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Effect of Mineral Nitrogen Fertilization and some Organic Materials on Garlic Yield and Soil Fertility under Different Irrigation Intervals

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ABSTRACT

Garlic (*Allium sativum* L.) is one of the most important crops in Egypt due to its high medical and nutritive values which were affected negatively by the excessive use in mineral nitrogen fertilizers and irrigation too. For this purpose, two field experiments were carried out during the successive winter seasons of 2015/2016 and 2016/2017 at a private farm in Besendela Village, Belqas District, Dakahlia Governorate, Egypt (31° 20' 326.7" N and 31° 45' 286.0" E) to assess the effect of mineral N fertilization (at three rates 72, 96, 120 kg N fed^{-1}) and some organic materials (control, 10 m^3 compost and 4 kg potassium-humate "KH" fed^{-1}) under different irrigation intervals (15, 20 and 25 days) on plant growth, yield, quality, nutrients uptake of garlic and soil fertility. Treatments were arranged in Strip-Split Plot Design with three replicates; irrigation treatments in the strip plots; organic materials in the main plots, and rates of nitrogen fertilizer in the split plots. Results demonstrated that, treatments and their interactions improved soil fertility indices (available N, P, K, Fe, Mn and Zn and organic matter content). Besides plant growth characters and its nutrients content, garlic yield and its nutritive values (N, P, K, S, Ca, Fe, Mn and Zn contents) showed significant increase with the application of organic materials and increasing N rates under irrigation intervals. Interactions among treatments had significant effect on most of parameters under study, with superior the interactions impact of the N-rate 96 kg N fed^{-1} either with compost or KH under irrigation every 20 days. For the yield quality; bulbs content of dry matter, sulfur and pungency enhanced with the applications of compost or KH alongside with mineral N fertilization up to 96 kg N fed^{-1}, moreover its content of nitrate was decreased. On the other hand, quality indices declined with increasing the application rate of mineral N fertilizer up to 120 kg N fed^{-1}, and accumulation of nitrate in bulbs increased. It could be concluded that application of compost or KH along with mineral nitrogen fertilizer at the rate of 96 kg N fed^{-1} with irrigation the plants every 20 days had favorable effect on the most studied traits of garlic yield and quality.

Keywords: Nitrogen, compost, potassium-humate, irrigation, soil fertility, garlic yield, quality and nutrients uptake.

INTRODUCTION

Garlic is one of the most important vegetable crops in Egypt and worldwide. Furthermore, Egypt ranks the fourth leading country in the world after China, India and South Korea for garlic production, (FAO, 2012). It is cultivated for both local consumption and export, and it used in the pharmaceutical industry. Garlic had many medical values; such as anti-bacterial, antifungal, anti-cancer, lowering of blood sugar, blood lipids and blood platelet aggregation as well as power supplies; also, it is used as an insecticidal (Alam *et al.,* 2016). So, increasing the productivity of garlic and its quality are of the importance goals which usually depend on many factors including nitrogen fertilization, organic fertilizers and irrigation.

Nitrogen fertilization is considered the most important limiting factor for garlic plant growth, yield and its quality. El-Zohiri and Abdou (2009) stated that increasing the nitrogen fertilizer level from 60 up to 120 kg N fed^{-1} significantly increased plant growth parameters of garlic i.e. plant height, number of leaves, fresh and dry matter of leaves. However, Ahmed *et al.,* (2012) showed that the vegetative growth of garlic plants and its yield were enhanced with increasing the level of nitrogen fertilization up to 200 kg N fed^{-1} on clay loam soil, but the weight loss % of storage yield was increased. Also, Ewais *et al.,* (2016) found that the maximum values of plant growth and garlic bulbs yield (8.980 t. fed^{-1}) were observed with the addition of nitrogen fertilizer at a rate of 150 kg N fed^{-1} with sulfur at the rate of 150 kg S fed^{-1} in sandy soil. In China, By Li Lujiu *et al.,* (2004) and Luji Bo *et al.,* (2016) reported that a high garlic yield (arrange from 7.75 to 15.8 t ha^{-1}) were gained with the addition of 300-375 kg N ha^{-1} (120-150 kg N fed^{-1}) as urea, 90 kg P_2O_5 ha^{-1} (36 kg P_2O_5 fed^{-1}) and 150 kg K_2O ha^{-1} (60 kg K_2O fed^{-1}). In India, Farooqui *et al.,* (2009) and Hore *et al.,* (2014) found that the highest yield of garlic, bulb diameter and number of cloves per bulb were obtained with the nitrogen fertilization at the rates from 200 to 250 kg N ha^{-1} (80-100 kg N fed^{-1}) in combination with 60 kg S ha^{-1} (24 kg fed^{-1}). In Ethiopia, Shiferaw *et al.,* (2014) and Shiferaw (2016) stated that combined applications of 138 kg N+ 40 kg P+ 60 kg S ha^{-1} attained the optimum bulb quality (dry matter, protein, pungency and S content) and the highest garlic contents of N, P, K and S.

However, some previous studies showed that the rapid increase in mineral nitrogen fertilizer use had a negative effect on the quality of garlic yield. El-Gazar *et al*., (2010) and Ahmed *et al.,* (2012) reported that mineral nitrogen fertilization significantly increased the weight loss % of storage garlic yield. Also, Nori *et al.,* (2012) found that increasing the application level of mineral N fertilizer up to 300 kg N ha^{-1} (120 kg N fed^{-1}) increased nitrate accumulation in garlic plants, and this was significant higher with the fed by urea (640 mg $NO3^-$ kg^{-1} dry weight) than ammonium sulfate. Zaki *et al*., (2014) stated that high accumulation of nitrate and nitrite in both garlic cultivars; Balady and Sids-40 was observed at the plants treated with 120 kg N fed^{-1} as mineral nitrogen fertilizer, while treated plants with 15 ton compost+ 60 kg N fed^{-1} decreased these accumulations.

Furthermore, previous studies demonstrated that application of organic fertilizers with inorganic ones became necessary for saving chemical fertilizers and reducing environmental pollution. In this respect, Hassan *et al.,* (2014) found that application of nitrogen at 120 kg N fed^{-1} in the both forms; inorganic and organic fertilizers recorded the highest values of plant growth and yield traits with good quality of garlic. Also, studies demonstrated that application of organic fertilizers decrease the accumulation of nitrate and nitrite in garlic (El-Gazar *et al*., 2010; El-Hifny 2010; Lima and Vianello, 2011; Ahmed *et al.,* 2012; Nori *et al.,* 2012; and Raslan *et al.,* 2015).

Nowadays, a lot of awareness has been offered in order to reduce mineral nitrogen fertilization and increase the quality of yield through the use of potassium-humate *(KH)* or humic acids (HA). KH is the salt of humic acid that resulting of organic matter decomposition. Some previous studies reported that the application of KH enhanced plant growth and the yield; Ahmed *et al.,* (2010) in clay soil demonstrated that soil application of KH at the rate of 5 kg fed^{-1} with 48 kg K_2O fed^{-1} increased the vegetative growth of garlic plant, yield, quality, storability and the bulbs and leaves contents of NPK. Abdel-Razzak and El-Sharkawy (2013) found that twice foliar spray of HA enhanced garlic bulb yield; bulb and clove diameter and bulb dry weight. Also, Zaki *et al*., (2014) stated that the highest values of total yield and bulb diameter were detected with garlic plants treated with 120 kg N fed^{-1} +2 kg KH fed^{-1}, adding with irrigation water in clay loam soil. Furthermore, Denre, *et al.,* (2014) observed that accumulation of mineral nutrition (Ca, Fe, S, Mg, P, Zn, K, Cu and Mn) and pungency in garlic were increased at the plants foliar sprayed with 300 ppm of KH three times. Also, Shafeek *et al.,* (2015) showed that soil addition of KH at a rate of 4 L fed^{-1} with 120 kg N fed^{-1} recorded the highest values of plant growth characters; total bulb yield and increased the percent of protein, N, P and K in garlic bulb.

Irrigation is one of the most important factors affected on growth, yield and quality of garlic. Determination of the suitable time of irrigation plays an important role in garlic yield and its quality. Many studies reported a direct relationship between the yield and its components of bulb crops and available moisture at the time of irrigation (Abo Sedera and Badr 1998; Hanson *et al.,* 2003 and Ortega *et al.,* 2004). In this respect and under field study in clay loam soil, Ahmed, *et al.,* (2009) demonstrate that irrigation of garlic plants once every 15 days followed by irrigation every 20 days were superior than other irrigation intervals (10 and 25 days) to exhibited the highest values of all vegetative growth characters, total garlic bulbs yield (8.743 ton fed^{-1}) and its components including volatile oil and garlic storability.

Therefore, this study aims to evaluate the effect of mineral N fertilization and some organic materials under different irrigation intervals on soil fertility, garlic yield and its quality and nutrients uptake for achieving the suitable treatments which attained the optimum yield with the highest quality under the ecological conditions of Dakahlia Governorate, Egypt.

MATERIALS AND METHODS

Two field experiments were carried out during the successive winter growing seasons of 2015/2016 and 2016/2017 at a private farm in Besendela Village Belqas District, Dakahlia Governorate, Egypt (that located between Latitude 31° 20' 326.7" N and Longitude 31° 45' 286.0" E). The current study aims to assess the impacts of mineral nitrogen fertilization, some organic materials (compost and KH) under different irrigation intervals on soil fertility (available N, P, K, Fe, Mn and Zn, and soil content of organic matter %), plant growth and its uptake of NPK, yield, quality parameters (dry matter, nitrate, pungency and sulfur) and yield contents of N, P, K, S, Ca, Fe, Mn and Zn of garlic grown under previous conditions.

Treatments were arranged in a Strip- Split Plot Design with three replicates; the strip plots were assigned for three intervals of irrigation: 15 (I_1), 20 (I_2) and 25 days (I_3). The main plots were allocated for three treatments of organic materials: control (without addition), compost (10 m^3 fed^{-1}), KH (4 kg potassium humate fed^{-1}). The spilt plots were divided for three rates of mineral nitrogen fertilization: 72 (N_1), 96 (N_2) and 120 kg N fed^{-1} (N_3). The spilt plot area was 9 m^2 (3 lines each one, 0.60 m width x 5 m length).

Samples of soil were taken from surface layer (0-30 cm) of the experiment fields before planting for physical and chemical analysis according to Page, (1982). pH was measured in 1:2.5 soil: water suspension, whereas EC, cations and anions concentrations were determined in soil paste extract (as shown in Table 1).

Table 1. Some physical and chemical properties of experimental soil (average of the two seasons).

Properties	**Particle size distribution (%)**			**Texture class**	**Bulk density (g cm^{-3})**	**SP %**	**O.M %**	**$CaCO_3$ %**	**pH (1:2.5)**
	Sand	**Silt**	**Clay**						
Values	25.73	28.96	45.31	Clay	1.40	70.30	2.08	5.84	8.09

EC (dSm^{-1}), cations and anions (m $mole_c$ L^{-1})

Properties	EC (soil paste ex.)	Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}
Values	3.40	13.0	9.0	11.75	0.25	N.D.	4.3	20.1	9.6

Total % of C, N, P and K, C/N ratio and available nutrients

Properties	Total %				C/N	Available nutrients (mg kg^{-1})								
	C	N	P	K	ratio	N	P	K	Ca	Mg	Fe	Mn	Zn	B
Values	1.21	0.12	0.14	0.21	10.1/1	48	10.2	252	850	192	6.8	5.4	0.85	0.45

Planting and harvesting:

Garlic cloves (cv. Sids-40) were planted on one side of line at a distance of 10 cm on October 1^{th} 2015 and harvested on April 8^{th} 2016 in the 1^{st} season and planted on October 6^{th} 2016 and harvested on April 10^{th} 2017 in the 2^{nd} season. All the recommended field practices for garlic crop were carried out for the two experiments according to the recommendations.

Application of fertilizers and treatments:

Compost manure (animals waste) was applied at the rate of 10 m^3 fed^{-1} with soil preparation before last tillage. Some chemical analyses of compost were carried out according to Page, (1982) as shown in Table 2. pH was measured in 1:10 compost: water suspension, and EC was determined in the extraction.

Table 2. Some properties of the applied compost.

Properties	pH	EC dSm^{-1}	Moisture %	Density ($kg\ m^{-3}$)	O.M %	C/N ratio	% C	% N	% P	% K
Values	7.65	5.12	19.4	600	35.79	14.8:1	20.75	1.40	0.65	0.57

Phosphorus fertilizer was applied to all plots with soil preparation according at the rate of 75 kg P_2O_5 fed^{-1} as single super phosphate (15% P_2O_5). Potassium fertilizer was applied at the rate of 48 kg K_2O fed^{-1} as potassium sulphate (48% K_2O) with 1st irrigation after planting. Nitrogen fertilizer was applied as ammonium nitrate (33.5 % N) at two equal doses with first and second irrigation after planting. KH was applied at the rate of 4 Kg fed^{-1}; it was dissolved in water then applied with irrigation water at 1st irrigation. Some chemical analyses of the applied KH were carried out at the dissolving in water (as shown in Table 3), whereas pH and EC were measured in 1:10 KH: water suspension (Page 1982). Total nitrogen % was determined in the acidic digested (sulphuric and perchloric acids), and total carbon % was determined using the method of Walkly – Black (Page 1982).

Table 3. Chemical analysis of potassium-humate (KH).

Properties	pH (1:10)	EC dSm^{-1}	O.M %	C/N ratio	C %	N %	P_2O_5 %	K_2O %	Fe $mg\ kg^{-1}$	Mn $mg\ kg^{-1}$	Zn $mg\ kg^{-1}$
Values	9.95	12.07	38.92	56.5:1	22.58	0.40	0.31	8.67	680	110	80

Irrigation:

Surface irrigation system in furrows (5 m length) was followed. The treatments of irrigation began after the first irrigation (after 25 days from planting) for all strips which received equal amounts of water. Garlic plants under the 1st irrigation interval (every 15 days) received 10 irrigations, and under 2nd interval irrigation (every 20 days) received 8 irrigations, and then under 3rd interval irrigation (every 25 days) received 6 irrigations. The quantity of water applied for each strip was measured using a water meter attached to the irrigation pump (VITARA; Model: WP30CX; Quantity: 1SET) with time. Water productivity (WP) was calculated as total garlic yield/total water applied ($kg\ m^{-3}$) as an indicator for field water use efficiency.

Soil and plant analysis after 110 days from planting:

Soil and plant Samples from each plot were taken randomly after 110 days from planting; vegetative growth parameters (plant height, leaves number $plant^{-1}$, leaf area, fresh and dry plant weights) were recorded then samples were dried at 70 C° and percentages of N, P and K were determined in the acidic digestion of dry samples according to Chapman and Pratt (1982). Soil samples were air dried and prepared for analysis; total carbon % and the available of N, P, K, Fe, Mn and Zn in soil were determined according to Page (1982).

Plant analysis at harvest:

At harvest stage (after 180 days from planting), plants of each plot area were collected and then left for 15 days in the field to be cured. Garlic yield parameters were recorded after curing (total yield, bulb diameter, average bulb weight, number of cloves $bulb^{-1}$ and average clove weight). Samples of bulbs (ten bulbs) were taken randomly from each plot after curing for garlic quality parameters including dry matter %, nitrate (Singh, 1988) and pungency (determined as a pyruvic acid, Randle and Bussard, 1993) and elemental analysis for N, P, K, S, Ca, Fe, Mn and Zn content Chapman and Pratt (1982). The cloves were cut and oven dried at 70°C then ground. Sub samples (0.5 g) were wet acid digested by sulphuric and perchloric acids as described by Chapman and Pratt (1982) for determination of nitrogen, phosphorus, potassium, calcium, iron, manganese and zinc concentrations and calculation of their uptakes. Sulfur was determined by turbidmetrically method using a spectrophotometer at wave length 420 nm as concentration and uptake (Singh *et al.,* 1999) in the acidic digested samples (1 g of the finely ground dried tissues was wet digested by nitric and perchloric acids) Chapman and Pratt (1982).

Statistical analysis:

The statistical analysis was done according to the method of Gomez and Gomez (1984) and means of treatments were compared against least significant differences test (L.S.D.) at confidence level of 5% and Duncan's multiple comparisons Test for single effects of treatments.

RESULTS AND DISCUSSION

1- Soil fertility indices: -

1-1- Before planting:

Data in Table 1 illustrate the initial status of soil fertility before applying the experimental treatments. It is clear from the results that soil texture was clay; pH was slightly alkaline (8.09) and according to EC value (3.40 dSm^{-1}), soil is considered slightly saline. For soil fertility, it was moderately fertile of available N, P, K and Mg, very high in available Ca, Fe and Mn and low in available Zn and B (Hamissa *et al.,* 1993). Also, soil content of O.M was 2.08 %, and this may be attributed to the residuals of previous crop (rice) before garlic cultivation. For C/N ratio, it seems from its value that it was suitable for N mineralization process, since it was less than 20/1(Mengel and Kirkby, 2001).

1-2- After 110 days from planting:

Data in Table 4 show the effect of studied treatments and their interactions on soil contents of O.M % and available N, P, K, Fe, Mn and Zn as mg kg^{-1} soil. In general soil fertility showed an increase following the application of experimental treatments as compared with soil status before planting (Table 1). Application of mineral nitrogen fertilizer rates up to N_3 significantly affected the available soil contents of N, P, Mn and Zn, but they had insignificant effects on O.M % and the available K and Fe.

Application of organic materials compost or KH significantly improved soil fertility given increment of O.M and the available N, P, K, Fe, Mn and Zn. Furthermore, compost was more effective on maximizing O.M and available N than KH (Table 4). This is mainly attributed to the highest O.M and nutrients content in compost as comparing with KH, whereas the benefit effects of KH in soil occur through several mechanisms; it contains many elements which enhance the soil fertility, increasing the availability of nutrients by holding them on specific surfaces, and improving soil physical, chemical and biological properties and complex metal ions (Serenella *et al.,* 2002; Abd El-Aal *et al.,* 2005 and Abdel-Razzak and El-Sharkawy 2013).

Table 4. Effect of mineral nitrogen fertilization, some organic materials on soil contents of O.M % and the available N, P, K, Fe, Mn and Zn (mg kg^{-1}) under different irrigation intervals after 110 days (average of the two seasons).

Treatments	O.M	The available of nutrients (mg kg^{-1})					
	%	N	P	K	Fe	Mn	Zn
Irrigation (I):							
I_1	1.98	119	14.4	263	8.1	5.2	0.96
I_2	2.22	139	17.6	293	7.9	5.3	1.04
I_3	2.22	109	13.2	255	7.5	5.0	0.88
Organic materials (O):							
Control	2.04	103	12.8	242	7.6	4.9	0.93
Compost	2.22	125	15.7	297	7.9	5.4	1.01
KH	2.16	140	16.7	272	7.9	5.2	0.94
Nitrogen rates (kg N fed^{-1}):							
72 (N_1)	2.16	109	13.6	268	7.85	5.01	0.93
96 (N_2)	2.14	122	15.2	271	7.69	5.05	0.96
120 (N_3)	2.12	136	16.3	269	7.96	5.41	0.99
L.S.D. at 5 %:							
I	0.14	10.3	2.21	3.8	0.40	0.19	NS
O	0.05	5.3	1.38	5.8	0.24	0.15	0.06
N	NS	5.8	1.09	NS	NS	0.14	0.04
N*O	NS	NS	NS	NS	NS	0.24	NS
N*I	0.07	NS	NS	9.2	0.37	0.24	NS
O*I	0.09	9.2	NS	10.0	0.41	0.27	NS
N*O*I	0.13	NS	NS	15.9	0.65	0.41	NS

Also, data in Table 4 demonstrate that soil content of O.M and the available contents of N, P, K, Fe and Mn significantly affected by irrigation at different intervals. Soil contents of available N, P, K, Mn and Zn increased with increasing the period between irrigations up to 20 days (I_2) then decreased under irrigation every 25 days (I_3). However, soil content of available Fe was the highest under irrigation every 15 days (I_1), and this may be attributed to when soil are waterlogged a reduction of Fe^{3+} to Fe^{2+} takes place accompanied by an increased in Fe solubility (Mengel and Kirkby, 2001) which happened under irrigation interval I_1. It is obvious from previous results that irrigating plants every 20 days (I_2) was more favorable for soil fertility.

The interactions of N*O*I significantly affected soil content of O.M and the available of K, Fe and Mn, but had insignificant effect on the available N, P and Zn (Table 4 and Figs. 1, 2 and 3). Yet, the interaction of O*I had significant effect on soil content of O.M % and the available of N, K, Fe and Mn. The interaction of N*I had significant effect on O.M % and the available of K, Fe and Mn. The interaction of N_1*Compost*I_2 had the highest effect on O.M (2.54%) and available K, Mn and Zn (359, 6.6 and 1.13 mg kg^{-1}, respectively), whereas the interaction of N_3*KH*I_2 had the highest effect on available N and P (175 and 24.5 mg kg^{-1}, respectively). So, these pervious mentioned results illustrated the important of compost or KH application for improving soil fertility.

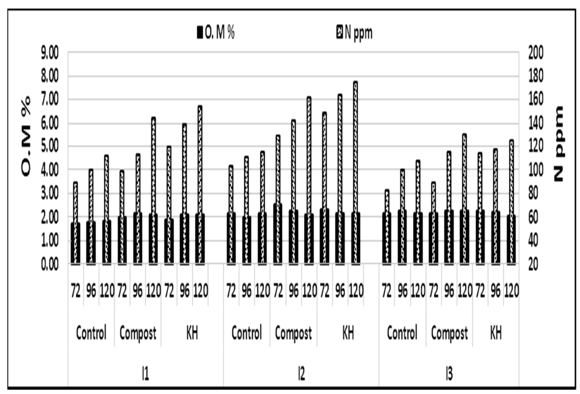

Fig. 1. Effect of interactions on soil O.M % and available N (mg kg^{-1}).

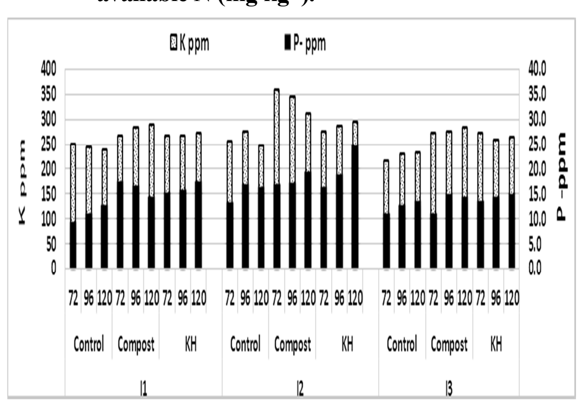

Fig. 2. Effect of interactions on soil available P and K (mg kg^{-1}).

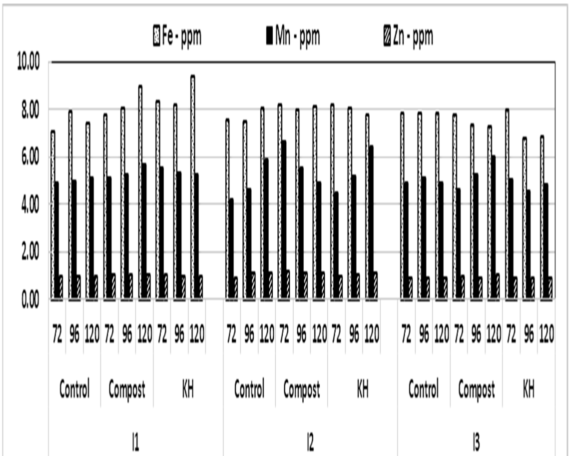

Fig. 3. Effect of interactions on available Fe, Mn and Zn (mg kg^{-1}).

2- Plant growth: -

Increasing the application rate of mineral N fertilizer up to 120 kg N fed^{-1} (N_3) significantly increased plant growth i.e. plant height and fresh weight plant^{-1}, but had insignificant effect on dry weight plant^{-1} (Table 5). The differences between N_2 and N_3 were insignificant for plant fresh and dry weights. The response of plant to the application rate of mineral N fertilizer may be attributed to initial soil content of available before planting which was moderately (Table 1). These results are in accordance with those obtained by El-Zohiri and Abdo (2009) and Ahmed *et al.,* (2010).

Growth of plant (plant height, fresh and dry weights of plant) significantly enhanced with application of organic materials; compost and KH as compared with control, whereas the differences between them were insignificant for plant fresh weight. KH was more effective than compost on maximizing plant height however; compost application was the superior on plant dry weight. This result may be attributed to compost and KH contents of nutrients (Tables 2 and 3), as well as it correlated positively with their impacts on soil fertility (Table 4). KH had content of potassium and growth regulators too; which is the most abundant cation in plants that associated or involved with many physiological processes supporting plant growth and development (Nardi *et al.*, 2002; El-Zohiri and Abdo 2009 and Ahmed *et al.*, 2009). In this respect, Zaki *et al.,* (2014) reported that application of organic treatments (60 kg N+ compost or 120 kg N+ compost) recorded the highest values of plant vegetative parameters compared with control (120 kg N as inorganic fertilizer).

Concerning the effect of irrigation treatments (15, 20 or 25 days intervals), results in Table 5 showed that plant height and plant fresh weight significantly affected with irrigation intervals, but the effect on plant dry weight was insignificant. Generally, the highest values of plant growth parameters were recorded with irrigation of plants every 20 days. These results are in agreement with Ahmed *et al.,* (2009) who reported that irrigation every 15 or 20 days intervals exhibited the highest values of all vegetative growth characters of garlic at Middle Delta-Egypt.

Table 5. Effect of mineral nitrogen fertilization, some organic materials and irrigation intervals on plant growth after 110 days from planting.

Treatments	Plant height (cm)			Plant Fresh weight (g)			Plant Dry weight (g)		
	1st*	2nd**	Mean	1st	2nd	Mean	1st	2nd	Mean
Irrigation (I):									
I_1	68.2	70.6	69.4^c	48.96	61.93	55.44^c	9.46	9.83	9.65^a
I_2	71.8	72.7	72.3^a	55.48	63.37	59.43^a	9.40	10.60	10.00^a
I_3	70.9	70.9	70.9^b	53.70	60.93	57.31^b	9.32	9.98	9.65^a
Organic materials (O):									
Control	60.7	62.1	61.4^c	48.07	57.26	52.67^b	9.33	9.77	9.55^b
Compost	74.4	75.7	75.1^b	54.63	64.30	59.46^a	9.49	10.79	10.14^a
KH	75.8	76.4	76.1^a	55.44	64.67	60.06^a	9.36	9.86	9.61^b
Nitrogen rates (kg N fed^{-1}):									
72 (N_1)	67.9	68.2	68.1^c	50.25	59.00	54.55^b	9.46	9.74	9.60^a
96 (N_2)	70.4	72.4	71.4^b	53.11	63.93	58.55^a	9.32	10.17	9.74^a
120 (N_3)	72.2	73.3	72.7^a	55.11	63.37	59.24^a	9.35	10.46	9.90^a
L.S.D. at 5 %:									
I	1.76	1.35	0.89	2.69	Ns	1.07	Ns	Ns	NS
O	1.09	1.49	0.71	2.06	3.48	1.69	Ns	Ns	0.25
N	0.90	1.23	0.73	2.05	2.29	1.89	Ns	Ns	NS
N*O	Ns	*	1.26	**	**	3.27	**	Ns	0.65
N*I	Ns	Ns	NS	Ns	Ns	NS	*	**	0.65
O*I	*	*	1.23	**	**	2.94	**	Ns	0.43
N*O*I	Ns	Ns	NS	*	Ns	NS	*	**	1.12

1st*: first season (2015/2016); 2nd: second season (2016/2017); *: significant **: high significant**

The interaction between mineral N fertilization and organic materials (N*O) significantly affected plant fresh and dry weights as well as plant height, with superior the interactions of N_3*KH and N_2*KH for plant height and plant fresh weight, respectively (Table 5 and Fig. 4). The interaction of organic with irrigation intervals (O*I) had significant impacts on plant height, fresh and dry weights of plant with superior the interaction of KH*I_2. The interactions of N*I and N*O*I had significant impacts on plant dry weight only, with superior the interaction of N_2*Compost*I_2. These results are in accordance with that obtained by Ahmed *et al.,* (2010), Nori *et al.,* (2012) and Zaki *et al.,* (2014).

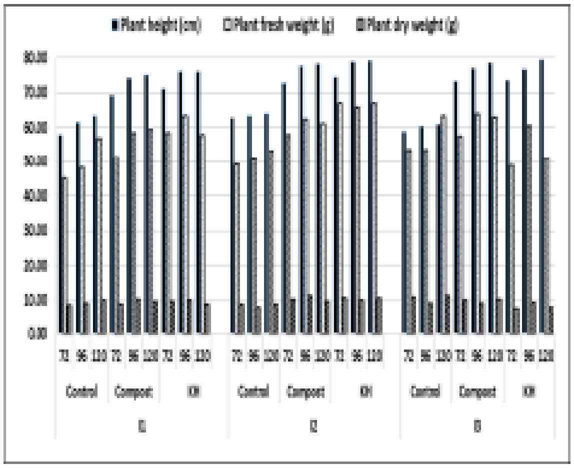

Fig. 4. Effect of interactions on plant height, fresh and dry weight of plant.

3- NPK-uptake Plant^{-1} after 110 days: -

Results in Table 6 showed that the uptake of NPK per plant (g plant^{-1}) significantly increased with increasing the rate of mineral N fertilization up to 120 kg N fed^{-1}, but without significant differences with the uptake at N-rate 96 kg N fed^{-1}. Application of organic materials; compost and KH improved the plant uptake of NPK in favor of compost.

Also, the plant uptake of NPK significantly affected with irrigation of plants at different intervals. The highest plant uptake of N (0.351 g plant^{-1}) was recorded at the irrigation every 25 days (I_3), whereas the highest plant uptake of P and K (0.025 and 0.215 g plant^{-1}, respectively) were recorded at the irrigation every 20 days (I_2). These results illustrate that increasing the period between irrigations (20 and 25 days) maximized the utilization of N fertilizer applied and decreased the losses of N in leaching, and improved soil fertility that was higher under these irrigation intervals (I_2 and I_3) than I_1 (as shown in Table 4). In this respect, Abo-Sedera and Badr (1998), Hanson *et al.,* (2003) and Ahmed *et al.,* (2009) found similar observations.

All interactions of N*O, N*I, O*I and N*O*I had significant effect on the plant uptake of NPK, except the interaction of N*I had insignificant effect on the N uptake plant^{-1} (Table 6). The highest plant uptake of NPK (0.419, 0.032 and 0.259 g plant^{-1}, respectively) were recorded with the interaction of N_2*Compost*I_2.

Table 6. Effect of mineral nitrogen fertilization, some organic materials on the plant uptake of N, P and K (g plant^{-1}) under different irrigation intervals after 110 days (average of the two seasons).

Treatments		N				P				K			
		I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	N_1	0.268	0.298	0.361	0.309	0.022	0.021	0.027	0.023	0.187	0.177	0.229	0.198
Control	N_2	0.296	0.281	0.306	0.294	0.026	0.022	0.023	0.024	0.209	0.166	0.194	0.189
	N_3	0.341	0.319	0.392	0.351	0.028	0.019	0.030	0.026	0.214	0.197	0.247	0.219
Mean		0.302	0.300	0.353	0.318^b	0.025	0.020	0.027	0.024^b	0.203	0.180	0.223	0.202^b
	N_1	0.302	0.353	0.329	0.328	0.022	0.031	0.021	0.024	0.194	0.231	0.206	0.211
Compost	N_2	0.361	0.419	0.299	0.360	0.027	0.032	0.019	0.026	0.238	0.259	0.186	0.228
	N_3	0.342	0.352	0.346	0.347	0.027	0.025	0.021	0.024	0.234	0.205	0.223	0.221
Mean		0.335	0.375	0.325	0.345^a	0.025	0.029	0.020	0.025^a	0.222	0.232	0.205	0.220^a
	N_1	0.321	0.348	0.257	0.309	0.020	0.023	0.022	0.022	0.201	0.238	0.162	0.200
KH	N_2	0.343	0.351	0.318	0.337	0.021	0.024	0.024	0.023	0.218	0.227	0.213	0.219
	N_3	0.304	0.373	0.272	0.316	0.022	0.027	0.020	0.023	0.199	0.232	0.167	0.200
Mean		0323	0.357	0.282	0.321^b	0.021	0.025	0.022	0.023^c	0.206	0.233	0.181	0.206^b
Mean of I		0.309^b	0.294^b	0.351^a	0.328	0.024^b	0.025^a	0.023^c	0.024	0.211^{ab}	0.215^a	0.203^b	0.209
Mean of N-rates (kg fed^{-1})													
72 (N_1)			0.315^b				0.023^b				0.203^b		
96 (N_2)			0.330^a				0.024^a				0.212^a		
120 (N_3)			0.338^a				0.024^a				0.213^a		
L. S.D. at 5 %													
Irrigation (I)			0.016				0.001				0.008		
Organic (O)			0.008				0.001				0.005		
Nitrogen (N)			0.013				0.001				0.008		
N*O			0.023				0.002				0.014		
N*I			NS				0.002				0.014		
O*I			0.013				0.001				0.008		
N*O*I			0.039				0.003				0.024		

4- Garlic yield: -

Data in Table 7 showed that total bulbs yield, bulb diameter and average clove weight significantly increased with increasing N fertilizer rates up to 120 kg N fed^{-1} (N_3). These results are in accordance with that obtained by Ahmed *et al.,* (2012) who found that garlic yield enhanced with increasing the level of nitrogen fertilization up to 200 kg N fed^{-1} in clay loam soil, and this means that garlic yield correlated positively with N fertilization.

Also, results in Table 7 showed that application of organic materials (compost or KH) significantly enhanced total yield, bulb diameter and clove weight as compared with control (without addition). Total yield increased by 8.5% and 7.6% with the addition of compost and KH, respectively. Concerning bulb diameter and average clove weight, the differences among the impacts of compost and KH were insignificant. Furthermore, KH had the highest value of bulb diameter (3.99 cm). These results showed the benefit effects of application KH, which are accordance with the studies that had been reported on the ability of humic substances to stimulate plant growth and yield by increasing soil fertility and enhanced nutrient and water uptake (Chen *et al.,* 2004; Osvalde *et al.,* 2012 and Mohsen *et al.,* 2017). In this admiration, Zaki *et al.,* (2014) stated that treating of garlic plants with compost or foliar humic increased total yield as compared with inorganic nitrogen fertilizers at 120 kg N fed^{-1}.

Table 7. Effect of mineral nitrogen fertilization, some organic materials on garlic yield and its components under different irrigation intervals.

Treatments	Total bulbs yield (t. fed^{-1})			Bulb diameter (cm)			Average weight (g clove^{-1})		
	1st	2nd	Mean	1st	2nd	Mean	1st	2nd	Mean
Irrigation (I):									
I_1	7.080	7.245	7.162^c	3.53	3.79	3.66^c	1.52	1.61	1.56^c
I_2	7.666	7.766	7.716^a	4.02	4.17	4.09^a	1.68	1.78	1.73^a
I_3	7.494	7.622	7.558^b	3.80	3.98	3.89^b	1.55	1.66	1.61^b
Organic materials (O):									
Control	7.004	7.194	7.099^c	3.61	3.78	3.69^b	1.50	1.60	1.55^b
Compost	7.662	7.736	7.699^a	3.84	4.07	3.95^a	1.63	1.72	1.68^a
KH	7.573	7.703	7.638^b	3.90	4.09	3.99^a	1.62	1.74	1.68^a
Nitrogen rates (kg N fed^{-1}):									
72 (N_1)	7.037	7.279	7.158^c	3.62	3.83	3.72^c	1.46	1.56	1.51^c
96 (N_2)	7.518	7.619	7.568^b	3.81	4.01	3.91^b	1.61	1.72	1.66^b
120 (N_3)	7.680	7.739	7.710^a	3.92	4.09	4.00^a	1.70	1.80	1.75^a
L.S.D. at 5 %:									
I	0.071	0.112	0.064	0.097	0.11	0.06	0.012	0.012	0.009
O	0.053	0.040	0.035	0.10	0.05	0.05	0.022	0.023	0.018
N	0.048	0.077	0.036	0.06	0.10	0.04	0.024	0.019	0.017
N*O	**	**	0.063	Ns	Ns	NS	NS	Ns	*
N*I	*	**	0.063	Ns	*	0.07	NS	Ns	Ns
O*I	**	**	0.061	Ns	Ns	0.09	0.038	**	**
N*O*I	**	**	0.109	Ns	Ns	NS	0.071	Ns	Ns

Irrigation of plants at different intervals had significant impacts on total yield and bulb diameter, since the highest yield (7.716 t. fed^{-1}) and bulb diameter (4.10 cm) was gained at irrigation every 20 days (I_2) as compared with other irrigation intervals. The rank of irrigation intervals for their effect on total bulbs yield, bulb diameter and average clove weight was as follows: $I_2 > I_3 > I_1$. So, it could be concluded that garlic yield and its components increased with increasing the period between irrigation which may be attributed to enhancing the rate diffusion of roots, plant growth, nutrients uptake and then yield (tables 5 and 6). In this respect, Ahmed *et al.,* (2009) found that irrigation every 15 days intervals had the highest values of total yield followed by irrigation every 20 days under the environmental conditions of Middle Delta-Egypt whereas, the location of this experiment was in North Delta-Egypt (the rate of annual precipitation is higher than in Middle Delta-Egypt).

Also, calculated results showed that the total quantity of irrigation water which applied was 3205, 2532 and 2410 m^3 fed^{-1} for the irrigation intervals I_1, I_2 and I_3, respectively (the means of two seasons). For water productivity (WP), the highest value was recorded at I_3 (3.14 kg m^{-3}) followed by I_2 (3.05) then I_1 (2.23). This result revealed that WP increased with increasing irrigation interval with a slight difference between I_2 and I_3. For interaction effect, the highest WP (3.27 kg m^{-3}) was attained at the interaction of 120 N*Compost*I_3 (Fig. 5).

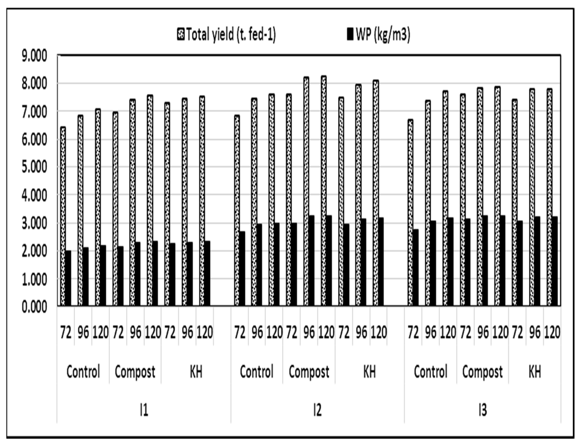

Fig. 5. Effect of interactions among treatments on total yield and water productivity (WP).

Concerning the effect of interactions, all interactions (N*O, N*I, O*I and N*O*I) had significant effect on total yield (Table 7 and Figs 5 and 6). The highest total yield (8.247 ton fed^{-1}) was gained at the interaction of N_3*Compost*I_2, without significant difference with yield that attained at the interaction of N_2*Compost*I_2 (8.208 ton fed^{-1}). Also, the interaction of O*I had significant effect on bulb diameter and average clove weight (Fig 6). The highest value of bulb diameter (4.40 cm) was recorded at the interaction effect of N_3*KH*I_2 whereas, the highest average of clove weight (1.90 g) was attained at the interaction of N_3*compost*I_2.

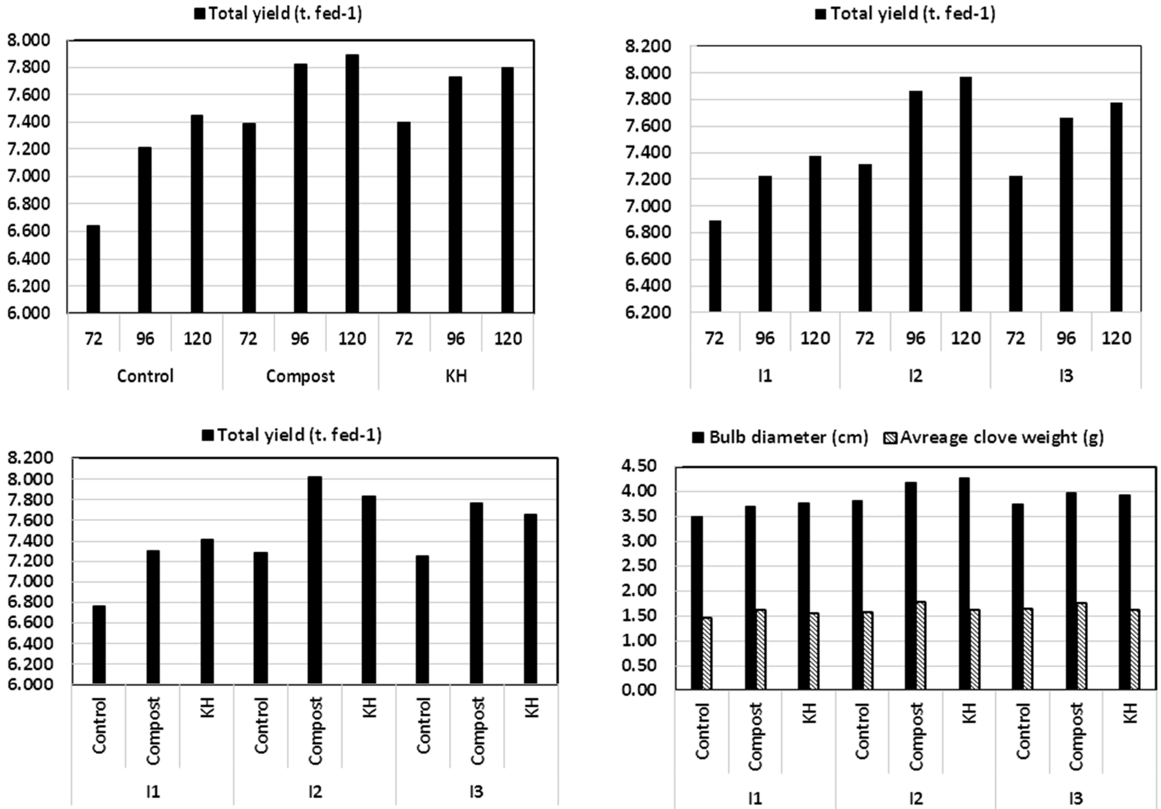

Fig. 6.Effect of interactions on total yield, bulb diameter and average clove weight.

5- Quality of garlic yield: -

Data in Table 8 illustrated the effect of treatments under study on some quality indices of garlic yield. It is obvious from results that increasing the application rate of mineral N fertilizer had significant effects on quality of garlic as its content of dry matter % (D.M), nitrate and sulfur, as well as the pungency content as a pyruvic acid (allicin). Bulbs content of D.M enhanced with increasing the application rate of N mineral fertilizer up to 96 kg N fed^{-1} (N_2) whereas, the accumulation of nitrate in bulbs increased with increasing the application rate of mineral N fertilizer up to 120 kg N fed^{-1} (N_3). However, pungency was declined with increasing the application rates of N mineral fertilization up to N_3 as compared with N_1 (72 kg N fed^{-1}). These results are agreeable with those obtained by Jones *et al.,* (2004) and Nori *et al.,* (2012) who found that accumulation of nitrate in garlic increased with increasing nitrogen fertilizer. Moreover, Bloem *et al.,* (2011) reported that application of high rates of sulfur in combination with low level of N fertilization significantly increased the allicin concentration in garlic, but high N levels had an adverse effect.

Application of organic materials; compost and KH had a positive effect on the quality of garlic (Table 8). Garlic content of D.M, sulfur and pungency significantly enhanced with the application of compost or KH as compare with control. Moreover, cloves content of nitrate significantly decreased with the addition of organic materials as compared with control. The lowest accumulation of nitrate in garlic was recorded with application of KH. For pungency, the differences between the effect of compost and KH were insignificant, but compost attained the superior impact on garlic content of D.M %. These results are in accordance with Lima and Vianello (2011) and Raslan *et al.,* (2015) who stated that allicin content (as pungency) was higher in organically garlic grown than conventionally grown and had a lower content of nitrate. Furthermore, Abd El-Aal *et al.,* (2005) found that application of KH at a rate of 6 L fed^{-1} with irrigation water significantly increased onion bulb dry weight. Abdel-Razzak and El-Sharkawy (2013) and Denre *et al.,* (2014) also found that pungency concentration of garlic enhanced with the application of humic acid.

Irrigation treatments had significant effect on quality indices of garlic yield, since cloves content of D.M, sulfur and pungency increased with increasing the period between irrigations (as shown in Table 8). Irrigation every 20 days (I_2) attained the superior impacts for bulbs content of D.M, sulfur and pungency. Additionally, the yield content of NO_3^- significantly decreased with increasing the period between irrigations up to I_3 (every 25 days). This result may be attributed to that reducing the period between irrigations (every 15 days) promote the content of moisture in plant that correlated negatively with estimation of D.M, sulfur and pungency too, whereas with increasing the period between irrigation the opposite occurred and quality indices of garlic enhanced. These results are in accordance with that obtained by Hanson *et al.,* (2003) and Ahmed *et al.,* (2009).

Also, results in Table 8 reveled that interaction of N*O had significant effect on the content of D.M and nitrate in garlic, but it had insignificant effect on bulbs yield content of sulfur and pungency.

Table 8. Effect of mineral nitrogen fertilization, some organic materials on quality of garlic yield under different irrigation intervals (average of the two seasons).

Treatments		Dry matter (%)				Nitrate "NO_3^-" (mg kg^{-1})				Sulfur (%)				Pungency (m Mol pyrovic g^{-1})			
		I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
Control	N_1	36.58	38.61	38.80	38.00	876	565	412	618	0.421	0.473	0.464	0.453	19.03	19.45	20.62	19.70
	N_2	37.55	39.39	39.49	38.81	945	617	500	688	0.441	0.505	0.479	0.475	18.83	19.39	20.32	19.51
	N_3	37.06	38.39	38.69	38.04	1084	629	604	772	0.447	0.511	0.487	0.482	18.54	19.74	19.93	19.40
Mean		37.06	38.79	38.99	38.28^c	969	604	505	693^a	0.436	0.496	0.477	0.470	18.80	19.52	20.29	19.54^b
Compost	N_1	37.09	39.00	38.87	38.82	776	366	397	513	0.443	0.493	0.484	0.473	19.91	20.12	21.14	20.39
	N_2	38.59	41.36	39.13	39.19	832	489	465	595	0.478	0.522	0.524	0.508	19.21	20.13	20.59	19.98
	N_3	37.53	40.20	39.36	39.03	872	532	497	634	0.495	0.534	0.529	0.519	19.09	19.81	20.21	19.70
Mean		37.74	40.19	39.12	39.01^a	827	462	453	581^b	0.472	0.516	0.512	0.500	19.41	20.02	20.65	20.02^a
KH	N_1	36.91	38.73	38.85	38.16	793	266	308	456	0.480	0.496	0.477	0.484	19.36	19.92	20.78	20.02
	N_2	37.10	39.50	39.66	38.75	883	278	341	501	0.532	0.545	0.490	0.522	19.30	19.96	20.55	19.94
	N_3	37.52	38.95	39.45	38.64	986	428	442	619	0.534	0.550	0.525	0.536	19.31	19.78	20.06	19.72
Mean		37.18	39.06	39.32	38.52^b	887	324	364	525^c	0.515	0.530	0.497	0.514	19.32	19.89	20.46	19.89^a
Mean of I		37.33^b	39.35^a	39.14^a	38.61	894^a	463^b	441^c	599	0.475	0.514	0.495	0.495	19.18^c	19.81^b	20.47^a	19.82
Mean of N-rates (kg fed^{-1})																	
72 (N_1)			38.32^c				539^c				0.471^b				20.03^a		
96 (N_2)			38.85^a				615^b				0.501^a				19.78^b		
120 (N_3)			38.57^b				675^a				0.512^a				19.61^c		
L. S.D. at 5 %																	
Irrigation (I)			0.20				21.5				NS				0.23		
Organic (O)			0.23				21.1				0.013				0.26		
Nitrogen (N)			0.25				20.4				0.015				0.17		
N*O			0.44				35.4				NS				NS		
N*I			NS				NS				NS				0.30		
O*I			0.41				36.5				0.022				NS		
N*O*I			NS				61.3				NS				NS		

Moreover, the interaction of N*I had significant effect pungency only. The interaction of O*I had significant effects on the content of D.M, nitrate and sulfur. The interaction of N*O*I had significant impacts on the garlic content of nitrate, but it had insignificant effect on its content of D.M, sulfur and pungency. The lowest bulb content of nitrate (266 mg kg^{-1}) was recorded at the interaction of N_1*KH*I_2, while the highest content (1084 mg kg^{-1}) was recorded at the interaction of N_3*control*I_1. Furthermore, the highest D.M % (41.36) was recorded at the interaction of N_2*Compost*I_2 (Fig. 7).

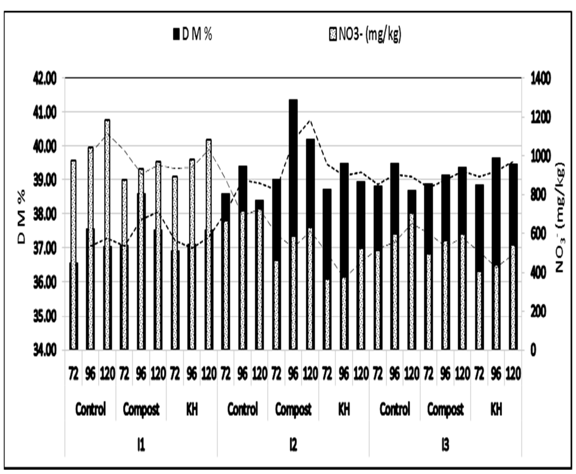

Fig. 7. Effect of interaction among treatments on bulbs content of dry matter and nitrate.

The highest content of pungency (21.14 m Mol pyrovic fresh g^{-1}) was obtained at the interaction of N_1*compost*I_3. It is clear from the above mentioned results that interaction of mineral N fertilization at 72 or 96 kg N fed^{-1} (N_1 or N_2) with application of compost or KH and irrigation every 20 days (I_2) had the favorable effect on quality indices of garlic. This may be attributed to increasing the bulbs contents of dry matter and nutritive values especially sulfur that related positively with pungency. Pungency level in garlic is correlating with synthesis and the content of S, containing amino acids that are precursors of flavor compounds and pyruvate (Randle and Bussard, 1993; Jones *et al.,* 2004; Denre *et al.,* 2014; Shiferaw *et al.,* 2014 and Mohsen *et al.,* 2017).

6- Bulbs yield uptake of nutrients (kg fed^{-1}): -

Data in Table 9 show that the net yield uptake of N, P, K, S, Ca, Fe, Mn and Zn significantly increased with increasing mineral N fertilization rate up to 120 kg N fed^{-1} (N_3). However, the uptake of P, K, S, Ca and Mn uptakes at N_2 (96 kg N fed^{-1}) were insignificant with those recorded at N_3. These results are in accordance with Ahmed *et al.,* (2012) and Ewais *et al.,* (2016) who reported that garlic yield uptake of NPK increased up to 105, 21.2 and 29.8 kg NPK fed^{-1}, respectively with increasing the application level of N up to 150 kg fed^{-1}.

Application of compost or KH significantly increased the garlic yield uptake of the above mentioned nutrients. For the yield uptake of N, K, S and Mn, the differences between the effect of compost and KH were insignificant. The highest yield uptake of K, S, Fe, Mn and Zn were obtained at the application of KH, while the highest yield uptake of N, P and Ca were attained at the application of compost. These results are in agreement with

Abdel-Razzak and El-Sharkawy (2013) who stated that foliar spraying of humic acids (HA) enhanced P and K concentrations of garlic bulb tissues. Denre *et al.,* (2014) also reported that K, S, Ca, Zn and Mn contents in garlic were significantly increased with increase the concentration of HA applications. Yet KH improved the soil fertility through providing nutrients that consequently affected positively on the plant nutrient uptake, growth and yield. KH also serve as growth regulators to control hormone levels that enhance plant growth and increase stress tolerance (Nardi *et al.,* 2002; Serenella *et al.,* 2002; Abd El-Aal *et al.,* 2005 and Abdel-Razzak and El-Sharkawy 2013).

Irrigation plants at different intervals had significant effects on the bulbs yield content of N, P, K, S, Ca, Fe, Mn and Zn (Table 9). The highest values of the yield content of N, P, K, S, Ca, Fe, Mn and Zn were obtained at irrigation plants every 20 days. The rank of irrigation intervals for its impacts on the yield content of nutrients was as follows: $I_2>I_3>I_1$. However, for garlic yield uptake of P, K and S the differences between their values that recoded at the irrigation intervals I_2 and I_3 were insignificant. These results may be attributed to increasing the period between irrigations gave the chance for plants to have the biggest rate of root diffusion which positively correlated with nutrients uptake. Also, these results are positively correlated with the effect of irrigation intervals on soil fertility (Table 4) and plant growth and nutrients uptake after 110 days (Tables 5 and 6). In the same trend, Ahmed *et al.,* (2009) found that the highest bulbs content of NPK were recorded with irrigation every 15 days followed by irrigation every 20 days without significant differences between them.

Table 9. Effect of mineral nitrogen fertilization, some organic materials on bulbs yield uptake of nutrients (Kg fed^{-1}) under different irrigation intervals (average of the two seasons).

Treatments	Kg fed^{-1}							
	N	P	K	S	Ca	Fe	Mn	Zn
Irrigation								
I_1	70.60^{c}	9.88^{b}	17.65^{b}	12.74^{b}	9.92^{c}	0.245^{c}	0.020^{b}	0.054
I_2	81.90^{a}	11.24^{a}	21.34^{a}	15.55^{a}	11.39^{b}	0.281^{a}	0.019^{c}	0.070
I_3	77.86^{b}	11.30^{a}	21.61^{a}	14.68^{a}	11.90^{a}	0.261^{b}	0.021^{a}	0.078
Organic materials								
Control	68.71^{b}	9.66^{c}	18.15^{b}	13.83^{b}	10.15^{c}	0.224^{b}	0.017^{c}	0.061
Compost	80.56^{a}	11.22^{b}	21.14^{a}	15.10^{a}	11.80^{b}	0.271^{a}	0.021^{b}	0.068
KH	81.08^{a}	11.53^{a}	21.31^{a}	15.15^{a}	12.25^{a}	0.263^{a}	0.022^{a}	0.067
Nitrogen rates (kg N fed^{-1})								
72 (N_1)	69.45^{c}	9.87^{b}	18.50^{b}	12.85^{b}	10.68^{b}	0.239^{c}	0.018^{b}	0.061^{c}
96 (N_2)	79.66^{b}	11.20^{a}	21.02^{a}	14.93^{a}	11.45^{a}	0.268^{b}	0.020^{a}	0.068^{b}
120 (N_3)	81.25^{a}	11.34^{a}	21.07^{a}	15.29^{a}	11.09^{ab}	0.280^{a}	0.021^{a}	0.072^{a}
L.S.D. at 5 %								
Irrigation (I)	1.06	0.36	0.36	1.47	0.47	0.007	0.0014	0.0003
Organic (O)	1.12	0.16	0.57	0.39	0.34	0.013	0.0012	0.002
Nitrogen (N)	1.25	0.23	0.46	0.43	0.48	0.011	0.0008	0.002
N*O	2.17	0.39	NS	NS	NS	0.019	NS	NS
N*I	NS	NS	NS	NS	NS	0.019	0.001	NS
O*I	1.94	0.28	0.99	0.68	0.59	NS	NS	0.004
N*O*I	NS	0.68	NS	NS	NS	0.032	NS	0.007

Interaction of N*O had significant effect on the bulbs yield content of N, P and Fe, but had insignificant effect on the yield contents of K, S, Ca, Mn and Zn (Table 9 and Fig. 8). The interaction of O*I had significant effect on the yield content of N, P, K, S, Ca and Zn (Fig. 9). For the interaction of N*O*I, it had significant effect on the yield content of P, Fe and Zn. The highest yield content of N (92.78 kg fed^{-1}) was obtained at the interaction of N_3*KH*I_2, and of P (12.88 kg fed^{-1}) was recorded at the interaction of N_2*KH*I_2. However, the highest yield content of K, S and Ca (24.70, 17.72 and 13.15 kg fed^{-1}, respectively) was attained at the interaction of N_2*Compost*I_2 (Figs. 10, 11 and 12).

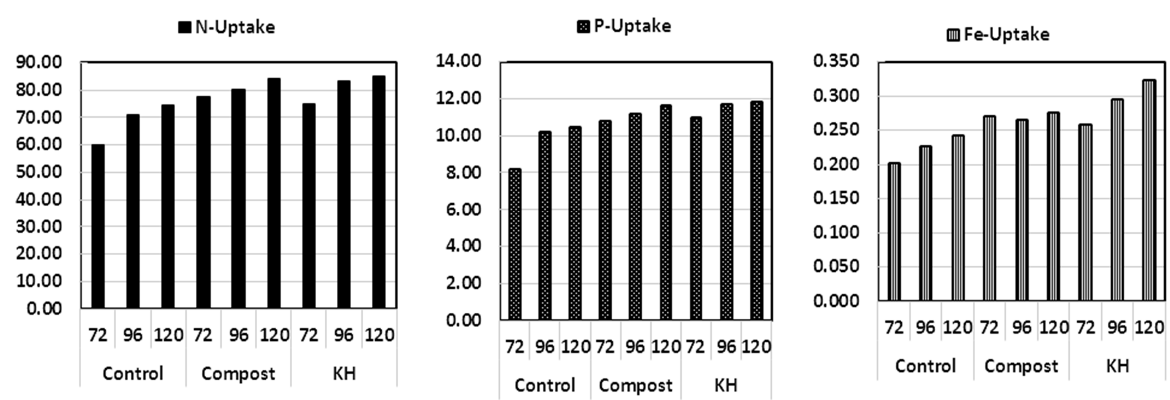

Fig. 8. Effect of interaction between nitrogen rates and organic materials on the uptake of N, P and Fe (kg fed^{-1}).

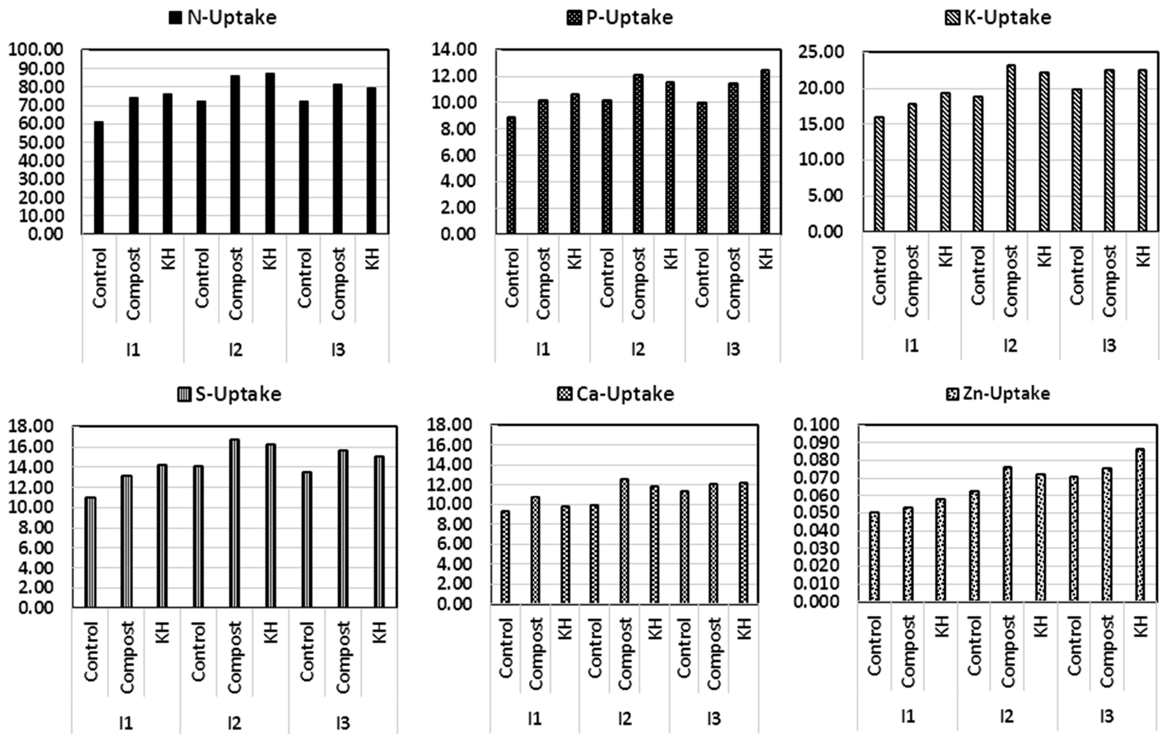

Fig. 9. Effect of interaction between organic materials and irrigation intervals on the uptake of N, P, K, S, Ca and Zn (kg fed^{-1}).

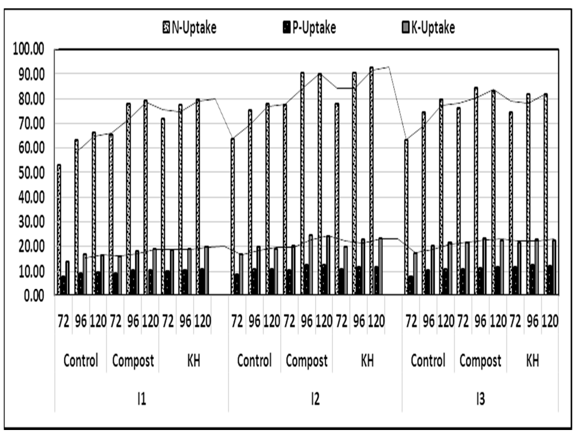

Fig. 10. Effect of interaction among treatments on the uptake of N, P and K (kg fed^{-1}).

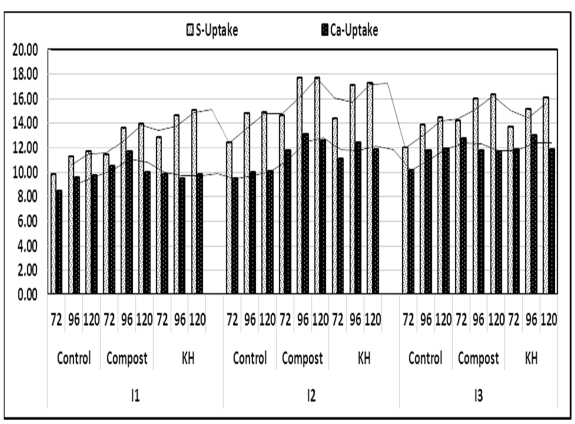

Fig. 11. Effect of interaction among treatments on the uptake of S and Ca (kg fed^{-1}).

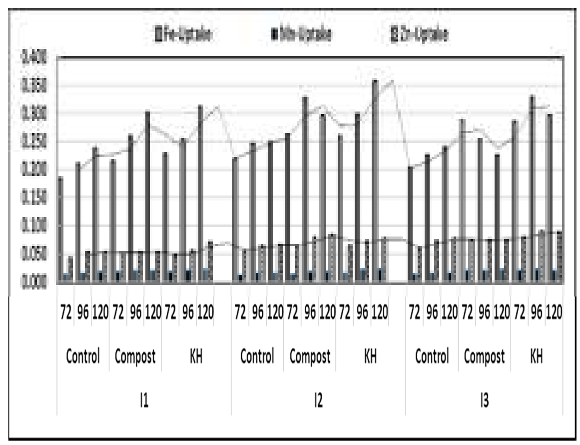

Fig. 12.Effect of interaction among treatments on the uptake of Fe, Mn and Zn (kg fed^{-1}).

CONCLUSION

From the previous results, it can be concluded that mineral nitrogen fertilization at a rate of 96 kg N fed^{-1} (N_2) along with the application of one of organic materials compost (at 10 m^3 fed^{-1}) or KH (at 4 kg fed^{-1}) and irrigation every 20 days had integrated effect on soil fertility, plant growth, total yield, quality parameters and the net yield uptake of N, P, K, S, Ca, Fe, Mn and Zn, as well as, it could be rationalize mineral N fertilization by 20%. Furthermore, the previous interactions (96N*Compost*I_2 and 96N*KH*I_2) attained the optimum yield (8.208 and 7.952 ton fed^{-1}) that had the highest indices of quality (the highest content of D.M, sulfur, pungency and nutrient content, as well had the lowest content of nitrate). Also, results too showed the possibility of application potassium humate (KH) as alternative of compost at the time that the cost of compost became more expensive and not available at all time, whereas potassium-humate was lower cost per feddan (200 L.E.) than compost (2000 L.E.) and had the highest net return.

So, under the environmental conditions of Dakahlia Governorate- Egypt, supplying garlic plants with nitrogen at a rate of 96 kg N fed^{-1} (as ammonium nitrate) with application of 4 kg potassium humate fed^{-1} (through irrigation water) and irrigation plants every 20 days can be recommended to attain the optimum yield that having the highest quality, as well addition the recommended doses of other nutrients.

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تأثير التسميد النتروجيني المعدني وبعض المواد العضوية على محصول الثوم وخصوبة التربة تحت فترات ري مختلفة

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الثوم (*Allium sativum* L.) هو واحد من أهم المحاصيل فى مصر نظراً لقيمه الطبية والغذائية العالية والتي تأثرت سلبا من الاستخدام المفرط للأسمدة النيتروجينية المعدنية والري أيضا؛ لهذا الهدف أجريت تجربتان حقليتان خلال موسمي الزراعة الشتويين 2016/2015 و 2017/2016 بمزرعة خاصة بقرية بسنديله –مركز بلقاس - محافظة الدقهلية– مصر (الواقعة بين خطي: عرض 31° - 20´ - 326.7" شمالاً وطول 31° -45´ - 286" شرقاً) لتقييم تأثير التسميد النتروجيني المعدني (عند ثلاث معدلات: 72 ، 96 و 120 كجم نتروجين للفدان) وبعض إضافات المواد العضوية (كنترول ، 10 م3 كمبوست و4 كجم هيومات بوتاسيوم للفدان) تحت تأثير الري عند ثلاث فترات (كل 15 ، 20 و25 يوم) وزلك على نمو ومحصول الثوم وجودته وامتصاص العناصر وخصوبة التربة؛ وزعت المعاملات في أرض التجربة في تصميم شرائح منشقة في ثلاث مكررات، حيث تمثلت فترات الري بالشرائح الرئيسية، والمواد العضوية في القطع الرئيسية ومعدلات التسماد النتروجيني المعدني بالقطع الشقية.هذا وقد أوضحت النتائج المتحصل عليها إلى تحسن خصوبة التربة معنوياً مع إضافة المعاملات والتدخلات بينهم حيث زاد محتوى التربة من الميسر من العناصر الغذائية: النتروحين والفوسفور والبوتاسيوم والحديد والمنجنيز والزنك ومن المادة العضوية؛ كذلك وقد أوضحت النتائج زيادة قياسات نمو النبات وامتصاصه من العناصر، محصول الثوم وقيمتة الغذائية من النتروجين والفوسفور والبوتاسيوم والكبريت والكالسيوم والحديد والمنجنيز والزنك معنوياً مع إضافات المواد العضوية (الكمبوست أو هيومات البوتاسيوم) بجانب التسميد النتروجينى المعدني تحت فترات الري؛ كما كان للتفاعلات بين المعاملات تأثيرات معنوية على معظم القياسات تحت الدراسة وذلك مع تفوق تأثير التفاعل بين التسميد النتروجيني المعدنى بمعدل 96 كجم نتروجين للفدان مع إضافة الكبوست أو هيومات البوتاسيوم والري كل 20يوم.وبالنسبة لجودة المحصول تحسنت الجودة حيث زاد محتوى رؤوس الثوم من المادة الجافة والكبريت والحرافة مع إضافات المواد العضوية بجانب التسميد النتروجيني المعدنى حتى معدل 96 كجم نتروجين للفدان، علاوة على ذلك انخفض محتوى الرؤوس من النترات؛ وعلى العكس انخفضت مؤشرات جودة المحصول بزيادة إضافة معدلات السماد النتروجيني المعدني حتى 120 كجم ن للفدان حيث زاد تراكم النترات؛ ولذا يمكن أن تخلص الدراسة إلى أن إضافة أى من الكمبوست أو هيومات البوتاسيوم بجانب التسميد النتروجيني المعدنى حتى معدل 96 كجم نتروجين للفدان و الرى كل 20 يوم كان له التأثير التكاملي المفضل على معظم صفات محصول الثوم المدروسة ولاسيما الجودة.