Response of two garlic cultivars (*Allium sativum* L.) to inorganic and organic fertilization

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Abstract: Humic acids (HAs) are the result of organic matter decomposition and are beneficial to plant growth and development. The integration of organic fertilizers appears to be suitable application for saving chemical fertilizers and reducing environmental pollution. In this study, two field experiments were conducted during two winter seasons 2011/2012 and 2012/2013 to investigate the effect of 16 treatments which were; two common garlic cultivars in Egyptian market Balady and Sids-40, two levels of inorganic fertilizers (100% and 50% of recommended dose) and one level of each compound of the following organic fertilizers; humic acid, fulvic acid and compost on garlic vegetative growth characteristics, yield and its components. Application of organic fertilizers showed superior effect for increasing garlic growth and productivity. Treatments of compost and 50% or 100% of RD inorganic fertilizers improved the plant height and shoot fresh weight. While, application of HAs; humic acid, fulvic acid combined with 100% of RD inorganic fertilizers increased the number of leaves and the shoot dry weight, respectively. The obtained results reflected generally that Balady cv. surpassed the Sids-40 cv. in plant height and high longevity traits, when the high total yield was observed in Sids-40 cv. plants. The highest values of total yield, neck diameter and bulb diameter were detected with garlic plants of Sids-40 cv. treated with 100% RD+humic acid. For the bulbing ratio, application of 50% RD+humic acid gave the highest mean. However, the lowest loss of weight of bulbs was found when garlic plants were treated with 100% RD+fulvic acid. High accumulation of nitrate and nitrite was observed in extracts of both cultivars when treated with 100% RD (control) while, treatments with compost + 50% RD decreased the contents of nitrate and nitrite.
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1. Introduction:

Garlic (*Allium sativum* L.), a member of the onion family, has been cultivated for thousands of years and is widely used for culinary and medicinal purposes (Hahn, 1996). Popularity of this crop has recently increased, in part because of the many health benefits attributed to garlic consumption. In Egyptian market, garlic is one of the most highest-value cash crops. Garlic has multifarious use in local consumption, food, processing and exportation. Value of this crop in Egypt, reaches 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).

Nowadays, there is a lot of awareness has been offered in order to reduce pollution in sustainable agricultural practices. One of the ways to decrease soil pollution is the use of organic compounds. Adding organic fertilizers is very important because they contain many nutrients which affect the growth and development parameters of plant (Kloos, 1986). Humic acids (HAs) constituting 65-75% of organic matter in soils are the subjects of studies in various areas of agriculture. HAs increase growth and yields of various crops including vegetables (Hayes and Wilson, 1997; Padem et al., 1997; Atiyeh et al., 2002; Zandonadi et al., 2007). Several mechanisms, one of which was their positive effects on nutrient uptake of vegetable crops (Akinremi et al., 2000; Cimrin and Yilmaz, 2005; Zandonadi et al., 2007), have been suggested to account for this stimulatory effects of HAs. It has also been demonstrated that HAs could serve as growth regulators to control hormone levels, enhance plant growth and increase stress tolerance, improve soil physical properties and complex metal ions (Stevenson, 1982; Serenella et al., 2002). HAs have a lower stability constant than synthetic chalets for metals, thus enhancing metal activity in solution (Mackowiak et al., 2001).

Compost as an organic substance can be used as a soil amendment to enhance the physical characteristics and productivity of soil. The positive effects of compost on plant growth and health are manifold. The influence of compost on plant development is by improving soil structure and elevating soil humus content as well as by supplying macro and micronutrients (Zebrath et al., 1999).

Garlic yield and its components are varied with agricultural practices and cultivar. Meanwhile, this study is intended to improve garlic yield and quality through the choice of appropriate combination of inorganic fertilizers (100% and 50% recommended dose) and organic fertilizers (humic acid, fulvic acid and compost) and suitable cultivar that maximizes the total bulb yield as well as improves bulbs quality of the two common garlic cultivars in Egyptian market Balady and Sids-40.

2. Materials and Methods:

Plant materials

Two garlic cultivars used in this study were local Balady "Egyptian" and Sids-40 cultivars. Both cultivars were recognized as the most common commercial garlic cultivars in Egypt (Osman et al., 1987). Balady cv. is a local cultivar grown in Egypt for its strong aroma which the mature cloves have white covering scale. While, Sids-40 cv. has big cloves size, easy peer and its mature cloves have colored skin.

Methods

Garlic cultivars were planted during two successive winter seasons of 2011/2012 and 2012/2013 at the farm of Horticulture Department, Fac of Agric., Minia Univ., El-Minia, Egypt, to investigate the influence of organic fertilizers; humic acids (humic and fulvic acids) and compost as well as their interactions on garlic vegetative growth, plant yield and its components. Moreover, nitrate, nitrite and functional oil compounds (FOCs) of bulbs of the two cultivars were analyzed. Soil composition of the experimental field was clay loam. 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 8.12, 1.09 %, 45.13, 11.25 and 81.15 ppm. These records were the average of the two growing seasons. The experiment included 16 treatments which were; two garlic cultivars Balady and Sids-40, two levels of inorganic fertilizers (100% and 50% of recommended dose) and one level of each compound of the following organic fertilizers; humic acid, fulvic acid and compost.

Treatments with HAs (humic acid, fulivic acid) and compost

Black granules of HAs; humic acid and fulvic acid (Humin Tech. Company, Germany) at the commercial rate 2 kg per feddan (one fed. = 4200 m^2 = 0.4 ha) were treated with water during irrigation. The other organic fertilizer; compost contained 1.8% N, 0.05%P and 0.45%K (ECARU company) at the rate of 15 ton per feddan was applied as soil treatment before irrigation of the growing garlic plants. Two levels of inorganic fertilizers were applied individually or in combinations with organic treatments. Control treatment which was treated with only inorganic fertilizers; 100% of recommended dose (RD) {200 kg of ammonium nitrate (33.5% N), 200 kg of calcium superphosphate (15.5% P_2O_5), 100 Kg of potassium sulphate (50%K_2O)} per feddan (Egyptian Ministry of Agriculture). The other treatment was 50% recommended dose of NPK. Each of P and K was applied two times during preparing the soil for planting and 70 days later, respectively. Nitrogen was added at three equal quantities; before planting, 30 and 60 days of plant old. Treatments of humic acid, fulvic acid and compost were started one month after planting date and every month for three times throughout the growing seasons.

For the two seasons of experiment, uniform and healthy cloves of the two cultivars were sown on Oct. 31 of 2011 and Oct. 15 of 2012. Treatments were arranged in a spilt-plots system in a Randomized Complete Blocks Design (RCBD) with three replicates. The main plots were allocated for two garlic Balady and Sids-40 cultivars whereas; the 8 treatments of the inorganic and organic fertilizers were randomly distributed in the sub-plots. Each experimental unit (sub-plot) was 3 x 3.5m. Prior to planting, garlic bulbs were split into the individual cloves. Cloves of both cultivars were planted upright with apical tip exposed at 10 cm inter row spacing. After sowing directly and before irrigation, weeds were controlled by using pre-emergence of herbicide. All other agricultural practices were performed as recommended for the commercial production. Plants of each plot were harvested when older leaves turned yellowish green and started withering. The harvested bulbs were spread in single layers under room temperature conditions (in two weeks period of time) for curing process.

Data recorded

Vegetative growth characteristics and yield components

At the harvesting time, samples of ten plants were collected from each plot to estimate:

a) Vegetative growth characteristics

1- Plant height.

2- Number of leaves.

3- Shoots fresh weight.

4- Shoots dry weight.

b) Yield and its components

1- Bulb fresh weight.

2- Neck and bulb diameter.

3- Bulbing ratio (neck diameter/bulb diameter) as described by Mann, 1952.

4-Total yield (ton/fed.)

Yield as ton/fed. was determined by harvesting the remaining plants per each sub-plot and converted to ton/fed after the addition of the sample weight.

c) Bulb loss weight

The plants were stored for the curing process at the typical room conditions to measure the bulb weight after curing and the loss of bulb weight %.

Chemical analysis

Chemical composition of garlic samples was carried out according to the official methods of the Association of Official Analytical Chemists (AOAC, 2000). Samples of dried cloves (20-30 g) were ground, wet digested then samples were packaged in polyethylene bags and stored at -4°C till chemical analysis.

Contents of Nitrite (NO_2^{-1}) and Nitrate (NO_3^{-1})

The NO_2^{-1} and NO_3^{-1} were extracted from garlic cloves by 1% K_2SO_4 solution and determined as described by Venhuis and Dewarg (1980).

Measurement of Functional Oil Compounds (FOCs)

Functional Oil Compounds (FOCs) of garlic were extracted 25 ml of water in a mortal. The fine pastes were magnetic stirred for 30 min and centrifuged at 8000 rpm for 15 min. The supernatants were cooled and transported to separation funnel. The upper layers were sucked by insulin syringe. The volumes of FOCs were measured (Gupta and Porter, 2001).

Statistical analysis

Data obtained in the two seasons of study was subjected to analysis using MSTATC software version 4 (1996). For treatments that were significant, mean separation was done using the Least Significant Differences (LSD) test at 0.05 probability level (Gomez and Gomez, 1984).

3. Results and Discussion:

Vegetative growth parameters and yield components

a) Vegetative growth parameters

Data presented in Table 1 and Table 2 showed the response of used two garlic cultivars to organic, inorganic fertilizers and their interaction treatments on vegetative growth characteristics of growing garlic plants. The results indicated that the two garlic cultivars reflected insignificant differences in number of leaves, shoot fresh and dry weight in both seasons and significant differences in plant height of the second season. Whereas, Balady cultivar recorded the longest plants, however, Sids-40 plants showed the heaviest shoot fresh and dry weight (Table 1). These results might be expected based on the genetic background of each cultivar and the variations between the two genotypes. These results were in agreement with those reported by Omer and Abou-Hadid (1992). On the other hand, the application of organic treatments gave the highest values of vegetative parameters compared with control (100% of RD of inorganic fertilizers). Treatments of compost combined with 50% or 100% of RD inorganic fertilizers improved the plant height and shoot fresh weight, respectively. While, application of HAs; humic acid, fulvic acid along with 100% of RD inorganic fertilizers increased the number of leaves and the shoot dry weight, respectively (Table 1).

Table 1. Vegetative growth characteristics of garlic plants as affected by cultivars, inorganic and organic fertilizers during two seasons of 2011/2012 and 2012/2013.

Garlic cultivars and treatments	Plant height (cm)		No. of leaves/plant		Shoot fresh weight(g)		Shoot dry weight(g)	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Garlic cultivars (A)								
Sids-40	70.27^a	54.63^b	6.417^a	8.583^a	35.46^a	37.08^a	23. 46a	27.29^a
Balady	72.91^a	72.96^a	6.238^a	9.500^a	35.21^a	35.33^a	23. 00a	23.58^a
Treatments (B)								
50% RD	71.52^ab	61.33^cd	6.250^ab	8.833^b	29.00^d	27.17^d	18.67^e	19.00^e
100% RD (control)	72.42^ab	66.00^b	6.167^ab	9.167^b	33.50^bc	33.33^cd	21.67^d	22.00^de
50% RD+humic acid	68.28^b	59.83^de	6.483^ab	9.167^b	34.17^bc	35.83^bc	22.83^cd	25.00^bcd
100% RD+humic acid	73.90 ^ab	66.33^b	6.767^a	10.17^a	38.50^a	42.50^a	26.00^ab	29.17^ab
50% RD+fulvic acid	72.43^ab	66.17^b	6.350^ab	9.167^b	32.17^cd	30.00^cd	22.17^d	23.67^cde
100% RD+fulvic acid	67.05^b	57.33^e	6.167^ab	7.833^c	39.33^a	41.67^ab	26.83^a	30.50a
50% RD+compost	77.72^a	69.50^a	6.100^b	8.833^b	36.50^ab	35.83^bc	23.17^cd	25.83^abcd
100% RD+compost	69.42 ^ab	63.83^bc	6.333^ab	9.167^b	39.50^a	43.33^a	24.50^bc	28.33^abc
L.S.D. (A)	16.24	6.373	0.5284	1.468	1.729	6.572	1.996	4.306
L.S.D. (B)	9.054	2.950	0.5696	0.558	3.669	6.585	2.112	4.931

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

RD = Recommended Dose

Adding humic acid, fulvic acid and compost increased most of plant vegetative growth parameters but with different trend for the garlic cultivars and traits (Table 2). In general, Balady cv. gave taller plants than Sids-40 one in present or absent of organic treatments. Sids-40 cv. gave heavier shoot fresh and dry weight comparing with Balady one for the organic applications. Plant height trait was recorded the highest value with Balady cv. plants that treated with 50% RD+compost comparing with control and Sids-40 cv under all treatments. While, Sids-40 revealed higher mean values for the shoot fresh weight and shoot dry weight, especially when treated with 100% RD+humic acid and 100% RD+fulvic acid, respectively. However, number of leaves of both cultivars was not affected by the addition of organic fertilizers. These results were obtained in the two seasons of experiment. This data could be referring the role of organic fertilizers; HAs and compost on increasing nutrient uptake by plants and the transport availability of micro-nutrient needed for plant growth and development. This in turn increases the vegetative growth of garlic plants. Similar results were obtained by (Bohme and Lua, 1997 and Karakurt et al., 2009).

Table 2. Interaction effects among two garlic cultivars, inorganic and organic fertilizer treatments on vegetative growth characteristics during two seasons of 2011/2012 and 2012/2013.

Garlic cultivars and treatments	Plant height (cm)		No. of leaves/plant		Shoot fresh weight(g)		Shoot dry weight(g)	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Sids-40 cv. x treatments								
50% RD	67.93^{bcd}	50.33^{hi}	6.033^{bc}	7.667^{hi}	25.67^{g}	23.33^{f}	16.33^{h}	13.67^{e}
100% RD (control)	70.13^{abcd}	55.33^{fg}	6.233^{abc}	8.333^{fgh}	33.00^{def}	33.33^{cde}	21.67^{fg}	19.00^{de}
50% RD+humic acid	66.33^{cd}	48.00^{i}	6.967^{a}	9.667^{bcd}	34.33^{b-f}	36.67^{bcd}	22.67^{defg}	24.67^{a-d}
100% RD+humic acid	68.47^{bcd}	53.33^{gh}	6.833^{ab}	9.667^{bcd}	40.33^{a}	46.67^{a}	27.00^{ab}	28.00^{abc}
50% RD+fulvic acid	71.23^{abcd}	57.33^{efg}	6.533^{abc}	9.000^{def}	33.33^{c-f}	33.33^{cde}	22.33^{defg}	22.00^{cd}
100% RD+fulvic acid	70.20^{abcd}	53.67^{gh}	6.500^{abc}	8.333^{fgh}	40.33^{a}	45.00^{ab}	27.33^{a}	30.33^{a}
50% RD+compost	73.47^{abcd}	59.33^{ef}	6.033^{bc}	8.000^{ghi}	38.00^{a-d}	36.67^{bcd}	22.33^{defg}	23.33^{bcd}
100% RD+compost	74.40^{abcd}	59.67^{e}	6.200^{abc}	8.000^{ghi}	38.67^{ab}	41.67^{abc}	24.33^{b-f}	27.67^{abc}
Balady cv. x treatments								
50% RD	72.90^{abcd}	72.33^{c}	6.267^{abc}	10.00^{abc}	32.33^{ef}	31.00 ^{def}	21.00^{g}	24.33^{a-d}
100% RD (control)	76.90^{abc}	76.67^{ab}	6.300^{abc}	10.00^{abc}	34.00^{b-f}	33.33^{cde}	21.67^{fg}	25.00^{a-d}
50% RD+humic acid	70.23^{abcd}	71.67^{cd}	6.000^{bc}	8.667^{efg}	34.00 $^{b-f}$	35.00^{cde}	23.00^{defg}	25.33^{a-d}
100% RD+humic acid	79.33^{ab}	79.33^{a}	6.700^{abc}	10.67^{a}	36.67^{a-e}	38.33^{a-d}	25.00^{a-d}	30.33^{a}
50% RD+fulvic acid	73.63^{abcd}	75.00^{bc}	6.167^{abc}	9.333^{cde}	31.00^{f}	26.67^{ef}	22.00^{efg}	25.33^{a-d}
100% RD+fulvic acid	63.90^{d}	61.00^{e}	5.833^{c}	7.333^{i}	38.33^{abc}	38.33^{a-d}	26.33^{abc}	30.67^{a}
50% RD+compost	81.97^{a}	79.67^{a}	6.167^{abc}	9.667^{bcd}	35.00^{b-f}	35.00^{cde}	24.00^{c-f}	28.33^{abc}
100% RD+compost	64.43^{cd}	68.00^{d}	6.467^{abc}	10.33^{ab}	40.33^{a}	45.00^{ab}	24.67^{a-e}	29.00^{ab}
L.S.D. (AB)	12.80	4.171	0.9161	0.7898	5.189	9.313	2.987	6.973

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

RD = Recommended Dose

b) Yield and its components

Data in Table 3 and Table 4 indicated that Sids-40 cv. gave the heaviest total yield (7.7 ton/fed) and the biggest neck and bulb diameters compared with Balady one. These results were true in both seasons. Similar results were obtained by Al-Otayk et al. (2008) who found that Balady cv. produced more cloves number compared with the Sids-40 one. While, Sids-40 cv. gave the highest mean value for bulb diameter over than Balady cv. These results also are in agreement with those of Noorbakhshian et al. (2008), who evaluated some agronomic traits that related to yield and its components for several garlic cultivars and reported that clove weight had the maximum positive effect on the yield parameter.

Treatments of garlic plants with organic fertilizers increases in tonnage total yield in the two seasons compared with control (100% of RD of inorganic fertilizers). Treatment of 100% RD+fulvic acid and 100% RD+humic acid significantly increased the garlic total yield in both seasons (Table 3). However, neck diameter, bulb diameter and bulbing ratio characters recorded insignificant differences in the first season, application of 50% RD+compost significantly improved these parameters especially in the second season (Table 3). This result may be due to the role of HAs and compost as a source of nutrients and increasing soil fertility which consequently increased production of assimilates and results in increased bulb yield and quality.

Table 3. Garlic yield and its components as affected by cultivars, inorganic and organic fertilizers during two seasons of 2011/2012 and 2012/2013.

Garlic cultivars and treatments	Total yield (ton/fed.)		Neck diameter (mm)		Bulb diameter (mm)		Bulbing ratio %	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Garlic cultivars (A)								
Sids-40	7.711^{a}	7.731^{a}	1.345^{a}	1.377^{a}	6.662^{a}	6.108^{a}	20.13^{a}	23.33^{a}
Balady	5.349^{b}	5.233^{b}	1.104^{a}	1.096^{b}	5.852^{a}	5.604^{b}	19.05^{a}	19.70^{b}
Treatments (B)								
50% RD	4.138^{e}	3.707^{e}	1.292^{a}	1.267^{abc}	6.175^{a}	5.433^{c}	21.04^{a}	23.40^{b}
100% RD (control)	5.297^{d}	5.143^{d}	1.192^{a}	1.058^{bc}	6.265^{a}	5.883^{b}	19.20^{a}	18.30^{c}
50% RD+humic acid	6.268^{c}	5.922^{d}	1.255^{a}	1.350^{abc}	6.278^{a}	5.350^{c}	20.07^{a}	26.60^{ab}
100% RD+humic acid	7.980^{a}	8.435^{a}	1.350^{a}	1.517^{ab}	6.523^{a}	6.333^{a}	20.59^{a}	23.61^{b}
50% RD+fulvic acid	7.105^{b}	7.177^{c}	1.095^{a}	1.100^{bc}	6.195^{a}	6.017^{b}	17.37^{a}	18.32^{c}
100% RD+fulvic acid	8.088^{a}	8.315^{ab}	1.147^{a}	0.9833^{c}	6.270^{a}	5.900^{b}	19.50^{a}	16.55^{c}
50% RD+compost	6.018^{cd}	5.680^{d}	1.373^{a}	1.583^{a}	6.260^{a}	6.017^{b}	21.27^{a}	27.83^{c}
100% RD+compost	7.345^{ab}	7.475^{bc}	1.093^{a}	1.033^{c}	6.093^{a}	5.917^{b}	17.67^{a}	17.51^{c}
L.S.D. (A)	0.8765	0.9998	0.3808	0.1361	0.9921	0.1242	3.748	2.509
L.S.D. (B)	0.7664	0.8536	0.3260	0.4731	0.7386	0.3129	4.471	3.489

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

RD = Recommended Dose

The interaction effect between both garlic cultivars and treatments of organic fertilizers reflected fluctuated influences on total yield and its components (Table 4). The obtained data showed that the highest value of total yield (10.12 and 10.41 ton/fed), neck diameter (1.510 and 1.900 mm) and bulb diameter (7.013 and 6.900 mm) were detected with garlic plants of Sids-40 cv. treated with 100% RD+humic acid. For the bulbing ratio, application of 50% RD+humic acid gave the highest mean.

Table 4. Interaction effects among two garlic cultivars, inorganic and organic fertilizer treatments on garlic yield and its components during two seasons of 2011/2012 and 2012/2013.

Garlic cultivars and treatments	Total yield (ton/fed.)		Neck diameter (mm)		Bulb diameter (mm)		Bulbing ratio %	
	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013	2011/ 2012	2012/ 2013
Sids-40 cv. x treatments								
50% RD	4.590^{fg}	4.183^{gh}	1.333^{abc}	1.033^{c}	6.540^{a-d}	5.467^{de}	20.35^{ab}	23.18^{c-f}
100% RD (control)	6.100^{de}	6.340^{de}	1.100^{bc}	0.7500^{cd}	6.633^{abc}	6.167^{b}	16.59^{b}	12.18^{hi}
50% RD+humic acid	7.420^{c}	7.300^{cd}	1.453^{a}	1.700^{ab}	6.260^{a-d}	4.667^{f}	23.33^{a}	36.63^{a}
100% RD+humic acid	10.12^{a}	10.41^{a}	1.510^{a}	1.900^{a}	7.013^{a}	6.900^{a}	21.18^{ab}	27.59^{bc}
50% RD+fulvic acid	8.710^{b}	8.613^{b}	1.287^{abc}	1.233^{a-d}	6.713^{ab}	6.733^{a}	19.16^{ab}	18.34^{fg}
100% RD+fulvic acid	9.427^{ab}	10.05^{a}	1.400^{ab}	1.300^{a-d}	6.560^{abc}	6.033^{bc}	21.29^{ab}	21.54^{def}
50% RD+compost	6.727^{cd}	6.460^{de}	1.473^{a}	1.867^{a}	7.013^{a}	6.833^{a}	20.80^{ab}	30.63^{b}
100% RD+compost	8.590^{b}	8.490^{bc}	1.203^{abc}	1.000^{cd}	6.567^{abc}	6.067^{b}	18.33^{ab}	16.50^{gh}
Balady cv. x treatments								
50% RD	3.687^{g}	3.230^{h}	1.250^{abc}	1.267^{a-d}	5.810^{bcd}	5.400^{de}	21.73^{ab}	23.62^{cde}
100% RD (control)	4.493^{fg}	3.947^{gh}	1.283^{abc}	1.367^{abc}	5.897^{bcd}	5.600^{cde}	21.82^{ab}	24.42^{cde}
50% RD+humic acid	5.117^{ef}	4.54^{fg}	1.057^{abc}	1.000^{cd}	6.297^{a-d}	6.033^{bc}	16.81^{b}	16.58^{gh}
100% RD+humic acid	5.837^{de}	6.460^{de}	1.190^{abc}	1.133^{bcd}	6.033^{a-d}	5.767^{bcd}	19.99^{ab}	19.62^{efg}
50% RD+fulvic acid	5.500^{ef}	5.740^{ef}	0.9033^{c}	0.9667^{cd}	5.677^{bcd}	5.300^{e}	15.58^{b}	18.29^{fg}
100% RD+fulvic acid	6.750^{cd}	6.580^{de}	0.8933^{c}	0.6667^{d}	5.980^{a-d}	5.767^{bcd}	17.71^{ab}	11.55^{i}
50% RD+compost	5.310^{ef}	4.900^{fg}	1.273^{abc}	1.300^{a-d}	5.507^{d}	5.200^{e}	21.75^{ab}	25.02^{cd}
100% RD+compost	6.100^{de}	6.460^{de}	0.9833^{bc}	1.067^{bcd}	5.620^{cd}	5.767^{bcd}	17.00^{b}	18.51^{fg}
L.S.D. (AB)	1.084	1.207	0.4611	0.669	1.044	0.4425	6.322	4.934

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

RD = Recommended Dose

It could be summarized that treatments of humic acid caused an increment in total garlic bulb yield as well as an enhancement in most of physical properties of growing garlic plants, especially in Sids-40 cv. The obtained results confirmed that there is a difficulty in determining whether genetic and/or environment has a key role in the growth behavior of garlic cultivars.

c) Bulb loss weight

Results in Table 5 and Table 6 reflected significant difference of Sids-40 cv. in bulb fresh weight trait compared with Balady cv. plants. This data was in accordance with Al-Otayk et al. (2008), who found that bulb fresh weight of Egyptian Balady cultivar was the lowest among the tested cultivars and clones of both Elephant and Chinese types tested. On contrary, the lowest total weight loss was detected with Balady cv. indicating on its high longevity more than Sids-40 cv. These variations between both cultivars in later characters could be referring to the genetical divergence which led to differences in tissues of garlic bulbs. However, bulb weight after curing was not significantly affected by using two garlic cultivars in both seasons. Application of HAs and compost had a significant effect on bulb fresh weight and bulb weight loss (%) in both seasons and on bulb dry weight in the second season (Table 5). The lowest loss of weight of bulbs was found when garlic plants were treated with 100% RD+fulvic acid in both seasons, while the highest value was obtained in garlic plants treated with 50% RD or 100 % RD (control treatment).

Table 5. Garlic bulb loss weight as affected by cultivars, inorganic and organic fertilizers during two seasons of 2011/2012 and 2012/2013.

Garlic cultivars and treatments	Bulb Fresh weight (g)		Bulb weight after curing (g)		Loss of total weight%	
	2011/2012	2012/2013	2011/2012	2011/2012	2012/2013	2012/2013
Garlic cultivars (A)						
Sids-40	107.3^{a}	107.7^{a}	20.13^{a}	22.15^{a}	36.30^{a}	35.37^{a}
Balady	74.54^{b}	72.92^{b}	19.05^{a}	19.98^{a}	32.53^{b}	32.41^{b}
Treatments (B)						
50% RD	57.67^{e}	51.67^{e}	21.04^{a}	15.64^{c}	40.01^{a}	35.91^{ab}
100% RD (control)	73.83^{d}	71.67^{d}	19.20^{a}	18.46^{b}	35.96^{ab}	38.04^{a}
50% RD+humic acid	87.33^{c}	82.50^{d}	20.07^{a}	20.62^{b}	34.09^{b}	32.99^{c}
100% RD+humic acid	111.2^{a}	117.5^{a}	20.59^{a}	25.57^{a}	32.27^{b}	30.74^{cd}
50% RD+fulvic acid	99.00^{b}	100.0^{c}	17.37^{a}	19.44^{b}	31.46^{b}	33.41^{bc}
100% RD+fulvic acid	112.3^{a}	115.8^{ab}	19.50^{a}	24.22^{a}	31.10^{b}	29.77^{d}
50% RD+compost	83.83^{cd}	79.17^{d}	21.27^{a}	20.69^{b}	36.16^{ab}	36.89^{a}
100% RD+compost	102.3^{ab}	104.2^{bc}	17.67^{a}	23.89^{a}	34.27^{b}	33.40^{bc}
L.S.D. (A)	11.83	13.92	3.748	2.641	2.023	2.755
L.S.D. (B)	10.73	11.87	4.471	2.714	5.659	2.854

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

RD = Recommended Dose

Concerning adding the organic fertilizers to the two garlic cultivars, the results listed in Table 6 showed that significant effect on bulb fresh weight, bulb dry weight and bulb weight loss % in both seasons. The highest values of bulb fresh and dry weight were obtained when Sids-40 garlic cv. plants were treated with humic acid +100% RD or humic acid+50% RD. The increment of both fresh and dry bulb weight of garlic plants by humic acid may be due to the function of HAs on improving the soil fertility and increasing the availability of several nutrients and consequently increased bulb weight. The lowest loss in weight of garlic bulbs was found when Sids-40 plants were treated with 100% RD+fulvic acid in both seasons. However, the highest weight loss was detected in Sids-40 cv. plants treated with 100% RD (control). Since the highest percentage as average of weight loss in Sids-40 cv. was 41.39% and 41.56% in the first and second season, respectively. The effect of using HAs on increasing fresh and dry weight of bulbs and decreasing bulb weight loss might be referred to improve the uptake of both macro and micro-elements which positively influenced by HAs. In addition to the growth promoting activity of HAs was found to be caused by plant hormone-like material cytokinins contained in HAs (Salman et al., 2005). This result in turn led to keep nutrient balance inside the bulb tissues.

Table 6. Interaction effects among two garlic cultivars, inorganic and organic fertilizer treatments on garlic bulb loss weight during two seasons of 2011/2012 and 2012/2013.

Garlic cultivars and treatments	Bulb Fresh weight (g)		Bulb weight after curing (g)		Loss of total weight%	
	2011/2012	2012/2013	2011/2012	2011/2012	2012/2013	2012/2013
Sids-40 cv. x treatments						
50% RD	64.00^{fg}	58.33^{gh}	20.35^{ab}	16.11^{e}	41.10^{a}	35.57^{bcd}
100% RD (control)	85.00^{de}	88.33^{de}	16.59^{b}	18.29d^{e}	41.39^{a}	41.56^{a}
50% RD+humic acid	103.3^{c}	101.7^{cd}	23.33^{a}	21.11^{cd}	33.63^{a-e}	35.01^{cd}
100% RD+humic acid	141.0^{a}	145.0^{a}	21.18^{ab}	27.59^{a}	38.76^{ab}	32.14^{def}
50% RD+fulvic acid	121.3^{b}	120.0^{b}	19.16^{ab}	20.32^{cd}	34.14^{a-d}	34.75^{cde}
100% RD+fulvic acid	130.7^{ab}	140.0^{a}	21.29^{ab}	27.43^{a}	32.39^{b-e}	31.60^{d-g}
50% RD+compost	93.67^{cd}	90.00^{de}	20.80^{ab}	21.13^{cd}	34.75^{a-d}	39.16^{ab}
100% RD+compost	119.7b	118.3^{bc}	18.33^{ab}	25.24^{ab}	34.24^{a-d}	33.20^{c-f}
Balady cv. x treatments						
50% RD	51.33^{g}	45.00^{h}	21.73^{ab}	15.17^{e}	38.92^{ab}	36.26^{bc}
100% RD (control)	62.67^{fg}	55.00^{gh}	21.82^{ab}	18.63d^{e}	30.53^{cde}	34.51^{cde}
50% RD+humic acid	71.33^{ef}	63.33^{fg}	16.81^{b}	20.13^{cd}	34.54^{a-d}	30.97^{efg}
100% RD+humic acid	81.33^{de}	90.00^{de}	19.99^{ab}	23.55^{bc}	25.77^{e}	29.35^{fg}
50% RD+fulvic acid	76.67^{ef}	80.00^{ef}	15.58^{b}	18.56d^{e}	28.78^{de}	32.07^{def}
100% RD+fulvic acid	94.00^{cd}	91.67^{de}	17.71^{ab}	21.01^{cd}	29.81^{cde}	27.94^{g}
50% RD+compost	74.00^{ef}	68.33^{fg}	21.75^{ab}	20.26^{cd}	37.56^{abc}	34.61^{cde}
100% RD+compost	85.00^{de}	90.00^{de}	17.00^{b}	22.54^{bc}	34.31^{a-d}	33.60^{cde}
L.S.D. (AB)	15.18	16.78	6.322	3.839	8.004	4.037

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

RD = Recommended Dose

Chemical analysis

Contents of Nitrate (NO_3^{-1}) and Nitrite (NO_2^{-1})

Interaction of nitrate and nitrite contents of the two garlic cultivars and organic and inorganic treatments is presented in (Fig.1). Nitrate concentration (mg/kg) measured in garlic extracts ranged from 26.88 to 43.20 mg/kg of fresh weight (Fig. 1 A and A`). The highest level (43.20 mg/kg) of nitrates was observed in extracts of Sids-40 cv. treated with 100% RD (control) and the lowest value was recorded on the same cultivar when treated with 50% RD+compost. The results are in good agreement with those reported by (Van-Der-Schee, 1998) who mentioned that the average of nitrate content in plants is 35 mg/kg. MAFF (1987) reported that nitrate contents in vegetable crops vary enormously, ranging from 1 to 1000 mg/kg of fresh weight. According to this classification garlic belongs to division I; crops containing low nitrate concentration (>250 mg/kg) of fresh weight. On the other hand, nitrite concentrations ranged from 1.12 to 1.526 mg/kg (Fig. 1 B and B`) and Balady plants contained the highest value (1.526 mg/kg) when treated with 100% RD (control). Sids-40 cv. gave the lowest level of accumulation when treated with 50% RD+compost. Results are true in both seasons. These levels were in the safe extent (10 mg/kg fw) and do not cause any toxic effects.

Measurement of Functional Oil Compounds (FOCs)

Fluctuated effects were detected between two garlic cultivars used and treatments on concentration of FOCs (Fig. 2). In general, Sids-40 cv. was surpassed Balady cv. under all treatments. Treatments with 100% RD+humic acid gave the highest concentration of FOCs in Sids-40 cv. (67.00 and 66.33 ml/kg) and in Balady cv. (62.0 and 63.33 ml/kg) in the first and second season, respectively (Fig. 2 A and A`).

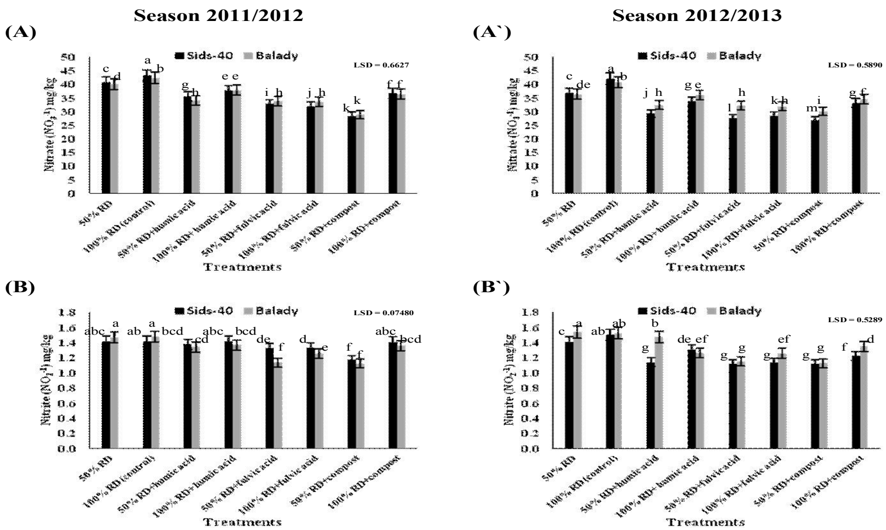

Fig.1 Interaction effects among two garlic cultivars (Sids-40 and Balady), inorganic and organic fertilizers on contents of nitrate (NO_3^{-1}) and nitrite (NO_2^{-1}) of garlic cloves during two seasons of 2011/2012 (A and A`) and 2012/2013 (B and B`), respectively.

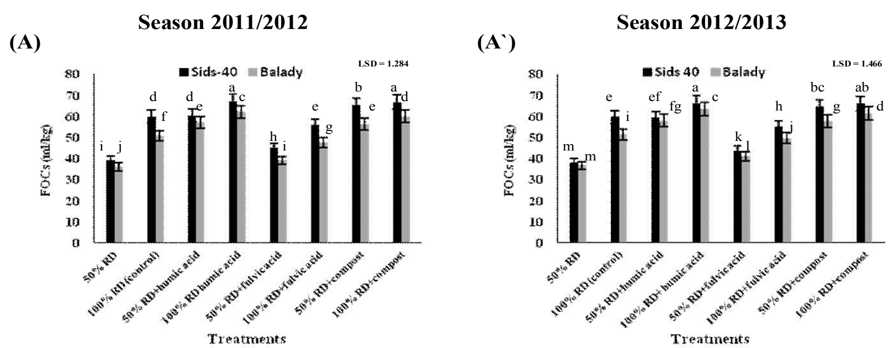

Fig.2 Interaction effects among two garlic cultivars (Sids-40 and Balady), inorganic and organic fertilizers on Functional Oil Compounds (FOCs) of garlic cloves during two seasons of 2011/2012 and 2012/2013 (A and A`), respectively.

Conclusion

The results clearly show that organic fertilizers especially humic acid can result in an increase and improvement of the garlic bulbs yield and quality. Garlic Sids-40 cv. shows great performance on total bulb yield comparing with Balady cv. The best interaction is treated garlic plant with 100% RD+humic acid for increasing bulb fresh weight and total yield. Treatment with 100% RD+fulvic increases the longevity of garlic and decreasing weigh loss of bulbs after curing.

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