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Effect of potassium Humate, Nitrogen Bio fertilizer and Molybdenum on Growth and Productivity of Garlic (*Allium sativum* L.)

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ABSTRACT

A field experiment was carried out during two winter seasons of 2014/2015 and 2015/2016 at El-Khattara Experimental Farm, Fac. Agric., Zagazig University, Sharkia Governorate, Egypt, to study the effect of foliar spray with potassium humate and molybdenum and Halex-2 (nitrogen biofertilizer) as soil application on growth characters, plant chemical composition, yield and bulb quality of garlic plants (Balady cv.) grown in sandy soil under drip irrigation system. The obtained results showed that, treating garlic plants with potassium humate +molybdenum as foliar spray + Halex-2 as soil application in combinations were the best treatments for increasing plant height, number of leaves/ plant, both neck and bulb diameter, total dry weight/ plant, N, P and K contents in bulbs and leaves, total yield/fed. and bulb dry matter as well as total soluble solid in bulbs in both seasons. In addition, T11 (Potassium humate at 5 g/L + molybdenum at 0.01g/L + Halex-2 at 2kg/fed.) recorded the maximum values of the above traits followed by T12 (Potassium humate at 5 g/L + molybdenum at 0.02 g/L + Halex-2 at 2kg/fed.), with no significant differences between T11and T12 treatments regarding number of leaves/plant in the two seasons. Moreover, there were no significant differences between T11 and T12 treatments with respect to neck diameter, dry weight of bulb and leaves, average bulb weight and total yield/fed.in the second season. In addition, T12 gave the highest values of TSS in bulb during two seasons. On the other hand, the plants which untreated (control) recorded the minimum values in this respect.

Key words: Garlic, potassium humate, molybdenum, Halex-2, growth, yield and bulb quality.

Introduction

Garlic (*Allium sativum* L.) is one of the most important vegetable crops in the world. It is widely used in flavouring of food and has health benefits including its antioxidant, anticancer, anti-microbial, and lowering sugar and lipids in blood (Baghalian, 2005). Furthermore, the economic importance of the garlic crop has increased considerably in recent years for local consumption and exportation. So, essential aims for growers are increasing yield and improving bulb quality.

Potassium humate is a commercial product contains many elements necessary to the development of plant life (Senn, 1991, El-Sharkawy and Abdel-Razzak, 2010). Foliar application of Humic substances is increasingly used in agricultural practice, the mechanism of possible growth promoting effect, usually attributed to hormone-like impact, activation of photosynthesis, accelerate cell division, increase the permeability of plant cell membranes and improved nutrient uptake, reduce the uptake of toxic elements and improve the plant response to salinity (Verlinden *et al*. 2009). Also, potassium humate can be used as a non-expensive source for potassium and it could be used as soil dressing, drenching or foliar applications. In addition, Humic acid (HA) is one of the major components of humus. Application of (HA) has several benefits and agriculturists all over the world are accepting HA as an integral part of their fertilizer program. (Abou El-Khair *et al.* 2010, Abdel-Razzak and El-Sharkawy, 2013, Mahmoud and Youssif , 2015, Shafeek *et al*., 2015 , Zeinali and Moradi, 2015) they found that, foliar application of humic acid led to positive effects on plant growth and improvement of production of garlic plant. In addition, potassium humate application led to improving plant growth parameters , yield and quality of sweet pepper plant (El - Bassiony *et al*.,2010).

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Molybdenum is an important micronutrient for plants, bacteria and all organisms.It plays a vital role in enzymes activity as nitrogenase, catalase and peroxidase (Marschner ,1995 and Campbell, 1999). Moreover, Mo is an element that is translocated with low mobility inside plants, which is the main reason for its low utilization by plant organs during the period of starvation (Gupta and Lipsett, 1981). Several studies have been dealing with the role of Mo on improving the plant growth, and yield quality (Chattopadhyay and Mukhopadhyay, 2004, Umma, 2012 on onion and Rohidas *et al*., 2011 on garlic).

Biofertilizer increases soil fertility and crop yield, the use of bio-fertilizers has currently attained a special significance in crop production to address the sustainability issues (Singh, 2014), and also, bio-fertilizers are known to play an important role in increasing availability of nitrogen and phosphorus beside improving biological fixation of atmospheric nitrogen and produce hormones and anti-metabolites (Gill *et al*., 1987, Bhat *et al*., 2013). Furthermore, microorganisms such as *Azotobacter, Azospirillum and Kelbsiella*; can secrete growth promoting factors similar to gibberellic acid and indole acetic acid, cytokinins and auxins which could stimulate plant growth, increased root length and were responsible for root hair branching with an eventual increase in absorption of nutrients, and their ability to produce antibacterial and antifungal compounds (Jagnow *et al*., 1991 and Marschner, 1995). In addition, using biofertilizers that contain different microbial strains has provided high quality products free of harmful agrochemicals for human safety and decrease its adverse effects on the environment (Roychowdhury *et al*., 2014).

Bio-fertilizers application resulted in improvement of growth and yield (El-Shabasi *et al*. 2003; El-Seifi *et al.* 2004; El-Morsy *et al.* 2009; Dawood *et al*., 2011; Dawa *et al*. 2012; Fawzy *et al.*, 2012; Mohsen (2012), Ahmed *et al.*, 2012, Abdel-Razzak and EI-Sharkawy, 2013, Abou El-Magd *et al.,* 2014 ; Zaki *et al*., 2014 and Hassan ,2015) on garlic.

The objective of this study was improving plant growth and yield of garlic plants by application potassium humate, molybdenum nutrient and nitrogen bio fertilizer (Halex-2), under sandy soil conditions in Egypt.

Materials and Methods

A field experiment was carried out during two winter seasons of 2014/2015 and 2015 /2016 at El-Khattara Experimental Farm, Fac. Agric., Zagazig University, Sharkia Governorate, Egypt, to study the effect of foliar spray with potassium humate, molybdenum as ammonium molybdate (54% Mo) and soil application of Halex-2 as nitrogen biofertilizer on growth characters, plant chemical composition, yield and bulb quality of garlic plants (cv. Balady) grown in sandy soil under drip irrigation system. Physicochemical characteristics of the investigated soils are presented in Table 1 (average 2 seasons). Soil was analyzed according to the methods described by USDA (1954).

Table 1: Physicochemical characteristics of the experimental soil site

Properties	
Texture class	Sand
Organic matter (g kg $^{-1}$)	6.30
EC (dS m^{-1}) [soil extract1:2.5]	0.45
pH [soil suspension 1:2.5]	7.98
Soluble ions (mmolc L^{-1})	
Na^+	1.12
K^+	0.27
Ca^{2+}	1.17
Mg^{2+}	0.54
Cl^{-1}	0.89
$HCO3^{-}$	1.01
$SO4^{=}$	1.20

This experiment included (twelve) treatments as follows:
T_1: Control (untreated plants).

T_2: Potassium humate at 5 g/L.
T_3: Molybdenum at 0.01g/L.
T_4: Molybdenum at 0.02g/L.
T_5: Halex-2(nitrogen biofertilizer) at 2 kg/fed.
T_6: Potassium humate at 5 g/L + molybdenum at 0.01g/L.
T_7: Potassium humate at 5 g/L + molybdenum at 0.02g/L.
T_8: Molybdenum at 0.01g/L + Halex-2 at 2 kg/fed.
T_9: Molybdenum at 0.02g/L + Halex-2 at 2 kg/fed.
T_{10}: Potassium humate at 5 g/L+ Halex-2 at 2 kg/fed.
T_{11}: Potassium humate at 5 g/L + molybdenum at 0.01g/L + Halex-2 at 2 kg/fed.
T_{12}: Potassium humate at 5 g/L + molybdenum at 0.02g/L + Halex-2 at 2 kg/fed.

These treatments were distributed in a randomized complete blocks design system with three replications. Garlic cloves were planted on 23 and 26 September on both sides of the dripper lines at 10 cm distance in the first and second seasons, respectively. The area of the experimental unit was 14.4m^2. It contained four dripper lines each of 6 m length and 0.60 m width.

The garlic plants were sprayed with potassium humate four times by 15 days by intervals at 60, 75 , 90 and 105 days , whereas molybdenum was sprayed with ammonium molybdate at 65, 80 , 95 and 110 days from planting. In addition, control treatment was sprayed with tap water and wetting agent. Potassium humate granule contains of (potassium humate 85% + K_2O 8% + fulvic acid 3%) and the source of potassium humate was Efco Egyptian Company for Fertilizers and Chemicals, Egypt.

Halex-2 was used as nitrogen biofertilizer (contains a mixture of N- fixing bacteria of the genera *Azotobacter, Azospirillum and Kelbsiella*). The source of Halex-2 was Fac. Agric., Alexandria University and it was added at rate of 2 kg per fed. as soil application directly before cloves planting.

All experimental units received equal amounts of botanical compost at 30 m^3/fed. during soil preparation. The recommended amounts of mineral N, P and K fertilizers for garlic cultivation under sandy soil conditions were applied to all experimental units as soil application. 400 kg/fed. ammonium sulphate (20.5%N) , 350 kg/fed. calcium superphosphate (16-18% P_2O_5) and 200 kg/fed. potassium sulphate (48% K_2O) were used as sources of N , P and K, respectively . One third of these fertilizers was added at soil application. The other two thirds were divided into 12 equal portions and added weekly through drip irrigation water beginning 30 days after planting and phosphatic fertilizer (added in the form of phosphoric acid). The other normal agricultural treatments for growing garlic plants, except fertilization treatments were practiced.

Data recorded:

A random sample of ten plants from each experimental unit was taken at 135 days after planting and the following data were recorded:

Plant growth characters:

a. Morphological characters:

1. Plant height (cm).
2. Number of leaves/plant.
3. Neck diameter (cm)/plant.
4. Bulb diameter (cm)/plant.

b. Dry weight:

At 135 days after cultivation, the different parts of garlic, i.e. roots, bulb and leaves were oven dried at 70°C till constant weight, and then the following data were recorded:
1. Dry weight of roots/plant (g).
2. Dry weight of bulb/plant (g).

3. Dry weight of leaves/plant (g).
4. Total dry weight of (leaves+ bulb+ roots)/plant (g).
5. Relative increases in total dry weight were calculated.

Plant chemical composition:

The dry weight of different plant parts, i.e. roots, bulb and leaves were finely ground and wet digested with sulfuric acid and perchloric acid (3:1). Nitrogen, phosphorus and potassium were determined as dry weight basis at 135 days after cultivation in the 2nd season only according to the methods described by Bremner and Mulvaney (1982), Olsen and Sommers (1982) and Jackson (1970), respectively.

Yield and its components:

At proper maturity stage of bulbs bulbs in every plot were harvested, then translocate to a shady place in the same day for curing. The following yield parameters were calculated as follow:
1. Average bulb weight (g).
2. Total yield (ton/ feddan).
3. Relative increases in total yield were calculated.

Bulb quality at harvest time:

1. Dry matter percentage (DM %): It was determined at harvest using 100 g. fresh bulbs oven dried at 105ºC till constant weight.
2. Total soluble solids percentage (T.S.S. ºBrix): It was determined in garlic bulbs by Carle Zeis Refractometer.
3. Molybdenum content: It was determined in the 2nd season only using Atomic Absorption Spectrophotometer (FAAS Perkin Elmer HGA 4000 programs).

Statistical analysis:

The obtained data were statistically analyzed using the SAS program and LSD test at the 5% level of probability was used to compare the treatments means according to Gomez and Gomez (1984).

Results and Discussion

Plant growth:

The presented data in Tables (2 and 3) show the effect of potassium humate and molybdenum (Mo) foliar spray as well as Halex-2 (nitrogen biofertilizers) soil application individually or in combinations on plant growth characters of garlic plants expressed as, plant height, number of leaves/ plant, both neck and bulb diameter as well as dry weight of different plant parts of garlic.

All tested treatments had significant effect on increasing all studied vegetative growth parameters compared to untreated plants in both seasons. It is interest to note that application of T11 (Potassium humate at 5 g/L + molybdenum at 0.01 g/L + Halex-2 at 2 kg/fed.) recorded the maximum values of plant height, number of leaves, both neck and bulb diameter, dry weight of roots, bulb and leaves as well as total dry weight of garlic plant in the two seasons, with no significant differences when compared with T12 (Potassium humate at 5 g/L + molybdenum at 0.02 g/L + Halex-2 at 2 kg/fed.) treatment regarding number of leaves/plant in in the two seasons. Moreover, there were no significant differences between T11 and T12 treatments with respect to neck diameter, dry weight of bulb and leaves in the second season. On the other hand, the plants which untreated (control) recorded the minimum values in this respect.

The increments in total dry weight/ plant in the case of T11 were about (170.10 and 151.16 %), (124.54 and 122.03 %), (137.91 and 129.26%), (152.85 and 139.05%) and (90.52 and 78.58) than treatments of T1, T2, T3 T4 and T5 in the first and second seasons, respectively.

Table 2: Effect of potassium humate, molybdenum, Halex-2 individually or in combinations on morphological characters of garlic plants at 135 days after planting during 2014/2015 and 2015/2016 seasons

Characters / Treatments	Plant height (cm)		Number of leaves / plant		Neck diameter (cm)		Bulb diameter (cm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
TI: Control (untreated).	72.10 i	72.15 h	8.30 e	8.00 f	1.33 g	1.35 e	2.77 f	3.72 c
T2: KH.	75.40 gh	75.85 f	8.90 d	8.50 ef	1.45 f	1.48 de	3.11 d-f	3.12 fg
T3: Mo_1	74.20 hi	74.05 g	8.70 d	8.50 ef	1.38 g	1.36 e	3.08 d-f	3.00 g
T4: Mo_2	73.40 hi	73.45 gh	8.60 d	8.50 ef	1.36 g	1.44 de	2.87 ef	2.98 g
T5: H.	78.40 ef	77.90 e	9.40 d	8.50 ef	1.61 d	1.65 bc	3.29 cd	3.45 de
T6: KH.+ Mo_1	77.50 fg	77.40 e	9.20 d	8.00 f	1.54 e	1.62 bc	3.26 cd	3.28 ef
T7: KH. + Mo_2	76.90 fg	77.35 e	9.20 d	9.00 d-f	1.50 ef	1.55 cd	3.18 c-e	3.23 f
T8: Mo_1+ H.	80.90 cd	81.25 d	9.80 bc	10.00 b-d	1.66 cd	1.67 bc	3.54 bc	3.52 d
T9: Mo_2+ H.	80.00 de	80.65 d	9.50 cd	9.50 c-e	1.64 d	1.64 bc	3.50 bc	3.71 c
T10: KH.+ H.	82.80 c	82.75 c	9.90 bc	10.50 bc	1.71 bc	1.71 ab	3.69 b	3.95 b
T11: KH. + Mo_1+ H.	89.50 a	89.00 a	11.00 a	11.00 ab	1.81 a	1.84 a	4.30 a	5.22 a
T12: KH. + Mo_2+ H.	85.30 b	85.50 b	10.40 ab	12.00 a	1.74 b	1.73 ab	3.82 b	3.76 c

Values having the same alphabetical letter(s) did not significantly different according to L.S.D at 0.05 level of probability.
KH. = Potassium humate of (5 g/L)., Mo_1 = Molybdenum (0.01 g/ L) ., Mo_2 = Molybdenum (0.02 g/ L) . and H. = Halex-2(2 kg/fed.).

Table 3: Effect of potassium humate, molybdenum, Halex-2 individually or in combinations on dry weight of different parts of garlic plants at 135 days after planting during 2014/2015 and 2015/2016 seasons

Characters / Treatments	Dry weight(plant parts/gm)						Total dry weight/ plant		Relative increases in total dry weight	
	Roots		Bulb		Leaves					
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
TI: Control (untreated).	2.05 i	2.39 f	2.90 j	2.72 i	3.28 l	3.06 i	8.23 j	8.17 i	00.00	00.00
T2: KH.	3.08 f	2.82 f	4.18 g	3.63 g	4.72 i	4.10 g	11.98 g	10.55 g	45.56	29.13
T3: Mo_1	2.68 g	2.56 f	3.85 h	3.48 g	4.35 j	3.92 g	10.88 h	9.96 gh	32.19	21.90
T4: Mo_2	2.38 h	2.45 f	3.42 i	3.16 h	3.85 k	3.56 h	9.65 i	9.16 h	17.25	12.11
T5: H.	3.75 e	3.69 de	5.18 ef	4.89 e	5.85 f	5.52 e	14.78 ef	14.10 e	79.58	72.58
T6: KH.+ Mo_1	3.65 e	3.58 de	4.90 f	4.62 f	5.53 g	5.22 f	14.08 f	13.42 ef	71.08	64.25
T7: KH. + Mo_2	3.22 f	3.34 e	4.45 g	4.65 ef	5.02 h	5.25 f	12.69 g	13.23 f	54.19	61.93
T8: Mo_1+ H.	4.15 d	3.89 cd	6.10 d	5.64 c	6.88 d	6.37 c	17.13 d	15.89 d	108.14	94.49
T9: Mo_2+ H.	3.85 e	3.95 cd	5.48 e	5.38 d	6.19 e	6.07 d	15.52 e	15.40 d	88.57	88.49
T10: KH.+ H.	4.40 c	4.26 bc	6.55 c	6.36 b	7.38 c	7.17 b	18.33 c	17.79 c	122.72	117.74
T11: KH. + Mo_1+ H.	5.55 a	5.41 a	7.84 a	7.10 a	8.84 a	8.01 a	22.23 a	20.52 a	170.10	151.16
T12: KH. + Mo_2+ H.	5.25 b	4.62 b	7.01 b	6.92 a	7.91 b	7.81 a	20.17 b	19.35 b	145.07	136.84

Values having the same alphabetical letter(s) did not significantly different according to L.S.D at 0.05 level of probability.
KH. = Potassium humate of (5 g/L)., Mo_1 = Molybdenum (0.01 g/ L) ., Mo_2 = Molybdenum (0.02 g/ L) . and H. = Halex-2(2 kg/fed.).

The increment in growth parameters may be due to that potassium humate contains many elements necessary to the development of plant life (Senn, 1991, El-Sharkawy and Abdel-Razzak, 2010) and the mechanism of possible growth promoting effect, usually attributed to hormone-like impact, activation of photosynthesis, accelerate cell division, increase the permeability of plant cell membranes and improved nutrient uptake and finally the activation of biomass production (Ulukan , 2008 and Verlinden *et al*., 2009). Moreover, Humic acid contains a stable fraction of carbon, thus regulating the carbon cycle and release the nutrients which improved plant growth.

Similar increases in plant growth by application of HA as foliar spray were obtained by Abou El-Khair *et al.* (2010), Abdel-Razzak and El-Sharkawy (2013), Mahmoud and Youssif (2015) , Shafeek *et al*. (2015) and Zeinali and Moradi (2015) on garlic , they found that foliar spray with humic acid recorded the best results for increasing plant growth of garlic plants. In addition, El-

Bassiony *et al*. (2010) found that potassium humate application led to improve plant growth parameters, yield and quality of sweet pepper plant.

Mo plays a vital role in improving the growth and development of plants, and acting as catalyst in promoting various organic reactions taking place within plants through the biosynthesis of endogenous hormones which responsible for promoting of plant growth(Marschner , 1995 and Campbell, 1999 and Bhatt and Srivastava, 2005). Several studies have been dealing with the role of Mo on improving the plant growth (Rohidas *et al*., 2011 on garlic and Umma, 2012 on onion). Also, Chattopadhyay and Mukhopadhyay (2004) found that Molybdenum application in the form of sodium molybdate at 0.25% had a significant effect on onion plant growth.

The increase in the vegetative growth of garlic plants by bio-fertilizers might be due to its effect on increasing availability of nitrogen and phosphorus beside improving biological fixation of atmospheric nitrogen and produce hormones and anti-metabolites in root zone (Gill *et al*., 1987, Bhat *et al*., 2013 and Zaki *et al*., 2014). Besides, microorganisms such as *Azotobacter, Azospirillum and Kelbsiella*; can secrete growth promoting substance similar to gibberellic acid and indole acetic acid, cytokinins and auxins which could stimulate plant growth, increased the surface area/ plant unit root length and were responsible for root hair branching with an eventual increase in absorption of nutrients and improving plant growth (Gomaa, 1995). Many investigators reported that Bio-fertilizers application increased growth of garlic plants (El-Morsy *et al*., 2009; Naidu *et al*., 2010; Dawood *et al*., 2011; Ahmed *et al*., 2012; Dawa *et al.,* 2012; Fawzy *et al*., 2012; Mohsen, 2012; Abdel-Razzak and EI-Sharkawy, 2013; Abou El-Magd *et al*., 2014 ; Marzauk, *et al*., 2014; Zaki *et al*., 2014 and Hassan, 2015).

Mineral contents:

Nitrogen, phosphorus and potassium content in roots, bulb and leaves were significantly affected by all tested treatments than control treatment in both seasons (Table, 4).However, T11 gave the higher values for N, P and K in roots, bulb and leaves of garlic plant, followed by T12. On the other hand the lowest values of N, P and K contents in roots, bulb and leaves were recorded with control treatment in both seasons.

Supplements of garlic plants with potassium humate, Mo or Halex-2 individually recorded the lower values of N, P and K contents of roots, bulb and leaves, while treating plants with the triple combinations enhanced N, P and K contents compared to plants with double combinations treatments in both seasons.

Table 4: Effect of potassium humate, molybdenum, Halex-2 individually or in combinations on N,P and K (%) in different parts of garlic plants at 135 days after planting during 2015/2016 seasons.

Characters / Treatments	N (%)			P (%)			K (%)		
	Roots	Bulb	Leaves	Roots	Bulb	Leaves	Roots	Bulb	Leaves
TI: Control (untreated).	1.06 i	2.19 e	2.45 i	0.13 i	0.23 i	0.33 i	0.43 i	2.33 i	1.23 i
T2: KH.	1.27 g	2.49 cd	2.53 fg	0.26 g	0.36 g	0.46 g	0.56 g	2.46 g	1.36 g
T3: Mo_1	1.16 h	2.42 d	2.51 g	0.20 h	0.30 h	0.40 h	0.50 h	2.40 h	1.30 h
T4: Mo_2	1.11 hi	2.27 e	2.48 h	0.15 i	0.25 i	0.35 i	0.45 i	2.35 i	1.25 i
T5: H.	1.43 de	2.62 bc	2.56 de	0.31 e	0.41 e	0.51 e	0.61 e	2.51 e	1.41 e
T6: KH.+ Mo_1	1.38 ef	2.49 bc	2.56 de	0.29 ef	0.39 ef	0.49 ef	0.59 ef	2.49 ef	1.39 ef
T7: KH. + Mo_2	1.34 f	2.53 cd	2.55 ef	0.28 fg	0.38 fg	0.48 fg	0.58 fg	2.48 fg	1.38 fg
T8: Mo_1+ H.	1.56 c	2.53 abc	2.58 d	0.35 d	0.45 d	0.55 d	0.65 d	2.55 d	1.45 d
T9: Mo_2+ H.	1.45 d	2.61 bc	2.56 de	0.32 de	0.42 de	0.52 de	0.62 de	2.52 de	1.42 de
T10: KH.+ H.	1.59 bc	2.64 ab	2.61 c	0.41 c	0.51 c	0.61 c	0.71 c	2.61 c	1.51 c
T11: KH. + Mo_1+ H.	1.72 a	2.58 a	2.66 a	0.51 a	0.61 a	0.71 a	0.81 a	2.71 a	1.61 a
T12: KH. + Mo_2+ H.	1.63 b	2.52 ab	2.64 b	0.45 b	0.55 b	0.65 b	0.75 b	2.65 b	1.55 b

Values having the same alphabetical letter(s) did not significantly different according to L.S.D at 0.05 level of probability. KH. = Potassium humate of (5 g/L)., Mo_1 = Molybdenum (0.01 g/ L) ., Mo_2 = Molybdenum (0.02 g/ L) . and H. = Halex-2(2 kg/fed.).

Potassium humate contains many elements necessary to the plant life development (Senn, 1991, El-Sharkawy and Abdel-Razzak, 2010) and the mechanism of possible growth promoting effect, usually attributed to hormone-like substances impact, activation of photosynthesis, accelerate cell division and

improved nutrient uptake (Ulukan , 2008 and Verlinden *et al*., 2009). Molybdenum plays a vital role in enzymes activity as nitrogenase, catalase and peroxidase (Marschner ,1995 ; Campbell, 1999 ; Ralf and Hansch, 2002) .The positive effects of bio-fertilizers on growth and productivity of plants could be attributed to the effect of different strain groups of microorganisms such as nitrogen fixers, nutrients mobilizing group which improve the availability of metals and increase the levels of extractable N, P and K (El-Karamany *et al*., 2000).

Similar increases in the contents of some nutrients by foliar application with HA were obtained by Ezzat *et al*. (2009) on potato, Abou El-Khair *et al*. (2010) and Mahmoud and Hafez (2010) they found that, HA increased N,P and K contents in different plant organs of .Also, Denre *et al*.(2014) found that Humic acid promote the conservation of mineral nutritions in the cloves of garlic bulb. High N and P content were also observed in the treatments having foliar applied humic acid.. (Azam Shah et al., 2016) on potato plants .In addition, spraying sweet pepper plants with potassium humate at a rate of 4 gm/L markedly increased plant chemical composition (El-Bassiony *et al*.,2010).

Concerning the effect of Mo, the results were agreement with those reported by Kandil *et al*. (2013). They found that treating common bean plants with Mo significantly increased N, P and K content in plant tissues compared to untreated plants.

Regarding the response of garlic plants to biofertilizers Dawood *et al*. (2011), Fawzy *et al.* (2012), Shedeed, *et al*. (2014 on onion) *and* Hassan (2015) found that treating of garlic plants with biofertilizers recorded the highest mineral contents in different parts of plant

Yield and bulb quality:

The results in Table 5 show that garlic plants treated with potassium humate, Mo, Halex-2 alone or in combinations had significant effect on average bulb weight , total yield/ fed., dry matter and TSS contents in bulbs compared to untreated plants in both seasons. Garlic plants treated with T11 recorded the highest values of average bulb weight, total yield/fed. and dry matter contents in bulb compared to untreated (check) or plants which treated with potassium humate , Mo, Halex-2 individually. Moreover, there were no significant differences between T11 and T12 treatments with respect to average bulb weight and total yield/fed. in the second season . On the other side, T12 gave the highest values of TSS in bulb during two seasons and D.M% in the second one.

Table 5: Effect of potassium humate, molybdenum, Halex-2 individually or in combinations on yield and bulbs quality of garlic plants during 2014/2015 and 2015/2016 seasons.

Characters / Treatments	Average bulb weight (g)		Total yield (Ton / fed.)		Relative increases in total yield		Dry matter		TSS (ºBrix)		Mo (ppm)
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	2nd season
TI: Control (untreated).	50.00 j	48.79 g	7.00 h	6.83 g	00.00	00.00	30.63 k	30.91 cd	28.17 c	27.04 c	0.105 k
T2: KH.	56.07 h	54.86 f	7.85 g	7.68 f	12.14	12.44	31.00 i	30.86 cd	28.33 bc	29.35 a-c	0.118 j
T3: Mo_1	53.57 i	55.93 f	7.50 g	7.83 f	07.14	14.64	30.90 ij	31.45 b-d	30.46 c	30.55 ab	0.229 i
T4: Mo_2	53.57 i	54.50 f	7.50 g	7.63 f	07.14	11.71	30.78 j	30.62 d	30.25 c	30.15 a-c	0.358 h
T5: H.	66.79 f	67.93 d	9.35 e	9.51 d	33.57	39.23	32.17 f	30.34 d	27.96 bc	28.20 a-c	0.364 g
T6: KH.+ Mo_1	64.86 f	65.64 de	9.08 e	9.19 de	29.71	34.55	31.46 g	31.36 b-d	27.53 bc	28.65 a-c	0.504 e
T7: KH. + Mo_2	60.36 g	62.14 e	8.45 f	8.70 e	20.71	27.37	31.22 h	31.75 b-d	27.33 bc	28.06 a-c	0.821a
T8: Mo_1+ H.	75.93 d	76.57 bc	10.63 cd	10.72 c	51.85	56.95	32.72 d	33.08 ab	28.84 ab	28.05 a-c	0.566 d
T9: Mo_2+ H.	72.79 e	75.79 c	10.19 d	10.61 c	45.57	55.34	32.32 e	32.67 a-c	28.12 a-c	27.65 bc	0.501 e
T10: KH.+ H.	78.57 c	80.43 b	11.00 bc	11.26 b	57.14	64.86	33.00 c	33.18 ab	31.16 ab	30.10 a-c	0.425 f
T11: KH. + Mo_1+ H.	87.36 a	87.36 a	12.23 a	12.23 a	74.71	79.06	38.43 a	34.54 a	26.87 b	30.05 a-c	0.671 b
T12: KH. + Mo_2+ H.	81.86 b	85.36 a	11.46 b	11.95 a	63.71	74.96	33.31 b	33.26 ab	31.39 a	31.15 a	0.612 c

Values having the same alphabetical letter(s) did not significantly different according to L.S.D at 0.05 level of probability.
KH. = Potassium humate of (5 g/L)., Mo_1 = Molybdenum (0.01 g/ L) ., Mo_2 = Molybdenum (0.02 g/ L) . and H. = Halex-2(2 kg/fed.).

The increases in total yield were about 74.71 and 79.06; 63.71 and 74.96 % for the plants treated with T11 and T12 in 1st and 2nd seasons, respectively. The increase in total yield may be owed to the

increase in vegetative growth (Tables 2 and 3), increasing N, P and K content in different plant parts (Table, 4) and high average bulb weight (Table, 5).

The higher bulb yield of garlic may be attributed the enhancement effect of the humic acid improving plant growth parameters and yield components which ultimately resulted in higher bulb yield and also due to the supply of humate, micronutrients and indirectly the physical condition of the soil viz., aggregation, aeration, permeability, water holding capacity and biological condition of soil, which resulted in significantly higher bulb yield of garlic (Yousuf *et al*. 2016).

Obtained results are in harmony with those reported by (Xin, 2006, Abou El-Khair *et al*., 2010 , Denre *et al*. 2014, Zeinali and Moradi, 2015) all on garlic they found that using of humic acid as foliar spray increased yield and yield components, also Ezzat *et al*., (2009) found that application of humic substances to potato enhanced tuberous yield quantity and quality.In addition, spraying sweet pepper plants with potassium humate at a rate of 4 gm/L markedly increased yield and fruit quality (El-Bassiony *et al*.,2010).Concerning the content of molybdenum in garlic bulbs, the data in Table 5 reveal that Mo foliar application at both tested concentration alone or in combination with other treatments markedly increased the content of Mo in garlic bulbs tissues . So, it could be said that there is no risk due to Mo application at the two tested concentrations because the content of Mo in tissues of the edible part in of garlic was below the safe limit for human health.

As for Mo effect, Chattopadhyay and Mukhopadhyay (2004) on onion, Rohidas *et al* ., 2011 and Yousuf *et al*. (2016) on garlic, Umma , 2012 on onion) they showed that sprayed plants with Mo recorded the best results for yield and its components.

The favorable effect of biofertilizer application on yield and average bulb weight were reported by (Naidu *et al*., 2010, Abou El-Magd *et al*., 2012, Ahmed *et al*., 2012, Abdel-Razzak and EI-Sharkawy, 2013, Abou El-Magd *et al*., 2014, Marzauk, *et al*., 2014 , Zaki *et al*., 2014 and Hassan, 2015) on garlic. . Moreover, Rather *et al*. (2003) found that *Azotobacter* inoculation recorded the maximum bulb dry matter content and total soluble solids in onion bulbs. In addition, El-Gamal (1996) found increase in yield and dry matter content in the tuber of potato tubers with inoculation of seed tuber with Halex-2. Also, Yaso *et al*. (2007) found that inoculation of onion transplants with Halex-2 significantly, improved onion bulb yield and its components.

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