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Effect of Biofertilizer and Humic Acid Applications on Growth, Yield, Quality and Storability of Two Garlic (*Allium sativum* L.) Cultivars

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ABSTRACT

The integration of biofertilizer and Humic Acid (HA) application appears to be a good trail for saving chemical fertilizer and reducing air and soil pollution. In this admiration, two field experiments were performed during two winter seasons of 2007/2008 and 2008/2009 at the Agricultural Research Station, Faculty of Agriculture, Alexandria University, Egypt to assess the effect of two inoculation treatments of a biofertilizer (Halex-2) and three numbers of sprays with humic acid on plant growth, productivity, bulbs quality and storability of the most common garlic cultivars in Egyptian market; Balady and Chinese. The obtained results reflected generally that Balady cultivar surpassed than Chinese cultivar in plant height, total yield and shelf-life characters. The higher yield that observed in Balady cultivar was related to the increase cloves number/bulb over than Chinese one. However, Chinese cultivar showed superior performance in bulb weight trait either at harvest or after storage as a result of increasing both cloves weight and diameter more than Balady cultivar. Inoculated garlic plants with Halex-2 and sprayed with humic acid for two times showed superior effect for increasing garlic productivity. However, sprayed inoculated plants for three times via humic acid gave best results for garlic longevity throughout increasing bulbs weight and decreasing bulbs weight loose after four months of storage.

Key words: Garlic, Halex-2, humic acid, cloves weight, bulbs yield, bulbs longevity

INTRODUCTION

Garlic (*Allium sativum* L.), is a second vital cultivated *Allium* species after onion worldwide. It is a widespread popular crop with various functions to people. It is widely consumed as a spice form, flavoring and seasoning dishes, pickles and sauces. Popularity of this crop has been increased owing to a lot of health benefits attributed to garlic consumption (Rosen and Tong, 2001). Also, dehydrated cloves and extracts are speedy replacing fresh bulbs for industrial and home usage in the production of medicines, insecticides, plant nourishments and explosives (Kilgori *et al*., 2007). Egypt ranks the fourth leading country in the world for garlic production (244.626 MT) after China, India and Korea (FAO, 2011; Abou El-Magd *et al*., 2012).

In Egypt, garlic is a high-value cash crop due to its multifarious use in local consumption, food processing and exportation. Value of Egyptian garlic exports, reach about 2.889 million dollars, representing 0.14% of the total value of Egyptian agricultural exports, in the period of 2007-2009 (Eleshmawiy *et al*., 2010).

Recent awareness has been offered to reduce pollution practices in sustainable agriculture. One of the ways to lessen soil pollution is the use of bio-stimulants compounds (Fawzy *et al*., 2012). Biofertilizers and humic compounds have beneficial return to increase population of soil microorganisms, especially in the surface layer of root rhizosphere, that create substances which stimulate plant growth (Awad, 2002). Further, combination between both types is the most imperative factors needed to diminish agricultural chemicals, protect the air, soil and water from pollution as well as acquiring high yield quality.

Free-living nitrogen-fixing bacteria; e.g., *Azotobacter chroococcum* and *Azospirillum lipoferum,* were found to have not only the ability to fix N but also the ability to release phytohormones similar to gibberellic acid and indole acetic acid which could stimulate plant growth, absorption of nutrients and photosynthesis (Fayez *et al*., 1985).

Nowadays, emphasis on multi-strain biofertilizer has already been organized and utilized in vegetable fields. A biofertilizer; Halex-2 (non-symbiotic N_2 fixing bacteria) has greater amounts of bacteria responsible for fixation of N. Application of Halex-2 realized the following values, increasing soil fertility, save N-fertilizer and expanding the availability of various nutrients to plant absorption. Many researchers reported that using non-symbiotic N_2 fixing bacteria as Halex-2 with adding minerals or organic fertilizers led to improve vegetative growth, yield and quality of several economic vegetables like tomato (Barakat and Gabr, 1998), potato (El-Ghinbihi and Ali, 2001), artichoke (Ghoneim, 2005) and onion (El-Desuki *et al*., 2006; Yaso *et al*., 2007).

Humic acid is a product contains many elements which improve the soil fertility and increase the availability of nutrient elements by holding them on mineral surfaces and, consequently, affect plant growth and yield (Akinci *et al*., 2009; El-Sharkawy and Abdel-Razzak, 2010). Humic substances are the subjects of studies in various areas of agriculture such as soil chemistry, fertility, plant physiology and environmental sciences, as the multiple roles played by these materials can greatly improve plant growth and nutrient uptake (Dursun *et al*., 2002; Paksoy *et al*., 2010). Many investigators reported that, application of humic substances led to a remarkable increment in soil organic matter which improve plant growth and increase crop production (Padem and Ocal, 1999; Abd El-Aal *et al*., 2005; Mahmoud and Hafez, 2010).

Garlic bulbs yield and quality are varied with climate, cultural practices and used variety. Therefore, this work was intended to improve the productivity and quality of the crop through the choice of appropriate combination among a biofertilizer (Halex-2), number of foliar sprays with humic acid and suitable cultivar that maximizes the bulbs yield characters as well as improves bulbs quality and storability of the two common garlic cultivars in Egyptian market; "Balady" and "Chinese".

MATERIALS AND METHODS

A two-years field study was executed during two winter seasons of 2007/2008 and 2008/2009 at the Agricultural Research Station, Faculty of Agriculture, Alexandria University, Egypt, to study the influence of a non-symbiotic N_2 fixing bacteria (Halex-2) and foliar sprays number of humic acid application as well as their interactions on vegetative growth, bulb yield and quality of two ordinary garlic cultivars; Balady and Chinese. Moreover, storability of the bulbs of two cultivars were under consideration. Soil texture of the experimental field was clay. Soil chemical analysis was applied using the method described by Page *et al*. (1982). Results of pH, organic matter and available inorganic N, P and K were 7.6-7.0, 1.6-2.2%, 220-198, 20-26 and 740-463 ppm in the first and second seasons, in that order. Each experiment included 16 treatments which were; two garlic

cultivars Balady and Chinese, two biofertilizer treatments (inoculated with Halex-2 and un-inoculated control treatment) as well as sprays number of humic acid (2.0 g L^{-1}) application (1, 2 and 3 times in addition to zero treatment; sprays with tap water).

Garlic cultivars: The two garlic cultivars used were local Balady and introduced Chinese one, the most common commercial garlic cultivars in Egyptian fresh market. Balady is a local garlic cv. popularly grown in Egypt for their strong smell owing to its natural properties, whose mature cloves have white covering scale with relatively long storability. While, Chinese cv. is well-known by its big cloves size, easy peer, whose mature cloves have bright white skin with purple vertical stripes.

Source of a biofertilizer (Halex-2): Halex-2, a biofertilizer (a mixture of growth promoting of non-symbiotic N-fixing bacteria of genera *Azospirillum, Azotobacter* and *Klebsiella*) was provided by the Bio-fertilization Unit, Department of Plant Pathology Faculty of Agriculture Alexandria University, was used as a mixed biofertilizer.

No. of sprays with humic acid (potassium humate): Black granules of potassium humate 85% humate and 15% potassium its origin from Spain were mixed with tap water and sprayed on the growing garlic plants at the treatment rate 2 g L^{-1}, in addition to zero (control treatment). The control plant was treated with tap water. Humic acid spraying numbers were started after one month from planting date and every 30 days for three times throughout the growing season.

For the two experiments, uniform and healthy cloves (each 1.0 g±0.1/clove) of the two garlic cultivars were sown on Nov. 15 of 2007 and Oct. 31 of 2008. Treatments were arranged in a split-split-plots system in a Randomized Complete Blocks Design (RCBD) with three replicates. The main plots were allocated for two garlic Balady and Chinese cultivars and the sub-plots were occupied by a Halex-2 inoculation treatments (with and without inoculation); whereas, the three numbers of humic acid foliar applications were randomly distributed in the sub-sub-plots. Each experimental unit (sub-sub-plot) was 5.6 m^2 area (2.0 ridges, each 4.0 m long and 0.7 m wide). Prior to planting, garlic bulbs were split into the individual cloves. Cloves of the two cultivars were inoculated by soaking in cell suspension of the Halex-2 (4×10^7 cells mL^{-1}) containing 5% Arabic gum, at the rate of 400 g/feddan (one fed. = 4200 = 2.4 ha) according to recommendation of the Bio-fertilization Unit, Department of Plant Pathology Faculty of Agriculture Alexandria University, for 30 min, just before planting. The inoculation process was again repeated three weeks later as side dressing beside seedlings (Ghoneim, 2005). Cloves of the un-inoculated control treatment were dipped in tap water. Cloves of both cultivars were planted upright with apical tip exposed at 10 cm inter row spacing. The plants were fertilized at the rate of 300 kg of ammonium sulphate (20.5% N), 200 kg of calcium superphosphate (15.5% P_2O_5) and 150 kg potassium sulphate (48% K_2O) per feddan. Each of P and K were applied two times during preparing the soil for planting and 75 days old, respectively. Nitrogen was added at two equal quantities; before planting and 60 days of plant old (Shafeek *et al*., 2003). After sowing directly and before irrigation, weeds were controlled by using pre-emergence of Sencor herbicide. All other agricultural practices were performed when they were required and as recommended for the commercial garlic production. At almost April 28th, 2008 and May 10th, 2009 when older leaves turned yellowish green and had started withering, plants of each plot were harvested. The harvested bulbs were spread in single layers in an open space (in two weeks time) for curing.

Data recorded

Vegetative growth characters: A random sample of ten plants of each cv. was collected from each plot after 150 days from planting to estimate the following parameters; plant height, number of leaves/plant and shoot dry weight/plant.

Garlic yield and its components: At harvest time, marketable plants of both garlic cultivars from each plot were cured (15 days after harvest) weighted in kg and converted to estimate total yield (ton/fed.). A random sample (10 bulbs derived from each cv.) was taken from each treatment to determine both bulb weight and diameter, as well as the number of cloves/bulb, clove weight and diameter.

Bulb quality (cloves chemical analysis): Samples of dried cloves (20-30 g) were ground, wet digested as depicted by Hesse (1971) and their nitrogen (N), phosphorus (P) and potassium (K) concentrations (%) were determined following Chapman and Pratt (1961) procedure.

Bulb storability: After curing process, random samples (5 kg of marketable yield from all sub-sub-plots) were collected, then stored at the typical room conditions and the loss of total weight (%) was monthly recorded through four months of storage.

Statistical analysis: Data obtained in the two seasons of study was subjected to analysis using Co-Stat software (2004). For treatments that were significant, mean separation was done using the revised Least Significant Difference (LSD) test at 0.05 probability level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Vegetative growth characters: Data presented in Table 1 show the effect of used two garlic cultivars; Halex-2 inoculation, number of humic acid foliar application and their interactions on vegetative growth aspects of growing plants. The results showed that the two garlic cultivars reflected significant differences in plant height and shoot dry weight traits. Whereas, Balady cv. recorded the longest plants, however, Chinese plants detected the heaviest shoot dry weight. These results might be expected based on the genetic structure that characterized each garlic cv. and the differences between genotypes. The obtained results are in harmony with those reported by Omer and Abou-Hadid (1992) and Al-Otayk *et al.* (2008). Number of leaves/plant had insignificant response between the two cultivars, in both seasons. On the other hand, either Halex-2 inoculation treatments or number of sprays with humic acid application did not reflect a clear tendency, except for plant height trait in the second season with humic acid sprays number.

Interaction effect between garlic cultivars and Halex-2 inoculation: Inoculated garlic cloves with Halex-2 increased most of vegetative growth characters but with different trend for two garlic cultivars (Table 2).

Generally, Balady cv. seemed to have taller plants than Chinese one in present or absent of Halex-2 inoculation. On the contrary, Chinese cv. reveled heavier shoot dry weight comparing with Balady cv. for the two inoculation treatments. However, number of leaves of both cultivars did not affect by inoculation treatment with Halex-2. These results are true in the two seasons of experiment, with only one exception for plant height in the second season, when Halex-2 inoculation treatment showed the highest significant value in Balady cv. comparing with other

Table 1: Vegetative growth characters of garlic plants as affected by cultivars, Halex-2 and number of sprays with humic acid during seasons of 2007/2008 and 2008/2009

	Plant height (cm)		No. of leaves/plant		Shoot dry weight (%)	
Plant characters treatments	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Garlic cultivars						
Balady	81.33[a]	74.78[a]	7.54[a]	8.14[a]	26.54[b]	25.37[b]
Chinese	68.38[b]	70.44[b]	8.01[a]	8.19[a]	28.97[a]	28.29[a]
Halex-2 inoculation						
With inoculation	75.72[a]	73.81[a]	7.77[a]	8.39[a]	27.93[a]	26.85[a]
Without inoculation	73.99[a]	71.41[a]	7.79[a]	7.93[a]	27.59[a]	26.89[a]
Humic acid sprays No.						
Control (zero spry)	75.36[a]	69.30[b]	7.74[a]	8.08[a]	28.07[a]	27.66[a]
One time spray	74.10[a]	79.00[a]	7.96[a]	7.91[a]	27.86[a]	26.72[a]
Two time sprays	76.18[a]	71.83[b]	7.68[a]	8.27[a]	27.16[a]	25.96[a]
Three time sprays	73.78[a]	71.29[b]	7.73[a]	8.39[a]	27.93[a]	26.97[a]

Values with the same letter(s) in the same column in each season are not significantly different at 0.05

Table 2: Interaction effects among two garlic cultivars, Halex-2 inoculation treatments and sprays number of humic acid application on vegetative growth characters during two seasons of 2007/2008 and 2008/2009

	Plant height (cm)		No. of leaves/plant		Shoot dry weight (%)	
Plant characters treatments	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Garlic cv.×Halex-2 treat						
Balady						
With Halex-2	82.56[a]	77.90[a]	7.52[a]	8.54[a]	26.61[b]	25.46[b]
Without Halex-2	80.10[a]	71.66[b]	7.56[a]	7.73[a]	26.48[b]	25.27[b]
Chinese						
With Halex-2	68.88[b]	69.72[b]	8.01[a]	8.24[a]	29.24[a]	28.14[a]
Without Halex-2	67.88[b]	71.16[b]	8.01[a]	8.13[a]	28.69[a]	28.43[a]
Garlic cv.×humic acid (HA) sprays No.						
Balady						
HA: 0	80.90[a]	66.82[d]	7.51[bc]	7.92[a]	26.55[a]	25.45[c]
HA: 1	80.56[a]	80.81[a]	7.86[a-c]	7.99[a]	25.83[a]	24.64[c]
HA: 2	83.00[a]	76.49[ab]	7.50[bc]	8.33[a]	26.71[a]	25.40[c]
HA: 3	80.86[a]	74.99[a-c]	7.30[c]	8.30[a]	27.08[a]	25.98[bc]
Chinese						
HA: 0	69.83[b]	69.79[b-d]	7.96[ab]	8.24[a]	29.60[a]	28.50[ab]
HA: 1	67.63[b]	77.70[ab]	8.06[ab]	7.83[a]	29.89[a]	28.79[ab]
HA: 2	69.36[b]	67.18[d]	7.86[a-c]	8.21[a]	27.62[a]	26.52[a-c]
HA: 3	66.70[b]	67.58[c-d]	8.16[a]	8.47[a]	28.77[a]	29.43[a]
Halex-2 treatment× HA sprays No.						
With inoculation						
HA: 0	76.60[ab]	71.85[b-d]	7.68[ab]	8.35[ab]	27.54[a]	26.44[a]
HA: 1	72.50[b]	74.23[bc]	7.80[ab]	8.33[ab]	28.95[a]	27.77[a]
HA: 2	79.40[a]	69.78[c-e]	7.66[ab]	8.36[ab]	26.97[a]	25.87[a]
HA: 3	74.40[ab]	79.38[ab]	7.93[ab]	8.53[a]	28.24[a]	27.14[a]
Without inoculation						
HA: 0	74.13[ab]	64.75[de]	7.80[ab]	7.91[bc]	28.61[a]	27.51[a]
HA: 1	75.70[ab]	83.78[a]	8.13[a]	7.49[c]	26.77[a]	25.67[a]
HA: 2	72.96[b]	73.89[bc]	7.70[ab]	8.18[ab]	27.36[a]	26.04[a]
HA: 3	73.16[b]	63.20[e]	7.53[b]	8.24[ab]	27.61[a]	28.18[a]

Values with the same letter(s) in the same column in each season are not significantly different at 0.05

treatments. This result may be referring to the role of bio- fertilizer Halex-2 on increasing the availability of N to plant absorption which in turn increases the vegetative growth of garlic plants. Similar finding was got by El-Desuki *et al.* (2006) and Yaso *et al.* (2007) on onion.

Interaction effect between garlic cultivars and HA number sprays: Fluctuated effects were detected between two garlic cultivars used and number of humic acid foliar sprays on vegetative growth characters (Table 2). Plant height trait was recorded the highest value with Balady garlic plants that treated with humic acid foliar spray, especially in the first season comparing with Chinese cv. under all humic acid number sprays. However, in the second season Balady cv. detected the highest value when plants sprayed one time with humic acid. On the other hand, Chinese cv. revealed higher mean values for number of leaves, in the first season and shoot dry weight, in the second one, especially when growing plants sprayed with humic acid for three times. These results can support by those of Bohme and Lua (1997) and Karakurt *et al.* (2009). They reported that potassium humate had beneficial effects on nutrient uptake by plants and was particularly important for the transport an availability of micro-nutrients needed for optimal plant growth and development.

Interaction effect between Halex-2 and HA number sprays: The interaction effect between Halex-2 and humic acid number sprays reflected significant differences on plant height and leaves number traits of garlic plants. However, shoot dry weight trait detected insignificant values by this interaction (Table 2). Inoculated garlic plants with Halex-2 and sprayed with humic acid for two or three times gave the highest mean values for plant height in the first season and number of leaves in the second one, in that order comparing with un-inoculated plants. On the contrary, sprayed garlic plants with humic acid for one time in absent of a biofertilizer Halex-2 recorded the highest values for both plant height and number of leaves characters in the second and first seasons, respectively.

Garlic bulb yield and its components

Effect of used garlic cultivars: Data in Fig. 1 and 2 indicated that Balady cv. gave the heaviest total bulb yield (2.12 and 1.91 ton/fed.) and the biggest number of cloves/bulb (28.45 and 23.22) compared with Chinese one (1.74 and 1.53 ton/fed.) and (19.70 and 19.97 cloves number). These results are in agreement with those of Abdlkader-Helmy *et al.* (2011). However, Chinese cv. revealed significant increase in clove weight and clove diameter than Balady cv. (Table 3). These results were true in both seasons. These results might be due to the genetic variations among garlic cultivars and their ability for exploiting the environmental sources particularly, light, CO_2, water and nutrients. Similar results were obtained by Al-Otayk *et al.* (2008), who found that Balady cv. produced more cloves number compared with the Chinese one. While, Chinese cv. gave the highest mean value for bulb diameter over than Balady cv. It could be concluded that, the largest garlic total yield was achieved owing to the increase in number of cloves/bulb than clove weight. Nevertheless, Noorbakhshian *et al.* (2008) evaluated some agronomic traits related to yield components for several garlic cultivars and reported that cloves weight had maximum positive effect on the yield character.

Effect of the Halex-2 inoculation: Inoculation of garlic plants with a biofertilizer Halex-2 caused increases in tonnage bulbs yield in the two seasons (Fig. 1) and clove weight in the first

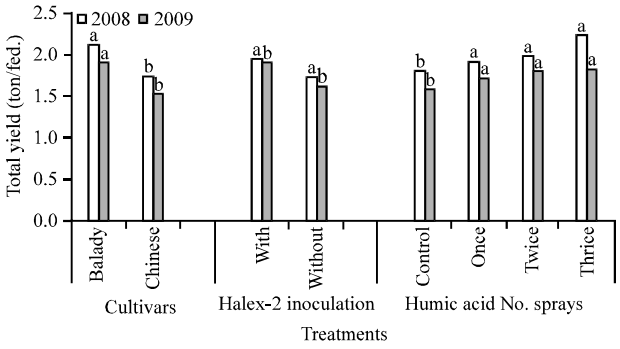

Fig. 1: Main effect of the studied treatments on the total yield trait during the two growing seasons of 2008 and 2009. Bars with the same letter are not significantly different at 0.05

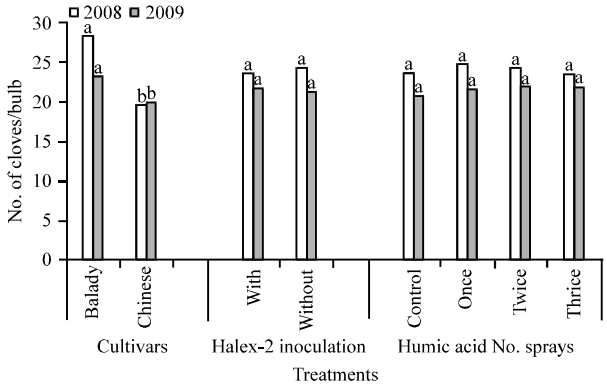

Fig. 2: Main effect of the studied treatments on the number of cloves/bulb trait during the two growing seasons of 2008 and 2009. Bars with the same letter are not significantly different at 0.05

season compared with un-inoculated plants (Table 3). However, bulb diameter, number of cloves/plant and clove diameter characters recorded insignificant differences.

Generally obtained high bulbs yield and clove weight of garlic may be due to the promoting effects of the non-symbiotic N_2 fixing bacteria on morphology and/or physiology of the root system. Noel *et al.* (1996) mentioned that the non-symbiotic N_2 fixing bacteria; *Azotobacter* and *Azospirillum*, created sufficient amounts of IAA, gibberellins and cytokinins, as well as synthesized some vitamins. These products increase the surface area/unit root length and improved the root hair branching with an ultimate increase on the uptake of nutrients and adsorption of water from the soil that eventually yield larger and in many cases, more productive plants (Dobbelaere *et al.* 2001).

Effect of the number of sprays with humic acid: Data in Fig. 1 and 2 and Table 3 displayed that the number of humic acid sprays application had clear significant effect on most of the total yield and its components. It is evident that all number sprays of humic acid enhanced garlic bulb yield and some of its properties like bulb and clove diameter over than check treatments (spray plants with a tap water). Such effect was significant in the two seasons except for clove diameter in the first season, where insignificant effect was detected among the three numbers of humic acid sprays and control treatment. On the other hand, foliar sprays with humic acid for twice resulted

Table 3: Garlic bulb characters as affected by cultivars, Halex-2 and number of sprays with humic acid during seasons of 2007/2008 and 2008/2009

	Bulb diameter (cm)		Clove weight (g)		Clove diameter (cm)	
Treatments	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Garlic cultivars						
Balady	4.36[a]	3.82[a]	2.41[b]	1.31[b]	1.30[b]	1.00[b]
Chinese	4.80[a]	4.01[a]	3.88[a]	2.03[a]	1.53[a]	1.22[a]
Halex-2 inoculation						
With inoculation	4.55[a]	3.96[a]	3.29[a]	1.86[a]	1.45[a]	1.11[a]
Without inoculation	4.61[a]	3.88[a]	2.99[b]	1.48[a]	1.38[a]	1.08[a]
Humic acid (HA) sprays No.						
HA: 0 (control)	4.30[b]	3.78[b]	3.23[a]	1.40[b]	1.40[a]	1.00[b]
HA: 1	4.64[a]	3.99[a]	3.16[a]	1.66[ab]	1.37[a]	1.07[b]
HA: 2	4.61[a]	4.00[a]	3.07[a]	1.86[a]	1.43[a]	1.17[a]
HA: 3	4.81[a]	3.88[a]	3.14[a]	1.79[ab]	1.46[a]	1.22[a]

Values with the same letter(s) in the same column in each season are not significantly different at 0.05

Table 4: Interaction effects among two garlic cultivars, Halex-2 inoculation treatments and sprays number of humic acid application on garlic bulb characters during two seasons of 2007/2008 and 2008/2009

	Bulb diameter (cm)		Clove weight (g)		Clove diameter (cm)	
Bulb characters treatments	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Garlic cv.×Halex-2 treat						
Balady						
With Halex-2	4.31[b]	3.92[a]	2.51[b]	1.48[bc]	1.33[b]	1.03[bc]
Without Halex-2	4.42[b]	3.85[a]	2.32[b]	1.15[c]	1.27[b]	0.96[c]
Chinese						
With Halex-2	4.80[a]	4.00[a]	4.08[a]	2.25[a]	1.57[a]	1.18[a]
Without Halex-2	4.81[a]	3.91[a]	3.69[a]	1.82[ab]	1.49[a]	1.21[a]
Garlic cv.×humic acid (HA) sprays No.						
Balady						
HA: 0	4.22[d]	3.51[b]	2.81[cd]	1.16[d]	1.36[bc]	0.88[d]
HA: 1	4.23[d]	3.91[a]	2.32[d]	1.31[d]	1.28[c]	0.93[d]
HA: 2	4.49[b-d]	3.94[a]	2.19[d]	1.46[c-d]	1.24[c]	1.09[c]
HA: 3	4.51[b-d]	3.79[ab]	2.29[d]	1.34[d]	1.32[c]	1.12[bc]
Chinese						
HA: 0	4.38[c-d]	3.86[ab]	3.65[ab]	1.65[b-d]	1.50[ab]	1.12[bc]
HA: 1	4.86[b]	4.14[a]	3.53[bc]	2.01[a-c]	1.52[a]	1.24[ab]
HA: 2	4.72[bc]	4.06[a]	4.39[a]	2.26[a]	1.49[ab]	1.26[ab]
HA: 3	5.26[a]	4.11[a]	3.98[ab]	2.24[ab]	1.61[a]	1.27[a]
Halex-2 treat.×HA sprays No.						
With inoculation						
HA: 0	4.16[d]	3.88[a]	3.14[ab]	1.34[b]	1.37[bc]	0.97[d]
HA: 1	4.64[a-c]	3.93[a]	3.43[ab]	1.57[ab]	1.46[a-c]	1.10 [a-d]
HA: 2	4.51[b-d]	4.13[a]	3.17[ab]	1.74[ab]	1.38[bc]	1.17[a-c]
HA: 3	4.93[a]	3.86[a]	3.53[a]	1.96[a]	1.59[a]	1.18[a-c]
Without inoculation						
HA: 0	4.44[c-d]	3.89[a]	3.32[ab]	1.46[ab]	1.48[ab]	1.03[c-d]
HA: 1	4.85[ab]	4.00[a]	3.37[a]	1.74[ab]	1.34[c]	1.04[b-d]
HA: 2	4.72[a-c]	3.87[a]	2.54[b]	1.99[a]	1.36[bc]	1.18[ab]
HA: 3	4.54[c-d]	3.75[a]	2.75[a]	1.62[ab]	1.33[c]	1.21[a]

Values with the same letter(s) in the same column in each season are not significantly different at 0.05

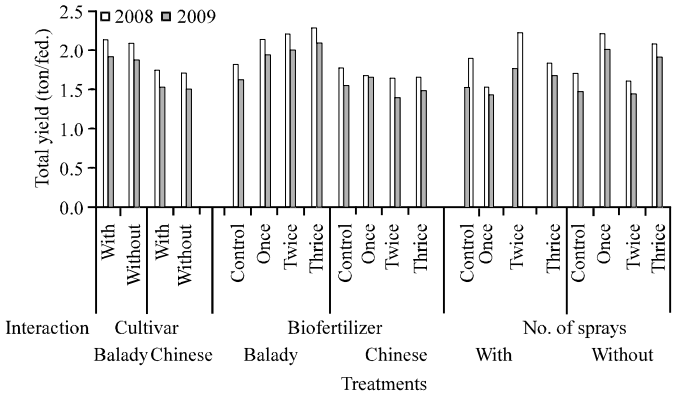

Fig. 3: First order interaction among cultivars, biofertilizer (Halex-2) and number of sprays with humic acid on the total bulb yield trait during the two growing seasons of 2008 and 2009

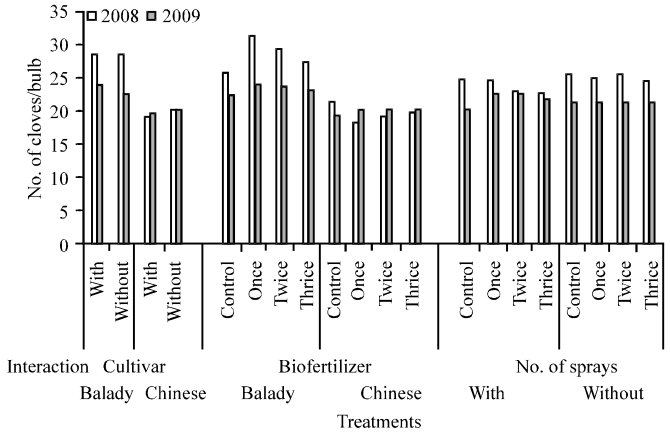

Fig. 4: First order interaction among cultivars, biofertilizer (Halex-2) and number of sprays with humic acid on number of cloves\bulb trait during the two growing seasons of 2008 and 2009

in the highest mean value for clove weight, in the second one comparing with other treatments. This result may be due to the role of humic acid as a source of nutrients and increasing the soil fertility which consequently increased production of assimilates and results in increased bulb size and weight.

Interaction effect between garlic cultivars and Halex-2 inoculation: The highest yield of garlic bulbs which had the largest number of cloves/bulb were associated with using Balady cv. that inoculated or un-inoculated with Halex-2 (Fig. 3 and 4). However, the highest mean values of clove weight, bulb diameter and clove diameter were obtained with Chinese cv. that inoculated or un-inoculated with Halex-2 (Table 4). These findings are in a good accordance in both seasons with only one exception for bulb diameter, in the second season. These data can supported by the findings of Al-Otayk *et al.* (2008) that Chinese cv. gave the highest values of clove weight, bulb diameter and clove diameter characters compared with Balady cv.

Interaction effect between garlic cultivars and HA number sprays: The interaction effect between both tested garlic cultivars and number of humic acid sprays reflected fluctuated influences on total yield and its components in the two seasons of experiment (Fig. 3, 4, Table 4). The recording data showed that the highest values of total yield (2.30 and 2.10 ton/fed.) and the number of cloves/bulb (31.33 and 23.91) were detected with garlic plants Balady cv. sprayed with humic acid for three times and one time, in that order (Fig. 3 and 4). On the other hand, clove weight, bulb diameter and clove diameter traits showed higher mean values with Chinese cv. sprayed with humic acid for twice or thrice, correspondingly (Table 4). It could be summarized that humic acid sprays caused an increment in total garlic bulb yield and caused an enhancement in most of physical properties of growing garlic plants.

Interaction effect between Halex-2 and HA number sprays: The interaction between two Halex-2 treatments and three numbers of humic acid sprays had diverse effects on the total yield and its component characters of garlic plants. Whereas, highest mean values of total yield were obtained with garlic plants inoculated with Halex-2 and sprayed with humic acid for twice (2.23 and 1.98 ton/fed.) as well as garlic plants that un-inoculated with Halex-2 and sprayed one time with humic acid (2.22 and 2.02 ton/fed.) as shown in Fig. (3). In general, the promoting effect of humic acid (potassium humate) on the garlic yield may be referring to potassium element is the prevalent action in plant and involved in maintenance of ionic balance in cells and it bounds initially to the enzyme pyruvate kinase which is essential in respiration a carbohydrate metabolic (Aisha *et al*., 2007). On the contrary, the lowest value of the total yield obtained when un-inoculated garlic plants sprayed twice with humic acid (1.61 and 1.45 ton/fed.) in both seasons (Fig. 3).

Bulb fresh and dry weights (at harvest and after storage) as well as percentage of weight loss

Effect of used garlic cultivars: Data in Table (5) revealed superior significant effect of Chinese cv. in bulb fresh weight character at harvest or after storage than Balady cv. This result was in accordance with Al-Otayk *et al*. (2008), who found that bulb fresh weight of Egyptian Balady cv. was the lowest among the cultivars and lines (Elephant and Chinese) tested. On the contrary, the lowest total weight loss was detected with Balady cv., indicating on their high longevity more than Chinese one. These differences between two cultivars in the later characters might be referring to the genetical divergences which led to the differences in tissues of garlic bulbs. However, bulb dry weight of garlic bulbs at harvest or after storage did not significantly affect by using two garlic cultivars in both seasons.

Effect of the Halex-2 inoculation: Data in Table 5 indicated that inoculation of garlic plants with Halex-2 exerted significant increment in bulb fresh weight at harvest and long storability of garlic bulbs compared with un-inoculated ones, in both seasons. Such results may suggest that beneficial effects of biofertilizer Halex-2 on fresh weight and bulb storability may referring to one or more of the following mechanisms; N-fixation facilitate, promoting substances or organic acids for production of plant growth, enhancing nutrient uptake for storage organs or protection against plant pathogens (El-Haddad *et al*., 1993; El-Morsy *et al*., 2005).

Table 5: Bulbs fresh and dry weights (at harvest and after storage) as well as bulb weight loss (%) of garlic plants as affected by cultivars, Halex-2 and number of sprays with humic acid during winter seasons of 2007/2008 and 2008/2009

	Bulb weight at harvest (g)		Bulb weight after storage (g)		Weight loss (%)		Bulb dry weight at harvest (g)		Bulb dry weight after storage (g)	
Treatments	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Garlic cultivars										
Balady	74.03^{b}	71.22^{b}	29.90^{b}	28.87^{b}	58.89^{b}	58.49^{b}	43.75^{a}	41.50^{a}	46.83^{a}	44.52^{a}
Chinese	88.25^{a}	85.12^{a}	32.07^{a}	32.57^{a}	60.46^{a}	62.20^{a}	43.25^{a}	40.45^{a}	45.94^{a}	45.31^{a}
Halex-2 inoculation										
With inoculation	83.93^{a}	79.61^{a}	33.82^{a}	32.78^{a}	58.06^{b}	59.56^{b}	43.33^{a}	41.66^{a}	45.76^{a}	46.02^{a}
Without inoculation	79.35^{b}	75.73^{b}	29.15^{a}	27.67^{a}	61.29^{a}	61.13^{a}	43.66^{a}	40.29^{a}	47.00^{a}	44.89^{a}
Humic acid (HA) sprays No.										
HA: 0 (control)	79.75^{b}	76.11^{b}	29.92^{b}	27.90^{b}	64.85^{a}	65.75^{a}	42.45^{b}	39.58^{b}	47.41^{a}	44.02^{a}
HA: 1	81.05$^{a b}$	76.61^{b}	30.45^{b}	28.40^{b}	59.54^{ab}	60.13^{ab}	42.89^{b}	40.91^{ab}	46.49^{a}	45.86^{a}
HA: 2	84.88^{a}	81.15^{a}	33.19^{ab}	31.11^{ab}	60.30^{ab}	61.14^{ab}	44.18^{a}	40.41^{ab}	45.78^{a}	44.75^{a}
HA: 3	80.67^{b}	76.81^{b}	36.38^{a}	33.48^{a}	54.09^{b}	54.36^{b}	44.41^{a}	41.50^{a}	45.87^{a}	47.17^{a}

Values with the same letter(s) in the same column in each season are not significantly different at 0.05

Effect of the number of sprays with humic acid: Number of humic acid sprays had a significant effect on bulb fresh weight at harvest or after storage, bulb weight loss (%) and bulb dry weight at harvest, in both seasons (Table 5). The lowest loss in weight of bulbs was found when garlic plants were sprayed with humic acid for three times in both seasons. Such improvement reflects throughout the effect of humic acid on the abundance of minerals in the soil solution which enhanced their uptake by plant roots leading to stimulation of plant growth (higher biomass production). These results validated with that reported by Abd El-Aal *et al.* (2005), who found that application of potassium humate with irrigation water (6 L fed.$^{-1}$) significantly increased onion bulb dry weight.

Interaction effect between garlic cultivars and Halex-2 inoculation: Regarding the interaction effect between both garlic cultivars and Halex-2 inoculation treatments, there were significant differences in bulb fresh weight at harvest and after storage in both seasons (Table 6). Generally, it could be stated that the highest bulb fresh weight were recorded in Chinese garlic inoculated with Halex-2 followed by using Chinese garlic cv. without inoculation by Halex-2 comparing with Balady cv. treatments and these findings were true in both experimental seasons.

Interaction effect between garlic cultivars and H. A. number sprays: Concerning sprays number of humic acid foliar application on two garlic cultivars, the results listed in Table 6 showed significant effect on bulb fresh weight at harvest and after storage, bulb weight loss in both seasons and for bulb dry weight at harvest, in the first season only. The highest values of bulb fresh weight at harvest and after storage were attained when Chinese garlic cv. plants sprayed with humic acid (2 g L^{-1}) for twice or one time, in that order. The increment in both fresh and dry bulb weight of garlic plants at harvest by humic acid foliar application, may be due to the role of humic acid on improving the soil fertility and increasing the availability of several nutrient elements and consequently increased bulb weight. The lowest loss in weight of garlic bulbs was found when either Chinese or Balady plants were sprayed with humic acid for three times in both seasons.

Table 6: Bulbs fresh and dry weights (at harvest and after storage) as well as bulb weight loss (%) of garlic plants as affected by interaction effect among cultivars, Halex-2 and number of sprays with humic acid during winter seasons of 2007/2008 and 2008/2009

	Bulb weight at harvest (g)		Bulb weight after storage (g)		Weight loss (%)		Bulb dry weight at harvest (g)		Bulb dry weight after storage (g)	
Treatments	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Garlic cv.×Halex-2 treat										
Balady										
With Halex-2	80.41^{ab}	75.92^{ab}	29.49^{b}	27.46^{b}	57.91^{a}	58.81^{a}	43.55^{a}	42.83^{a}	46.98^{a}	45.74^{a}
Without Ha-2	75.65^{b}	72.53^{b}	30.31^{b}	28.28^{b}	59.88^{a}	58.17^{a}	43.96^{a}	40.16^{a}	46.68^{a}	44.69^{a}
Chinese										
With Halex-2	87.45^{a}	83.30^{a}	36.15^{a}	34.09^{a}	58.22^{a}	63.45^{a}	43.14^{a}	40.50^{a}	44.54^{a}	46.29^{a}
Without Ha-2	83.04^{ab}	78.94^{ab}	33.99^{ab}	31.05^{ab}	62.71^{a}	60.95^{a}	43.37^{a}	40.41^{a}	47.33^{a}	45.08^{a}
Garlic cv.×humic acid (HA) sprays No.										
Balady										
HA: 0	81.38^{bc}	78.03^{bc}	27.05^{bc}	25.08^{bc}	65.89^{b}	66.74^{ab}	42.88^{bc}	41.66^{a}	47.47^{a}	42.43^{a}
HA: 1	75.50^{d}	70.63^{d}	22.49^{c}	20.49^{c}	57.52^{bc}	57.91^{bc}	43.49^{a-c}	41.50^{a}	47.93^{a}	44.91^{a}
HA: 2	76.16^{cd}	73.15^{cd}	34.19^{ab}	32.09^{ab}	54.86^{c}	55.87^{bc}	44.31^{ab}	41.51^{a}	47.01^{a}	45.49^{a}
HA: 3	79.10^{cd}	75.10^{cd}	35.87^{a}	33.84^{a}	54.30^{c}	54.56^{c}	44.33^{a}	41.33^{a}	44.92^{a}	48.06^{a}
Chinese										
HA: 0	79.96^{cd}	75.60^{cd}	32.80^{ab}	30.73^{ab}	70.22^{a}	71.63^{a}	42.20^{c}	39.50^{a}	47.33^{a}	45.62^{a}
HA: 1	86.61^{b}	82.60^{b}	38.40^{a}	36.31^{a}	55.22^{c}	55.49^{bc}	42.29^{c}	40.33^{a}	45.06^{a}	46.83^{a}
HA: 2	93.60^{a}	89.16^{a}	32.20^{ab}	30.13^{ab}	65.72^{ab}	66.44^{ab}	44.05^{ab}	41.52^{a}	44.55^{a}	44.01^{a}
HA: 3	80.82^{cd}	77.13^{bc}	36.89^{a}	33.12^{a}	53.87^{c}	54.17^{c}	44.49^{a}	40.51^{a}	46.81^{a}	46.28^{a}
Halex-2 treatment×HA sprays No.										
With inoculation										
HA: 0	79.51^{b}	75.83^{c}	28.20^{b}	26.18^{b}	66.84^{a}	67.86^{a}	43.08^{bc}	42.50^{ab}	49.07^{ab}	45.08^{a}
HA: 1	82.51^{ab}	77.10^{bc}	29.62^{b}	27.57^{b}	64.33^{ab}	65.18^{a}	43.44^{bc}	40.16^{a-c}	47.93^{a-c}	48.33^{a}
HA: 2	86.23^{a}	81.66^{ab}	32.96^{ab}	30.88^{ab}	61.78^{ab}	62.25^{a}	43.27^{bc}	43.01^{a}	43.70^{bc}	44.31^{a}
HA: 3	87.50^{a}	83.96^{a}	40.51^{a}	38.48^{a}	49.03^{c}	49.23^{b}	43.58^{b}	41.00^{a-c}	42.36^{c}	46.35^{a}
Without inoculation										
HA: 0	73.85^{c}	69.66^{d}	31.65^{b}	29.63^{b}	56.48^{bc}	56.79^{ab}	42.00^{c}	38.66^{c}	45.73^{a-c}	42.97^{a}
HA: 1	79.60^{b}	76.23^{bc}	31.28^{b}	29.23^{b}	61.09^{ab}	61.94^{ab}	42.34^{bc}	41.66^{ab}	45.06^{a-c}	43.40^{a}
HA: 2	83.53^{ab}	80.65^{ac}	33.42^{ab}	31.34^{ab}	58.86^{a-c}	60.02^{ab}	45.04^{a}	40.00^{bc}	47.85^{a-c}	45.19^{a}
HA: 3	80.40^{b}	76.42^{bc}	32.28^{b}	28.48^{b}	59.14^{ab}	59.51^{ab}	45.23^{a}	40.83^{a-c}	49.38^{a}	47.99^{a}

Values with the same letter(s) in the same column are not significantly different at 0.05

However, the highest weight loss was detected when Chinese cv. plants sprayed with tap water (Table 6). Since, the highest percentage as average of weight loss in Chinese cv. was 30.35% and 32.23% in the first and second seasons, respectively. Close trend was obtained by Rosen and Tong (2001), who detected 27.5% loss weight for garlic bulbs when bulbs stored at 19 to 21°C after 6 months. The superiority of the using higher number of humic acid foliar application on increasing bulb weight after storage and decreasing bulb weight loss might be referred to increased uptake of both macro- and micro-elements, influenced by humic substances, in addition to the growth promoting activity of humic substances was found to be caused by plant hormone-like material (cytokinins) contained in the humic substances (Salman *et al.*, 2005; El-Sharkawy and Abdel-Razzak, 2010) which possibly led to keep nutrient balance inside bulb tissues and improve bulb weight of garlic during garlic storage.

Interaction effect between Halex-2 and HA number sprays: Data in Table 6 showed that inoculated garlic plants with Halex-2 and sprayed for three times with humic acid was favorable for the garlic plants to express their best performance on either fresh bulb weight at harvest or after storage and decrease bulb weight loss in both seasons. On the other hand, bulb dry weight at harvest and after storage was increased by using foliar application of humic acid for three times without inoculated garlic cloves with Halex-2, particularly in the first season. The favorable influence of humic acid attributed to that humic substance will maximize the efficient use of soil plant nutrients and help in release those plant nutrients presently bound in minerals and salts which in turn reflect on bulb development. These results are in agreement with Hafez (2004) and El-Ghamry *et al.* (2009).

Mineral composition of garlic cloves

Main effect: Data in Table 7 recorded that all main treatments effect had no statistical variation on N concentration in garlic bulb tissues of both seasons as well as P and K concentrations, in the first season only. On the other hand, K concentration increased in the second season by inoculated garlic plants with Halex-2 regarding to un-inoculated control treatment. However, increasing number of humic acid sprays for growing garlic plants caused an enhancement in both P and K concentrations of garlic bulb tissues, in the second season as compared to control plants or plants sprayed once with humic acid. Generally, concentrations of N, P and K in the clove tissues were near to that obtained by Islah (2010) and Fawzy *et al.* (2012), who found that averages of N, P and K concentrations in Chinese garlic tissues were ranged between 2.5-5.7, 0.15-0.35 and 1.6-2.2%, respectively in both studies.

Interaction effect between garlic cultivars and Halex-2 inoculation: The results presented in Table 8 indicated that inoculated cloves of two garlic cultivars with a biofertilizer Halex-2 before planting increased K concentration in garlic tissues compared with un-inoculated plants. This result is true in the second season only. This result might be owing to that; the soil experiment was deficient in K concentration, particularly in the second season as mentioned in the materials and methods part. However, concentrations of N and P did not reflect any differences between two garlic cultivars in both seasons.

Interaction effect between garlic cultivars and HA number sprays: It is interested to note that sprayed garlic plants with humic acid for three times increased P concentration in the two garlic cultivars clove tissues compared with other treatments, mainly, in the second season only. However, K concentration detected different values with the two cultivars Sprayed Chinese cv. for one time with humic acid gave the highest value of K (4.28%), in the first season. However, sprayed Balady cv. for twice with humic acid gave higher value of K (5.83%), in the second one.

Interaction effect between Halex-2 and HA number sprays: Data in Table 8 showed that inoculated garlic plants with Halex-2 and sprayed for one or two times with humic acid produced the highest value of P, in the first season and K concentration, in the second one. However, sprayed un-inoculated garlic plants twice or thrice with humic acid increased P concentration, in the second season only of experiment. Also, sprayed un-inoculated plants with humic acid once or twice led to

Table 7: Chemical components of garlic cloves as affected by cultivars, Halex-2 and number of sprays with humic acid during seasons of 2007/2008 and 2008/2009

	N (%)		P (%)		K (%)	
Clove mineral content treatments	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Garlic cultivars						
Balady	2.20^{a}	2.41^{a}	0.30^{a}	0.24^{a}	3.67^{a}	5.34^{a}
Chinese	2.11^{a}	2.32^{a}	0.29^{a}	0.22^{a}	3.62^{a}	5.09^{a}
Halex-2 inoculation						
With inoculation	2.15^{a}	2.43^{a}	0.31^{a}	0.22^{a}	3.65^{a}	5.69^{a}
Without inoculation	2.15^{a}	2.31^{a}	0.30^{a}	0.25^{a}	3.64^{a}	4.73^{b}
Humic acid (HA) sprays No.						
HA: 0 (control)	2.10^{a}	2.32^{a}	0.29^{a}	0.21^{c}	3.31^{a}	5.16^{ab}
HA: 1	2.22^{a}	2.34^{a}	0.28^{a}	0.23^{bc}	4.06^{a}	4.76^{b}
HA: 2	2.15^{a}	2.41^{a}	0.30^{a}	0.25^{ab}	3.87^{a}	5.60^{a}
HA: 3	2.12^{a}	2.41^{a}	0.32^{a}	0.27^{a}	3.31^{a}	5.32^{ab}

Values with the same letter(s) in the same column in each season are not significantly different at 0.05

Table 8: Interaction effects among two garlic cultivars, Halex-2 inoculation treatments and sprays number of humic acid on chemical components of garlic cloves during two winter seasons of 2007/2008 and 2008/2009

	N (%)		P (%)		K (%)	
Clove mineral content treatments	2007/08	2008/09	2007/08	2008/09	2007/08	2008/09
Garlic cv.×Halex-2 treat						
Balady						
With Halex-2	2.25^{a}	2.47^{a}	0.29^{a}	0.23^{a}	3.66^{a}	5.80^{a}
Without Halex-2	2.15^{a}	2.36^{a}	0.31^{a}	0.24^{a}	3.68^{a}	4.88^{bc}
Chinese						
With Halex-2	2.05^{a}	2.39^{a}	0.30^{a}	0.22^{a}	3.62^{a}	5.59^{a}
Without Halex-2	2.15^{a}	2.26^{a}	0.30^{a}	0.25^{a}	3.62^{a}	4.58^{c}
Garlic cv.×humic acid (HA) sprays No.						
Balady						
HA: 0	2.11^{a}	2.39^{a}	0.32^{a}	0.22^{bc}	3.48^{ab}	5.37^{ab}
HA: 1	2.31^{a}	2.27^{a}	0.31^{a}	0.20^{c}	3.83^{ab}	4.72^{b}
HA: 2	2.19^{a}	2.42^{a}	0.28^{a}	0.25^{ab}	3.82^{ab}	5.83^{a}
HA: 3	2.18^{a}	2.57^{a}	0.30^{a}	0.27^{a}	3.55^{ab}	5.45^{ab}
Chinese						
HA: 0	2.09^{a}	2.26^{a}	0.32^{a}	0.23^{a-c}	3.18^{b}	4.95^{ab}
HA: 1	2.14^{a}	2.38^{a}	0.30^{a}	0.21^{c}	4.28^{a}	4.83^{ab}
HA: 2	2.11^{a}	2.41^{a}	0.28^{a}	0.25^{ab}	3.93^{ab}	5.37^{ab}
HA: 3	2.07^{a}	2.25^{a}	0.29^{a}	0.27^{a}	3.07^{b}	5.20^{ab}
Halex-2 treat.×H.A sprays No.						
With inoculation						
HA: 0	2.12^{a}	2.42^{a}	0.31^{ab}	0.23^{b}	3.70^{ab}	5.38^{bc}
HA: 1	2.15^{a}	2.36^{a}	0.32^{a}	0.18^{c}	3.88^{ab}	5.22^{bc}
HA: 2	2.21^{a}	2.45^{a}	0.27^{b}	0.23^{b}	3.55^{ab}	6.55^{a}
HA: 3	2.14^{a}	2.51^{a}	0.29^{ab}	0.26^{ab}	3.42^{ab}	5.63^{ab}
Without inoculation						
HA: 0	2.11^{a}	2.26^{a}	0.32^{ab}	0.22^{b}	2.97^{b}	4.93^{bc}
HA: 1	2.30^{a}	2.29^{a}	0.29^{ab}	0.23^{b}	4.23^{a}	4.33^{bc}
HA: 2	2.09^{a}	2.37^{a}	0.29^{ab}	0.27^{a}	4.20^{a}	4.65^{bc}
HA: 3	2.11^{a}	2.31^{a}	0.31^{ab}	0.28^{a}	3.20^{b}	5.02^{bc}

Values with the same letter (s) in the same column in each season are not significantly different at 0.05

increase K content, in the first season. Therefore, sprayed garlic plants for one or two times with humic acid in present or absent of Halex-2 increased both P and K concentrations of garlic clove tissues at harvest. These findings can explain on the basis that the application of humic acid through foliar sprays might be increase the soil organic matter which improved retention of nutrients, also increased the soil microbial activity which converts the nutrients from organic to mineralized form as reported by Stevenson (1994).

Interaction effect among garlic cultivars, Halex-2 and HA sprays numbers on some major characteristics of garlic plants: Balady cv. reflected superior influence in total yield (ton fed^{-1}) character, particularly when plants inoculated with Halex-2 and sprayed twice with humic acid comparing with Chinese cv. On the other side, Chinese cv. showed superior effect in bulb weight either at harvest or after storage, especially when plants inoculated with Halex-2 and sprayed with humic acid twice or thrice, in that order comparing with Balady cv. The variations between the response of the two garlic cultivars to Halex-2 inoculation and humic acid sprays number on bulb weight and bulb yield might be referring to a genetic factor as the two cultivars were subjected to the same nutrient and environmental conditions (Abou El-Magd *et al.*, 2012). The highest reduction in bulb weight loose was obtained with garlic Balady cv. + Halex-2 inoculation + sprayed for three times with humic acid followed by the same interaction with Chinese one.

CONCLUSION

A biofertilizer Halex-2 inoculation treatment and humic acid foliar spray applications can result in an increase and improvement in the garlic bulbs yield and quality as well as bulbs storability. Garlic Balady cv. showed superior performance on total bulbs yield as a result of increasing number of cloves/bulb as well as bulbs storability comparing with Chinese one. The best interaction is treated garlic plants with Halex-2 inoculation and sprayed with humic acid for twice for increasing bulb weight and total yield at harvest or sprayed for three times by humic acid for increasing longevity of garlic and decreasing weight loss of bulbs after storage.

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