International Journal of GEOMATE, Oct., 2019 Vol.17, Issue 62, pp. 250 - 259
ISSN: 2186-2982 (P), 2186-2990 (O), Japan, DOI: https://doi.org/10.21660/2019.62.35037
Special Issue on Science, Engineering & Environment

INFLUENCE OF USING AUTOMATIC IRRIGATION SYSTEM AND ORGANIC FERTILIZER TREATMENTS ON FABA BEAN WATER PRODUCTIVITY

Hani A. Mansour[*1,2], Hu Jiandong[*2], Ren Hongjuan[2], Abdalla N. O. Kheiry[2, 3] and Sameh K. Abd-Elmabod[4]

[1,4]National Research Centre, Egypt, [2]Xilingol Vocational College, China, [3]Sudan University of Science and Technology, Sudan,[4]Jiangsu Academy of Agricultural Sciences, China

*Corresponding author: Received: 21 April 2019, Revised: 13 May 2019, Accepted: 01 June 2019

ABSTRACT: Egypt faces challenges to irrigation water shortage concerns because of its arid region location, which requires the use of modern irrigation systems, and appropriate agriculture management especially in sandy soils, to improve the soil and to avoid water stress. Field experiments were carried out at the NRC farm of research and production in Nubaria, Egypt, during the winter season 2017/2018 and 2018/2019 in a sandy soil cultivated by faba bean (*Vica Faba L.)* (G 843Variety), using the drip irrigation system with four different irrigation levels of the ET_0 35, 65, 100 and 135 %, and two rates of Humic Acid Compost Fertilizers (HACF) 40 and 20 kg per feddan. The obtained results indicated that the best production of faba bean was under 40 kg HACF with water treatments ET_0 100% or 135%. Also, there is no significant difference between the economic faba bean crop data under both two water treatments ET_0 135% and 100%. Under current experimental conditions, no more than 100% of the Evapotranspiration of water should be added due to the non-response of the crop to additional quantities of water. By increasing the amount of water more than ET_0 100%, no significant increase resulted in yield and water and fertilizers productivity, therefore, it is not recommended to add more water than ET_0 100% under this condition. It could be concluded that a large amount of compost with 100% or 65% of ET_0, it was helped to save more water in the sandy soil to avoid water stress on faba bean plants.

Keywords: *Drip irrigation, Water stress, Sandy soil, Humic compost, Arid climate*

1. INTRODUCTION

The drip irrigation system is characterized as the usual irrigation system of many advantages regarding the application efficiency of water and irrigation uniformity, especially in the case of scarcity of irrigation water. The use of drip irrigation system helps to save large quantities of irrigation water and increase the productivity and quality of the crop. The use of many forms of modern technology related to irrigation punctuation, assist to increase the regular distribution of irrigation water and addition efficiency to farms and fields [1]. Bressler [2] found that the maximizing uniformity in the application of water is one of the ways of saving the irrigation water, therefore it is necessary to evaluate the uniformity emission of the drip irrigation system in the field. Hanafy [3] states that the moisture profile of the frequent irrigation treatments under the cropped conditions, downward water movement is restricted to depth 0.6 m in which lateral movement occurs and no further than 0.6m from the emitter. Whereas, the same authors mentioned that the movement of water was observed to almost 1.0 m from the emitter, while downward movement is restricted to about 0.65 m.

The soil moisture distribution varied when the irrigation water was applied with different rates of the drippers discharges. In addition, the continuous drip irrigation treatments showed a water loss, by the deep percolation, about 26 % of the total water amount of irrigation water below 0.6 m depth after 720 min. Moreover, the lateral lines, water distribution, in the same treatments, showed that 80 % of the water in the wetted volume was distributed up to 0.45 and 0.43 m horizontally from the point source after 720 and 1440 min, respectively. Only 12% of water loss under the depth of 0.6 m was found with the pulsed irrigation group and 0.29 and 0.4 m lateral distribution after 720 and 1440 min, respectively [4]. Bacon and Davy [5] stated that drip irrigation system resulted in the outward movement of water from the application point to wet the profile. The size and duration of the wetted profile depended on the irrigation period, irrigation intervals and the length of the season time for drip irrigation, but the deployment depth was caused by the lowest hydraulic conductivity of the irrigated soil. The lateral movement of drip irrigation was enhanced if the soil was stratified, initial soil moisture was low, and the rate of application was low. At the high moisture tension (low moisture content), the lateral movement of the drip irrigation system was low in coarser layers and high in the fine soil layers,[6].

The organic matter decomposes, resulting in a final humus product, and the humus benefits are several in different agricultural systems. The most important use of humus is to increase the soil's water retention capacity. This will assist to increase water productivity in sandy soil [7]. Adding humic compost to the soil aids to better water conserve and higher nutrients efficiency in sandy soils [8]. Selim *et al.*, [9] found that the application of organic fertilizer and plant residues assist to increase the statues of nutrients in the soil significantly. Also, in the increasing, the concentration of micronutrients helps to increase crop production, particularly in the sandy soil.

The following studies have confirmed the importance of humus to maximize water productivity under different irrigation systems [10-19]. Another related study on the maize crop had proved the role of the good drip irrigation system in saving water irrigation and increasing crop productivity. Otherwise, increasing plant density leads to increase the maize grain production until the optimal density of plants is obtained in the unit area [20]. Regarding [21-22] the density of maize plants, 90,000 plants per hectare had the higher maize yield and is common plant density in many countries where maize crop is grown. Regarding [23] that conducted a field experiment to investigate the effect of fertilization and water irrigation treatments on Faba bean yield, where the three irrigation rates were 35, 65 and 100% of the field capacity, in addition of adding phosphorus and potassium fertilizers. The same author found that the best irrigation treatment was 65% of the field capacity and under fertilization 100, 200 kg/ha-1 of phosphorus and potassium respectively. Moreover, [24-25] focused on studying the new energy, and water lifting equipment in off-grid pastoral areas (2012), applied the FSH-400 high-performance wind water-lifting machine to the remote pastoral areas. In addition to providing the needs of drinking water for people and livestock. Also, an experiment was carried out based on micro-drip irrigation technology, and saving water irrigation in field crop, rural landscape.

In the drip irrigation system of agricultural wind-driven water lifting unit, the use of a capsule diaphragm pump to extract groundwater enhances the anti-corrosion ability, improves the volumetric efficiency and expands the application range of drip irrigation system, trials were being carried out on small farms in Sudan [26-28]. Tayel *et al.*, [29] studying the effect of different water amounts of drip irrigation with expressed as a percent of reference evapotranspiration, crop evapotranspiration, on soil, water holding capacity and (irrigation requirement / cumulative pan evaporation ratio), it was obvious that yield (quantity and quality), growth characters and water productivity increased with increasing irrigation water applied up to specific amounts depending on crop species, climate, irrigation method and soil.
The objective of this study is to investigate the effect of the automatically controlled drip irrigation system with different irrigation water (ET_0) and organic fertilizer rates on the faba bean yield, water and fertilizers productivity.

2. MATERIAL AND METHODS

This filed experiment was carried out at the National Research Centre (NRC) farm of research and production, El-Nubaria district, western Delta, Egypt at coordinates 30o 30’ 0’’ - 30o 30’ 5’’N and 30o 19’ 20’’ - 30o 19’ 30’’ E (Fig. 1), during the winter seasons of 2017/2018 and 2018/2019 in a sandy soil. Moreover, the experiential farm located in a hyper-arid climate where the maximum temperature reached to 36.4 in June, and negligible annual precipitation with 18.5 mm, and with significant annual evapotranspiration of 1450 mm.

The experiment was carried out on the sandy soil with the faba bean crop (Vica Faba L.) (G 843 Variety), the cultivation was on October, and the plants remained for 135 days, which is the length of the growing season, with using automatic control drip irrigation system, under four irrigation water addition rates from reference evapotranspiration ET0 35, 65, 100 and 135%, and two composting levels from Humic Acid Compost Fertilizers (HACF), 40 and 20 kg per feddan. Soil physical analysis was determined according to [30] as shown in Table 1 Soil bulk density (BD), was measured according to the reference [31]. Evapotranspiration calculation using a soil water balance

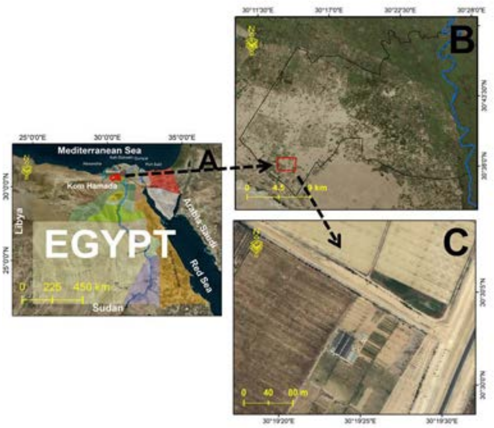


Fig. 1. Location of Agricultural Research Station, NRC. Egypt (A), western Delta (B), and NRC farm (C).

The crop evapotranspiration (ET) was determined using the following

Soil water balance equation

$$\mathbf{ET} = \mathbf{I} + \mathbf{R} - \mathbf{Dp} - \mathbf{Rf} \pm \boldsymbol{\Delta S} \qquad (\mathbf{1})$$

Where, R, the rainfall (mm); I, the amount of irrigation (mm); Dp, drainage below the root zone (mm) which was taken as 90 cm in this case; ΔS, change in soil water storage (mm); and Rf, surface runoff (mm). There were no major rainfall events to cause runoff. The equation then reduces to

$$\mathbf{ET} = \mathbf{I} + \mathbf{R} - \mathbf{Dp} \pm \boldsymbol{\Delta S} \qquad (\mathbf{2})$$

2.1 Soil and Water Analysis

Soil hydraulic conductivity (HC) was determined under a constant head technique by [33]. Soil chemical characteristics were determined according to [34] and [35] as shown in Table 2. The source of irrigation water was underground water. An irrigation water analysis is given in Table 3 Particle Size distribution PSD according to [32] and moisture retention, according to [36]. Soil and water chemical analysis were carried out regarding [37].

Table 1 Soil physical analysis

Depth, cm	PSD (%)				Texture class	θ_S % on weight basis			HC (cmh^{-1})	BD (g/cm^3)	P (cm^3 voids /cm^3 soil)
	C. Sand	F. Sand	Silt	Clay		FC	WP	AW			
00-15	8.5	77.5	8.4	5.6	Sandy	14.0	6.0	8.0	6.68	1.69	0.36
15-30	8.6	77.7	8.3	5.4	Sandy	14.0	6.0	8.0	6.84	1.69	0.36
30-45	8.5	77.5	8.8	5.2	Sandy	14.0	6.0	8.0	6.91	1.69	0.36
45-60	8.8	76.7	8.6	5.9	Sandy	14.0	6.0	8.0	6.17	1.67	0.37

FC, Field Capacity; WP, Wilting Point; AW, Available Water; HC, Hydraulic conductivity (cmh^{-1});
BD, Bulk density(g/cm^3); and Porosity (cm^3 voids/cm^3 soil); PSD, Particle Size distribution (%).

Table 2 Soil chemical analysis

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^{-}
00-15	8.30	0.33	0.35	0.39	1.02	0.23	0.0	0.11	0.82	1.27
15-30	8.20	0.34	0.51	0.44	1.04	0.24	0.0	0.13	0.86	1.23
30-45	8.30	0.35	0.56	0.41	1.05	0.23	0.0	0.12	0.81	1.23
45-60	8.40	0.74	0.67	1.46	1.06	0.25	0.0	0.14	0.86	1.22

Table 3 Irrigation water chemical analysis

pH	EC (dS/m)	Soluble cations, meq/l				Soluble anions, meq/l				SAR
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{--}	
7.3	0.37	0.74	0.26	2.62	0.11	0	0.93	0.25	2.55	1.14

2.2 Automatic Drip Irrigation Design

The drip irrigation, automatic control system consists of damp sensors, temperature sensors, signal circuits, digital adapters, an LCD module, a data transfer engine and a spiral coil control. A signal is sent via the unit in Figure 1, and important data are automatically estimated by ground moisture and temperature measurements. Resistance Tensiometer Domain (RTD), such as PT100, is used as temperature sensors, but a density sensor can be used to detect soil moisture. The sensors are installed in the soil below a certain depth (depending on the cultivated plant).

It can be shortened as follows: When the soil moisture increasing till the saturation status, the sensors send signals that are quickly amplified by the amplifier AMP signals to the control unit for the purpose of stopping the irrigation and thus transfer them to the valves. Otherwise, in case of water deficit valves will receive an order through irrigation system control to irrigate the farm.The electrostatic drip related to the execution of an order to close it and the automatic system is activated without the intervention of the human factor in the process throughout the growing season until the start of harvesting measures as in the forms in Fig. 2 and 3 of the automatic control unit and application in the field.

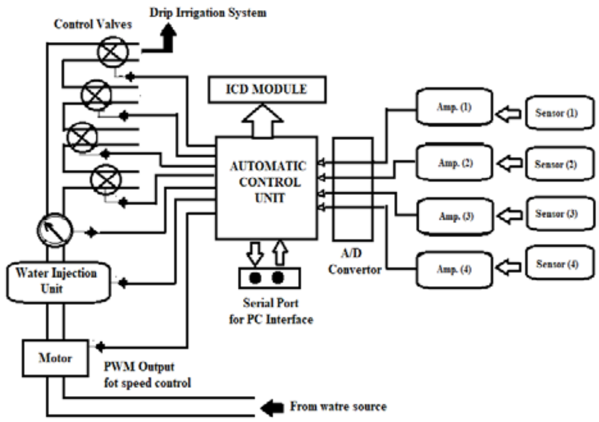
The drip irrigation network includes the following parts and described in Fig. 3;

1 - Main control unit: It is located beside the source of water, and includes: centrifugal pump 4/4 (ID Φ), and works with an electric motor and the disposal of the pump is about 100 m3 / hour and 50 m lift, filter sand 48" (2 tanks), screen filter 2" (120 mesh) non-return valve, pressure regulator, pressure gauges, disposal meters, control valves and

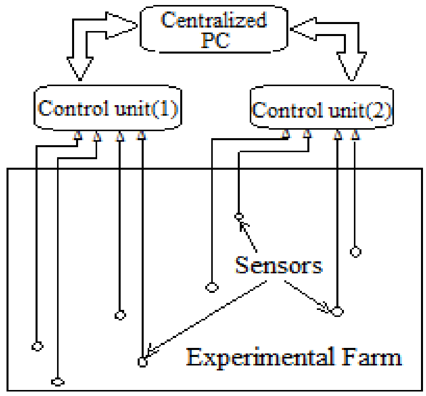
fertilization unit., 2 - Main lines: PVC pipes with a diameter of 4-6" (ID Φ), and connect water from the water source to the sub-main lines., 3. Sub-main lines: PVC pipes with a diameter of about 63 mm (IDΦ), which connect water from the main pipes to distribution lines or what is known as manifold., and 4. Lateral lines: These are pipes made of PE diameter 16 mm (IDΦ) and installed inside or on the dots or drip irrigation devices, which in turn to add water to the plants at the required rates and working in optimal conditions at the pressure of 1 bar to give a flow of 4 liters / hour., These components of irrigation systems were installed and operated according to, [11, 12] and [14].

2.3 Statistical Analysis

Statistical analysis was performed using the COSTAT program. The comparison between all treatments, the study factors and interactions were done using the P technique to analyze the differences between the ANOVA values and using the least significant difference at the level of 1% [38].



A) Automatic controller unit components



B) Applied sensors in the experimental field

Fig. 2. Automatic controller unit components, A); and Applied sensors in the experimental field, B).

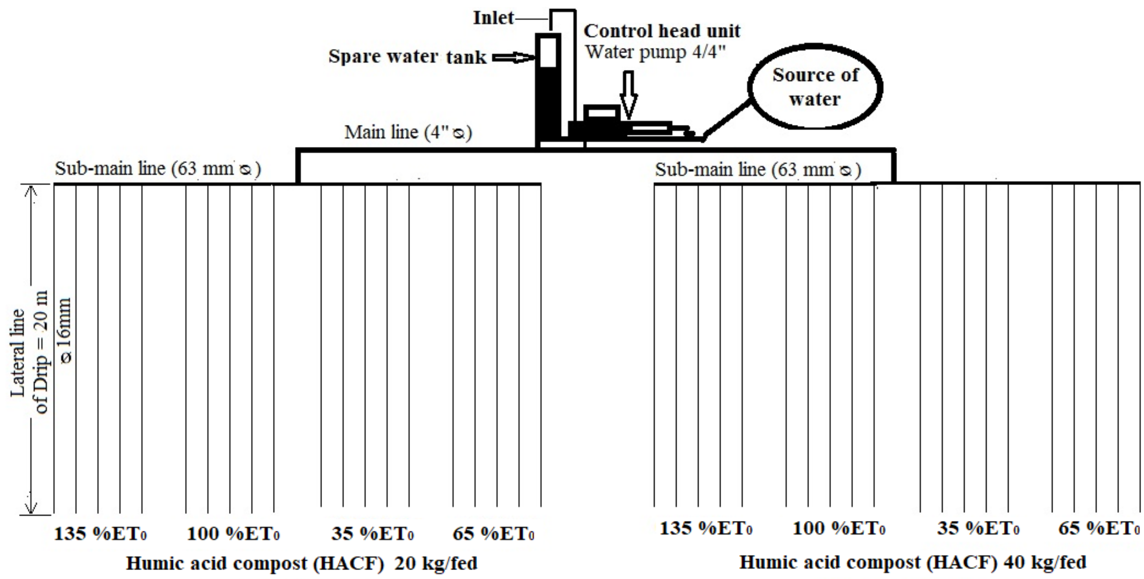


Fig. 3. The layout of the field experiments under drip irrigation systems design

3. RESULTS AND DISCUSSION

3.1 Climate Conditions

The climate parameters (temperature and precipitation) data of the last 20 consecutive years (1997-2017) of the nearest weather station to the study area were obtained. The climate parameters were attached into the climate database CDBm of MicroLEIS DSS [39], the elementary data of CDBm were the daily data of mean, minimum and maximum, temperatures, as well as daily precipitation. Fig.4 illustrates the climate condition during the aforementioned period.

Agro-climatic factors, such as potential evapotranspiration and aridity index (Ari), numbers of arid months in which the actual precipitation is lower than evapotranspiration was calculated based on the data (1997-2017) of the closest weather station to the study area. Potential evapotranspiration (PE) was calculated based on the following two methods; [39, 40].. Hence, the climate of the study area can be characterized as a hyper arid climate where the annual evapotranspiration (ET) reached 1450 mm by [39] and the annual precipitation represent only 18.5 per year, Table 4 Therefore, the experiment based on using different quantities of irrigation from the Nile as a result of the negligible rainfall. Table 4 illustrates the climatic parameters of the climate station of the study area. These include Tm, mean temperature (oC), Tmax, maximum temperature (OC), Tmin, minimum temperature (OC), P, precipitation (mm).

The monthly distribution of precipitation means temperature and evapotranspiration of the climate analysis is shown in Fig. 4 The data were joined into the climate database CDBm of MicroLEIS DSS [42], where the elementary data of CDBm are the mean values of daily data set for a specific month such as maximum, minimum and mean temperatures, as well as daily precipitation.

3.2 Yield, Water and Fertilizer Productivity

In respect to faba bean yield under drip irrigation system by the automation controller system, when using humic acid compost fertilizer (HACF) 20 kg/fed as shows Table 5 grain yield production was the highest value (2070 kg/fed) by using (ET0 100%), then came the (ET0 65%) value

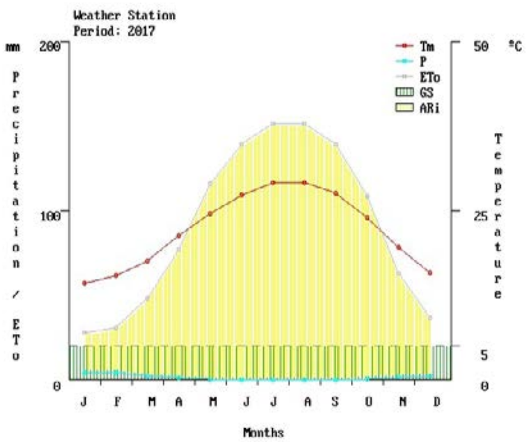


Fig. 4. The climatic parameters of the closest weather station to the experiment area. Tm, mean temperature (OC); P, precipitation (mm); ET0, potential Evapotranspiration (mm); GS, Growing season; Ari, Aridity index.

was (1535 kg/fed). The lowest value (970 kg/fed) was achieved under (ET0 35%).

There was a significant difference at the 1% level in faba bean yield between the three treatments. When HACF 20 kg/fed, as shows Fig 5; Fig. 6; Fig. 1; ET0 135% treatment of faba bean yield was the highest yield value (2139 kg/fed); then under (ET0 100%) value (2134 kg/fed); followed by ET0 65% that a had a yield value of 1643 kg/fed, while the lowest value (1012 kg/fed) was observed under ET0 35%. There was the non-significant difference at the 1% level between the treatment 135 % ET0 and 100% ET0, and there is a significant difference between both of 100 % and 135 % from ET0 and others 65% and 35% from ET0 in Faba bean yield treatments.

The increase in Faba bean yield under HACF 40 kg/fed were 14.0, 4.5 and 6.2 % in comparison with HACF 20 kg/fed under ET0 (35, 65, and 100) %, respectively. According to water productivity WP (kg/m3) as shown in Fig 5 and Fig. 6, treatments used could be arranged in the following ascending order: 135 > 100 > 65 > 35 % ET0 under HACF 40 and 20 kg/fed. WP values of ET0 (100, 65, and 35)% were 2.0, 1.9, 1.8 respectively and it were 2.2, 2.0, 1.9 under HACF 20 kg/fed and HACF 40 kg/fed, respectively.

Differences between any two treatments were significant at the 1 % level except (HACF 20 kg/fed with 100 % ET0), (HACF 40 kg/fed with 65 % ET0) and (HACF 20 kg/fed with 65 % ET0), (HACF 40 kg/fed with 35 % ET0). Interactions were significant at the 1 % level. The increase in WP under HACF 40 kg/fed were 14.0, 4.5 and 6.2 % in comparison with HACF 20 kg/fed under ET0 (100, 65, and 35) %, respectively.

In Fig 7, we noticed that: the change in NP took the same trend of grain yield and parameter and thus took the same trend of WP, due to aforementioned reasons mentioned. Concerning the positive effect of (HACF and ET0) on NP, PP and KP they could be ranked in the following descending orders: HACF 40 kg/fed > HACF 20 kg/fed and 135 > 100 > 65 > 35 % ET0. In respect to HACF and field capacities treatments effect on faba bean nitrogen, phosphorus and potassium use efficiencies (NP, PP and KP) in the unit (kg grain yield / kg fertilizers) as shows Table 6, a significant difference at the 5 % level between all means values of HACF factor and ET0 treatments. According to the effect of HACF factor and field capacities treatments on (NP, PP and KP), there were significant differences at the 5 % level at all interactions. The maximum and minimum values of (NP, PP and KP) were obtained in HACF factor 40kg/fed * 100 % ET0 and HACF factor 20 kg/fed * 35 % ET0, on ranking. The increase in NP, PP and KP under HACF 40 kg/fed were 14.0, 4.5 and 6.2 % in comparison with HACF 20 kg/fed under 35, 65, and 100 % ET0, respectively.

3.3 Discussion

Because the yield of broad bean of winter crops, the temperature drops on the day further after the completion of flowering and with increasing the amount of irrigation water enough help to increase the quality of heat around the total vegetative and thus the plant faba bean continue to increase vegetative growth dramatically in areas dry and semi-arid as in the present study. This helps to increase the grain yield of the faba beans in the absence of water stress as these areas don't have long-season rains. Therefore, the post-pollination period in the faba bean is short, of the spring in this region where the temperature control dramatically in vegetative growth of faba bean and at the same time, adequate and regular irrigation operation is performed along the season, which helps to increase the productivity of water and fertilizer,[10-19].

Table 4 Summary of Agro-meteorological parameters of the represented climate station. Tm, mean temperature (^{O}C); Tmax, maximum temperature (^{O}C); Tmin, minimum temperature (^{O}C) ; P, precipitation (mm); ET_0(T), Evapotranspiration calculated by Thornthwaite method; ET_0(H), Evapotranspiration calculated by Hargreaves method.

Months	Tm	Tmax	Tmin	P, mm	ET_0(T) mm	ET_0(H) mm
January	14.3	20.0	8.6	4.2	28.0	90.1
February	15.5	21.5	9.4	4.5	31.3	99.9
March	17.6	24.4	10.9	2.4	48.3	113.2
April	21.3	28.7	13.9	1.3	77.3	127.7
May	24.6	32.2	16.9	0.4	116.1	132.3
June	27.4	35.0	19.9	0.0	139.5	134.9
July	29.2	36.4	21.9	0.1	151.7	139.2
August	29.2	36.1	22.3	0.0	151.7	143.7
September	27.7	34.3	21.0	0.0	139.5	142.8
October	24.0	30.2	17.8	1.0	108.8	126.8
November	19.7	25.6	13.8	1.8	63.0	107.8
December	15.9	21.4	10.4	2.8	37.0	91.6
Annual	22.2	28.8	15.6	18.5	1092.2	1450.1

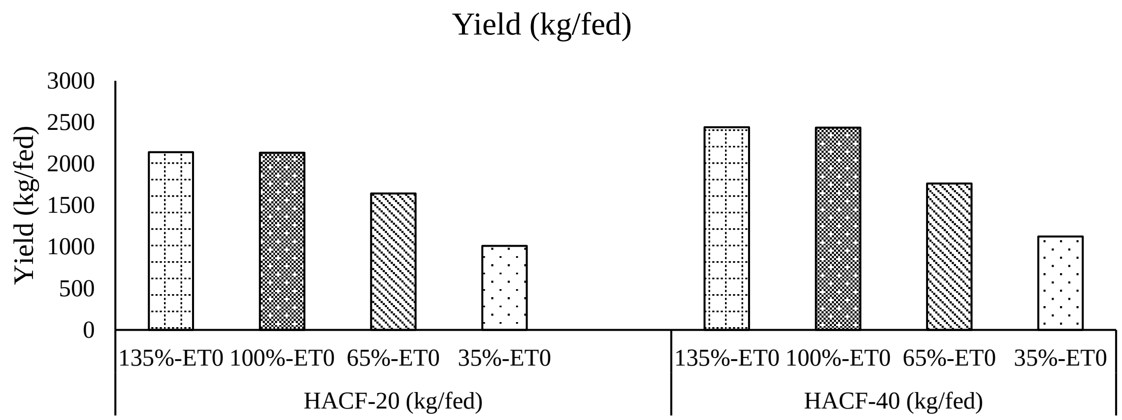


Fig. 5 Effect of drip irrigation by the automatic control system, different humic acid compost fertilizer (HACF) and Evapotranspiration (ET_0) rates on faba bean yield.

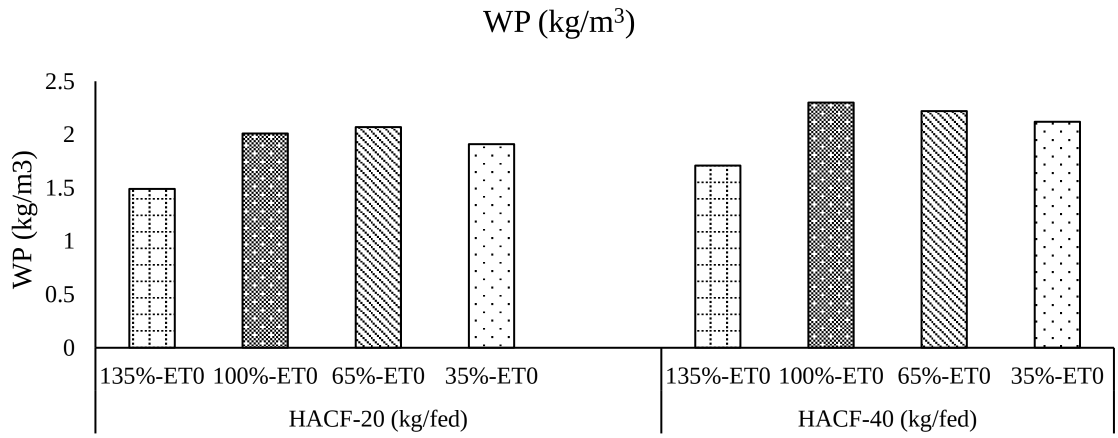


Fig. 6 Effect of drip irrigation by the automatic control system, different humic acid compost fertilizer (HACF) and Evapotranspiration (ET_0) rates on Faba bean water productivity.

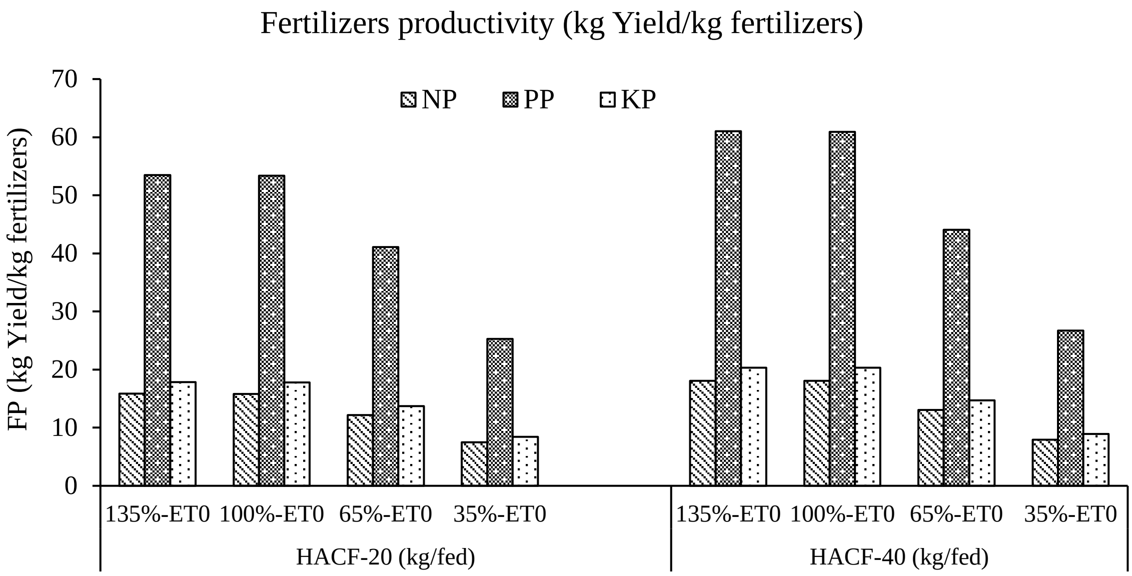


Fig. 7 Effect of drip irrigation by the automatic control system, different humic acid compost fertilizer (HACF) and Evapotranspiration (ET0) rates, on faba bean Fertilizers Productivity.

These results attributed to Faba bean plants avoid the water stress under 100 % ET0 but adversely affected by water stress under ET0 35 and 65%. The biggest addition amount of HACF 40 kg/fed impacted positively on Faba bean plants, because of containing more content of macro and micro nutrients and it helps save water with sandy soil, which leads to avoiding water stress as well. In respect to fertilizers productivity (FP), the effect of both HACF and ET0 treatments on faba bean nitrogen, Phosphorus and potassium productivity (FP), (NP, PP; KP) in the unit (kg grain yield/kg Fertilizers). These results agree with those obtained by [43-47].

The vegetative growth cover is one of the most important determinants of the water productivity of dry matter, grain yield of Faba beans, and hence productivity, water and fertilizers, because it significantly controls the rate of radiation that occurs during the vegetable growth phase of the Faba bean, which in turn increases yield productivity, [48-49].

However, in some cases, lead to a negative impact, preventing and reducing the process of connecting the light to all parts of the vegetative growth of faba bean farmyard which reduces the productivity of the yield of the grain, bean municipal crop, can know the maximum limit to the size of the growth of vegetation by the productivity of the plant leaves and index leaves space Plant to the stage of flowering in the faba bean [50-58].

Nevertheless, there are some crops are not limited in size in the vegetative growth, such as faba bean, especially some varieties of crops that mature in the middle of the post-flowering, and in this case, irrigation is ineffective dramatically after the completion of maturity where vegetation does not grow significantly after arrival to this stage, the addition of water may have a negative impact on the irrigation efficiency and water productivity of the faba bean. But if there is no water stress on plants in the vegetative growth stage helps a positive relationship between vegetation after flowering above-ground dry matter (AGDM) and grain yield of faba bean crop, where it is estimated the water productivity of grain yield depending on the size of the vegetative growth in the post-flowering and start grain formation, [59-66].

4. CONCLUSION

Under drip irrigation with the automatic control system in sandy soil, the highest yield of faba bean was observed under 40 kg/fed humic acid compost fertilizer (HACF) and 100% ET0, while the crop adversely impacted under 20 kg/fed HACF and 35% ET0 with lower grain yield. Significantly, using a large amount of HACF helped to save water irrigation and avoided water stress on bean plants under 65% ET0 irrigation treatment, which means 35 % of irrigation water have been saved. Consequently, under 40 kg/fed of HACF and 65 %, 100% of ET0 faba bean have been avoiding the water stress and there is no negative impact on crop productivity. Hence this research achieved that the using of modern irrigation system jointly with a high amount of HACF helps to save irrigation water by one third, therefore this work assists the Egyptian policy for horizontal expansion and reclaiming new land particularly under this desertic condition and Egyptian water scarcity

5. ACKNOWLEDGMENT

The authors would like to thank the “Grassland Talents” project, Inner Mongolia[2016] 40, Xilingol Vocational College; Talented Young Scientist Programs (Egypt-18-050 and Sudan-18-005), CHINA and the National Research Centre, EGYPT, for the support and fund for publishing processing this great research work.

6. REFERENCES

[1] Camp, C.R., Subsurface Drip Irrigation: A Review. Transactions of the ASAE, 1988, 41, 1353-1367. http://dx.doi.org/10.13031/2013.17309.

[2] Bressler, E., Trickle-drip irrigation principles and application to soil-water management. Advances in Agronomy, 1977, 29:343-393. https://www.sciencedirect.com/science/article/pii/S0065211308602229.

[3] Hanafy, M., Effect of Allowable soil-water depletion and installation depth on drip irrigation tomatoes in sandy soil. Misr J. Agr. Eng.,1993, 10(3): 628-642.

[4] Levin, I.; P. G. Vanrooyan and F. C. Vanrooyan, The effect of discharge rate and intermittent water application by, point source irrigation, on the soil moisture distribution pattern. Soil Sci. Soc. Am., 1979, 43:8-1.

[5] Bacon, P. E. and B. G. Davy, Nutrient availability under trickle irrigation: I. Distribution of water and bray No; 1 phosphate. Soil. Sci. Soc. Am. J. 1982, 46:981-987.

[6] Norris, L. m. and V. A. Tennessee, A review of field-scale physical solute transport processes in saturated and unsaturated project 2485-7 Electric Power Research Institute. 1985.

[7] Eldardiry, E.E., Hellal, F., Mansour, H.A.A. Performance of sprinkler irrigated wheat – part II.Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp.41

[8] Tayel, M.Y., El-Gindy, A.M., Mansour, H.A. Effect of drip irrigation circuits design and lateral line length on III-dripper and lateral discharge. Journal of Applied Sciences Research, 2012, 8 (5), pp.2725

[9] Selim E.M., El-Neklawy A.S, Soad M. El-Ashry, Beneficial effects of humic substances fertigation on soil fertility to potato grown on sandy soil. Aust J Basic Appl Sci, 2009, 3:4351–4358.

[10] Mansour, H. A., Performance automatic sprinkler irrigation management for production and quality of different Egyptian wheat varieties. International Journal of ChemTech Research. 2015, Vol.8, No.12 pp 226-237.

[11] Mansour, H. A., Abdel-Hady, M.,Eldardiry, E.I., Bralts, V.F., Performance of automatic control different localized irrigation systems and lateral lengths for emitters clogging and maize (Zea mays L.) growth and yield. International Journal of GEOMATE, 2015, Vol. 9, No. 2 (Sl. No. 18), pp. 1545-1552.

[12] Mansour, H. A., Pibars, S.K., Abd El-Hady, M., Ebtisam I. Eldardiry, Effect of water management by drip irrigation automation controller system on Faba bean production under water deficit. International Journal of GEOMATE, 2014, Vol. 7, No. 2 (Sl. No. 14), pp. 1047-1053.

[13] Mansour, H. A., Sabreen Kh. Pibars, M.S. Gaballah, and Kassem A. S. Mohammed. Effect of Different Nitrogen Fertilizer Levels, and Wheat Cultivars on Yield and its Components under Sprinkler Irrigation System Management in Sandy Soil., 2016, Vol.9, No.09 pp.1-9.

[14] Mansour, H. A., M. Abd El-Hady, V. F. Bralts, and B. A. Engel, Performance Automation Controller of Drip Irrigation System and Saline Water for Wheat Yield and Water Productivity in Egypt. Journal of Irrigation and Drainage Engineering, American Society of Civil Engineering (ASCE), J. Irrig. Drain Eng. 05016005, http://dx.doi.org/10.1061/(ASCE)IR, 2016.1943-4774.0001042.

[15] Mansour, H.A., E.F.Abdallah, M.S.Gaballah and Cs.Gyuricza, Impact of Bubbler Discharge and Irrigation Water Quantity on 1- Hydraulic Performance Evaluation and Maize Biomass Yield. Int. J. of GEOMATE, Dec. 2015, Vol. 9, No. 2 (Sl. No. 18), pp. 1538-1544.

[16] Mansour, H.A., Pibars, S.K.; Bralts, V.F., The hydraulic evaluation of MTI and DIS as a localized irrigation systems and treated agricultural wastewater for potato growth and water productivity. International Journal of ChemTech Research, 2015, Vol.8, No.12 pp 142-150.

[17] Mansour, H.A., Saad, A., Ibrahim, A.A.A., El-Hagarey, M.E., Management of irrigation system: Quality performance of Egyptian wheat (Book Chapter). Micro Irrigation Management: Technological Advances and Their Applications. 2016. pp. 279-293.

[18] Mansour, H.A.A. and Aljughaiman, A.S. Water and fertilizer use efficiencies for drip irrigated corn: Kingdom of Saudi Arabia (book chapter) closed circuit trickle irrigation design: theory and applications, Apple Academic Press, Publisher: Taylor and Frances. 2015. pp. 233-249

[19] Mansour, H.A.A. and El-Melhem, Y. Performance of drip irrigated yellow corn: Kingdom of Saudi Arabia (Book Chapter),

closed circuit trickle irrigation design: theory and applications, Apple Academic Press, Publisher: Taylor and Frances. 2015. pp. 219-232

[20] Holt, D.F., D.R. Timmons, Influence of precipitation, soil water, and plant population interactions on corn grain yields. Agron. J. 1968, 60, 379–381.

[21] Modarres, A.M.; Hamilton, R.I.; Dijak, M.; Dwyer, L.M.; Stewart, D.W.; Mather, D.E. and D.L. Smith, Plant population density effects on maize inbred lines grown in the short-season environment. Crop Sci. 1998, 38, 104–108.

[22] Fulton, J.M., Relationship among soil moisture stress plant population, row spacing and yield of corn. Can. J. Plant Sci. 1970. 35, 31–38.

[23] Alderfasi, A. A. and S.S. Alghamdi, Integrated water supply with nutrient requirements on growth, photosynthesis, productivity, chemical status and seed yield of Faba bean. Amer. Eurasion J. of Agron., 2010. 3(1): 8-17.

[24] Hu Jiandong, Zou Zhanwu, Xu Shuangxin. Design Test and Research of FSH-400 Type Wind Power Water Pumping Machine[J]． Acta Energiae Solaris Sinica, 2013, 34(5): 595-901．

[25] Chen Shaoheng, Dong Lijiang, Hu Jiandong, et al.Experimental Study on FSM-3.5 Type Wind-powered Water Pumping Machine in Wetland Restoration[J]. Animal Husbandry and Feed Science, 2017, 38(3): 59- 62.

[26] Abdalla N. O. Kheiry, Yuan Liwei et al., Design and Characteristic Analysis of FSH(M) Agricultural Use Wind pump. Journal of Agricultural Mechanization Research, 2019,41 (4):246-250.

[27] Hu Jiandong, Chen Shaoheng, Dong Lijiang et al., Application Strategy Research of High Lift and Little Flow Wind Power Water Pumping Machine[J]. Journal of Agricultural Mechanization Research, 2014, 36(2):210-214.

[28] Hu Jiandong, Chen Shaoheng, et al. Promotion and Application of New Energy Pumping Water Equipment in No Electricity Pastoral Areas [J]. Journal of Agricultural Mechanization Research, 2012, 34 (9): 215-219.

[29] Tayel, M. Y., H.A. Mansour, and S.Kh. Pibars, Performance of drip irrigated soybean. Book chapter, Closed Circuit Trickle Irrigation Design, Theory and Applications.2015.pp.250-263

[30] Gee, G.W. and J. W. Bauder, Particle size analysis. methods of soil analysis. Part 1 Agron. 2nd ed. 383 – 412 ASA and SSSA, Madison, WI (c. ed. Klute, R.). 1986.

[31] Black, G. R. and K. Hartge, Bulk density. Methods of Soil Analysis. Part 1 Agron. 2nd ed. 363 – 376 ASA and SSSA, Madison, WI (c. ed. Klute, R.). 1986.

[32] Walter, H. and Gardener, Water content. Methods of Soil Analysis. Part 1 Agron. 2nd ed. 493-544 ASA and SSSA, Madison , WI (c. ed. Klute, R.). 1986.

[33] Klute, A. and C. Dirksen, Hydraulic conductivity and diffusivity: Laboratory methods. P.687-734 Methods of soil analysis. Part 1 Agronomy 2nd edition. ASA and SSSA, Madison, WI. In. A. Klute (ed.). 1986.

[34] Jackson, M. L., Soil Chemical Analysis, Prentice Hall, Inc., Englewood Cliffs, USA.1967.

[35] Soil Survey Staff, Soil Survey ManPl. USDA Handbook No: 18, Washington, USA .1993.

[36] Rebecca B. Soil Survey Laboratory Methods Manual.(Soil Survey Laboratory Investigations Report No. 42) Rebecca Burt Research Soil Scientist MS 41, Room 152, 100 Centennial Mall North, Lincoln, NE 68358-3866. 2004. (402) 437-3506.

[37] Goyal, M.R. and Mansour H.A.A. Closed circuit trickle irrigation design: theory and applications, (book), Apple Academic Press, Publisher: Taylor and Frances. 2015.

[38] Steel R.G.D., and Torrie J.H. Analysis of covariance, In Principles and Procedures of Statistics: a Biometrical Approach, 1980. pp. 401-437. McGraw-Hill, New York.

[39] Tayel, M.Y.; S. M. Shaaban; H. A. Mansour and E.F. Abdallah, Response of Fodder Beet Plants Grown in a Sandy Soil to Different Plowing Conditions. International Journal of ChemTech Research. 2016. Vol.9, No.09 pp.20-27.

[40] Hargreaves, D. A., Hargreaves, G. H., and Riley, J. P. Irrigation Water Requirements for Senegal River Basin. J. Irri. Drain. Div. 1985. 3: 265-275.

[41] Thornth waite, C. W. An Approach toward a Rational Classification of Climate. The Geographic Rev.1984. 38: 55-94.

[42] Doorenbos, J. and Pruitt, W.O., Crop water requirements irrigation and drainage.1977. p: 24. Food and Agricultural Organization (FAO), the United Nations, Rome, Italy.

[43] Pibars, S.K., and Mansour, H.A., Evaluate the response of sunflower productivity to modern chemigation systems in newly reclaimed lands. International Journal of ChemTech Research. 2015. 8 (12): 160-169.

[44] Mansour, H.A.A., El-Hady, M.A., Gyurciza, C.S. Water and fertilizer use efficiencies for drip irrigated maize (Book Chapter). Closed Circuit Trickle Irrigation Design: Theory and Applications. 2015. pp. 207-218.

[45] Mansour, H.A.A. Design considerations for closed circuit design of drip irrigation system (Book Chapter).2015. pp.61-133.

[46] Tayel, M. Y., A.M. El-Gindy and H.A. Mansour. Effect of drip irrigation circuit design and lateral line lengths iv- on uniformity coefficient and coefficient of variation. Journal of Applied Sciences Research. 2012. 8(5): 2741-2748.

[47] Tayel, M.Y., Shaaban, S.M., Mansour, H. A. Effect of plowing conditions on the tractor wheel slippage and fuel consumption in sandy soil. International Journal of ChemTech Research, 2015. Vol.8, No.12 pp 151-159.

[48] Husain, M.M., Hill, G.D., Gallagher, J.N., The response of field beans (Vicia Faba L.) to irrigation and sowing date. 2. Growth and development in relation to yield. J.Agric. Sci. Camb. 1988. 111 (2), 233–254. https://doi.org/10.1017/S0021859600083180.

[49] De Costa, W.A.J.M., Dennett, M.D., Ratnaweera, U., Nyalemegbe, K., Effects of different water regimes on field-grown determinate and indeterminate Faba bean (Vicia Faba L.). II. Yield, yield components and harvest index. Field Crops Res.1997. 52, 169–178.

[50] Minguez, M.I., Ruiz-Nogueira, B., Sau, F., Faba bean productivity and optimum canopy development under a Mediterranean climate. Field Crops Res.1993. 33, 435–447.

[51] K. Zeleke and C. Nendel. Growth and yield response of Faba bean to soil moisture regimes and sowing dates: Field experiment and modeling study, Agricultural Water Management. 2019. 213. 1063–1077.

[52] Abd-Elmabod, S.K.; Bakr, N.; Muñoz-Rojas, M.; Pereira, P.; Zhang, Z.; Cerdà, A.; Jordán, A.; Mansour, H.; De la Rosa, D.; Jones, L. Assessment of Soil Suitability for Improvement of Soil Factors and Agricultural Management. Sustainability 2019, 11, 1588. doi: 10.3390/su11061588

[53] Sabreen Kh Pibars and H. A. Mansour. Effect of tillage management practices and humic acid applications on some engineering properties of peanut. Plant Archives Vol. 19, Supplement 1, 2019 pp. 636-643.

[54] Mansour H. A., Sameh K. Abd-Elmabod and B. A. Engel. Adaptation of modeling to the irrigation system and water management for corn growth and yield. *Plant Archives* Vol. 19, Supplement 1, 2019 pp. 644-651.

[55] Tayel, M.Y.; S.M. Shaaban and H.A. Mansour. Impact of seedbed preparation condition on aggregates stability, yield, water productivity and fertilizers use efficiency on maize (zea mays). *Plant Archives* Vol. 19, Supplement 1, 2019 pp. 706-710.

[56] Samir S. Attia, Abdel-Ghany M. El-Gindy, Hani A. Mansour, Soha E. Kalil and Yasser E. Arafa. performance analysis of pressurized irrigation systems using simulation model technique. Plant Archives Vol. 19, Supplement 1, 2019 pp. 721-731.

[57] Tayel, M.Y., Shaaban, S.M., Eldardiry, E.A., Mansour, H.A. Wheat yield versus seed bed conditions. 2018, Bioscience Research, 15(3), pp. 1943-1951.

[58] El-Hagarey, M.E.,Mehanna, H.M., Mansour, H.A. Soil moisture and salinity distributions under modified sprinkler irrigation. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp.3-21.

[59] Tayel, M.Y., Mansour, H.A.A., Pibars, S.K. Performance of sprinkler irrigated wheat – part I. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp.23-40.

[60] Tayel, M.Y., Pibars, S.K., Mansour, H.A.A. Evaluation of emitter clogging. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp.287-300.

[61] Pibars, S.K., Mansour, H.A.A., Abd El-Hady, M., Eldardiry, E.E.I. Evaluation of emitter clogging for drip irrigated snap beans.Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp.273-286.

[62] Tayel, M.Y., Mansour, H.A.A., Pibars, S.K. Performance of maize under bubbler irrigation system. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp.135-147.

[63] Ibrahim, A., Csúr-Varga, A.,Jolánkai, M., Mansour, H., Hamed, A. Monitoring some quality attributes of different wheat varieties by infrared technology. Agricultural Engineering International: CIGR Journal 20 (1), 2018, pp.201-210.

[64] Mansour, H.A.A., Mehanna, H.M., El-Hagarey, M.E.,Hassan, A.S. Automation of mini-sprinkler and drip irrigation systems.Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp.179-204.

[65] Mansour, H.A.A., Tayel, M.Y.,Lightfoot, D.A.,El-Gindy, A.M. Energy and water savings in drip irrigation systems. Closed Circuit Trickle Irrigation Design: Theory and Applications, 2015, pp.149-178.

[66] Mansour, H.A., Aljughaiman, A.S. Water and fertilizers use efficiency of corn crop under closed circuits of drip irrigation system. Journal of Applied Sciences Research, 2012, 8 (11), pp.5485-5493.