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EFFECT OF NITROGEN FERTILIZATION AND SOME STIMULANTS ON DRY WEIGHT, YIELD, BULB QUALITY AND STORABILITY OF GARLIC

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ABSTRACT: Two filed experiments were carried out during the winter seasons of 2016/2017 and 2017/2018 at the Experimental Farm, El-Gemmeiza, Agric Res. Station, (ARC), Gharbya Governorate (Middle Delta, Egypt), to study the effect of nitrogen fertilization at 90 and 120 kg/fad., and some stimulants; viz, salicylic acid (SA at 100 mg/l), lithovit at 2 g/l and algae extract at 2%, beside unsprayed treatment on dry weight, yield, bulb quality and storability of garlic, Balady cultivar under clay soil conditions using flood irrigation system. The obtained results revealed that, the interaction between using 120 kg N/fad., and lithovit at 2 g/l increased dry weight of bulb, leaves and total dry weight/plant, N, P and K contents in bulb and leaves mineral uptake, uptake by bulb, leaves and their total uptake by plant as well as total chlorophyll in leaves, average bulb weight, marketable and total yields/faddan. While, the interaction between using 90 kg N/fad., and lithovit or SA increased nitrogen use efficiency, dry matter (DM). TSS, Pungency in bulbs at harvesting time and decreased total weight loss percentage after 180 days from storage in both seasons. The relative increases in total yield/fad., were about 41.96 and 61.11% for the interaction between fertilizing garlic plants with 120 kg N/fad., and spraying with lithovit at 2 g/l over 90 Kg N without spraying with stimulants in the 1st and 2nd seasons, respectively. In the same time, the interaction between 90 kg N/fad., and lithovit recorded increases in total yield/fad., were about 9.59 and 10.10% over the plants which received 120 kg N/fad., without spraying with stimulants in the 1st and 2nd seasons, respectively.

Key words: Garlic, nitrogen, salicylic acid, lithovit, algae extract, yield, storability.

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most important bulb vegetable crops and is next to onion in importance. It is commonly used as a spice or in the medicinal purposes. In Egypt, it has been generally cultivated for both local consumption and export. Therefore, increasing garlic yield and improving bulb quality are essential aims for both growers and consumers, but it usually depends on many factors especially that influence the plant growth throughout the growth period.

The requirement of nitrogen for garlic production may vary with soil type, the previous crop grown, the amount of organic matter present and the climatic conditions during crop growing season. Nitrogen is one of the major essential nutrient elements that contributes a lot for the production of crop.

Increasing nitrogen fertilizer increased plant growth, yield and its components and bulb quality (**Kakar *et al*., 2002; El-Shabasi *et al.*, 2003; El-Seifi *et al*., 2004; Ershadi *et al*., 2009; Farooqui *et al*., 2009; Zaman *et al*., 2011; Ahmed *et al*., 2012; Abou El-Magd *et al.*, 2014; Hassan, 2015; Mohamed, 2015; Kumar *et al*., 2018**) on garlic.

Salicylic acid (SA) a natural signal molecule, has been shown to play an important role in regulating a number of physiological processes in plants. Its exogenous application has promoted plant performance under biotic and abiotic

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stresses (**Senaratna *et al.,* 2000**). Spraying plants with salicylic acid was the superior for enhancing the total dry weight/plant, leaf pigments, N, P and K uptake by leaves and bulb, exportable, marketable and total yield/fad., as well as average bulb weight compared to control treatment (**Bardisi, 2004** on garlic, **Amin *et al.*, 2007** on onion, **Al-Zohiri, 2009, Bideshki *et al.*, 2013; Abou El- Khair and Khalil, 2014** on garlic).

Modern agricultures searching for new biotechnologies that would allow for a reduction in the use of chemical inputs without negatively affecting crop yield or the farmers' income. In recent years, the use of natural algae as fertilizer has allowed for partial substitution of conventional synthetic fertilizer (**Zodape *et al.*, 2011**). In addition, a number of commercial algae extract products are available for use in agriculture and horticulture and can be used as liquid extracts applied as foliar spray, soil drench, or in granular/powder form as soil conditioners and manure **(Thirumaran *et al.*, 2009).** Spraying plant with algae extracts increased dry weight, N,P and K contents and their uptake, yield and its components as well as bulb quality than unsprayed plants **(Abou El-Khair *et al.*, 2010; Fawzy *et al.*, 2012; Mohsen, 2012; Shalaby and El-Ramady, 2014** on garlic**, Babilie *et al.*, 2015; Shafeek *et al.*, 2015; Hidangmayum and Sharma, 2017; Yassen *et al.*, 2018** on onion).

Nano-fertilizers are used recently as an alternative to conventional fertilizers for slow release and efficient use by plants. Nano-fertilizers could enhance nutrient use efficiency and decrease the costs of environmental protection, (**Naderi and Shahraki, 2013**). Lithovit compound containing silica (5%), magnesium carbonate (4%) and calcium carbonate (75%) particles, extremely small, which gives them the ability to enter through the stomata in leaves of plants when applied as foliar spray (**Raven, 2003**). Increasing lithovit rates from zero (untreated) to the highest rate, significantly increased plant growth, yield and its components as well as bulb quality (**Abdelghafar *et al.,* 2016** on onion and **Merwad, 2018** on garlic).

Therefore, the aim of this research is the possibility of reducing the rate of nitrogen fertilization by using some stimulants to increase productivity, bulb quality and storability of garlic.

MATERIALS AND METHODS

Two filed experiments were carried out during the winter seasons of 2016/2017 and 2017/2018 at the Experimental Farm of El-Gemmeiza, Agric Res. Station, (ARC), Gharbya Governorate (Middle Delta, Egypt), to study the effect of nitrogen fertilization and some stimulants on growth, yield, bulb quality and storability of garlic Balady cultivar under clay soil conditions using flood irrigation system.

The used soil properties were: Clay loam soil in texture for the average two seasons, while it had 1.27% organic matter, 8.19 pH, 1.07 mmhos/cm EC, 76.7 available N, 12.4 available P and 272 available K as mg/kg soil.

This work included eight treatments which were the combination between two levels of mineral nitrogen at 90 and the recommended rate (120 kg/fad.) with three stimulants, *i.e.,* salicylic acid (SA) at 100 mg/l, lithovit at 2 g/l and algae extract at 2%, beside spraying with tap water treatment.

These treatments were arranged in a split - plot design with three replicates. Nitrogen levels were randomly arranged in the main plots, while foliar spray treatments with some stimulants were randomly distributed in the sub plots.

Green micro Algae extract was produced by National Res. Cent. (NRC, Giza, Egypt). It containing 50.56% crude protein, 7.39 % ether extract, 9.83% crude fiber, 9.18% ash, 4.51% moisture, 8.09% N, 2.69% P, 0.65% K, 2057 ppm Fe, 722 ppm Zn, 747 ppm Mn and 93 ppm Cu.

The lithovit was obtained from Agrolink Company as a powder, the Chemical analysis of lithovit were 79.19% Calcium carbonate, 0.06%N, 0.01% P, 0.21% K_2O, 4.62% Magnesium carbonate, 11.41% Selenium dioxide, 0.33% sulphur, 1.31% Iron, 0.005% Zinc, 0.002% Copper, 0.014% Manganese and 0.55, Sodium oxide.

Salicylic acid (SA-2 hydroxybenzoic acid) was obtained from Sigma Chemical Co. (St. Louis, USA) Salicylic acid (SA) was dissolved in absolute ethanol then added drop-wise to water (ethanol/water: 1/1000, *V/V*).

The plants were sprayed with SA, algae extracts and lithovit at four times at 60, 80, 100 and 120 days after planting. Each plot received 2L. solutions of each stimulant using spreading agent in all treatments to improve adherence of the spray to the plant foliage for increasing stimulants absorption by the plants. The untreated plants (check) were sprayed with tap water and spreading agent.

One ridge was left as buffer zone between each two experimental units to avoid seepage of materials sprayed.

One third of mineral nitrogen in the form of ammonium sulphate (20.6% N) was added during soil preparation and the rest amounts were added at three portions as soil application by one month intervals beginning one month after planting.

Garlic cloves were selected for uniformity in shape and size. Cloves were planted at distance of 10 cm apart in both sides of the ridge on the first week of October in both seasons.

The experimental unit area was 10.8 m^2 .It contained three ridges with 6m length and 60 cm in width. One ridge was used for the samples to measure vegetative growth and the other ridges were used for yield determination.

All plots received the recommended dose of P and K at the rates 60 kg P_2O_5/fad., and 75 kg K_2O/fad., in the form calcium super phosphate (15.5% P_2O_5) and potassium sulphate (48-50% K_2O), respectively. One third of potassium sulphate and all calcium super phosphate were added during soil preparation and the first amounts of ammonium sulphate with farmyard manure (FYM) at 30 m^3/fad., while the two third of K_2O was added at three portions as soil application by one month intervals beginning one month after planting.

The other normal agricultural practices for growing garlic were carried out as commonly followed in district.

Data Recorded

Plant growth

Ten plants were randomly taken for each plot at 135 days after planting, and they were separated into different organs; *i.e.* bulb and leaves, then they were oven dried at 70°C tell constant weight. Dry weight was recorded as bulb, leaves, dry weights/plant (g). In addition, total plant dry weight (bulb +leaves/ plant) was calculated.

Total chlorophyll

A disc sample from the fourth outer leaf of garlic plant was randomly taken from every experimental unit 135 days after planting in both growing seasons to determine chlorophyll a and b, according to the method described by **Wettestein (1957)** and after that total chlorophyll (a+b) were calculated.

Mineral contents, uptake and total uptake

Dried represented samples of bulb and leaves of the all tested treatments at 135 days after planting in both seasons were finely ground and wet digested. Then, N, P and K contents were determined according to the methods described by **AOAC (1995)**. Uptake and total uptake of N, P and K were calculated.

Yield and its components

At proper maturity stage of bulbs (200 days) every plot was harvested and graded into four categories according to the **Ministry of Economy Egypt (1963)**, Grade 1: bulbs with diameter more than 5.5 cm, grade 2 : bulbs with diameter more than 4.5 to 5.5 cm, grade 3: bulbs with diameter less than 4.5 cm and grade 4:bulbs with diameter less than 3.5 cm, each grade was counted and weighed separately at the same harvest day and the following data were calculated as ton/fad., marketable yield (grade 1 + grade 2 + grade 3), unmarketable yield (grade 4) and total yield (grade 1+ grade 2 + grade 3 + grade 4). Also, average bulb fresh weight (g) was recorded.

Nitrogen use efficiency (NUE)

It was determined by dividing the bulb yield/ fad., by the nitrogen quantity/fad., and expressed as kg bulb/kg N according to **Clark (1982)**.

Bulb quality at harvesting date

Dry Matter (%)

One hundred grams of the grated mixture were dried at 105°C till constant weight and DM (%) was recorded.

Total soluble solids (TSS)

It was measured in bulbs using Carl Zeis refractometer.

Pungency as pyruvic acid

It was determined in fresh garlic cloves tissues using the method described by **Schwimmer and Westen (1961**).

Bulb Storability

Just after harvesting on April 20th for the two experimental seasons, bulb yield of each plot was separately collected and translocated to curing for 15 days in aired shady place. After curing (on May 5th), dried plant tops were discarded and four kilograms of uniform cured bulbs for each plot were putted in palm crates and then stored at room temperature. Storage was prolonged to six months, so the storage zero time was May 5th and it was ended on November 5th in both seasons. The average room temperature and relative humidity during storage months are presented in Table A.

Bulb storability was monthly tested and the following data were recorded:

Weight loss (%)

Bulbs of each treatment were weighed at 30 days intervals, and then the cumulative weight loss percentage was calculated.

Statistical Analysis

Collected data were subjected to statistical analysis of variance according to **Snedecor and Cochran (1980**), and means separation was done using LSD at 5% level of probability.

RESULTS AND DISCUSSION

Dry Weight

Effect of nitrogen levels

Results in Table 1 show that dry weight of bulb, leaves and total dry weight/plant were significantly affected by nitrogen level in both seasons.

Fertilizing garlic plants with 120 kg nitrogen gave the highest value for each of dry weight of bulb, leaves and total dry weight/plant in both seasons.

The relative increases in total dry weight/ plant were about 19.43 and 36.06 for 120 kg N/fad., over 90 kg N/fad., in the 1st and 2nd seasons, respectively.

The increase of plant growth by increasing nitrogen level might be due to its role in photosynthesis, protein synthesis, cell division and enlargement which are the basal steps of plant growth. In addition, nitrogen plays an important role in the enzyme activity which reflects more products needed in plant growth (**Gardener *et al*., 1985**).

These results are in harmony with those reported by **Kakar *et al*. (2002), Ahmed *et al*. (2012)** and **Abou El-Magd *et al*. (2014)** on garlic. They found that increasing of nitrogen fertilizer significantly increased dry weight of different plant organs of garlic.

Effect of some stimulants

Results in Table 1 also, reveal that foliar application of different stimulants such as salicylic acid (SA), algae extract and lithovit resulted in significant increases for all dry weight of different organs of garlic plant than control treatment in both seasons of the study.

Spraying garlic plants with lithovit gave the highest value for each of dry weight of bulb, leaves and total dry weight/plant, followed by spraying with algae extract in both seasons

The relative increases in total dry weight/ plant were about 19.07 and 30.76 for spraying plants with lithovit, as well as 12.80 and 13.38% for spraying plants with algae extract over the control treatment (spraying with tap water) in the 1st and 2nd seasons, respectively.

Respecting the effect of lithovit on increasing the dry weight/plant, lithovit contain macro and micro- elements, which encourage and activities the metabolism of the compounds formations, then increased the growth of plants (**Bidwell, 1979**).

These results are in harmony with those of **Abdelghafar *et al.* (2016)** on onion with respect to lithovit effect, **Fawzy *et al.* (2012) and Mohsen (2012)** on garlic as for algae extract effect.

Effect of the interaction between N levels and some stimulants

The interaction between fertilizing garlic plants with 120 kg N/fad., and spraying with lithovit had significantly increased bulb, leaves and total dry weight/plant compared with the other treatments and control in both seasons of study, without any significant differences with

Table A. The average room temperature (^oC) and relative humidity (%) during storage period

Month	Temperature (^oC)		Relative humidity (%)	
	2017 season	2018 season	2017 season	2018 season
May	27.32	29.32	87.91	90.25
June	31.60	32.90	86.18	88.24
July	31.74	32.80	88.15	92.54
August	32.13	31.00	87.48	95.58
September	29.76	26.33	81.46	89.66
October	28.26	27.12	84.67	82.24
November	24.83	25.14	87.40	83.24

Table 1. Effect of nitrogen levels and some stimulants as well as their interactions on dry weight of different organs at 135 days after planting during 2016/2017 and 2017/2018 seasons

Treatment	Character	Bulb dry weight (g)		Leaves dry weight/plant (g)		Total dry weight/plant (g)		Relative dry weight increase (%)	
		Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
				Effect of nitrogen levels					
90 kg/fad.		3.49	2.87	4.54	4.09	8.03	6.96	00.00	00.00
120 kg/fad.		4.13	4.04	5.46	5.43	9.59	9.47	19.43	36.06
LSD at 0.05 level		0.32	0.19	0.26	0.24	0.26	0.3	--	--
				Effect of some stimulants					
Tap water		3.46	2.99	4.51	4.26	7.97	7.25	00.00	00.00
SA at 100 mg/l		3.82	3.34	4.96	4.57	8.78	7.91	10.16	09.10
Lithovit at 2 g/l		4.09	4.02	5.40	5.46	9.49	9.48	19.07	30.76
Algae at 2%		3.86	3.46	5.13	4.75	8.99	8.22	12.80	13.38
LSD at 5% level		0.23	0.14	0.19	0.17	0.11	0.27	--	--
N (kg/fad.)	stimulants			Effect of the interaction					
90	Tap water	3.08	2.32	4.09	3.51	7.17	5.83	00.00	00.00
	SA at 100 mg/l	3.53	2.55	4.49	3.75	8.02	6.30	11.85	08.06
	Lithovit at 2 g/l	3.78	3.77	4.89	5.12	8.67	8.89	20.92	52.49
	Algae at 2%	3.57	2.84	4.69	3.99	8.26	6.83	15.20	17.15
120	Tap water	3.84	3.67	4.94	5.01	8.78	8.68	22.45	48.89
	SA at 100 mg/l	4.12	4.13	5.43	5.39	9.55	9.52	33.19	63.29
	Lithovit at 2 g/l	4.40	4.27	5.92	5.81	10.32	10.08	43.93	72.90
	Algae at 2%	4.16	4.09	5.57	5.52	9.73	9.61	35.70	64.84
LSD at 5% level		0.33	0.20	0.27	0.24	0.16	0.28	--	--

Season 1= 2016/2017, season2 = 2017/2018, SA: Salicylic acid , total dry weight (leaves and bulb) the interaction between nitrogen at 120 kg/fad., and spraying plants with algae extract regarding to dry weight of bulb in both seasons (Table 1).

The relative increases in total dry weight/ plant were about 43.93 and 72.90% for the interaction between N at 120 kg/fad., and spraying with lithovit over the control treatment in the 1st and 2nd seasons, respectively.

The increase in plant growth in response to nitrogen and lithovit may be due to, its role as a long term reservoir supplying plants with CO_2 (**Kumar, 2011**); thus, it can enhance plant growth and productivity, where elevated CO_2 concentrations generally increased carbon assimilation, biomass and leaf area of plants (**Maswada and Abd El-Rahman, 2014**). It is well known that lithovit particles remain as a thin layer on the surface of leaves and penetrate frequently when they get wet with dew at night.

Minerals Content, Uptake and Total Chlorophyll

Effect of nitrogen level

Results in Tables 2, 3 and 4 show that, concentration of elements, *i.e.*, N, P and K in bulb and leaves, uptake by bulb and leaves and their total uptake by plant as well as total chlorophyll (a+b) in leaves were significantly increased due to fertilizing plants with nitrogen levels in both seasons.

The highest value of for each all minerals contents, its uptake by bulb and leaves as well as total uptake by plants were observed when fertilizing garlic plants with 120 kg N/fad., than 90 kg N/fad., in both seasons. Also, the highest total chlorophyll in leaves were found in those plants which received the highest level of N in both seasons.

The increase in minerals concentration in tissues of garlic plant as a result of increasing the addition of nitrogen fertilizer might be attributed to the stimulating effect of absorbing efficiency of the plant. In addition, application of nitrogen fertilizer stimulates synthesis of carbohydrates to which the dry matter content is a reliable index. This might be due to increase in amount of carbohydrates in roots consequently the minerals uptake became greater (**Mengel and Kirkby, 1978**).

These results are agreed with **El-Shabasi *et al.* (2003)** and **El-Seifi *et al.* (2004)** on garlic. They showed that increasing nitrogen fertilizer increased photosynthetic pigments, mineral contents and its uptake by garlic plants.

Effect of some stimulants

The same results in Tables 2, 3 and 4 indicate that, spraying garlic plants with different stimulants SA, algae and lithovit had a significant effect on N, P and K contents and their uptake by bulb and leaves as well as total N,P and K uptake by plant and total chlorophyll in leaves of garlic than unsprayed plants, except K content in bulb in the 2nd season. Spraying garlic plants with lithovit significantly increased N , P and K contents and their uptake by bulb and leaves as well as total N,P and K uptake by plant and total chlorophyll in leaves without any significant differences with algae extract as for N and P content in both season, K (%) in bulb and N and K (%) in leaves in the 1st season and with SA regarding P (%) in bulb in the 2nd season and K (%) in leaves in the 1st season. It could be concluded that, spraying garlic plants with lithovit recorded the highest values of all mineral parameters in garlic plants.

The increases in chemical constituents as a result of foliar spray with lithovit may be due to its chemical constituents from macro and micro-nutrients.

These results are in agreement with those obtained by **Abo-Sedera *et al.* (2016)** on snap bean concerning lithovit effect and **Hidangmayum and Sharma (2017) and Yassen *et al.* (2018)** on onion regarding the effect of algae extract.

Effect of the interaction between N levels and some stimulants

The interactions between nitrogen rates and spraying plants with some stimulants had a significant effects on N, P and K contents and their uptake by bulb and leaves as well as total uptake of N, P and K by plant and total chlorophyll in leaves in both seasons (Tables 2, 3 and 4).

In general, the interaction between 120 kg N/ fad., and spraying with lithovit significantly increased N, P and K contents and their uptake by bulb and leaves as well as total uptake of N,P and K by plant and total chlorophyll in leaves,

Table 2. Effect of nitrogen levels and some stimulants as well as their interactions on mineral content of garlic plants at 135 days after planting during 2016/2017 and 2017/2018 seasons

Character / Treatment	Mineral content (%)											
	Bulb						Leaves					
	N		P		K		N		P		K	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
	Effect of nitrogen levels											
90 kg/fad.	1.47	1.53	0.34	0.35	1.49	1.48	3.37	3.54	0.37	0.28	2.51	2.71
120 kg/fad.	1.93	1.91	0.44	0.47	1.80	1.85	3.91	3.95	0.43	0.35	2.85	3.16
LSD at 00.05 level	**0.20**	**0.24**	**0.031**	**0.05**	**0.22**	**0.27**	**0.38**	**0.32**	**0.04**	**0.03**	**0.27**	**0.34**
	Effect of some stimulants											
Tap water	1.51	1.56	0.35	0.36	1.51	1.64	3.43	3.50	0.39	0.31	2.55	2.81
SA at 100 mg/l	1.61	1.70	0.39	0.41	1.54	1.63	3.60	3.71	0.39	0.30	2.69	2.89
Lithovit at 2 g/l	1.91	1.88	0.42	0.45	1.77	1.82	3.90	4.07	0.44	0.37	2.81	3.17
Algae at 2%	1.77	1.76	0.40	0.42	1.75	1.58	3.65	3.70	0.39	0.30	2.68	2.88
LSD at 5% level	**0.14**	**0.17**	**0.02**	**0.04**	**0.16**	**NS**	**0.27**	**0.23**	**0.03**	**0.02**	**0.19**	**0.24**
N (kg/fad.) stimulants	**Effect of the interaction**											
Tap water	1.33	1.40	0.35	0.32	1.30	1.44	3.13	3.29	0.36	0.27	2.44	2.56
90 SA at 100 mg/l	1.36	1.41	0.33	0.34	1.37	1.42	3.38	3.52	0.36	0.27	2.50	2.60
Lithovit at 2 g/l	1.64	1.74	0.38	0.40	1.66	1.70	3.62	3.84	0.42	0.34	2.62	3.10
Algae at 2%	1.55	1.60	0.33	0.34	1.64	1.39	3.38	3.52	0.36	0.27	2.50	2.60
120 Tap water	1.70	1.72	0.36	0.41	1.73	1.85	3.73	3.72	0.43	0.35	2.66	3.07
SA at 100 mg/l	1.86	1.99	0.46	0.49	1.72	1.84	3.83	3.90	0.42	0.34	2.88	3.18
Lithovit at 2 g/l	2.18	2.03	0.46	0.50	1.89	1.94	4.18	4.31	0.47	0.40	3.00	3.24
Algae at 2%	1.99	1.92	0.48	0.51	1.86	1.78	3.93	3.88	0.42	0.34	2.86	3.16
LSD at 5% level	**0.20**	**0.25**	**0.031**	**0.06**	**0.23**	**0.27**	**0.39**	**0.32**	**0.04**	**0.03**	**0.27**	**0.32**

Season 1= 2016/2017, season2 = 2017/2018, SA: Salicylic acid

Table 3. Effect of nitrogen levels and some stimulants as well as their interactions on mineral uptake by different parts of garlic plants at 135 days after planting during 2016/2017 and 2017/2018 seasons

Character / Treatment	Mineral uptake (mg/organ)											
	Bulb						Leaves					
	N		P		K		N		P		K	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
	Effect of nitrogen levels											
90 kg/fad.	51.57	44.87	12.143	10.207	52.42	43.29	153.83	146.14	17.07	11.94	114.35	112.45
120 kg/fad.	80.15	77.63	18.245	19.375	74.45	74.88	214.65	215.29	23.81	19.47	156.09	171.97
LSD at 5% level	**6.21**	**4.96**	**1.86**	**1.24**	**4.34**	**3.72**	**11.17**	**15.52**	**3.72**	**2.48**	**18.94**	**14.90**
	Effect of some stimulants											
Tap water	53.12	47.80	12.30	11.23	53.23	50.65	156.14	150.93	17.98	13.51	115.43	121.84
SA at 100 mg/l	62.32	59.07	15.30	14.45	59.61	56.10	179.87	171.11	19.48	14.23	134.32	134.45
Lithovit at 2 g/l	78.95	76.14	17.30	18.21	72.95	73.46	212.24	223.51	24.18	20.32	152.86	173.48
Algae at 2%	69.06	61.98	15.87	15.26	67.96	56.14	188.71	177.32	20.13	14.77	138.28	139.09
LSD at 5% level	**4.44**	**3.55**	**1.33**	**0.88**	**3.11**	**2.66**	**8.00**	**11.11**	**2.66**	**1.77**	**13.56**	**10.67**
N (kg/fad.)stimulants	**Effect of the interaction**											
Tap water	40.96	32.48	10.78	7.42	40.04	33.41	128.02	115.48	14.72	9.48	99.80	89.86
90 SA at 100 mg/l	48.01	35.96	11.65	8.67	48.36	36.21	151.76	132.00	16.16	10.13	112.25	97.50
Lithovit at 2 g/l	61.99	65.60	14.36	15.08	62.75	64.09	177.02	196.61	20.54	17.41	128.12	158.72
Algae at 2%	55.34	45.44	11.78	9.66	58.55	39.48	158.52	140.45	16.88	10.77	117.25	103.74
120 Tap water	65.28	63.12	13.82	15.05	66.43	67.90	184.26	186.37	21.24	17.54	131.40	153.81
SA at 100 mg/l	76.63	82.19	18.95	20.24	70.86	75.99	207.97	210.21	22.81	18.33	156.38	171.40
Lithovit at 2 g/l	95.92	86.68	20.24	21.35	83.16	82.84	247.46	250.41	27.82	23.24	177.60	188.24
Algae at 2%	82.78	78.53	19.97	20.86	77.38	72.80	218.90	214.18	23.39	18.77	159.30	174.43
LSD at 5% level	**6.28**	**5.03**	**1.88**	**1.25**	**4.40**	**3.77**	**11.32**	**15.72**	**3.77**	**2.51**	**19.18**	**18.77**

Season 1= 2016/2017, season2 = 2017/2018, SA: Salicylic acid

Table 4. Effect of nitrogen levels and some stimulants as well as their interactions on total mineral uptake by garlic plants and total chlorophyll in leaves at 135 days after planting during 2016/2017 and 2017/2018 seasons

Character / Treatment		Total mineral uptake (mg/organ)						Total chlorophyll (mg/100 g DW)	
		N		P		K			
		Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
		Effect of nitrogen levels (kg/fad.)							
90 kg/fad.		205.40	191.01	29.22	22.15	166.78	155.75	3.57	3.74
120 kg/fad.		294.80	292.92	42.06	38.84	230.63	246.85	4.60	4.58
LSD at 5% level		**24.84**	**18.63**	**3.10**	**3.72**	**12.42**	**20.49**	**0.34**	**0.26**
		Effect of stimulants							
Tap water		209.26	198.73	30.28	24.74	168.84	172.48	3.60	3.81
SA at 100 mg/l		242.19	230.18	34.78	28.68	193.93	190.55	4.15	3.91
Lithovit at 2 g/l		291.20	299.65	41.48	38.54	225.82	246.95	4.45	4.60
Algae at 2%		257.78	239.30	36.01	30.03	206.24	195.23	4.14	4.34
LSD at 5% level		**17.79**	**13.34**	**2.22**	**2.66**	**8.89**	**14.67**	**0.24**	**0.19**
N (kg/fad.)	**Stimulants**	**Effect of the interaction**							
	Tap water	168.98	147.96	25.50	16.90	139.84	123.26	3.15	3.43
90	**SA at 100 mg/l**	199.77	167.96	27.81	18.80	160.61	133.71	3.58	3.60
	Lithovit at 2 g/l	239.01	262.21	34.90	32.49	190.87	222.81	4.00	4.22
	Algae at 2%	213.86	185.89	28.67	20.43	175.80	143.22	3.56	3.74
120	**Tap water**	249.54	249.50	35.07	32.58	197.84	221.70	4.05	4.19
	SA at 100 mg/l	284.60	292.40	41.76	38.56	227.25	247.39	4.72	4.22
	Lithovit at 2 g/l	343.38	337.09	48.06	44.59	260.76	271.08	4.90	4.99
	Algae at 2%	301.69	292.70	43.36	39.63	236.68	247.23	4.73	4.95
LSD at 5% level		**25.15**	**18.86**	**3.14**	**3.66**	**12.57**	**20.75**	**0.35**	**0.27**

Season 1= 2016/2017, season2 = 2017/2018 and SA: Salicylic acid

followed by the interaction between 120 kg N/fad., and spraying plants with algae extract in both seasons.

Yield and its Components as Well as Nitrogen Use Efficiency

Effect of nitrogen levels

Results in Table 5 indicate that, fertilizing garlic plants with 120 kg N/fad., significantly increased average bulb weight, marketable and total yield/fad., and decreased unmarketable yield than fertilizing plants with 90 kg/fed., in both seasons.

As for nitrogen use efficiency, fertilizing plants with 90 kg N/fad., gave the highest values of nitrogen use efficiency (87.89 and 87.88 kg bulb/1kg N) against 73.67 and 75.26 kg bulb/one kg N) for 120 kg N/fad.) in the 1st and 2nd seasons, respectively.

The relative increases in total yield/fad., were about 11.77 and 14.20 for fertilizing plants with 120 kg N/fad., over fertilizing with 90 kg N/fad., in the 1st and 2nd seasons, respectively.

Availability of nitrogen is of prime importance for growing plants as it is major and indispensable constituent of protein and nucleic acid molecules. An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs finally leading to higher productivity (**Hore *et al*., 2014**).

The obtained results are in accordance with those of **Farooqui *et al*. (2009), Zaman *et al*. (2011), Ahmed *et al*. (2012), Abou El-Magd *et al*. (2014), Hassan (2015), Mohamed (2015) and Kumar *et al*. (2018)** on garlic. They found that increasing nitrogen fertilizer levels increased yield and its components.

Effect of some stimulants

Results in Table 5 show that, average bulb weight, marketable, total yield and nitrogen use efficiency were significantly increased by spraying plants with lithovit than other treatments in both seasons without significant differences with algae extract as for total yield in the 2nd season. Unsprayed plants recorded the highest unmarketable yield in both seasons.

Table 5. Effect of nitrogen levels and some stimulants as well as their interactions on yield and its components and nitrogen use efficiency of garlic plants during 2016/2017 and 2017/2018 seasons

Treatment \ Character		Average bulb weight (g)		Marketable yield (ton/fad.)		Unmarketable yield (ton/fad.)		Total yield (ton/fad.)		Relative increases in total yield (%)		N use efficiency (kg bulb/ I kg N)	
		Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
						Effect of nitrogen levels							
90 kg/fad.		49.21	49.02	6.982	7.066	0.927	0.842	7.910	7.909	00.00	00.00	87.89	87.88
120 kg/fad.		61.03	60.23	8.442	8.489	0.398	0.543	8.841	9.032	11.77	14.20	73.67	75.26
LSD at 5% level		**4.34**	**4.96**	**0.248**	**0.372**	**0.024**	**0.037**	**0.310**	**0.434**	--	--	**5.58**	**4.34**
						Effect of some stimulants							
Tap water		49.73	48.64	6.273	6.057	0.979	0.950	7.252	7.008	00.00	00.00	69.69	66.84
SA at 100 mg/l		52.38	53.06	7.774	7.937	0.713	0.706	8.488	8.644	17.04	23.34	81.91	83.49
Lithovit at 2 g/l		61.72	61.22	8.654	8.800	0.372	0.465	9.026	9.266	24.46	32.22	87.16	89.35
Algae at 2%		56.65	55.59	8.148	8.316	0.587	0.649	8.736	8.965	20.46	27.93	84.38	86.61
LSD at 5% level		**3.11**	**3.55**	**0.177**	**0.266**	**0.017**	**0.026**	**0.222**	**0.311**	--	--	**4.00**	**3.11**
N (kg/fad.)	Stimulants					Effect of the interaction							
90	Tap water	42.99	44.27	5.337	5.018	1.324	1.060	6.661	6.078	00.00	00.00	74.01	67.53
	SA at 100 mg/l	45.98	48.27	7.063	7.266	0.983	0.987	8.046	8.253	20.79	35.78	89.40	91.70
	Lithovit at 2 g/l	57.34	53.58	8.020	8.177	0.577	0.563	8.597	8.740	29.06	43.80	95.52	97.11
	Algae at 2%	50.54	49.99	7.511	7.806	0.827	0.761	8.338	8.567	25.18	40.95	92.64	95.19
120	Tap water	56.47	53.02	7.209	7.097	0.635	0.841	7.844	7.938	17.76	30.60	65.37	66.15
	SA at 100 mg/l	58.78	57.86	8.486	8.609	0.444	0.426	8.930	9.035	34.06	48.65	74.42	75.29
	Lithovit at 2 g/l	66.10	68.87	9.289	9.424	0.167	0.368	9.456	9.792	41.96	61.11	78.80	81.60
	Algae at 2%	62.77	61.19	8.786	8.826	0.348	0.538	9.134	9.364	37.13	54.06	76.12	78.03
LSD at 5% level		**4.40**	**5.03**	**0.251**	**0.377**	**0.025**	**0.037**	**0.314**	**0.440**	--	--	**5.66**	**4.40**

Season 1= 2016/2017, season2 = 2017/2018 and SA: Salicylic acid

The relative increases in total yield/fad., were about 24.46 and 32.22% for spraying plants with lithovit, 20.46 and 27.93% for spraying plants with algae extract over the control treatment in the 1st and 2nd seasons, respectively.

The increase of total yield/fad., might be due to the increase in average bulb weight (Table 5). Also, this might be due to the favorable effect of lithovit on dry weight (Table 1), total chlorophyll and mineral contents and their uptake (Tables 2, 3 and 4).

In this regard, the superiority of using lithovit on total produced yield and its components may be attributed to the role of it as a source of calcium and carbonate which reduced inside plant cell to form carbon dioxide which accumulate in cells and increased the rate of photosynthetic assimilation and consequently increased vegetative growth and produced yield (**Abo-Sedera *et al*., 2016**).

These results are in harmony with those reported by **Merwad (2018)** on garlic regarding lithovit effect, **Shalaby and El-Ramady (2014)** on garlic, **Babilie *et al*. (2015) and Shafeek *et al.* (2015)** on onion concerning algae extract effect.

Effect of the interaction between N levels and some stimulants

It is clear from results in Table 5 that there were significant effect between nitrogen levels and some stimulants as foliar application on yield and average bulb weight in both seasons. The interactions between fertilizing plants with 120 kg N/fad., and spraying with lithovit significantly increased average bulb weight, marketable and total yield/fad., and decreased unmarketable yield and nitrogen use efficiency in both seasons, without significant differences with the interaction between 120 kg N /fad., and spraying with algae extract as for total yield/ fad., in both seasons.

Nevertheless, the interaction between fertilizing plants with 90 kg N/fad., and spraying with lithovit produced the highest values of nitrogen use efficiency (95.52 and 97.11 kg bulb/kg N against 78.80 and 81.60 kg bulb/kg N for the interaction between 120 kg N/fad., and spraying with lithovit) in the 1st and 2nd seasons, respectively.

The relative increases in total yield/fad., were about 41.96 and 61.11% for the interaction between fertilizing garlic plants with 120 kg N/fad., and spraying with lithovit over 90 Kg N only in the 1st and 2nd seasons, respectively. In the same time fertilizing garlic plants with 90 kg N/fad., and spraying with lithovit recorded increases in total yield/fad., were about 9.59 and 10.10% over the plants which received 120 kg N/fad., only (control treatment) in the 1st and 2nd seasons, respectively.

Bulb Quality

Effect of nitrogen levels

Results in Table 6 evidently show that fertilizing garlic plants with different nitrogen levels had a significant effect on dry matter, TSS, pungency and total weight loss of bulb through storage period in both seasons.

Fertilizing garlic plants with 90 kg N/fad., gave the highest value for each of dry matter, TSS, pungency at harvesting time and lowest values of total weight loss percentage after 180 days from storage than fertilizing with 120 kg/fad., in both seasons.

Similar results were obtained by **Hassan (2015), Mohamed (2015**) and **Kumar *et al.* (2018)** on garlic.

Effect of some stimulants

Results in Table 6 show that, dry matter, TSS%, pungency and total weight loss percentage in bulbs through storage period were significantly increased due to spraying plants with all stimulants than control treatment in both seasons.

Spraying garlic plants with lithovit gave the maximum values of dry matter, TSS, Pungency in bulb at harvesting time and minimum values of total weight loss percentage after 180 days from storage, followed by the plants which sprayed with SA in both seasons.

The decreasing in total weight loss percentage in bulb during storage may be due to the increase in dry matter and TSS in bulb (Table 6).

These results are in harmony with those reported by **Abdelghafar *et al.* (2016)** on onion and **Merwad (2018)** on garlic regarding the effect of lithovit and **Bardisi (2004)** and **Abou El-Khair and Khalil (2014)** on garlic as for SA effect.

Effect of the interaction between N levels and some stimulants

It is obvious from results in Table 6 that the interaction between nitrogen fertilizer and spraying with some stimulants as foliar application had significant effects on all bulb quality of garlic such as, dry matter, TSS and pungency in bulbs at harvesting stage and total weight loss percentage in bulbs during storage period (180 days) in both seasons.

The highest value for each of dry matter, TSS and pungency in bulbs at harvesting time and the lowest values of total weight loss percentage after 180 days from storage period were shown when garlic plants fertilized with 90 kg N/fad., and sprayed with lithovit, followed by the interaction between fertilized plants with 90 kg N/fad., and sprayed with SA in both seasons.

The increasing in pungency and decreasing in total weight loss might be due to the increases in bulb weight (Table 5) and TSS in bulbs (Table 6).

Further studies are recommended to try using 90 kg N/fad., and lithovit which recorded increases in total yield/fad., were about 9.84% over the plants which received 120 kg N/fad., only (control treatment) average two seasons as well as gave the best bulb quality and storability.

Table 6. Effect of nitrogen levels and some stimulants as well as their interactions on bulb quality and weight loss (%) of garlic plants at harvest time during 2016/2017 and 2017/2018 seasons

Treatment / Character		Dry matter (%)		TSS (%)		Pungency (Pyrovic acid) (mol /g FW)		Weight loss after six months (%)	
		Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
		Effect of nitrogen levels							
90 kg/fad.		38.72	40.25	34.50	37.25	0.276	0.290	31.35	32.64
120 kg/fad.		32.63	33.81	31.75	33.17	0.178	0.187	39.99	39.21
LSD at 5% level		**2.48**	**3.10**	**1.86**	**1.58**	**0.024**	**0.037**	**2.77**	**3.81**
		Effect of some stimulants							
Tap water		35.02	35.99	32.16	33.61	0.204	0.205	37.85	39.11
SA at 100 mg/l		35.38	37.24	33.00	35.16	0.222	0.240	35.27	35.51
Lithovit at 2 g/l		37.79	38.66	34.92	37.54	0.275	0.295	32.06	32.35
Algae at 2%		34.49	36.25	32.41	34.54	0.207	0.215	37.51	36.73
LSD at 5% level		**1.77**	**2.22**	**1.33**	**1.13**	**0.017**	**0.026**	**1.98**	**2.73**
N (kg/fad.)	**Stimulants**	**Effect of the interaction**							
90	**Tap water**	37.71	38.34	33.00	35.31	0.241	0.230	34.37	36.15
	SA at 100 mg/l	38.39	40.47	34.50	37.57	0.266	0.290	29.93	31.70
	Lithovit at 2 g/l	41.07	42.25	36.67	39.60	0.342	0.370	27.65	28.93
	Algae at 2%	37.71	39.97	33.83	36.54	0.256	0.270	33.41	33.78
120	**Tap water**	32.34	33.64	31.33	31.91	0.167	0.180	41.27	42.08
	SA at 100 mg/l	32.38	34.01	31.50	32.76	0.179	0.190	40.62	39.32
	Lithovit at 2 g/l	34.52	35.08	33.17	35.49	0.208	0.220	36.48	35.77
	Algae at 2%	31.28	32.53	31.00	32.55	0.159	0.160	41.62	39.68
LSD at 5% level		**2.51**	**3.14**	**1.88**	**1.60**	**0.025**	**0.037**	**2.81**	**3.86**

Season 1= 2016/2017, season2 = 2017/2018 and SA: Salicylic acid

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تأثير التسميد النيتروجينى وبعض المحفزات على الوزن الجاف والمحصول وجودة الأبصال والقدرة التخزينية للثوم

فوزى يحيى عمر منصور- محمد محمد عبداللطيف رمضان - حماده ماهر بدير المتولى
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أجريت تجربتان حقليتان فى موسمى شتاء متتاليين ٢٠١٧/٢٠١٦ ، ٢٠١٨/٢٠١٧ فى محطة البحوث الزراعية بالجميزة محافظة الغربية (وسط الدلتا) وذلك لدراسة تاثير مستويات التسميد النيتروجينى (٩٠ ، ١٢٠ كجم نيتروجين/فدان) وبعض المحفزات (حمض السليسلك بمعدل ١٠٠ مللجرام /لتر ، والليثوفيت بمعدل ٢جم/لتر ومستخلص الطحالب بمعدل ٢% وبدون معاملة) على الوزن الجاف ، المحصول وجودة الأبصال والقدرة التخزينية للثوم الصنف البلدى تحت ظروف الأرض الطينية وباستخدام نظام الرى بالغمر، ويمكن تلخيص أهم النتائج فى الأتى: أدت معاملة التفاعل بين تسميد نباتات الثوم بمعدل ١٢٠كجم نتروجين/فدان والرش بالليثوفيت إلى زيادة الوزن الجاف للبصلة والأوراق والوزن الجاف الكلى للنبات، ومحتوى الأبصال والأوراق من النيتروجين والفوسفور والبوتاسيوم والممتص منهما والممتص الكلى بواسطة النبات ومحتوى الاوراق من الكلوروفيل الكلى، ومتوسط وزن البصلة، المحصول القابل للتسويق والمحصول الكلى /فدان، بينما أدت معاملة التفاعل بين تسميد نباتات الثوم بمعدل ٩٠كجم نيتروجين/فدان و الرش بالليثوفيت و حمض االسيلسيلك الى زيادة كفاءة استخدام النبات من النيتروجين ومحتوى البصله من المادة الجافة والمواد الصلبة الذائبة الكلية والحرافة وقت الحصاد و خفض نسبة الفقد الكلى فى الوزن للأبصال بعد ١٨٠ يوم من التخزين فى كلا الموسمين، هذا وكان مقدار الزيادة النسبية فى المحصول الكلى حوالى ٤١,٩٦ ، ٦١,١١% لمعاملة التفاعل بين تسميد نباتات الثوم بمعدل ١٢٠كجم نيتروجين/فدان والرش بالليثوفيت أعلى من المعاملة بـ ٩٠كجم نتروجين/فدان بدون الرش بالمحفزات فى الموسم الاول و الثانى، على التوالى. فى نفس الوقت، سجلت معاملة التفاعل بين تسميد نباتات الثوم بمعدل ٩٠كجم نيتروجين/فدان و الرش بالليثوفيت زيادة نسبية فى المحصول الكلى/فدان بمقدار ٩,٥٩ ، ١٠,١٠% أعلى من النباتات التى تم تسميدها بمعدل ١٢٠كجم نيتروجين/فدان بدون الرش بالمحفزات فى الموسم الأول و الثانى، على التوالى.

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