Effect of Humic acid foliar application on growth, yield, and quality of some garlic genotypes under Aswan Governorate

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ABSTRACT

A field experiment was carried out during the two consecutive winter seasons of 2018/2019 and 2019/2020 in the experimental farm of Faculty of Agriculture and Natural Resources, Aswan University, Egypt, to evaluate three garlic genotypes namely Egaseed1, Sids40 and Clone4 under foliar application of five rates of humic acid as control "distilled water", 1000, 1500, 2000 and 2500 mg.l^{-1}. The results showed that the highest plants came with 2000 mg.l^{-1} treatment of humic acid during both seasons meanwhile Sids40 gave the highest plants during both seasons. The highest mean values of cured bulbs owing to 2000 mg.l^{-1} treatment of humic acid in both seasons. While the least weight loss percentage due to 2500 mg.l^{-1} treatment of humic acid in both seasons. The highest average cured clove weight came with the treatment of 2000 mg.l^{-1} humic acid in both seasons and with the genotype Sids40.

INTRODUCTION

Garlic (*Allium sativium* L.) is one of the most important bulb vegetable crops and next to onion (*Allium cepa*) in economic importance in the family Alliaceae (1). It is commonly used as a spice and in the medicinal purpose. The most important parts of garlic for medicinal purposes are fresh bulbs, dried bulbs, and the oil extracted. Garlic contains about 40% dry matter, 6-7% proteins, 0.2% lipids, 23-28% carbohydrates, 0.7-0.9% fiber, 1.1-1.4% ash matter and vitamins, especially A, B1, B2, B6 and C. It has been reported to possess several biological properties including anticarcinogenic, antioxidant, antidiabetic, reno protective, anti-atherosclerotic, antibacterial, antifungal, and antihypertensive activities in traditional medicines. It is rich in several sulfur-containing phytoconstituents such as alliin, allicin, and flavonoids such as quercetin (2). In Egypt, garlic is grown as a wintry crop, where it sows through September month and harvested during the following March and April months, for local consumption and as exporter crop. According to FAO (Food and Agriculture Organization,2020) statistics (3) Egypt ranks the fourth

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leading country in the world for garlic production after China, India and Korea. In Egypt the cultivated agricultural area with garlic reached 15719 hectares producing 333543 tons.

Garlic has known since ancient Egypt and it's cultivation is estimated that has been done for 5000-6000 years (4). Currently, there are about 600 garlic varieties worldwide (5). Although it is propagated asexually, large scale morphological and agronomic diversity have been observed in garlic (6). The morphological and genetic variations are great in most of garlic characteristics (bulb weight, bulbing ratio, T.S.S. (total soluble solids), ascorbic acid, minerals, aroma components, antioxidant activity, sulfur compounds and storability) among garlic genotypes (7, 8). The adaptation of varieties under different environmental conditions is very important and has a clear impact on growth, quality, and productivity. High productivity and good quality are very important for the farmer because they generate a high income for him. Under Aswan conditions, the farmers cultivated old garlic varieties with low productivity and unimproved. Therefore, one of the objectives of this study was to evaluate the performance of some improved garlic genotypes under Aswan Governorate conditions.

Recent studies proved that use bio-stimulants such as humic acid in garlic production can directly or indirectly influence the physiological activities in plant growth. Moreover, such compounds can improve plant resistance and tolerance to environmental stresses as well as improve productivity, quality, and storability of garlic bulbs (9). The uptake of humic substances by plant tissue resulting in various biochemical effects through an increased nutrient uptake and maintaining levels of vitamins and amino acids in plant tissues; and thus, stimulating root growth and whole plant (10). The foliar application of humic extracts in plants of has been shown to considerably increase their development and fruit production. These bio stimulating effects can be attributed to the presence of humic substances that contains humic acid and fulvic acid molecules (11, 12). The humic substances has a supramolecular structural organization composed of chemical domains that allows root-level interaction with plants and exerts stress protection effects (13), which increases the efficiency of nutrient uptake (14) and stimulates growth through hormonal regulation (15).

The investigation reported herein included a series of field and postharvest studies, which were conducted to evaluate some garlic genotypes at different rates of foliar application with humic acid to determine the best genotype and humic concentration for maximizing the yield and quality of garlic bulbs, as well as follow up its effects on the postharvest quality and storability under Aswan condition.

MATERIALS AND METHODS

Experimental sites

Two field experiments were carried out during the two successive winter seasons of 2018/2019 and 2019/2020, at experimental farm of the faculty of agriculture, Aswan university, Egypt to study of the effect of foliar

application of humic acid levels on vegetative growth, yield and storability of some garlic "*Allium sativum* L " genotypes under Aswan governorate condition.

Before planting, random soil samples of 0-30 cm depth from different places of the planting field were collected and analyzed for some important chemical and physical properties according to **(16)** are presented in Table (1).

The physical and chemical analyses of the soil, as reported earlier were carried out at Soil and Natural Resourses Departement, The Faculty of Agriculture, Aswan University, Egypt.

Table (1). Some physical and chemical properties of the experimental site during both seasons of the experimentation (2018/2019 and 2019/2020).

Soil properties	Seasons	
	2018/2019	2019/2020
Mechanical Analysis:		
Clay (%)	03.00	03.50
Silt (%)	0.00	0.00
Sand (%)	97.00	96.50
Textural class	Sandy	Sandy
Chemical analysis:		
pH (1:1 water suspension)	7.64	7.70
EC (1:1 water extract) dS\cm at 25° C	0.33	0.32
Soluble cations in (1:1) soil: water extract (mmol/l)		
Ca^{++}	3.06	3.10
Mg^{++}	1.02	1.05
K^{+}	0.83	0.85
Na^{+}	0.76	0.80
Soluble anions in (1:1) soil: water extract (mmol/l)	5.67	
HCO_3^{-}	7.10	7.06
Cl^{-}	3.60	3.57
SO_4^{--}	0.40	0.44
Available N (mg/kg soil)	128.31	130.00
Available P (mg/kg soil)	08.00	10.00
Available K (mg/kg soil)	175.00	180.00

Meteorological data of the cultivation area during time-course of the present study 2018/2019 and 2019/2020 seasons (*i. e.*, the maximum, minimum and average air temperatures) are listed in Table (2).

Table (2). The maximum, minimum and average net temperatures air per month in Aswan Governorate during the two growing seasons of 2018/2019 and 2019/2020.

Month	Air temperature [°C]			Air temperature [°C]		
	Max.	Min.	x^-	Max.	Min.	x^-
	2018/2019			2019/2020		
Oct.	43.03	26.58	34.81	38.02	21.8	29.91
Nov.	32.97	20.8	26.89	31.7	15.84	23.77
Dec.	24.29	10.67	17.48	26.72	11.2	18.96
Jan.	21.6	8.81	15.21	20.88	7.24	14.06
Feb.	24.61	6.93	15.77	23.08	7.2	15.14
Mar.	20.6	8.1	14.35	26.21	10	18.11
Apr.	33.94	16.44	25.19	33.81	17.08	25.45

Meteorological data from Central Lab. for Agricultural Climate, Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Egypt.

The experimental treatments

Treatments were consisted of two factors as a foliar applicants, *i.e.*; five concentrations of humic acid (HA) as control, 1000, 1500, 2000 and 2500 $mg.l^{-1}$ in combination with three garlic genotypes. Control plants were sprayed with distilled water. Garlic plants were sprayed with the allocated or assigned treatments three times during the growing seasons, the first one at 105 days after planting, the second application was 15 days after the first one, and the last one was 15 dayes later.

Three colored genotypes of garlic cv. namely "Egaseed 1", " Sids 40 " and " Clone 4" were used in this study. The sources and bulb color of these genotypes are listed in Table (3).

Table (3). Sources and bulb color of the genotypes used in this study.

Genotype name	Genotype source	Genotype bulb color
Egaseed-1	The Agricultural Egyptian Company for Seed Production, Beni Swif, Egypt.	Slightly red
Sids-40	Sids Horticulture Rsearch Station, The Agricultural Research center, Beni Swif, Egypt.	Slightly red

Clone-4	Horticulture Department, the Faculty of Agriculture , Aswan University.	Red

Agricultural practices

Garlic cloves were sowed under open field condition at the apical tip on the ridge as four rows with 80 cm width and of 10 cm spacing between the cloves, using drip irrigation system on october 17th and 20th in 2018/2019 and 2019/2020, respectively.

All other agro-managements practices such as fertigation, irrigation, cultivation, diseases and pest control were carried out whenever they were necessary and as recommended for the commercial production of garlic under drip irrigation on open field at Aswan district.

Experimental Layout

The experimental layout was a Factorial Experiments in a Randomized Complete Blocks Design with three replications. Each experiment included 15 treatments, which were the combinations of five levels of humic acid foliar application and three garlic genotypes. Each experimental unit contained four rows of 10 m length and 0.80 m width.

Harvesting

Whole garlic plants were harvested at 5 th of April 2019 and 6th of April, in the first and second seasons, respectively. Harvested garlic bulbs were weighed immediately, and then were cured, for 21 days, in a clean, shaded, well-ventilated and dry room, at a temperature (25^{o}c ±2). After finishing the curing process, garlic bulbs of each experimental unit were weighed.

Experimental data collection

Vegetative growth characters

Plant height (cm)

It was measured in cm. from the base of the plant to the terminal point of the tallest leaf at 60, 90, 105, 120 and 135 days from planting date as average of randomly five plants.

Leaves number plant

It was counted at 60, 90, 105, 120 and 135 days from planting date as average of randomly five plants from each experimental unit.

Bulb characters

Bulb diameter (cm)

- On field, At 105, 120, 135, days

- At harvesting time

- After curing

- bulb diameter was measured at the widest part of each bulb for five bulbs that randomly selected from each experimental unit, and the average bulb diameter in (cm) was measured by vernier calliper.

Bulbing ratio (%)

It is determined at the same times of bulb diameter determined as an average of the previous five bulbs that randomly selected from each experimental unit, according to the following equation:

$$Bulbing\ ratio = \frac{Neck\ diameter\ (cm)}{Bulb\ diameter\ (cm)} \times 100$$

Bulb yield and its components

Average number of cloves/ bulb

It was determined at harvest as an average of number of the previous randomly five bulbs selected .

Average clove weight (g)

It was determined at harvest before curing and after curing (after 21 days from harvesing) as an average of cloves of the previous randomly five bulbs selected of garlic.

Yield (Ton/Fed.)

The total yield of all harvested bulbs befoe curing for each plot was determined and converted into the total yield fed^{-1} (tons fed^{-1}). It also was determined as cured yield by converting the weight of all plants, of each experimental unit, after finishing the curing process into ton fed^{-1}.

Cloves chemicals constituents

Cloves dry matter percentage

It was determined at harvest before curing and after curing by using about a fifty-gram sample of fresh cloves, which were randomly taken from each plot, then these samples were oven dried at 70^{o}C for 48 hours to constant weight, and then samples were reweighted to estimate the percentage of dry matter.

Total soluble solid (T.S.S %)

The total soluble solids in the bulbs were measured by using a digital refractmeter, at harvest and at the end curing duration according to **(17)**. It was determined for five random bulbs obtained from each plot it was taken from the juice of each bulb and the average was calculated.

The post-harvest quality and Storability

The Post-Harvest Quality and Storability of garlic bulb was expressed by estimating weight loss.

Statistical Analysis

All obtained data of the present study were statistically analyzed according to the design used by the COSTAT computer software program and were tested by analysis of variance. The least significant difference test at 0.05 level of probability was used to compare the differences among the given means of the various treatment combinations as illustrated by **(18).**

Result and Discussion

- **Vegetative growth characters**

Results in Table (4) showed some vegetative growth characters *i.e*., plant height and leaves number of some garlic genotypes as affected by foliar application with humic acid during the winter seasons of 2018/2019 and 2019/2020.

Data illustrated, generally, that there was no significant difference among humic(ha) acid foliar applications treatments in plant height and number of leaves characters at 125 and 140 days after planting during both seasons. The insignificant effect of humic acid foliar application may be due to suitable of environmental conditions for vegetative growth of garlic during the treatment period (Meteorological data Table 3). Also, perhaps due to the lack between the different concentrations of humic acid, and therefore we need in future research to increase the humic concentration also the garlic plants may be more responsive to humic acid soil application than foliar application. The positive effects for HA on plant growth might be attributed to that its effect on increasing of cell membrane permeability, oxygen uptake, respiration and photosynthesis, phosphate uptake, root and cell elongation and ion transport (19). These obtained results seemed to be in general agreements with those reported by (20, 21, 22) on vegetative growth of garlic plants using humic acid application.

Respecting garlic genotypes results demonstrated that sids-40 showed the highest mean values of plant height and number of leaves characters after 125 and 140 days after planting during both seasons but it in general did not differ significantly from clone-4 at 125 and 140 days after planting.Egaseed-1 showed the lowest significant mean values for vegetative growth characters during the first season at all stages but it in general did not differ significantly from sids-40 and clone-4 genotypes during the second season.

Table (4). Vegetative growth characters of some garlic genotypes as affected by foliar application with humic acid during the winter seasons of 2018/2019 and 2019/2020.

Treatments		Plant height (cm.)				Leaves number			
		Days after planting							
		125		140		125		140	
		2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Humic acid (main effect)									
Control (distilled water)		67.97	53.90	69.99	56.33	9.84	8.13	9.82	8.87
1000 mg.l^{-1}		63.10	51.57	65.30	53.74	9.36	8.33	9.73	9.18
1500 mg.l^{-1}		65.03	53.96	67.08	56.67	9.34	8.18	10.07	8.84
2000 mg.l^{-1}		68.59	54.74	70.71	57.31	9.80	8.71	10.18	9.49
2500 mg.l^{-1}		64.74	53.96	65.91	56.13	9.84	8.58	9.64	9.24
LSD (0.05)		5.15	5.74	4.87	5.26	0.41	0.69	0.47	0.67
Genotypes (main effect)									
Egaseed1		61.92	52.76	63.75	55.27	9.40	8.24	9.36	9.08
Sids40		68.89	55.34	70.52	57.48	9.92	8.56	10.13	9.21
Clone4		66.85	52.76	69.13	55.37	9.59	8.36	10.17	9.08
LSD(0.05)		3.99	4.45	3.77	4.07	0.32	0.45	0.36	0.52
Combinations effects									
Humic acid (ppm)	Genotypes								
Control	Egaseed1	62.13	51.00	65.00	52.67	8.87	8.20	8.87	8.87
	Sids40	72.57	56.03	73.37	58.93	9.93	8.07	9.80	8.80
	Clone4	69.20	54.67	71.60	57.40	10.73	8.13	10.80	8.93
1000 mg.l^{-1}	Egaseed1	60.57	50.63	60.93	54.00	9.07	8.13	9.27	9.40
	Sids40	65.57	52.40	68.43	54.53	9.87	8.47	10.20	9.13
	Clone4	63.17	51.67	66.53	52.70	9.13	8.40	9.73	9.00
1500 mg.l^{-1}	Egaseed1	61.30	54.13	62.43	56.13	9.80	8.27	10.27	9.00
	Sids40	66.05	57.27	68.37	59.00	9.42	8.60	9.87	9.20
	Clone4	67.73	50.47	70.43	54.87	8.80	7.67	10.07	8.33
2000 mg.l^{-1}	Egaseed1	63.20	57.20	66.03	58.73	9.60	8.80	9.93	9.27
	Sids40	70.70	54.97	72.07	57.93	10.27	8.47	10.40	9.27
	Clone4	71.87	52.07	74.03	55.27	9.53	8.87	10.20	9.93
2500 mg.l^{-1}	Egaseed1	62.40	50.83	64.33	54.80	9.67	7.80	8.47	8.87
	Sids40	69.57	56.03	70.37	57.00	10.13	9.20	10.40	9.67
	Clone4	62.27	55.00	63.03	56.60	9.73	8.73	10.07	9.20
LSD(0.05)		8.93	9.94	8.43	9.10	0.71	1.20	0.81	1.16

These results might be expected based on the genetic background of each cultivar and the variations between the genotypes. These results agree with those obtained by (23) and (24).

The results in Table (4) showed also that the interaction effect between foliar application of humic acid and garlic genotypes on vegetative growth characters were insignificant during both seasons.

- **Bulbing ratio (%)**

The effects of foliar application with humic acid on bulbing ratio of some garlic genotypes at 125, 140 from planting, and at harvest, during the winter seasons of 2018/2019 and 2019/2020 are shown in Table (5).

The results showed that there was no significant difference in bulbing ratio between the five treatments of humic acid at all stages in both seasons except at 125 days from planting in the first season the humic treatment at 2000 mg.L^{-1} showed the highest bulbing ratio and the lowest bulbing ratio were recorded from the plants treated with humic acid at 2500 mg.L^{-1}. Data showed that there were no significant differences in bulbing ratio between the three genotypes in both seasons except at 125 days from planting in the first season and at harvest in the second season clone-4 genotype recorded the highest bubing ratio. The interaction effect between humic acid treatments and garlic genotypes on bulbing ratio were insignificant except at 125 days from planting in the first season garlic cultivar 'Clone-4' treated with humic treatment at 1000 mg.L^{-1} gave the highest bulbing ratio.

Table (5). Bulbing ratio character of some garlic genotypes as affected by foliar application with humic acid during the winter seasons of 2018/2019 and 2019/2020.

Treatments		Days after planting					
		125		140		(At harvest)	
		2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Humic acid (main effect)		2018/2019					
Control (distilled water)		0.36	0.37	0.27	0.24	0.20	0.21
1000 mg.l^{-1}		0.36	0.37	0.27	0.20	0.18	0.21
1500 mg.l^{-1}		0.37	0.38	0.26	0.20	0.18	0.20
2000 mg.l^{-1}		0.38	0.36	0.28	0.21	0.20	0.21
2500 mg.l^{-1}		0.34	0.35	0.26	0.21	0.18	0.24
LSD(0.05)		0.035	0.04	0.03	0.06	0.03	0.039
Genotypes (main effect)							
Egaseed1		0.35	0.36	0.27	0.24	0.20	0.19
Sids40		0.36	0.37	0.27	0.20	0.19	0.21
Clone4		0.38	0.37	0.27	0.20	0.18	0.24
LSD(0.05)		0.027	0.029	0.02	0.047	0.02	0.03
Combinations effects Humic acid (ppm)	Genotypes						
Control	Egaseed1	0.32	0.33	0.26	0.33	0.19	0.16
	Sids40	0.35	0.39	0.25	0.21	0.18	0.20
	Clone4	0.40	0.40	0.29	0.18	0.22	0.28
1000 mg.l^{-1}	Egaseed1	0.36	0.37	0.27	0.22	0.20	0.18
	Sids40	0.31	0.38	0.26	0.19	0.17	0.21
	Clone4	0.42	0.36	0.27	0.19	0.17	0.23
1500 mg.l^{-1}	Egaseed1	0.34	0.37	0.26	0.21	0.19	0.18

	Sids40	0.37	0.39	0.27	0.20	0.18	0.22
	Clone4	0.40	0.38	0.26	0.20	0.18	0.20
2000 mg.l^{-1}	Egaseed1	0.37	0.36	0.30	0.21	0.19	0.19
	Sids40	0.39	0.37	0.27	0.21	0.21	0.21
	Clone4	0.39	0.34	0.29	0.23	0.19	0.23
2500 mg.l^{-1}	Egaseed1	0.35	0.36	0.27	0.24	0.20	0.24
	Sids40	0.38	0.34	0.28	0.19	0.20	0.21
	Clone4	0.30	0.35	0.22	0.20	0.14	0.25
LSD(0.05)		0.06	0.06	0.05	0.11	0.04	0.07

Table (6). Yield and its component characters of some garlic genotypes as affected by foliar application with humic acid during the winter seasons of 2018/2019 and 2019/2020.

Treatments		Average bulb weight (g)				Average clove weight (g)				Yield (Ton/Fed.)			
		Before curing		After curing		Before curing		After curing		Before curing		After curing	
		2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Humic acid (main effect)													
Control		69.11	40.02	49.91	31.22	4.14	3.25	3.05	2.66	9.10	8.89	5.83	6.32
1000 mg.l^{-1}		64.12	44.24	44.02	35.18	3.64	3.56	2.71	3.17	8.07	9.05	5.86	6.53
1500 mg.l^{-1}		67.59	42.60	47.92	33.58	4.41	3.52	3.13	3.07	8.53	8.89	6.16	6.46
2000 mg.l^{-1}		69.15	47.28	56.07	38.79	4.52	4.16	3.48	3.40	8.95	9.28	6.69	7.12
2500 mg.l^{-1}		63.79	42.94	51.52	36.08	4.01	3.48	3.35	3.00	8.79	8.95	6.61	7.15
LSD(0.05)		11.05	8.50	7.66	7.52	0.92	0.69	0.38	0.59	1.08	1.34	0.580	0.977
Genotypes (main effect)													
Egaseed1		55.52	39.61	41.85	31.42	3.74	3.46	2.64	2.81	7.30	8.71	5.08	6.51
Sids40		65.96	45.88	50.73	37.15	4.37	3.75	3.44	3.07	9.01	9.60	6.37	7.10
Clone4		78.76	44.77	57.08	36.34	4.32	3.58	3.35	3.30	9.75	8.73	7.23	6.54
LSD(0.05)		8.56	6.58	5.93	5.83	0.71	0.54	0.30	0.46	0.84	1.04	0.66	0.757
Combinations effects													
Humic acid (ppm)	Genotypes												
Control	Egaseed1	63.89	34.98	47.32	25.78	3.57	2.82	2.72	2.17	7.57	8.77	5.49	6.37
	Sids40	67.96	45.69	48.13	36.27	4.47	3.62	3.35	3.14	9.95	9.68	7.28	6.81
	Clone4	75.49	39.39	54.27	31.59	4.39	3.32	3.08	2.65	9.78	8.23	7.30	5.77
1000 mg.l^{-1}	Egaseed1	53.15	36.42	38.09	29.56	3.20	2.95	2.52	2.91	6.95	8.55	4.64	6.50

	Sids40	63.70	46.31	44.73	35.67	3.71	3.74	2.74	3.38	8.17	9.42	5.92	6.63
	Clone4	75.50	50.01	49.25	40.32	4.00	3.98	2.87	3.22	9.10	9.17	7.01	6.46
1500 mg.l^{-1}	Egaseed1	55.11	44.21	40.09	32.89	3.62	3.96	2.52	3.03	6.65	9.22	4.56	6.74
	Sids40	57.84	44.68	48.94	36.78	4.20	3.29	3.49	3.55	8.47	9.70	6.43	6.95
	Clone4	89.83	38.91	54.73	31.08	5.41	3.31	3.37	2.62	10.46	7.74	7.47	5.68
2000 mg.l^{-1}	Egaseed1	56.21	45.71	47.51	36.77	4.91	4.70	3.00	3.13	7.98	8.88	6.12	6.73
	Sids40	73.60	45.67	56.59	37.35	4.80	3.82	3.84	3.34	8.81	9.53	6.37	7.33
	Clone4	77.63	50.47	64.10	42.25	3.84	3.96	3.59	3.73	10.06	9.43	7.34	7.31
2500 mg.l^{-1}	Egaseed1	49.27	36.73	36.25	32.09	3.41	2.87	2.43	2.81	7.37	8.13	4.59	6.22
	Sids40	66.72	47.03	55.25	39.67	4.67	4.26	3.76	3.08	9.65	9.69	5.86	7.79
	Clone4	75.37	45.06	63.07	36.47	3.96	3.31	3.84	3.12	9.34	9.04	7.04	7.45
LSD(0.05)		19.14	14.72	13.26	13.03	1.59	1.20	0.66	1.02	1.88	2.32	1.47	1.69

Table (7). Cloves chemical characters of some garlic genotypes as affected by foliar application with humic acid during the winter seasons of 2018/2019 and 2019/2020.

Treatments		Cloves dry matter percentage				TSS % (Brix)			
		Before curing		After curing		Before curing		After curing	
		2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
Humic acid (main effect)									
Control (distilled water)		35.64	37.36	59.59	50.80	34.83	34.11	38.83	38.17
1000 mg.l^{-1}		37.54	38.47	61.28	51.19	34.48	36.06	38.44	39.83
1500 mg.l^{-1}		44.49	41.39	63.46	51.54	34.11	37.50	38.78	40.33
2000 mg.l^{-1}		44.17	43.21	62.94	55.46	34.38	38.22	39.17	40.72
2500 mg.l^{-1}		42.93	43.84	64.20	56.77	36.06	38.44	39.39	39.89
LSD(0.05)		1.46	1.83	4.39	5.06	2.71	2.20	1.61	1.67
Genotypes (main effect)									
Egaseed1		43.53	41.02	64.17	53.16	35.97	37.43	39.87	40.67
Sids40		40.35	40.38	60.90	53.02	34.99	36.60	38.87	39.30
Clone4		38.98	41.16	61.81	53.28	33.36	36.57	38.03	39.40
LSD(0.05)		1.27	1.41	3.40	3.92	2.10	1.71	1.24	1.29
Combinations effects									
Humic acid (ppm)	Genotypes								
Control	Egaseed1	36.89	37.69	65.58	50.98	35.67	35.67	38.83	42.00
	Sids40	35.07	36.13	55.95	48.69	34.00	31.67	39.33	35.00

	Clone4	34.98	38.25	57.25	52.74	34.83	35.00	38.33	37.50
1000 mg.l^{-1}	Egaseed1	41.13	38.02	64.56	53.25	35.83	35.17	38.50	39.83
	Sids40	35.58	37.51	59.47	49.66	34.43	36.00	38.33	39.50
	Clone4	35.90	39.87	59.81	50.67	33.17	37.00	38.50	40.17
1500 mg.l^{-1}	Egaseed1	50.28	41.83	61.80	53.22	35.33	37.00	40.83	40.33
	Sids40	46.63	41.12	60.65	56.57	34.83	37.83	36.67	40.83
	Clone4	36.57	41.22	67.92	56.58	32.17	37.67	38.83	39.83
2000 mg.l^{-1}	Egaseed1	47.36	44.94	65.12	58.27	36.67	39.83	40.33	41.33
	Sids40	40.88	43.33	64.62	56.69	33.00	37.83	39.17	40.83
	Clone4	44.26	43.24	59.09	55.35	33.47	37.00	38.00	40.00
2500 mg.l^{-1}	Egaseed1	42.00	42.60	63.78	50.08	36.33	39.50	40.83	39.83
	Sids40	43.57	43.79	63.83	53.49	38.67	39.67	40.83	40.33
	Clone4	43.21	43.22	64.98	51.05	33.17	36.17	36.50	39.50
LSD(0.05)		2.84	3.16	7.61	8.77	4.69	3.82	2.78	2.89

- **Yield and its components**

Results in Table (6) showed some yield and its components characters *i.e.*, weight of bulb and clove, and yield.fed^{-1} at harvest and after curing duration of some garlic genotypes as affected by foliar application with humic acid during the winter seasons of 2018/2019 and 2019/2020.

Results illustrated that plants treated with 2000 mg.L^{-1} gave the highest mean values and enhanced all yield and its components characters as bulb and clove weight, and yield before and after curing compare to other treatments during both seasons. The positive effects of the HA on yield potential of garlic plants might be related to its beneficial effect on vegetative growth as previously mentioned, which probably supplied more photosynthetic substances needed for bulbs formation and development and hence, might help in improving yield potential. The present results agreed to the great extent with those reported by (25, 26, 27) on increasing garlic yield and its components with using humic foliar application.

Concerning effect of genotypes, data in Table (6) demonstrated that clone-4 genotype gave in general the highest mean values for all studied characters during both seasons. These results seemed to be, in general, agreement with those reported by (28) who reported that there was a wide variation in yield and its components belonging to different garlic genotypes.

In the case of interaction effects data showed that insignificant effects were found between humic application and garlic genotypes for all characteristics studied in both seasons of the study. In general data illustrated that sids-40 and clone-4 genotypes applicated with any humic levels showed the highest mean values for all yield and its components characters during both seasons of the study.

- **Cloves chemicals constituents**

Data in Table (7) showed some cloves chemical characters *i.e.*, dry matter percentage, and TSS % (Brix) at harvest and after curing duration of some garlic genotypes as affected by foliar application with humic acid during the winter seasons of 2018/2019 and 2019/2020.

The obtained results in Table (7) showed that dry matter percentages and total soluble solids of garlic cloves gradually increased at the end of the curing duration. These results can be explained based on increased respiration rate and bioactivity of garlic bulbs which leads to the consumption of carbohydrate and increase water loss. This

result is agreement with those reported by (29) who found that at storage, as time progresses, the rate of respiration increases of garlic bulbs.

Also, results illustrated that the highest significant mean values of cloves dry matter and TSS percentages were found when garlic plants treated with the highest level of humic acid concentration (2500 $mg.L^{-1}$) compared to untreated plants during both seasons. Data also showed that the highest humic concentration (2500 $mg.L^{-1}$) doesn't different significantly from humic acid at 2000 $mg.L^{-1}$ concentration in their effect on clove chemical characters during both seasons of the study. These results may be due to the stimulatory effect of HA on growth parameters, where HA was added through enlargement bulb stage, which may lead to an increase in the contents of dry matter and TSS percentages of garlic cloves. These results seemed to be, in general, agreement with those reported by (30, 31, 32) who reported improvements in garlic dry matter and TSS percentages with humic acid foliar application.

Concerning genotypes effect, results presented that Egaseed-1 genotype appear highest mean values of cloves dry matter and TSS percentages during both seasons. These results seemed to be, in general, agreement with (33) and (24) who found variation in dry matter and TSS percentages among different garlic genotypes.

In the case of the interaction between humic acid and garlic genotypes, results exhibited insignificant effect in relation to cloves dry matter and TSS percentages characters before or after curing during both seasons except for cloves dry matter percentage before curing in first season and TSS after curing in the second season. In general Egaseed-1 genotype gave the highest mean values when treated with 2000 or 2500 $mg.L^{-1}$ during both seasons.

- **The post-harvest quality and Storability**

Data in Table (8) showed weight loss percentage of some garlic genotypes as affected by foliar application with humic acid during the winter seasons of 2018/2019 and 2019/2020.

The obtained results in Table (8) showed that the weight loss percentages of garlic bulbs gradually increased with increasing the storage duration up to 5 months and then found to decrease at the end of the storage duration (9 months). These results can be explained based on increased respiration rate and bioactivity of garlic bulbs, especially, during the second storage duration (2-4 months), which leads to the consumption of carbohydrate and increase water loss. This result is agreement with those reported by (29) who found that at storage, as time progresses, the rate of respiration increases of garlic bulbs.

Also, data in Table (8) illustrated that after curing duration, plants treated with 2500 $mg.L^{-1}$ gave the lowest significant weight losses percentages during both seasons. While there were no significant differences between humic acid treatments during both seasons in weight loss percentages after 3, 5 and 9 months. Concerning the effect of humic acid on storability of garlic bulbs, data show that storability of garlic bulbs was markedly influenced by the application of humic acid. Generally, treated plants with humic acid had better storability than untreated plants during storage in both seasons. These results may be due to the stimulatory effect of HA on growth parameters, where HA was added through enlargement bulb stage, which may lead to an increase in the contents of the T.S.S., dry matter and total carbohydrates percentages of garlic bulbs, which contributed to the reduction of weight loss during storage. These results seemed to be, in general, agreement with those reported by (26) and (34), who reported that the lowest weight loss of the garlic bulbs and the highest total carbohydrate was achieved with the application of humic and fulvic acid.

Data in Table (8) showed that Egaseed-1 genotype gave the lowest significant weight loss percentage after curing, 3, 5 and 9 months in the first season only but don't significantly differ from other genotypes in the second season. These variations between cultivars could be referring to the genetic divergence which led to differences in tissues of garlic bulbs.

Table (8). Weight loss percentage of some garlic genotypes as affected by foliar application with humic acid during the winter seasons of 2018/2019 and 2019/2020.

Treatments		After curing		After 3 months		After 5 months		After 9 months	
		27th May, 2019	28th May, 2020	27th Aug., 2019	28th Aug., 2020	27th Oct., 2019	28th Oct., 2020	27th Feb., 2020	28th Feb., 2021
Humic acid (main effect)									
Control (distilled water)		28.42	28.90	19.43	15.49	23.52	18.70	31.33	29.39
1000 mg.l^{-1}		24.45	27.48	19.93	15.18	23.98	17.63	30.33	29.06
1500 mg.l^{-1}		24.75	27.38	21.27	12.95	26.07	16.86	32.59	29.27
2000 mg.l^{-1}		29.60	23.24	19.92	15.57	24.12	19.14	32.32	30.43
2500 mg.l^{-1}		22.93	20.27	18.06	16.67	23.38	21.40	30.99	33.74
LSD(0.05)		4.82	3.78	6.14	3.75	6.05	4.55	6.19	5.25
Genotypes (main effect)									
Egaseed1		22.63	24.96	14.79	15.99	20.13	19.07	28.20	31.71
Sids40		27.24	26.13	23.21	14.12	27.76	19.00	34.51	30.30
Clone4		28.22	25.26	21.16	15.41	24.75	18.17	31.83	29.11
LSD(0.05)		3.73	2.93	4.76	2.91	4.68	3.53	4.80	4.07
Combinations effects Humic acid (ppm)	Genotypes								
Control	Egaseed1	25.16	27.03	15.53	14.95	20.51	16.92	28.58	29.87
	Sids40	29.38	29.65	24.16	16.93	28.48	22.47	35.91	31.75
	Clone4	30.71	30.00	18.61	14.59	21.58	16.70	29.50	26.56
1000 mg.l^{-1}	Egaseed1	20.03	23.69	12.43	17.91	17.21	19.86	23.87	31.98
	Sids40	25.95	29.47	23.50	13.40	28.05	15.55	34.24	26.00
	Clone4	27.38	29.28	23.85	14.23	26.68	17.49	32.88	29.20
1500 mg.l^{-1}	Egaseed1	21.50	26.73	15.36	14.12	20.52	18.16	27.57	31.97
	Sids40	25.58	28.30	28.62	9.43	34.11	14.90	39.62	26.37
	Clone4	27.17	27.11	19.82	15.31	23.59	17.52	30.60	29.46
2000 mg.l^{-1}	Egaseed1	25.17	23.87	17.57	13.88	22.52	17.99	32.47	28.60
	Sids40	31.13	23.42	25.07	16.84	28.98	19.90	35.82	33.01
	Clone4	32.50	22.42	17.12	16.00	20.87	19.52	28.66	29.67
2500 mg.l^{-1}	Egaseed1	21.31	23.46	13.07	19.11	19.91	22.41	28.52	36.14
	Sids40	24.18	19.83	14.69	13.98	19.17	22.19	26.95	34.39
	Clone4	23.31	17.50	26.43	16.93	31.05	19.61	37.51	30.68
LSD(0.05)		8.35	6.55	10.64	6.50	10.47	7.88	10.72	9.10

The interaction effect between treatments and garlic genotypes was insignificant in weight loss percentages after curing, 3, 5 and 9 months ring both seasons.

Conclusion

Under Aswan conditions Governorate, the farmers cultivated old garlic varieties with low productivity and unimproved. From our results we noticed that clone-4 and Sids-40 genotypes gave highest growth and yield but less

quality as clove dry weight, TSS and weight losses percentages than Egaseed-1 genotype which gave highest quality. Therefore, we recommended that farmers, under Aswan Governorate, should cultivated clone-4 and Sids-40 genotypes to produce a crop for fresh consumption directly without storage. However in the case of long-term storage, the Egaseed-1 genotype must be planted.

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