INFLUENCE OF IRRIGATION WATER QUANTITY AND BIO-FERTILIZER ON CAULIFLOWER PRODUCTIVITY IN SANDY CALCAREOUS SOIL

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ABSTRACT:

Water stress adversely affects plant productivity. Plant growth and curd production of cauliflower are limited under water stress. Hence, this research was an attempt to determine the effect of water regimes on cauliflower yield, enhance the productivity in the sandy calcareous soils by using active dry yeast extract or potassium humate and maximize of the water unite production. The cauliflower plants have shown varying responses against water regimes, which was irrigation with 80% of Reference Evapotranspiration (ET_o) gives the highest values for all studied parameters. Moreover, soil applications of active dry yeast extract or potassium humate had the greatest stimulation effect on plant growth characters under different irrigation regimes (100%, 80% and 60% of ET_o) in compared with control. The results of the interaction revealed that the second irrigation (80% of ET_o) plus adding active dry yeast extract or potassium humate to soil recorded the largest curd diameter, biggest curd weight, and also the highest total yield of cauliflower during 2014/2015 and 2015/2016 seasons, respectively.

Keywords: Sandy soil, Drip Irrigation system, Humic, Yeast extract.

INTRODUCTION

Vegetables are considered cash crops, significant contributors to farmer’s income and very important foods for human nutrition. Cauliflower is one of the popular winter season vegetable grown throughout the world. The edible curd is a rich source of protein, minerals and vitamins, which protects human from certain cancers and heart diseases (Keck, 2004).

Cauliflower growth and productivity is controlled by genetic constitution, nutrients, planting time and by several environmental factors (Arora et al., 2002; Saruhan *et al.,* 2012; Chatterjee and Mahanta, 2013). Among the most common environmental stresses to affect plant growth and influence crop quality and productivity is water deficit (Jones, 2009). Water stress in plants is characterized by continuous water loss through transpiration into the atmosphere and by decreased water uptake resulting from reduced soil moisture (Barbara *et al.,* 2014). Moreover, climatic model predict that global warming will further escalate drought as a result of increasing evapotranspiration (Obidiegwu *et al.,* 2015). In addition, due to the limited areas of the Nile Valley and the competition of the main crops, increasing the cultivated area should be done in the reclaimed land. But most of newly reclaimed soil was sandy or sandy calcareous soils that’s occur naturally in arid and semi-arid regions because of relativity little leaching. They also occur in humid and semi arid zones if their parent material is rich in $CaCO_3$, such as lime stone, shells, and the parent material is relativity young and has undergone little weathering (Brody and weil, 1999) .Calcareous soils cover more than 30% of the earth surface, and their $CaCO_3$ content varies from a few percent to 95% (Marschner, 1995). El-Damaty *et al.* (1973) proposed 8-10% CaCO3 as limit for defining calcareous. In Egypt, about 25-30% of the total area was a calcareous soil (Abu-Elela, 2002).

Therefore, many efforts are needed to develop strategies for enhancing plant resistance to drought stress. Increased fertilization or improved plant nutrition resulting in increase drought resistance or yield when crops were exposed to varying periods of water stress. Bio-fertilizer can promote plant growth, modulate plant development, enhance yield characteristics and increase crop tolerance to abiotic stress. Humic and yeast extract are known to improve plant nutrition and can stimulate growth and yield of plants grown under well-watered conditions as well as under water stress. Understanding of the interaction between the crop yield and water application, and the influence of irrigation regime and bio-fertilizer are needed for best irrigation management.

Consequently, the presented work aimed to quantify the influence of water stress on the cauliflower productivity, to study the effect of different irrigation levels combined with potassium humate and active dry yeast extract on yield and its components as well as water use efficiency.

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 2014/2015 and 2015/2016 to detect the production and quality of cauliflower seedlings (*Brassica oleraceae* var. Kasper L.) as influenced by irrigation level and bio-fertilizer. 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).

Cauliflower transplanting

In both experiments, 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-fertilizer (active dry yeast extract 5g/L, potassium humate 4 kg/fed and active dry yeast extract plus potassium humate) were assigned in sub-plot.

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

Parameters / Month	Temperature (°C)		Relative Humidity%	Wind Speed km/day	Sunshine hours	ET_o mm
	Max	Min				
2014/2015						
November	26.6	12.3	45.0	283.2	9.4	3.50
December	23.2	8.5	48.4	345.6	9.0	3.15
January	20.5	5.5	44.0	383.8	8.9	3.25
February	22.7	7.6	38.8	393.6	9.7	4.11
2015/2016						
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

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

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). Cauliflower seedlings of Kasper cultivar were selected for uniformity in size and healthy seedling and were sown on one side of each dripper line at 60 cm apart between cauliflower seedlings. Seedlings were transplanted at second week of November in the first and second seasons. Common cultural practices were used for the cauliflower production such as fertilization, weed and pest control were accomplished according to recommended practices for cauliflower in the commercial fields. The last irrigated of cauliflower plants were in the last week of February in both of seasons and cauliflower plants were harvested at the first of March 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.

Potassium humate 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 15 days from transplanting cauliflower seedlings 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 15 days from transplanting cauliflower seedlings in both seasons and was repeated three times later with two weeks in between.

Measurements of yield and yield components

Cauliflower heads were harvested at 105 and 109 days after transplanting in winter season of 2014/2015 and 2015/2016, respectively. Data of plant length (cm), number of leaves, weight of above ground biomass (g), straw weight, curd diameter (cm), curd weight (g), curd/above ground biomass ratio, and total yield/feddan (kg) were recorded.

After estimated the actual total irrigation water were applied the irrigation water use efficiency (IWUE) was calculated as follow:

$$IWUE = \frac{Total\ yield\,(Kg\ /\ fed.)}{Irrigation\ water\ Applied\,(m^3\ /\ fed.)}$$

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:

Plant length (cm)

The analysis of variance for plant length of cauliflower confirmed that irrigation regime, bio-fertilizer treatments, and their interaction have significant effects on plant length ($p<0.05$) in both seasons. Results illustrated that irrigated plants with 80% of ET_o recorded the longest plant length in compare with 100% and 60% of ET_o, which were 40.0 cm and 35.0 cm in two seasons, respectively (Table 3).

Moreover, bio-fertilizer treatments under study differed significantly in plant length during both seasons. The tallest plants were observed when treated plants by active dry yeast extract (38.4 cm and 34.7 cm during 2014/2015 and 2015/2016, respectively), which was no significant difference with potassium humate during two seasons.

Regarding the interaction between treatments, results presented in Table (3) indicated that under irrigation with 80% of ET_o and soil application with active dry yeast extract plus potassium humate in the 1st season or active dry yeast extract in the 2nd season recorded the highest values for plant length trait (41.0 cm and 38.0 cm, respectively). However, the shortest plants (33.5 cm and 29.5 cm) were recorded with the control under water irrigation with 60% of ET_o in first and second seasons, respectively.

Number of leaves

Means of leaves number for cauliflower plants as affected by irrigation regimes and bio-fertilizer treatments as well as their interaction in two seasons are presented in Table (3).

Regarding to irrigation treatments, the maximum number of leaves (24 and 21.3) was observed with 80% of ET_o followed by ET_o 60% (23.9 and 21.1) and 100% of ET_o (22.8 and 20.4) in both seasons, respectively. Moreover, the results of bio-fertilizer effects were significantly with untreated treatments. The highest leaves number was given by soil application with potassium humate during 2014/2015 and 2015/2016 seasons (23.9 and 21.3, respectively), which was no significant difference with active dry yeast extract during two seasons.

In addition, mentioned data in Table (3) revealed that there was no significant difference for the interaction between the different irrigation regimes and bio-fertilizer treatments during experiment seasons.

Curd diameter (cm)

The results in Table (4) indicated that irrigation regimes and bio-fertilizer have significant effect on curd diameter of cauliflower. Among all irrigation regimes, curd diameter was increased when the plants were irrigated with 80% of ET_o during two seasons (36.4 and 34.6 cm, respectively).

Regarding to the influences of bio-fertilizer, soil application with different bio-fertilizer increased curd diameter as compared to control (Table 4).

Table (3) Plant length and number of leaves per plant as affected by irrigation level and bio-fertilizer during two seasons of 2014/2015 and 2015/2016.

Treatments		Plant Length (cm)		No of Leaves Per Plant	
Irrigation Level (A)	**Bio-Fertilizer (B)**	**2014/2015**	**2015/2016**	**2014/2015**	**2015/2016**
%100 of ET_o	Control	36.3	33.6	22.0	19.9
	Yeast (Y)	38.4	34.2	22.9	20.4
	Humic (H)	36.5	35.2	23.3	20.9
	Y+H	36.6	35.5	22.9	20.4
Mean		**36.9**	**34.6**	**22.8**	**20.4**
%80 of ET_o	Control	39.2	32.3	23.7	20.8
	Yeast (Y)	39.3	38.0	23.8	21.6
	Humic (H)	40.7	34.8	24.3	21.9
	Y+H	41.0	35.1	24.2	21.2
Mean		**40.0**	**35.0**	**24.0**	**21.3**
%60 of ET_o	Control	33.5	29.5	22.4	20.2
	Yeast (Y)	37.5	32.0	24.3	21.8
	Humic (H)	36.8	29.4	24.3	21.3
	Y+H	36.1	30.5	24.5	21.3
Mean		**36.0**	**30.4**	**23.9**	**21.1**
Over all Mean of B	Control	**36.3**	**31.8**	**22.7**	**20.3**
	Yeast (Y)	**38.4**	**34.7**	**23.7**	**21.2**
	Humic (H)	**38.0**	**33.1**	**23.9**	**21.3**
	Y+H	**37.9**	**33.7**	**23.9**	**20.9**
LSD 0.05	A	1.18	0.58	0.34	0.38
	B	0.44	1.11	0.63	0.64
	A×B	0.76	1.93	N.S	N.S

ET_o = Reference Evapotranspiration

The maximum curd diameter was obtained with application of active dry yeast extract (34.4 cm and 32.3 cm, respectively) and or potassium humate (34.4 cm and 31.7 cm, respectively) in two experiment seasons.

The interaction effects of irrigation regimes and difference bio-fertilizer were not significantly differing in the first season. However, during the 2nd season, the interaction had significant effect on curd diameter. The widest cauliflower curd was recorded in the second season with soil application of active dry yeast extract under irrigation regime of ET_o 80% (37.7 cm).

Curd weight (g)

Analysis of variance showed that irrigation levels and bio-fertilizer treatments had significant effect on curd weight (Table 4). Whilst, the interaction of the two factors was found not significant for curd weight in the 2014/2015, but was significant in the second season. Plants under less water (80% of ET_o) gave the maximum average curd weight, which were 1233.1 g and 1080.9 g in both seasons, respectively.

Table (4) Cauliflower curd diameter (cm) and curd weight (g) as affected by irrigation level and bio-fertilizer during two seasons of 2014/2015 and 2015/2016.

Treatments		Curd Diameter (cm)		Curd Weight (g)	
Irrigation Level (A)	**Bio- Fertilizer (B)**	**2014/2015**	**2015/2016**	**2014/2015**	**2015/2016**
%100 of ET_o	Control	30.1	29.9	748.3	840.4
	Yeast (Y)	34.0	30.8	907.1	890.1
	Humic (H)	33.7	33.2	928.8	971.6
	Y+H	33.8	31.0	942.3	914.6
Mean		**32.9**	**31.2**	**881.6**	**904.2**
%80 of ET_o	Control	35.0	31.5	1084.0	914.9
	Yeast (Y)	36.9	37.7	1262.8	1204.7
	Humic (H)	36.9	34.7	1317.6	1098.6
	Y+H	36.9	34.7	1268.1	1105.2
Mean		**36.4**	**34.6**	**1233.1**	**1080.9**
%60 of ET_o	Control	31.3	25.1	811.8	651.0
	Yeast (Y)	32.3	28.6	900.6	847.7
	Humic (H)	32.6	27.4	886.8	768.6
	Y+H	31.9	27.3	896.8	770.1
Mean		**32.0**	**27.1**	**874.0**	**759.3**
Over all Mean of B	Control	**32.1**	**28.9**	**881.4**	**802.1**
	Yeast (Y)	**34.4**	**32.3**	**1023.5**	**980.8**
	Humic (H)	**34.4**	**31.7**	**1044.4**	**946.3**
	Y+H	**34.2**	**31.0**	**1035.7**	**930.0**
LSD 0.05	A	1.27	0.828	64.77	43.310
	B	1.15	1.054	44.04	37.638
	A×B	N.S	1.826	N.S	65.191

ET_o = Reference Evapotranspiration

Furthermore, mentioned data in Table (4) regarding the bio-fertilizer effects on the curd weight were in the same trend with previous parameters. The minimum curd weight (881.4 g and 802.1 g in 2014/2015 and 2015/2016, respectively) during both seasons was observed with untreated treatment (control). The heaviest cauliflower curd was recorded with potassium humate (1044.4 g) in the 1st season. However, in the second season, active dry yeast extract recorded 980.8 g for curd weight. Meanwhile, yeast extract and potassium humate were not significant differ from each other in both seasons.

Irrigation regimes and bio-fertilizer interaction were significant in the 2^{nd} season but was not in the 1^{st} seasons. Yeast extract recorded 1204.7 g for cauliflower curd weight in the second season.

Weight of above ground biomass (g)

The influences of water treatments, soil application with bio-fertilizer and their interaction on biomass weight of above ground per plant are summarized in Table (5). The stem leaves and curd increased with decreasing water quantity to 80% of ET_o. The higher biomass for above ground part was 2044.0 g and 1765.5 g in both seasons, respectively. However, for 100% of ET_o was 1523.0 g and 1472.1 g and for 60% of ET_o was 1463.9 g and 1316.6 g in the two seasons of the study, respectively.

Table (5) Cauliflower weight of above ground biomass per plant (g) and straw weight per plant (g) as affected by irrigation level and bio-fertilizer during two seasons of 2014/2015 and 2015/2016.

Treatments		Weight of Above Ground Biomass (g)		Straw Weight Per Plant (g)	
Irrigation Level (A)	**Bio-Fertilizer (B)**	**2014/2015**	**2015/2016**	**2014/2015**	**2015/2016**
%100 of ET_o	Control	1354.9	1379.9	606.6	539.5
	Yeast (Y)	1563.1	1455.8	656.0	565.7
	Humic (H)	1625.9	1553.7	697.1	582.1
	Y+H	1548.2	1498.8	605.9	584.2
Mean		**1523.0**	**1472.1**	**641.4**	**567.9**
%80 of ET_o	Control	1878.5	1500.7	794.5	585.7
	Yeast (Y)	2069.9	1965.2	807.2	760.6
	Humic (H)	2138.7	1789.0	821.1	690.4
	Y+H	2089.0	1807.1	820.9	701.9
Mean		**2044.0**	**1765.5**	**810.9**	**684.6**
%60 of ET_o	Control	1342.5	1176.5	530.8	525.5
	Yeast (Y)	1505.3	1426.0	604.7	578.3
	Humic (H)	1538.8	1327.0	652.0	558.4
	Y+H	1469.2	1336.8	572.4	566.7
Mean		**1463.9**	**1316.6**	**590.0**	**557.2**
Over all Mean of B	Control	**1525.3**	**1352.3**	**643.9**	**550.2**
	Yeast (Y)	**1712.8**	**1615.7**	**689.3**	**634.9**
	Humic (H)	**1767.8**	**1556.6**	**723.4**	**610.3**
	Y+H	**1702.1**	**1547.6**	**666.4**	**617.6**
LSD 0.05	A	83.03	75.909	39.54	45.463
	B	72.42	61.670	48.15	36.809
	A×B	N.S	106.82	N.S	N.S

ET_o = Reference Evapotranspiration

Furthermore, there was significant difference between bio-fertilizer substance and control. The lower weight of above ground biomass in the control treatment was 1525.3 g and 1352.3 g for 2014/2015 and 2015/2016 seasons, respectively. However, potassium humate in the 1st season and active dry yeast extract in the 2nd season recorded the higher biomass weight of above ground per plant (1767.8 g and 1615.7, respectively), which was no significant differ between each other in both seasons.

In the case of the interaction, during first season no significant results between irrigation regimes and bio-fertilizer treatments. However, the interaction recorded significant difference regarding the weight of above ground biomass per plants in the second season. Soil application with active dry yeast extract under irrigation with 80% of ET_o recorded the highest value of above ground biomass weight per plant, which were 1965.2 g.

Straw Weight (g)

Results illustrated in Table (5) showed significant straw weight per plant (g) regarding various irrigation regimes and bio-fertilizer treatments but no significant differ for their interaction. Among three added water quantity, watering plants with 80% of ET_o recorded higher straw weight per plant (810.9 g and 684.6 g during 2014/2015 and 2015/2016, respectively).

In addition, over all bio-fertilizer application increased the weight of straw per plant significantly in compare to control in both season. In 2014/2015 season, potassium humate recorded the maximum straw weight (723.4 g/plant). However, in the 2nd season, active dry yeast extract showed the highest value (634.9 g/plant), which was no significant differ between them in both seasons.

The effect of the interaction between irrigation water levels and bio-fertilizer treatments was not significant during two experiment seasons.

Curd/Weight of above ground biomass ratio

The presented results in Table (6) showed that less irrigation (80% of ET_o) caused increase in this trait, which highest percentage was 60.28% and 61.22 in 2014/2015 and 2015/2016 seasons, respectively. This result was significantly in the second season but was not in the first season. In contrast, the bio-fertilizer effect was significant in the 1st season but was not in the 2nd season. Where, soil application with active dry yeast extract or potassium humate gave the maximum percentage of curd/above ground biomass (60.64% and 60.63%, respectively).

Regarding the interaction effect between experiment factors, the results were in the same trend with the bio-fertilizer effect. Which were significant in the 2014/2015 season but was not in 2015/2016 season. The highest curd/ above ground biomass ratio (61.62 %) in the 1st season was recorded when soil was treated with potassium humate under irrigation regime 80% of ET_o.

Table (6) Cauliflower curd/ Weight of above ground biomass ratio (%) and total straw yield (ton/fed) as affected by irrigation level and bio-fertilizer during two seasons of 2014/2015 and 2015/2016.

Treatments		Curd/Weight of Above Ground Biomass Ratio (%)		Straw Yield (Ton/Fed)	
Irrigation Level (A)	**Bio- Fertilizer (B)**	**2014/2015**	**2015/2016**	**2014/2015**	**2015/2016**
%100 of ET_o	Control	55.27	60.93	8.322	7.401
	Yeast (Y)	58.03	61.12	9.000	7.761
	Humic (H)	57.12	62.54	9.564	7.987
	Y+H	60.85	61.03	8.313	8.016
Mean		**57.82**	**61.40**	**8.800**	**7.791**
%80 of ET_o	Control	57.72	60.97	10.901	8.036
	Yeast (Y)	61.00	61.32	11.074	10.435
	Humic (H)	61.62	61.42	11.265	9.472
	Y+H	60.76	61.16	11.263	9.630
Mean		**60.28**	**61.22**	**11.126**	**9.393**
%60 of ET_o	Control	60.49	55.31	7.282	7.210
	Yeast (Y)	59.90	59.48	8.296	7.934
	Humic (H)	57.53	57.92	8.945	7.661
	Y+H	61.01	57.65	7.854	7.774
Mean		**59.73**	**57.59**	**8.094**	**7.645**
Over all Mean of B	Control	**57.83**	**59.07**	**8.835**	**7.549**
	Yeast (Y)	**59.65**	**60.64**	**9.457**	**8.710**
	Humic (H)	**58.76**	**60.63**	**9.925**	**8.373**
	Y+H	**60.88**	**59.95**	**9.143**	**8.473**
LSD 0.05	A	N.S	1.545	0.5426	0.6237
	B	1.716	N.S	0.6606	0.5048
	A×B	2.972	N.S	N.S	N.S

ET_0 = Reference Evapotranspiration

Straw yield

Nowadays, total straw yield is an important parameters because the compost industry. Results from Table (6) revealed that cauliflower plants were significantly affected on total straw yield (ton/fed) by irrigation regimes and bio-fertilizer treatments in 2014/2015 and 2015/2016.

As for the effect of irrigation regimes, results indicated that 80% of ET_0 recorded the biggest straw yield (11.126 and 9.393 ton/fed during 1^{st} and 2^{nd} seasons, respectively). Total straw yield was increased by bio-fertilizer soil application significantly. Where, in first season, soil application by potassium humate gave the maximum straw yield (9.925 to/fed). However, the highest value of total straw yield (8.710 ton/fed) during second seasons was recorded by applying active dry yeast extract to the soil, which was no significant differ between them in both seasons.

In the respect of the interaction effect between irrigation regimes and bio-fertilizer treatments was not significant on the trait of total straw yield during both seasons of the experiment.

Total yield

Curd total yield is the result of the effect of experiment factors and their interaction on the different growth parameters e.g. plant length, leaves number, curd diameter, and curd weight. Consequently, the total yield of cauliflower per fed was in the same trend with previous mentioned parameters. Where, the highest curd yield (16.918 and 14.830 ton/fed in both seasons, respectively) was obtained under irrigation water with 80% of ET_o during 2014/2015 and 2015/2016, followed by 100% of ET_o (12.096 and 12.405 ton/fed during 1st and 2nd seasons, respectively) and then 60% of ET_o (11.991 and 10.418 ton/fed in two seasons, respectively). Furthermore, soil application by bio-fertilizer increased total curd yield as compared with untreated plots (control). Similarly, potassium humate application recorded the heaviest total yield during the first season (14.329 ton/fed), while active dry yeast recorded the heaviest total yield during the second season (13.457 ton/fed) which was no significant differ between them in both seasons.

The interaction effect was also in the same trend with curd diameter and weight. Which were significant differ in the 2nd season but was not in the 1st season. Active dry yeast extract showed the maximum total yield (16.528 ton/fed) in second season of the experiment.

Irrigation water applied

The seasonal irrigation water applied values for cauliflower crop were greatly affected by the regimes of drip irrigation (100%, 80% and 60% of reference evapotranspiration ET_o). The irrigation water applied was found to be 1750.8, 1400.7 and 1050.5 m^3/fed for 100 %, 80 % and 60 % ET_o, respectively in the first season (2014/2015). And were 1813.8, 1451.0 and 1088.3 m^3/fed for 100 %, 80 % and 60 % ET_o, respectively in the second season (2015/2016).

Crop evapotranspiration (ETc).

Crop evapotranspiration refers to the amount of water that is lost through evapotranspiration. Crop coefficients (Kc) was used to determination the crop evapotranspiration as follows from this equation (FAO, 1979),

$ETc = Kc \times ET_o$

Where:-

ETc = Crop evapotranspiration (mm),

Kc = crop coefficient,

ET_o = reference evapotranspiration (mm).

Table (7) Cauliflower total yield (ton/fed) and irrigation water use efficiency (IWUE) as affected by irrigation level and bio-fertilizer during two seasons of 2014/2015 and 2015/2016.

Treatments		**Total Yield (ton/fed)**		**Irrigation Water Use Efficiency (IWUE)**	
Irrigation Level (A)	**Bio- Fertilizer (B)**	**2014/2015**	**2015/2016**	**2014/2015**	**2015/2016**
%100 of ET_o	Control	10.267	11.531	10.62	10.44
	Yeast (Y)	12.445	12.212	12.25	11.01
	Humic (H)	12.744	13.331	12.74	11.75
	Y+H	12.928	12.548	12.13	11.34
Mean		**12.096**	**12.405**	**11.94**	**11.13**
%80 of ET_o	Control	14.872	12.553	18.40	14.19
	Yeast (Y)	17.325	16.528	20.28	18.58
	Humic (H)	18.077	15.073	20.95	16.92
	Y+H	17.398	15.164	20.46	17.09
Mean		**16.918**	**14.830**	**20.02**	**16.69**
%60 of ET_o	Control	11.137	8.931	17.53	14.83
	Yeast (Y)	12.356	11.630	19.66	17.98
	Humic (H)	12.166	10.546	20.10	16.73
	Y+H	12.303	10.566	19.19	16.85
Mean		**11.991**	**10.418**	**19.12**	**16.60**
Over all Mean of B	Control	**12.092**	**11.005**	**15.52**	**13.15**
	Yeast (Y)	**14.042**	**13.457**	**17.39**	**15.86**
	Humic (H)	**14.329**	**12.983**	**17.93**	**15.13**
	Y+H	**14.210**	**12.759**	**17.26**	**15.09**
LSD 0.05	A	0.8885	0.5942	0.786	0.682
	B	0.6042	0.5164	0.852	0.707
	A×B	N.S	0.8945	N.S	1.224

ET_0 = Reference Evapotranspiration

The total value of ETc for cauliflower was 322.1 mm in the first growing season and 367.1 mm in the second growing season as calculated from Penman Monteith, equation,

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 cauliflower was obtained from the total yield values divided by the values of irrigation water applied (m^3/fed.). The results were illustrated in table 7. The results show that IWUE rates varied between 10.62 and 10.44 kg/m^3 at control under irrigation with 100% ET_o, while the highest (20.95 and 18.58 kg/m^3) values were obtained at application potassium humate in the first season and yeast extract in the second season under irrigation with 80% ET_o, in the first and second seasons, respectively.

DISCUSSION

Crop performance and optimization of crop management under limited water supply conditions and in the newly reclaimed soils, which the soil is characterized by low organic matter and especially nearly 30% of the total area is calcareous soils, are requires to understand.

The above mentioned results of evaluation of bio-fertilizer (active dry yeast extract and potassium humate) under various irrigation regimes on cauliflower growth and yield indicated that soil application of active dry yeast extract or by potassium humate under less water (80% of ET_o) leads to increase the studied parameters. Ana-Maria Seciu *et al.* (2016) obtained similar results that developed newly bio-stimulant composition and resulted in increasing water stress tolerance of cauliflower crop. In addition, Sarhan *et al.* (2011) reported that humic acid and bread yeast was highly improved the growth and yield traits of eggplant. Also, Hammad and Ali (2014) recommended that application of natural substance could be led to overcome the deleterious effects of drought and consequently resulted in improved the productivity of wheat and its grain quality.

This increase in growth parameters may be attributed to that yeast contains macro and micro-nutrition; also, it has growth regulators and vitamins or may be due to that yeast stimulates the plant to build up dry matters (Soha and Ezzat, 2010). This also was in agreement with Shehata *et al.* (2012), who reported that yeast is a source of phytohormones and has a stimulatory effect on the cell division and amplification, protein and nucleic acids synthesis, chlorophyll formation and protective mechanism against various stresses. Furthermore, El-Tohamy *et al.* (2015) concluded that the application of yeast extract as an environmentally-safe method could be improve water status and subsequently had positive effects on growth, productivity and quality of sweet potatoes under sandy soil conditions. In agreement with our results, Agamy *et al.* (2013) indicated that growth parameters of sugar beet plants were significantly enhanced by application of yeast.

Regarding to the potassium humate effects, humic compounds can improve microelements absorption, enhance photosynthesis and root development (Shahid *et al.*, 2012 and Zhang, 2006). In addition, humic substances can affect the physiological processes of plant growth indirectly and directly. They provide minerals, increase the microorganism population, provide biochemical substances, and carry trace elements and growth regulators (Yang 2004). The potassium humate derived from lignite brown coal, which is aromatic in nature and contains plenty of carboxylic and phenolic groups, provides favorable conditions for chemical reactions, biological activity and increase pH buffering, improves physical structure of soil and accelerate transport of nutrients to plants (Amjad, 2010).

CONCLUSION

In conclusion, water requirements for cauliflower crops under drip irrigation in Assiut governorate as average of two seasons were 1425.8 m^3/fed that gives the highest yield. The results indicate that soil application with bio-fertilizer, active dry yeast extract or potassium humate, had a positive effect under different irrigation regimes.

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تأثير كمية مياه الري والمخصبات الحيوية على إنتاجية القنبيط بالأراضي الرملية الجيرية.

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الإجهاد المائي يؤثر سلبا علي إنتاجية النبات. نمو النبات و إنتاجية أقراص القنبيط محدودة تحت الإجهاد المائي. و لذلك، هذا البحث كان محاولة لتحديد تأثير نظم ري على محصول القنبيط، و زيادة الإنتاجية في الأراضي الرملية الجيرية بإستخدام هيومات البوتاسيوم و مستخلص الخميرة و زيادة إنتاجية وحدة المياه. قد أظهرت نباتات القنبيط استجابة متفاوتة مع أنظمة المياه، حيث كان الري ب ٨٠% من البخر نتح المرجعي يعطي أعلى القيم لجميع الصفات المدروسة. علاوة على ذلك، كان لمعاملة التربة بهيومات البوتاسيوم أو مستخلص الخميرة التأثير التحفيزي الأكبر على صفات النمو تحت أنظمة الري المختلفة (١٠٠%، ٨٠% و ٦٠% من بخر نتح المرجعي) بالمقارنة بمعاملة المقارنة. تشير نتائج تأثير التداخل أن نظام الري الثاني (٨٠% من بخر نتح المرجعي) مع إضافة مستخلص الخميرة أو هيومات البوتاسيوم للتربة سجلت أكبر قطر و وزن للقرص، و أيضا أعلى محصول من القنبيط خلال موسمي ٢٠١٥/٢٠١٤ و ٢٠١٦/٢٠١٥، على التوالي.