil to hold more water. In other words, a soil with a high percentage of silt and clay particles, which describes fine soil, has a higher water-holding capacity [19] who added that organic matter, content also influences soil water capacity as the percentage increases, it increases because of the affinity organic matter has for water. They added that the increase of compost tea application rates was associated with the increase of nutrients, keeping in sandy soil, which was reflected on increasing macro and micronutrient concentration in crop yield, as well as increase concentration of these nutrients in sandy soil after harvesting.

Table (2): Effect of drip irrigation by the automation controller system, Compost tea and different field capacities, on faba bean yield, irrigation water used, and WUE.

Compost tea (Liters/fed)	Irrigation treatments (%FC)	Yield (Kg/fed)	Irrigation water used (m^3/fed)	Water use efficiency WUE (kg/m^3)
50	100	2070 b	1060	1.95 b
	75	1550 d	795	1.95 d
	50	970 f	530	1.83 f
Mean		1530		1.91
100	100	2360a	1060	2.23 a
	75	1620c	795	2.04 cb
	50	1030e	530	1.94 ed
Mean		1670a		2.07 a
Irrigation treatments	Mean 100 %	2215 a		2.09 a
	Mean 75 %	1585 b		1.99 b
	Mean 50 %	1000 c		1.89 c
	LSD 1 %	1352		0.1
Compost tea x irrigation treatments		1456		0.1

Faba bean fertilizers use efficiency:

Data in Table (3) and Fig. (4) Revealed that increasing compost tea application by 100 % improves FUE under examined fertilizer and the percentage in the change was about 9 %. While irrigation treatments have a positive effect on the FUE of the fertilizers used by about 78 % comparing 100 % with 50 % irrigation treatment inside in compost treatments. Many organic farmers make a pre-plant application of manure and compost, but do not supplement with fertilizer applications during the crop growing season. The lack of N applications as well as synchronizing available N with crop demand for N is essential to maximizing yields [20].

With respect to fertilizers use efficiency (FUE) (Table 3) the effect of both compost tea and irrigation treatments on faba bean, N, P and K use efficiencies (NUE, PUE and KUE) in unit (Kg grain yield / kg Fertilizers). One can notice that the change in NUE took the same trend of grain yield and thus took the trend of WUE also due to previous reasons mentioned before. Concerning the positive effect of (compost tea and irrigation treatments) on NUE, PUE and KUE, they could be ranked in the following descending order: 100 liters/fed > 75 liter/fed > 50 liters/fed compost tea and 100 > 75 > 50 % irrigation treatments. Regarding to the effect of irrigation treatments, data pointed out that FUE increased by about 1.4, 2.2 and 1.6 when compare 100 with 75; 50 and 75 to 50 % FC irrigation treatments, respectively. These findings attributed mainly to its benefits of the agricultural system are its ability to capture more moisture content, which will increase water use efficiency (WUE) in the treated sandy soil comparing with control. It is relatively stable products of organic matter accumulate in the environmental systems to increase moisture retention and nutrient supply potentials of sandy soils [21].

Table (3) Effect of drip irrigation by the automation controller system, compost tea and different field capacities, on faba bean fertilizer use efficiency.

Compost tea (Liters/fed)	Irrigation treatments % (FC)	N (Liters/fed)	P_2O_5 (Liters/fed)	K_2O (Liters/fed)	Yield (Kg/fed)	Fertilizer use efficiency Kg yield /kg fertilizer: N	P	K
50	100	150	40	120	2070 b	13.8 b	51.8 b	17.3 b
	75				1550 d	10.3 d	38.8 d	12.9 d
	50				970 f	6.5 f	24.3 f	8.1 f
Mean					1530	10.2	38.3	12.8
100	100				2360 a	15.7 a	59.0 a	19.7 a
	75				1620 c	10.8 c	40.5 c	13.5 c
	50				1030 e	6.9 e	25.8 e	8.6 e
Mean					1670	11.1	41.8	13.9
Irrigation treatments	100 %				2215a	14.8a	55.4a	18.5a
	75 %				1585b	10.6b	39.6b	13.2b
	50 %				1000c	6.7c	25.0c	8.3c
LSD 1 %					10.5	0.4	1.8	1.2
Interaction (I) X (II)					11.8	0.3	1.5	1.3

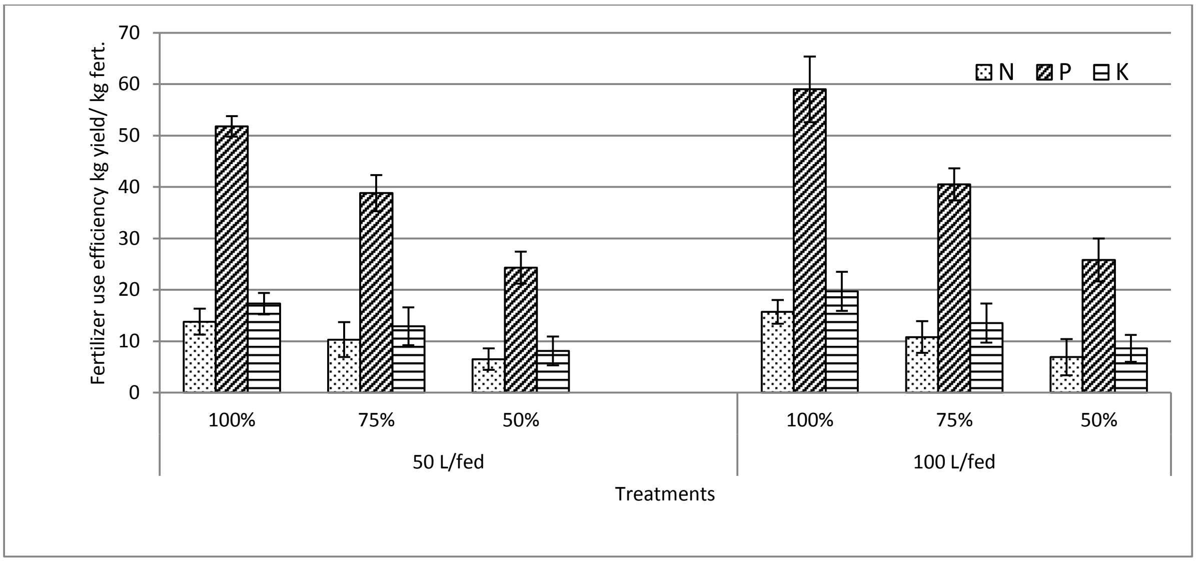

Fig.(4): Effect of compost tea and water deficit on faba bean fertilizer use efficiency under drip irrigation by the automation controller system

4. CONCLUSION

Irrigation scheduling is important and can be achieved by monitoring soil, water status with tensiometers under drip irrigation by the automation controller system in sandy soil. It is very important for the farmer to maintain the content in the field. In this paper the design of a Microcontroller based drip irrigation mechanism is proposed, which is a real time feedback control system for monitoring and controlling all the activities of drip irrigation system more efficiently. Irrigation system controls valves by using automated controller allows the farmer to apply the right amount of water at the right time, regardless of the availability of the labor to turn valves. It improves crop performances and help in time saving in all the aspects. Benefits of compost tea could be summarized in follows: i) Improves soil structure, increasing the friability of clay soils and reduces leaching in sandy soils and increases a soil's water holding capacity, ii) Improves soil cation exchange capacity, increasing a plants ability to uptake nutrient, iii) Provides organic carbons and mineral substances and stimulates soil microbial activity, and iv) Reduces the tendency for the soil pH to change dramatically when fertilizers and other materials are applied to soil.

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Corresponding Author: Hani A. Mansour