EFFECT OF IRRIGATION LEVEL AND BIO-STIMULANTS ON PRODUCTIVITY AND QUALITY OF GARLIC (*ALLIUM SATIVUM* L) IN CALCAREOUS SOILS

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ABSTRACT:

The aim of the present investigation was to improve the productivity of garlic grown on the sandy calcareous soil of Arab El-Awammer Experimental Station, Assiut governorate through using bio-stimulants and the suitable level of irrigation under drip irrigation system. For this purpose two field experiments were conducted during two winter seasons of 2015/2016 and 2016/2017 in split plot design with three replicates to detect the production and quality of garlic (Balady variety) as influenced by irrigation level in main plots (100%, 80% and 60% of Reference Evapotranspiration ET_o) and bio-stimulants (control, active dry yeast extract 5g/l, potassium humate 4 kg/fed, and both of them) in the sub plots. The obtained results indicated that irrigated garlic plants with 100% of ET_o recorded significant increases for plant growth, yield and yield components as compared to irrigation level by 80% and 60% from ET_o during both seasons. On the other hand, all bio-stimulants treatments were surpassed the control significantly. Soil application with potassium humate showed the highest values of studied parameters. Regarding to the interaction between the tested factors in the two trial seasons, irrigated garlic plants with 100% of ET_o treated with potassium humate recorded the greatest values of all estimated parameters for plant growth, yield and yield components.

Keywords: Sandy soil, drip irrigation system, humic acid, yeast extract.

INTRODUCTION

Food security and food safety to its people has become the focus of many governments around the world. The ever-increasing human population, which it is calculated that the human population by the year 2050 will reach nine billion, and decreasing land and water resources worldwide, makes the necessity of high yield production from less land and water resources as a paramount importance. On the other hand, most of newly reclaimed soil was sandy or sandy calcareous soils that’s naturally occur in arid and semi-arid regions if their parent materials are rich in $CaCO_3$ and when the parent material is relativity young and has undergone little weathering (Brody and Weil, 1999). In Egypt, the calcareous soils constitute about 25-30% of the total area (Abou-Elela, 2002). The main problems in land utilization of calcareous soils in agriculture are: crusting of soil surface, cemented condition of the subsoil layers, poor physical characteristics, poor water retention, the high pH level results in low availability of nutrients especially nitrogen, phosphorus, essential micronutrients, and rapid nutrients fixation if added to the soil (Kadry, 1973).

Nowadays, awareness has been offered to reduce pollution practices in sustainable agriculture. Bio-stimulants compounds are one of the approaches to lessen soil pollution (Fawzy *et al.,* 2012, b).

Humic substances have positive effects on nutrient uptake, especially major inorganic elements such as nitrogen, phosphorus, potassium and sulfur (Trevisan *et al.,* 2010). Moreover, it can improve the physical, chemical and biological properties of soil and favorably influence plant growth (Nardi *et al,* 2002) and improve water holding capacity (McDonnell *et al.,* 2001). Furthermore, Zaki *et al.,* (2014) concluded that humic acid can result in an increase and improvement of the garlic bulbs yield and quality.

In addition, active dry yeast is a natural bio-substances appear to be of useful stimulatory, nutritional and protective functions when it is applied on vegetable plants during stressful condition attributed to its hormones, sugars, amino and nucleic acids, vitamins and minerals (Sampedro *et al.,* 2004; Boby *et al.,* 2007; Mohamed, 2015; Abdel-Monnem, 2016). Also, it contain many nutrient elements produce a compounds of semi growth regulator like auxins, gibberellins and cytokinins (Fawzy *et al.,* 2012, a) and have the ability to produce some enzymes that help in converting process of monosaccharide to alcohol and CO_2 which is essential for photosynthesis (Dinha and Khazrajy 1990). Shalaby and El-Ramady (2014) reported that application of active dry yeast as bio-stimulants can be recommended to enhance total yield and bulb quality of garlic.

Garlic is the second most widely used Allium crop after onion (Rubatzky and Yamaguchi 1997). It has been used as both food and medicine in many cultures for thousands of years. Nowadays, garlic plants are cropped world-wide and are of major economic importance, as it is traded and consumed in most countries not only as a spice and vegetable, but also as a medicinal plant (Takagi 1990).On the other hand, Egypt ranks the fourth leading country in the world for garlic production (244.626 MT) after China, India and Korea (FAO, 2011) Also, In Egyptian market, garlic is one of the most highest-value cash crops.

Thus, the current study was conducted to investigate the influences of different irrigation regimes, bio-stimulants and their interaction on garlic yield and yield components. Also, to improve plant growth under water stress and to reduce the negative effect of water stress.

MATERIALS AND METHODS

Site and experimental description

Two field experiments were conducted under drip irrigation system in sandy calcareous soil (it is classified as typic torripsamments) at the Experimental Farm of Arab El-Awammer Research Station, Agric. Res. Center (A.R.C.)., Assiut Governorate, Egypt (which, lies between latitude 27°, 11′ N, longitude 31°, 06′ E and 71 m above sea level) during two growing winter seasons of 2015/2016 and 2016/2017 to detect the production and quality of garlic (*Allium sativum* L cv. Balady) as influenced by irrigation level and bio-stimulants. Climatic data for experimental sites during the two growing seasons are shown in Table (1). The important physical and chemical characteristics of representative soil samples from the surface layer (0-25 cm) of the field experimental site are shown in Table (2).

Table (1): Average monthly meteorological data of Assiut weather station during the two growth seasons of 2015/2016 and 2016/2017.

Parameter / Month	Temperature (C°) Max	Temperature (C°) Min	Relative Humidity%	Wind peed km/day	Sunshine hours	ET_o mm
2015/2016						
October	33.0	19.5	51.3	391.2	10.0	5.35
November	26.3	13.2	59.5	364.8	9.4	3.53
December	20.4	7.2	63.2	403.2	9.0	2.74
January	19.0	5.1	60.3	348.0	8.9	3.54
February	24.5	8.3	50.7	408.0	9.7	5.09
March	28.0	13.1	41.0	408.0	9.9	7.09
2016/2017						
October	32.8	17.7	49.5	362.4	10.0	7.65
November	27.0	12.7	54.7	403.2	9.4	5.03
December	19.9	6.3	59.7	348.0	9.0	3.7
January	19.3	5.3	55.3	355.2	8.9	3.73
February	20.5	6.3	52.6	348.0	8.9	4.33
March	25.3	11.0	42.5	412.8	9.7	6.44

Table (2): Physical and chemical properties of representative soil samples from the field experimental site of the surface layer (0-25 cm).

Physical properties									
Particle size distribution				**Moisture content % (w/w)**			**Organic Matter %**	**Total $CaCO_3$ %**	**Bulk Density**
Sand %	**Silt %**	**Clay %**	**Texture Grade**	**S.P.**	**F.C.**	**W.P.**			
93.91	3.90	2.19	Sandy	23.70	10.97	4.45	0.21	32.10	1.63
Chemical properties									
pH (1:1)	EC (1:1)	Soluble Cations (meq / L)				Soluble Anions (meq / L)		Total N (%)	Available P (mg/kg)
		Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^-+HCO_3^-	Cl^-		
8.73	0.97	4.79	2.77	1.55	0.47	4.71	3.71	0.008	6.50

Garlic plantation

In both seasons, the experimental design was split plot with three replications; The main plot was three regimes of drip irrigation (100%, 80% and 60% of Reference Evapotranspiration ET_o), while the bio-stimulants (active dry yeast extract 5g/L, potassium humate 4 kg/fed and active dry yeast extract plus potassium humate) were assigned in sub-plot. The area of each sub- plot was 10.5 m^2 (3 line x 7 m long x 0.5 m apart = 10.5m^2 = 1fed/400). The granular superphosphate (15.5% P_2O_5) at a rate of 150 kg/fed was broadcasted and thoroughly mixed with soil surface layer (0 - 25cm) during plot preparation. Garlic cloves of Balady cultivar were selected for uniformity in size healthy cloves and were sown on both sides of each dripper line at 7 cm apart between planted cloves. Cloves were planted at second week of October in the first and second seasons. Ammonium nitrate (33.5 %N) was added at the rate of 100 kg N/fed in six equal doses. Potassium sulfate (48% K_2O) was, added at a rate of 25 kg/fed in two equal doses. Chelated Fe, Mn and Zn in liquid solution, containing 100 ppm of each was used as foliar spray at a rate of 200 L/fed, sprayed twice. The last irrigated of garlic plant was in the first of April in both of seasons and garlic plants were harvested at second week of April in the first and second seasons.

Treatment description

Regimes of drip irrigation treatment: The amounts of actual applied irrigation water requirement under each irrigation treatment were determined according to James (1988) using the following equation:

$$I.Ra = \frac{ETc + Lf}{Er}$$

Where:

I. Ra = total actual irrigation water applied mm/ interval.

ETc = Crop evapotranspiration using Penman Monteith equation. The CROPWAT model was used to calculate Penman Monteith equation (Smith, 1991).

Lf = leaching factor 10 %.

Er = irrigation system efficiency.

Humic acid treatment: Black granules of potassium humate 90% humate and 10% potassium oxide its origin from China were mixed with water and applied in the form of soil application at rate of 1 kg/fed (one fed = 4200 m^2= 0.42 ha) after one month from sowing cloves in both seasons and were repeated three times later with two weeks in between.

Yeast extract preparation: 5g of baker's active dry yeast (*Saccharomyces cerevisiae*) was dissolved in warm water followed by the accessory addition of the Egyptian Treacle (as a source of sugar) and kept overnight in a warm place for brewed and reproduction of yeast then water was added to 1 liter final volume. Mixture was applied in the form of soil application at rate of 200 L/fed after one month from sowing cloves in both seasons and was repeated three times later with two weeks in between.

Measurements of yield and yield components

Data were measured by selecting 10 plants randomly from each replicate then plant height, number of leaves, neck diameter, bulb diameter, bulbing ratio, number of cloves per bulb and weight of 100 cloves were recorded. At harvest three square meters from the center of each plot were manually harvested and total yield were recorded. After estimated the actual total irrigation water were applied the irrigation water use efficiency (IWUE) was calculated as follow: Irrigation water use efficiency =

$$\frac{\text{Total Yield (kg/fed)}}{\text{Irrigation water Applied (m}^3\text{/fed)}}$$

Statistical analysis

All collected data were subjected to the statistical analysis of variance and data showing significant difference at $P \leq 0.05$ was put to comparison of treatments means by LSD test. Data was processed using Statistix 8.1 software (Analytical Software, 2005).

Results and discussion

Plant height and number of leaves

Results of these traits are illustrated in Table (3) for 2015/2016 and 2016/2017 seasons, respectively. It could be observed that plant height and leaves number were significantly affected by irrigation treatments and bio-stimulants application. Plots received 100 % of ET_o produced the highest average of plant height (64.4 and 57.4 cm/plant) and number of leaves (8.0 and 7.2) for 2015/2016 and 2016/2017 seasons, respectively compared to 80% and 60 % of ET_o.

Potassium humate application among all bio-stimulants treatments gave the maximum value of plant height (63.7 cm and 56.4) during first and second seasons. Meanwhile, control treatment recorded shortest plant heights, which were 58.5 cm and 51.6 cm in both seasons. For number of leaves, there was a significant affect between bio-stimulants application and control but no significant difference among bio-stimulants. In generally, potassium humate recorded the biggest number of leaves (8.1 and 7.2 leave/plant in 2015/2016 and 2016/2017 seasons, respectively).
Regarding the interaction between irrigation regimes and bio-stimulants treatments, no significant difference was recorded. Soil application with potassium humate and irrigated plants with 100 % of ET_0 gave longest plant height in both seasons. However, the maximum leaves number in 2016/2017 was found in yeast extract treatments (7.4 leaves/plant). This result might be because humates enhance nutrient uptake, improve soil structure and influence plants growth (MacCarthy et al., 2001; Shafeek et al., 2015). Furthermore, Garcia, et al (2008) reported that humic increases the porosity of soil and improve growth of root system which leads to increase the shoot system. In addition, the obtained results were in agreement with Shalaby and El-Ramady, (2014) who reported that bio-stimulants contain amino acids and some other elements, which enhance the metabolism processes in plant tissues.

Table (3) Garlic plant height and no of leaves per plant as affected by irrigation level and bio-stimulants during two seasons of 2015/2016 and 2016/2017.

Treatments		**Plant height (cm)**		**No. of leaves/plant**	
Irrigation Level (A)	**Bio-Stimulants (B)**	**2015/2016**	**2016/2017**	**2015/2016**	**2016/2017**
%100 of ET_o	Control	62.4	53.9	7.8	6.9
	Yeast (Y)	62.4	58.3	7.9	7.4
	Humic (H)	67.9	59.4	8.1	7.2
	Y+H	64.7	58.1	8.1	7.3
Mean		**64.4**	**57.4**	**8.0**	**7.2**
%80 of ET_o	Control	57.2	51.6	7.7	6.7
	Yeast (Y)	60.3	55.1	7.9	7.2
	Humic (H)	61.6	55.7	8.1	7.2
	Y+H	61.4	56.6	8.0	7.3
Mean		**60.1**	**54.8**	**7.9**	**7.1**
%60 of ET_o	Control	56.0	49.3	7.6	6.7
	Yeast (Y)	59.5	52.5	7.8	6.9
	Humic (H)	61.5	54.2	8.0	7.1
	Y+H	60.6	53.8	7.8	6.9
Mean		**59.4**	**52.5**	**7.8**	**6.9**
Over all Mean of B	Control	**58.5**	**51.6**	**7.7**	**6.8**
	Yeast (Y)	**60.8**	**55.3**	**7.9**	**7.2**
	Humic (H)	**63.7**	**56.4**	**8.1**	**7.2**
	Y+H	**62.2**	**56.2**	**8.0**	**7.2**
LSD 0.05	A	1.12	2.00	N.S	0.14
	B	1.41	2.69	0.16	0.33
	A×B	N.S	N.S	N.S	N.S

ET_o = Reference Evapotranspiration

Bulb and neck diameter

Data concerning average bulb and neck diameter during two experiment seasons was presented in Table (4). Results revealed that bulb and neck diameter were significant affected by irrigation treatments in both seasons. However, the affect of bio-stimulants factors was significantly in bulb diameter but there is no significant difference on neck diameter.

Table (4): Garlic bulb and neck diameter as affected by irrigation level and bio-stimulants during two seasons of 2015/2016 and 2016/2017.

Treatments		Bulb diameter (mm)		Neck diameter (mm)	
Irrigation Level (A)	**Bio-Stimulants (B)**	**2015/2016**	**2016/2017**	**2015/2016**	**2016/2017**
%100 of ET_o	Control	52.41	49.43	12.35	11.75
	Yeast (Y)	53.96	51.04	12.16	11.37
	Humic (H)	54.25	51.31	11.73	11.31
	Y+H	53.91	52.01	12.43	11.73
Mean		**53.63**	**50.95**	**12.17**	**11.54**
%80 of ET_o	Control	48.49	47.18	10.25	10.30
	Yeast (Y)	50.76	49.18	10.35	10.08
	Humic (H)	51.60	50.00	10.64	10.01
	Y+H	50.65	49.31	10.65	10.18
Mean		**50.38**	**48.92**	**10.47**	**10.15**
%60 of ET_o	Control	46.67	46.70	9.28	9.72
	Yeast (Y)	50.09	48.79	9.89	9.40
	Humic (H)	50.08	49.29	9.56	9.27
	Y+H	50.31	48.83	10.02	9.82
Mean		**49.29**	**48.40**	**9.69**	**9.55**
Over all Mean of B	Control	**49.19**	**47.77**	**10.63**	**10.59**
	Yeast (Y)	**51.60**	**49.67**	**10.80**	**10.29**
	Humic (H)	**51.97**	**50.20**	**10.64**	**10.19**
	Y+H	**51.62**	**50.05**	**11.03**	**10.58**
LSD 0.05	A	0.769	1.535	0.328	0.236
	B	0.817	1.058	N.S	N.S
	A×B	N.S	N.S	N.S	N.S

ET_o = Reference Evapotranspiration

The highest average of bulb and neck diameter was observed in water application with 100 % of ET_o in two seasons, which was 53.63 mm, 12.17 mm and 50.95 mm, 11.54 mm during 2015/2016 and 2016/2017 seasons, respectively. However, 60 % of ET_o average bulb and neck diameter recorded 49.29 mm, 9.69 mm and 48.4 mm, 9.55 mm for two seasons, respectively.

Furthermore, there was significant difference between bio-stimulants treatments and untreated treatment but among different bio-stimulants was no significant differ for each other regarding bulb diameter. The widest bulb diameter was obtained with soil application of potassium humate, which were 51.97 mm and 50.20 mm in 2015/2016 and 2016/2017 respectively.

Likewise, the interaction effect between irrigation treatments and different bio-stimulants was not significantly on the bulb and neck diameter.

These results could be supported by the obtained results of Bohme and Lua (1997) and Karakurt et al. (2009) who reported that potassium humate had beneficial effects on nutrient uptake by plants and was particularly important for the transport and availability of micro-nutrients needed for optimal plant growth and development.

Number of cloves per bulb and weight of 100 cloves

In the same trend with plant height, leaves number, bulb and neck diameter bio-stimulants treatments recorded significant results regarding number of cloves per bulb and weight of 100 cloves (Table 5). In seasons of 2015/2016, potassium humate application registered the highest number of cloves per bulb (35.2) and heaviest weight of 100 cloves (129.2 g). However, in 2016/2017 season, yeast extract plus potassium humate application gave the maximum value of cloves number/bulb (32.0) and the biggest weight of 100 cloves (129.6 g).

Table (5): Garlic no of cloves/bulb and 100 cloves weight as affected by irrigation level and bio-stimulants during two seasons of 2015/2016 and 2016/2017.

Treatments		No. of cloves/bulb		100 Cloves weight (g)	
Irrigation Level (A)	**Bio-Stimulants (B)**	**2015/2016**	**2016/2017**	**2015/2016**	**2016/2017**
%100 of ET_o	Control	34.2	32.2	132.3	123.0
	Yeast (Y)	36.5	33.1	131.8	133.6
	Humic (H)	36.0	32.8	142.2	132.1
	Y+H	36.0	34.5	134.1	137.7
Mean		**35.6**	**33.2**	**135.1**	**131.6**
%80 of ET_o	Control	33.1	29.9	119.3	114.7
	Yeast (Y)	34.3	32.3	124.5	129.3
	Humic (H)	34.9	31.7	125.6	126.9
	Y+H	34.4	31.6	125.1	127.3
Mean		**34.2**	**31.4**	**123.6**	**124.5**
%60 of ET_o	Control	32.6	28.7	100.8	113.6
	Yeast (Y)	33.6	30.0	119.9	122.1
	Humic (H)	34.7	29.9	119.8	122.4
	Y+H	34.2	29.9	122.3	123.7
Mean		**33.8**	**29.6**	**115.7**	**120.5**
Over all Mean of B	Control	**33.3**	**30.3**	**117.5**	**117.1**
	Yeast (Y)	**34.8**	**31.8**	**125.4**	**128.3**
	Humic (H)	**35.2**	**31.5**	**129.2**	**127.1**
	Y+H	**34.9**	**32.0**	**127.2**	**129.6**
LSD 0.05	A	0.78	1.30	13.98	N.S
	B	1.04	1.09	7.58	9.39
	A×B	N.S	N.S	N.S	N.S

ET_o = Reference Evapotranspiration

For the effect of water irrigation treatments, data in table 5 showed that the results were significantly differ regarding the number of cloves per bulb and weight of 100 cloves during study seasons except 2016/2017 season for trait of 100 cloves weight. Similarly, experiment plots received 100% of ET_o obtained the bigger number of cloves per bulb (35.6 and 33.2) than water irrigation with 60 % of ET_o (33.8 and 29.6) in both seasons respectively. This result was in the same trend in the first seasons for weight of 100 cloves, which 100 % of ET_o recorded the biggest value of 100 cloves weight. The interaction effect between bio-stimulants treatments and irrigation regime was not significantly differ for number cloves/bulb and weight of 100 cloves. These results might be due to the role of humic as a source of nutrients, which increase soil fertility, and consequently increased production of assimilates and results in increased cloves number and weight of 100 cloves (Abdel-Razzak and El-Sharkawy, 2013; Zaki, et al., 2014).

Bulbing ration and total yield and irrigation.

Results of bulbing ratio shown in Table 6 revealed that effect of irrigation treatments and bio-stimulants were significant. Plants received the 60 % of ET_o gave the least values for this trait (19.66 % and 19.75 % in both seasons, respectively). However, the highest bulbing ratio was recorded with 100 % ET_o (22.70 % and 22.66 % in study seasons). In addition, soil application by potassium humate obtained the lowest value for bulbing ratio (20.44 % and 20.29 % during 2015/2016 and 2016/2017). A similar result was observed for the interaction between irrigation regime and bio-stimulants, which was not significant at 5 % level.

Regarding total yield, data in Table 6 reveals that there were a significant variation between irrigation regime and bio-stimulants but no significant difference in their interaction. Appling of 100% of ET_o produced the highest value of garlic yield in both seasons, which was 7.380 ton/fed and 6.362 ton/fed during 2015/2016 and 2016/2017 seasons, respectively. Whereas the lowest yield production of garlic were from 60% of ET_o (5.442 and 4.805 ton/fed in 1st and 2nd seasons, respectively). Moreover, adding potassium humate to soil gave the greatest total yield in compare with other bio-stimulants, which recorded 6.971 ton/fed in 2015/2016 and 6.034 ton/fed in 2016/2017. On the contrast, untreated plots with bio-stimulants (control treatment) showed a significant reduction in garlic total yield, which were 5.457 and 4.763 ton/fed during two experiment seasons, respectively. Furthermore, the interaction between irrigation treatments and soil application with bio-stimulants showed a significant effect in second seasons whereas in first experiment seasons no significant effect of the interaction for total yield of garlic. Watering plants with 100 % of ET_o and adding potassium humate for soil produced the highest total yield 8.085 and 6.981 ton/fed during two experimental seasons. On the other hand, the lowest results of total yield were obtained with irrigation regime from 60 % of ET_o and without bio-stimulants application (4.158 and 3.683 ton/fed during first and second seasons, respectively. The obtained results could be attributed to humic increase nutrient uptake influenced root system development followed by an increment in some growth parameters e.g. plant height, number of leaves, cloves number, cloves weight that it would be effective in enhancement the bulbing ratio and total yield (Mohsen et al., 2017; Gaviola and Lipinski, 2008). Moreover, humic was found to promote soil water holding capacity and reduce watering requirements for plants (MacCarthy et al., 2001).

Table (6) Garlic bulbing ratio, total yield and irrigation water use efficiency (IWUE) as affected by irrigation level and bio-stimulants during two seasons of 2015/2016 and 2016/2017.

Treatments		**Bulbing ratio (%)**		**Total Yield (ton/fed)**		**Irrigation water use efficiency**	
Irrigation Level (A)	**Bio-Stimulants (B)**	**2015/ 2016**	**2016/ 2017**	**2015/ 2016**	**2016/ 2017**	**2015/ 2016**	**2016/ 2017**
%100 of ET_o	Control	23.58	23.78	6.723	5.891	2.79	2.28
	Yeast (Y)	22.53	22.27	7.077	6.288	2.94	2.43
	Humic (H)	21.61	22.05	8.085	6.981	3.36	2.70
	Y+H	23.06	22.55	7.636	6.288	3.17	2.43
Mean		**22.70**	**22.66**	**7.380**	**6.362**	**3.06**	**2.46**
%80 of ET_o	Control	21.15	21.86	5.491	4.715	2.85	2.28
	Yeast (Y)	20.40	20.51	5.963	5.446	3.09	2.63
	Humic (H)	20.62	20.01	6.447	5.510	3.35	2.66
	Y+H	21.02	20.66	6.107	5.636	3.17	2.72
Mean		**20.80**	**20.76**	**6.002**	**5.327**	**3.11**	**2.57**
%60 of ET_o	Control	19.90	20.82	4.158	3.683	2.88	2.37
	Yeast (Y)	19.74	19.27	5.592	4.928	3.87	3.18
	Humic (H)	19.09	18.80	6.380	5.610	4.41	3.61
	Y+H	19.92	20.10	5.639	5.000	3.90	3.22
Mean		**19.66**	**19.75**	**5.442**	**4.805**	**3.76**	**3.10**
Over all Mean of B	Control	**21.54**	**22.15**	**5.457**	**4.763**	**2.84**	**2.31**
	Yeast (Y)	**20.89**	**20.69**	**6.211**	**5.554**	**3.30**	**2.75**
	Humic (H)	**20.44**	**20.29**	**6.971**	**6.034**	**3.70**	**2.99**
	Y+H	**21.33**	**21.10**	**6.460**	**5.641**	**3.41**	**2.79**
LSD 0.05	A	0.827	0.566	0.277	0.586	0.162	0.322
	B	0.654	0.716	0.348	0.254	0.207	0.128
	A×B	N.S	N.S	N.S	0.441	0.358	0.222

ET_o = Reference Evapotranspiration

Irrigation water use efficiency (IWUE):-

Irrigation water used efficiency is defined as yield per unit of irrigation water applied of grown plants, and is expressed as kg / m^3 in the current study. Irrigation water use efficiency for garlic total yield (Marketable yield) was obtained from the garlic total yield (kg/fed) values divided by the values of irrigation water applied (m^3/ fed.). The results were illustrated in table 6. The results show that IWUE rates varied between 2.79 and 2.28 kg/m^3 at control under irrigation with 100% ETo, while the highest (4.41 and 3.61 kg/m^3) values were obtained at application potassium humate under irrigation with 80 % ETo, in the first and second seasons, respectively. Application of potassium humate increased irrigation water used efficiency at different levels of irrigation water. Ati et al. (2013) reported that, irrigation water use efficiency (IWUE) values for potato increased with application potassium humate. These obtained trends are in general agreement with those reported by Abd-All et al. (2017).

CONCLUSION

Water requirements for garlic crops under drip irrigation system in Assiut governorate as average of two seasons were 2498 m^3/fed. Bio-stimulants especially humic can increase and improve yield and quality of garlic and saving irrigation water.

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تأثير الري والمحفزات الحيوية على إنتاجية وجودة الثوم (*Allium sativum* L) بالأراضي الجيرية

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استهدفت هذه الدراسة تحسين إنتاجية الثوم المزروع بالأراضي الرملية الجيرية بمحطة بحوث عرب العوامر الزراعية بمحافظة أسيوط من خلال استخدام المحفزات الحيوية والمستوى الأمثل للري تحت نظام الري بالتنقيط، لذلك الغرض صممت تجربتين حقليتين في تصميم قطع منشقة مرة واحدة خلال الموسمين الشتويين لعام ٢٠١٦/٢٠١٥م و ٢٠١٧/٢٠١٦م لدراسة تأثير مستويات مختلفة من الري بالتنقيط (الري بكمية مياه تعادل ١٠٠ % و ٨٠ % و ٦٠ % من البخر نتح المرجعي) كعامل رئيسي و إضافة المحفزات الحيوية (بدون إضافة - إضافة هيومات بوتاسيوم بمعدل ٤ كجم /فدان- إضافة مستخلص الخميرة الجافة النشطة ٥جم/لتر و إضافتهما معا) كعامل فرعى، على إنتاجية وجودة الثوم (الصنف البلدي).ويمكن تلخيص أهم النتائج المتحصل عليها كما يلي:- حدثت زيادة معنوية في محصول الثوم و مكونات المحصول عند الري بمعدل ١٠٠% من البخر نتح المرجعي مقارنة بالري بمعدل ٨٠% و ٦٠ % من البخر نتح المرجعي وذلك خلال الموسمين. من الناحية الأخرى فان جميع محفزات النمو قد أدت إلى زيادة معنوية في المحصول ومكوناته مقارنة بالكنترول. أدت إضافة هيومات البوتاسيوم إلى الحصول على اعلي قياسات في المحصول ومكوناته مقارنة بالكنترول. أدت إضافة هيومات البوتاسيوم مع الري بكمية مياه تعادل ١٠٠% من البخر نتح المرجعي إلى الحصول على اعلي قياسات في النمو ومحصول الثوم وجودته.