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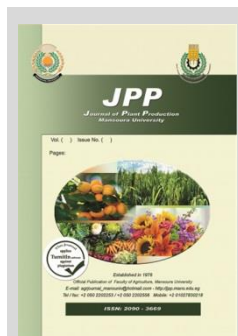
Effect of Foliar Spray with Licorice Root Extract on Production and Quality of Egyptian and Chinese Garlic

Hamam, M. A^{1*}; Y.M.M². Moustafa; M.A.M³. Ali and Asmaa S.H³. Saleh

¹ Vegetable Department, Faculty of Agriculture, Assuit University, Assuit, Egypt.

² Horticulture Department, Faculty of Agriculture, Minia University, Minia, Egypt.

³ Horticulture Department, Faculty of Agriculture, New Valley University, Kharja, New Valley, Egypt.



ABSTRACT

Garlic is a very important crop in Egypt and in whole world and cultivation of garlic in new reclaimed soils is broadly increasing. Thus, these experiments were conducted in a newly reclaimed sandy soil of the experimental farm of the Faculty of Agriculture, New Valley University, Kharja, Upper Egypt during the two successive seasons of 2018/2019 and 2019/2020. The experiments aimed to study the effect treatment of licorice root extract on garlic cultivars and on growth behavior and bulbs production and quality. Results showed that all growth traits of garlic plants, production of bulbs, and quality of those bulbs were enhanced by cloves soaking and plants foliar sprayed with licorice root extract using different concentrations; 0.0, 2.5, 5.0, and 7.5 g/L. Hence, these promising cheap treatments could be recommended for garlic producers who plant garlic under similar environmental conditions to get high yield of garlic green or dry bulbs with high qualities suitable for local production or exportation.

Keywords: Garlic (*Allium sativum* L.), licorice (*Glycyrrhiza glabra*) root extract, yield components.

INTRODUCTION

Garlic (*Allium sativum* L.) is an important edible bulbous crop belonging to the family *Alliaceae*. It is the second most widely cultivated after onion and has been used throughout history for culinary and medicinal purposes. Garlic is grown worldwide in all temperate to subtropical and tropical hilly areas as an important spice and medicinal plant (Pandey, 2012).

Garlic has higher nutritive value especially Allicin of garlic which has antibacterial properties (Al-Otayk *et al.*, 2009 and Sterling and Eagling, 1997) In addition, garlic is widely used in all households throughout the year. According to Amagase *et al.*, (2001) and Iciek *et al.*, (2009), the unique flavor and health-promoting functions of garlic are generally attributed to its rich content of sulfur-containing compounds such as alliin, g-glutamylcysteine, and their derivatives. Processing a fresh and intact garlic bulbs by crushing, grinding, or cutting induces the release of the vacuolar enzyme *alliinase*, which quickly catalyzes *allien* to *allicin*. *Allicin* is a very unstable compound, soon rearranged and transformed into numerous lipid-soluble sulfur-containing byproducts, mostly diallyl disulfide but also diallyl sulfide, diallyl trisulfide, allylmethyl trisulfide, and diallyl tetrasulfide (Iciek *et al.*, 2009).

Clinically, garlic has been evaluated for lowering blood pressure, cholesterol, and glucose concentration, as well as for the prevention of arteriosclerosis and cancer (Tsai *et al.*, 2012). In addition, the biological activities of garlic, including antibacterial, antithrombotic, antioxidant, immunomodulatory, and antidiabetic actions and modulation of drug metabolism, have been extensively investigated (Gad El-hak *et al.*, 2012; Tsai *et al.*, 2012).

Extract of licorice roots (*Glycyrrhiza glabra*) contain some compounds, which have similar effects to that of growth promoters, a wide range of minerals (calcium, potassium, magnesium, iron, zinc, phosphorus), amino acids (alanine, lysine, arginine), vitamins (B1, B2, B6), and in addition; carbohydrate and nitrogen (Moses *et al.*, 2002; Al-Ajeeli, 2005; Sabry *et al.*, 2009). It also contains mevalonic acid used in gibberellins synthesis (Al-Marsoumi, 1999).

So, the aim of this study was to investigate the effect licorice root extract on Egyptian and Chinese garlic growth behavior in poor soils, production of bulbs, and chemical compositions of bulbs.

MATERIALS AND METHODS

Description of the experiments site:

Two field experiments were conducted during two successive winter seasons of 2018/2019 and 2019/2020. These experiments were conducted at the Agricultural Research Farm of the Faculty of Agriculture, New Valley University, Kharja, Egypt (25°26'31° N, 30°33'36° E, altitude 283 m).

Generally, the experiment soil which both Egyptian and Chinese garlic cultivars were planted was not fertile and suffers lack of almost all elements essential for garlic vegetative growth and bulbs production. That was the nature of soil of experimental farm in the faculty of Agriculture, New Valley governorate.

Experimental soil analysis:

Five samples of soil were randomly taken from the experimental soil surface (0-30 cm depth) before cultivation to determine the physical and chemical characteristics in according to Black (1965) and Page *et al.* (1982), respectively. Data of soil analysis is presented in Table 1.

* Corresponding author.

E-mail address: Mohamed.ali@agr.nvu.edu.eg

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Table 1. Soil physical and chemical analysis of the experimental soil during 2018/2019 and 2019/2020 seasons:

Soil properties	Season		
	2018/2019	2019/2020	
Particle size distribution (%)			
Physical analysis	Coarse sand	4.92	5.10
	Fine sand	76.34	75.38
	Silt	11.76	12.80
	Clay	6.98	6.72
Textural class Sandy Sandy			
Chemical analysis	E.C. (dsm-1 1:5)	1.32	1.24
	pH (1:2.5 w/v)	8.09	8.19
	Organic matter (%)	0.57	0.59
	CaCO ₃ (%)	5.78	5.98
	SP %	38.6	40.3
	Available nutrients (mg/kg dry soil)		
	N	40.3	41.2
	P	5.10	5.34
K	87.6	86.5	

Experimental design and studied treatments:

The garlic cloves were planted on October 20th and October 21st in 2018 and 2019 seasons, respectively. The experiments were conducted in a randomized complete block design (RCBD) using split plots with 3 replicates in which the main plots were devoted for the two garlic cultivars (Egyptian and Chinese), while the sub-plots contained four concentrations of licorice root extract (control (without), 2.5 g/L, 5 g/L, 7.5 g/L). The cloves of these two cultivars were soaked in these licorice root extract concentrations before planting. Garlic plants were sprayed with the same concentrations of licorice root extract three times at days 45, 60, 80 after planting. Each experimental plot consisted of four rows and each row was 3 m long and 60 cm wide. Garlic cloves were planted on the two sides of each row at distance of 10 cm apart. Soil analysis is shown in Table 1. Fertilization and control were carried out according to the recommendations of the Ministry of Agriculture.

Meteorological data:

The average air temperature and relative humidity (RH %) in the two successive seasons were determined by the Meteorological Station of El-Kharga Oasis, New Valley Governorate, Egypt and are shown in Table 2.

Recorded data:**1- Vegetative growth parameters:**

Representative samples, ten plants were randomly taken from each plot at different growth stages, i.e., 30, 60, 90 and 120 days after plantation to estimate the following characteristics:

a- Cloves germination percentage: germinated cloves after 15 and 30 days from plantation were counted and the cloves germination percentage were recorded according to the following equation:

$$\text{Cloves germination percentage} = \frac{\text{Number of germinated cloves of each treatment}}{\text{Number of total planed cloves of the same treatment}} \times 100$$

Preparation and application of Licorice root extract

Licorice extracts were extracted using weights of (0.0, 2.5, 5.0 and 7.5) grams of dry licorice roots and were soaked in distilled water at 50°C for 24 hours, then it was filtered and added to the final volume of liter to reach the

concentrations of (control, 2.5, 5.0 and 7.5 g/L) and were ready to be used as the four treatments of the experiments in the two successive winter seasons of 2018/2019 and 2019/2020. Licorice root extract chemical composition is described in Table 2.

Table 2 .chemical components of licorice root extraction

Composition	Licorice roots	
mg/100g p.w	Fe	18.31
	K	53.14
	Mg	54.76
	Ca	71.34
	Mn	4.19
	Cu	2.86
	P	846
	N	9.72
	Carbohydrates	10.38
	Ash	11.47
%	water	8.28
	Vitamin B1	32.4
	Vitamin B2	33.7
	Vitamin B6	41.9

b- Plant height: It was measured in cm starting from the surface tip of soil to the longest leaf blade of the plant.

c- Number of leaves/plant: All visible leaves of selected plants were counted to record number of leaves per plant.

d- Fresh weight/plant: The vegetative parts (bulbs and leaves) of selected plants of each plot were weighted to record the fresh weight per plant.

f- Dry weight/plant: The vegetative parts (bulbs and leaves) of previously selected fresh plants of each plot were oven dried at 70°C for 72 hours till constant weight and the dry weights were recorded.

2. Bulb traits:

A random sample from five plants was taken from each plot at harvesting date to determine the following parameters:

a) Average bulb fresh weight.

b) Average bulb and neck diameter.

c) Bulbing ratio: It was measured as reported by Mann (1952).

d) Bulb dry weight: one hundred grams of previously selected fresh bulbs of each plot were made into slices and oven dried at 70°C for 72 hours till constant weight and the dry weights were recorded.

3. Total yield:

At harvesting time, (end of April in both seasons) all garlic plants of each plot were harvested and cured for 15 days, weighed and the following data were recorded:

a. **Marketable yield** fed.

b. **Non-marketable yield** fed.

c. **Total yield** fed.

d. **Relative total yield (%)**: determined using the following equation:

$$\text{Relative total yield} = \frac{\text{Total yield of treatment}}{\text{Total yield of control}} \times 100$$

4. Statistical analysis:

All obtained data were subjected to statistical analysis of variance according to Snedecor and Cochran (1980) and means separation was carried out according to Duncan (1958) at 5 % levels of probability.

Table 3. monthly temperature at the New Valley Governorate (El-Kharga Oasis) during two growing seasons.

Season	Day	2018/2019		Relative humidity%	2019/2020		Relative humidity%
		Temperature °C			Temperature °C		
		Max.	Min.		Max.	Min.	
October	1-10	33.2	13.9	43.5	34.9	15.3	42.2
	11-20	29.6	14.7	40.3	33.8	13.6	44.5
	21-31	34.1	12.4	42.2	35.1	10.9	45.3
	Average	32.3	13.6	42	34.6	13.2	44
November	1-10	28.4	9.6	45.2	30.3	14.4	44.2
	11-20	30.5	11.8	43.9	29.6	13.2	46.3
	21-31	29.2	8.2	42.3	24.5	9.8	44.5
	Average	27.7	9.8	43.8	28.1	12.4	44.5
December	1-10	27.3	8.3	53.2	29.2	12.0	37.9
	11-20	22.7	6.4	52.4	23.6	6.8	42.3
	21-31	28.7	10.4	53.7	29.7	10.0	38.8
	Average	26.2	8.4	53.1	27.5	9.6	39.7
January	1-10	24.7	7.3	50.5	21.9	7.4	54.4
	11-20	25.4	6.6	51.9	21.8	7.8	53.8
	21-31	28.1	8.1	47.2	27.9	6.3	43.1
	Average	26.0	7.3	49.9	23.9	7.2	50.4
February	1-10	27.7	12.4	47.0	26.7	11.7	39.3
	11-20	21.4	6.8	48.2	21.2	6.6	38.3
	20-29	32.7	6.3	45.5	22.4	6.9	39.1
	Average	27.3	8.5	46.9	23.4	8.4	38.9
March	1-10	34.4	16.4	49.8	27.5	10.3	45.4
	11-20	30.4	16.0	49.6	29.5	8.3	37.9
	21-31	31.7	15.1	48.2	30.6	11.7	38.9
	Average	32.2	15.8	49.2	29.2	10.1	40.7
April	1-10	34.6	15.8	22.3	30.2	12.9	31.9
	11-20	36.9	18.0	23.1	34.5	12.3	30.0
	21-31	35.1	18.3	29.3	33.3	15.4	28.4
	Average	35.5	17.4	24.9	32.6	13.5	30.1

RESULTS AND DISCUSSION

RESULTS

Growth characters

1. Cloves germination

Data in Table 4 and Fig1,2 showed that the germination percentage of cloves of the Egyptian cultivar were significantly higher than those of the Chinese cultivar after 15 and 30 days from planting. Also, treating garlic cloves before plantation of foliar spraying plants with the licorice root extract increased the germination percentage of both cultivars at the previously mentioned periods gradually from lower concentrations to higher ones. The concentration of 7.5 g/L of licorice root extract increased the germination percentage of Egyptian garlic cloves to be 95.36 and 96.96 % after 30 days from planting, comparing to the control treatment which showed 89.90 and 90.28 %; and increased that of the Chinese cloves to be 91.58 and 92.15 % comparing to its control treatment which gave 83.28 and

83.53 % in the first and second season, respectively. Furthermore, the interaction between cultivars and treatments showed a significant effect for garlic cloves germination percentage (Table 4).

Table 4A. Effect of garlic varieties and Licorice root extract on germination % after 15 and 30 days during winter seasons of 2018/2019 and 2019/2020.

Treatments	Germination % after 15 days		Germination % after 30 days	
	1 st	2 nd	1 st	2 nd
	Season	Season	Season	Season
Garlic varieties				
Egyptian	77.74 a	78.20 a	93.02 a	93.78 a
Chinese	71.02 b	71.68 b	87.51 b	88.12 b
Licorice concentrations (g/l)				
control	70.96 d	71.42 d	86.59 d	86.90 d
2.5	72.76 c	73.21 c	89.18 c	89.94 c
5	75.90 b	76.36 b	91.82 b	92.41 b
7.5	77.91 a	78.76 a	93.47 a	94.55 a

Table 4B. Effect of interaction between garlic varieties and Licorice root extract on germination % after 15 and 30 days during winter seasons of 2018/2019 and 2019/2020

Treatments	Germination % after 15 days		Germination % after 30 days		
	1 st Season	2 nd Season	1 st Season	2 nd Season	
	Interaction				
Egyptian	control	74.59 cd	75.14 cd	89.90 c	90.28 d
	2.5	75.83 c	76.07 c	92.33 b	92.86 c
	5	78.91 b	79.44 b	94.50 a	95.03 b
	7.5	81.63 a	82.38 a	95.36 a	96.96 a
Chinese	control	67.34 f	67.92 f	83.28 e	83.53 f
	2.5	69.68 e	70.36 e	86.03 d	87.02 e
	5	72.88 d	73.28 d	89.15 c	89.80 d
	7.5	74.20 cd	74.92 cd	91.58 b	92.15 c

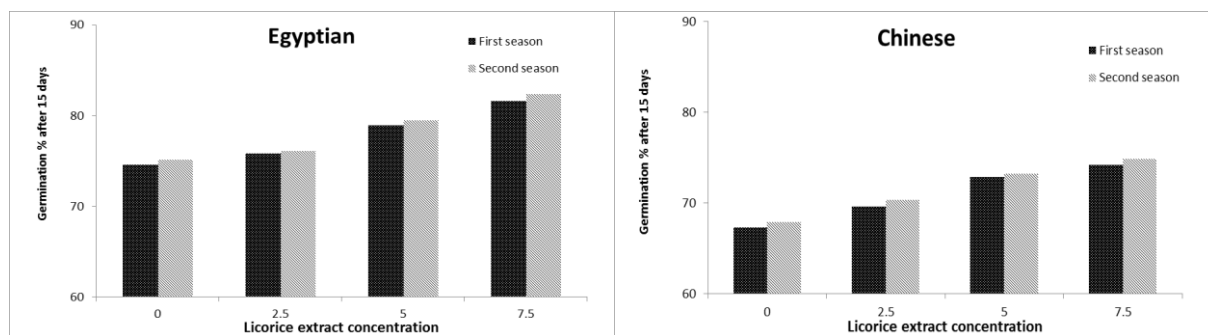


Fig. 1. Effect of interaction between garlic varieties and Licorice root extract on germination % after 15 days during winter seasons of 2018/2019 and 2019/2020.

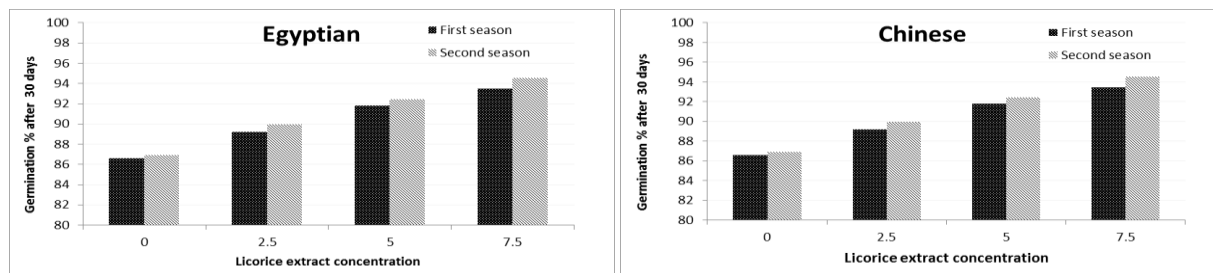


Fig. 2. Effect of interaction between garlic varieties and Licorice root extraction germination % after 30 days during winter seasons of 2018/2019 and 2019/2020.

2. Plant height

This character was recorded 4 times; after 20, 60, 90, and 120 days from planting cloves of Egyptian and Chinese garlic cultivars in the soil. Data in Table 5 and Fig 3 is showing that the Egyptian cultivars recorded higher values of plant height than those of the Chinese cultivar especially at the recording time of 120 days in the two seasons (62.34, 63.33 cm and 53.46, 54.32 cm), respectively. Also, treating

garlic cloves with the licorice root extract before planting increased the values of garlic plant height significantly to reach the values of 70.82 and 71.58 cm in the first and second seasons, respectively. Furthermore, the interaction between cultivars and treatments showed significant effects for this character as the Egyptian cultivar showed the highest values of garlic plant height in all recorded times (Table 5).

Table 5A. Effect of garlic varieties and Licorice root extract on garlic plant height at 30, 60, 90 and 120 days after planting during winter seasons of 2018/2019 and 2019/2020.

Treatments	Plant height (cm)							
	Days after planting							
	30		60		90		120	
	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season
	Garlic varieties							
Egyptian	34.04 a	34.34 a	41.17 a	41.62 a	52.55 a	52.99 a	62.34 a	63.33 a
Chinese	24.35 b	24.96 b	36.94 a	37.51 a	47.85 b	48.53 b	53.46 a	54.32 a
	Licorice concentrations (g/l)							
control	22.83 d	23.14 d	29.86 d	30.53 d	40.83 d	41.45 d	45.71 d	46.39 d
2.5	26.16 c	26.71 c	36.35 c	36.95 c	47.15 c	47.87 c	52.81 c	54.02 c
5	30.90 b	31.21 b	42.79 b	43.11 b	53.32 b	53.90 b	62.26 b	63.31 b
7.5	36.91 a	37.55 a	47.22 a	47.67 a	59.50 a	59.83 a	70.82 a	71.58 a

Table 5B. Effect of interaction between garlic varieties and Licorice root extract on garlic plant height at 30, 60, 90 and 120 days after transplanting during winter seasons of 2018/2019 and 2019/2020.

Treatments	Plant height (cm)								
	Days after planting								
	30		60		90		120		
	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season	
	Interaction								
Egyptian	control	26.97 cd	27.45 cd	33.85 e	34.90 e	41.92 de	42.83 de	48.96 cd	49.88 d
	2.5	30.39 c	30.69 bc	38.98 d	39.16 d	49.45 c	49.75 c	57.85 bc	59.15 c
	5	35.92 b	36.04 b	43.95 bc	44.16 bc	55.93 b	56.21 b	66.58 b	67.93 b
	7.5	42.89 a	43.19 a	47.90 a	48.25 a	62.92 a	63.16 a	75.96 a	76.38 a
Chinese	control	18.69 e	18.83 e	25.86 f	26.16 f	39.74 e	40.06 e	42.46 d	42.90 e
	2.5	21.93 de	22.73 de	33.72 e	34.73 e	44.85 d	45.98 d	47.76 cd	48.90 d
	5	25.88 cd	26.38 cd	41.63 cd	42.05 cd	50.71 c	51.58 c	57.93 bc	58.70 c
	7.5	30.92 c	31.92 bc	46.55 ab	47.10 ab	56.09 b	56.50 b	65.69 b	66.79 b

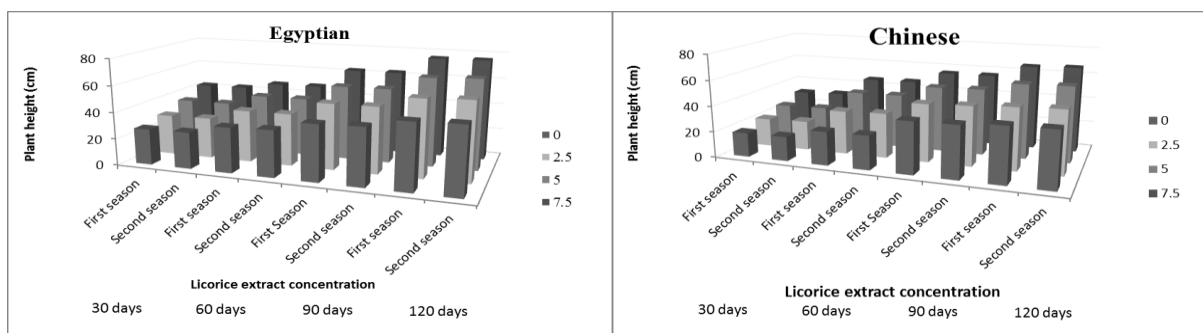


Fig. 3. Effect of interaction between garlic varieties and Licorice root extract on garlic plant height at 30, 60, 90 and 120 days after planting during winter seasons of 2018/2019 and 2019/2020.

3.Number of leaves/plant

Table 6 and Fig 4 is describing the total number of leaves/plant in studied garlic cultivars, treating their cloves or non-treating with licorice root extract and data showed that the Egyptian cultivar had higher number of leaves than the Chinese cultivar. Moreover, the treatments with licorice root extract significantly increased this number of leaves/plant with increasing the treatment concentration at

the studied ages; 30, 60, 90, and 120 days of cloves plantation. The treatment with the highest used (7.5 g/L) concentration of licorice root extract increased the total number of leaves/plant up to 9.70 and 9.84 in the two seasons comparing to the non-treated clove (6.61 and 6.75), respectively. The interaction between cultivars and treatments had a significant effect on this character (Table 6).

Table 6A. Effect of garlic varieties and Licorice root extract on garlic number of leaves/plant at 30, 60, 90 and 120 days after planting during winter seasons of 2018/2019 and 2019/2020.

Treatments	Number of leaves/plant							
	Days after planting							
	30		60		90		120	
	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season
Garlic varieties								
Egyptian	3.83 a	3.91 a	5.25 a	5.36 a	6.43 a	6.54 a	8.05 a	8.22 a
Chinese	3.40 a	3.49 a	4.61 b	4.76 b	6.12 b	6.25 a	7.72 a	7.86 a
Licorice concentrations (g/l)								
0	2.90 c	2.99 c	3.97 d	4.10 d	5.23 c	5.28 d	6.61 c	6.75 d
2.5	3.16 c	3.22 c	4.56 c	4.65 c	5.56 c	5.73 c	7.10 c	7.20 c
5	3.85 b	3.94 b	5.13 b	5.25 b	6.55 b	6.66 b	8.12 b	8.38 b
7.5	4.55 a	4.66 a	6.06 a	6.26 a	7.76 a	7.91 a	9.70 a	9.84 a

Table 6B. Effect of interaction between garlic varieties and Licorice root extract on garlic Number of leaves/plant of garlic plants at 30, 60, 90 and 120 days after planting during winter seasons of 2018/2019 and 2019/2020.

Treatments	Number of leaves/plant								
	Days after planting								
	30		60		90		120		
	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season	
Interaction									
Egyptian	0	3.14 bc	3.22 cd	4.29 e	4.40 d	5.33 d	5.40 de	6.83 d	6.93 de
	2.5	3.26 bc	3.33 cd	4.80 de	4.86 cd	5.66 cd	5.78 d	7.28 cd	7.33 d
	5	4.20 a	4.21 b	5.33 bc	5.46 b	6.93 b	7.06 b	8.33 b	8.66 b
	7.5	4.73 a	4.88 a	6.60 a	6.73 a	7.80 a	7.93 a	9.75 a	9.98 a
Chinese	0	2.67 c	2.77 d	3.65 f	3.80 e	5.13 d	5.16 e	6.40 d	6.56 e
	2.5	3.06 bc	3.11 cd	4.33 e	4.43 d	5.46 d	5.69 d	6.92 d	7.06 de
	5	3.49 b	3.66 c	4.93 cd	5.03 c	6.16 c	6.26 c	7.91 bc	8.10 c
	7.5	4.37 a	4.44 ab	5.53 b	5.80 b	7.73 a	7.90 a	9.65 a	9.71

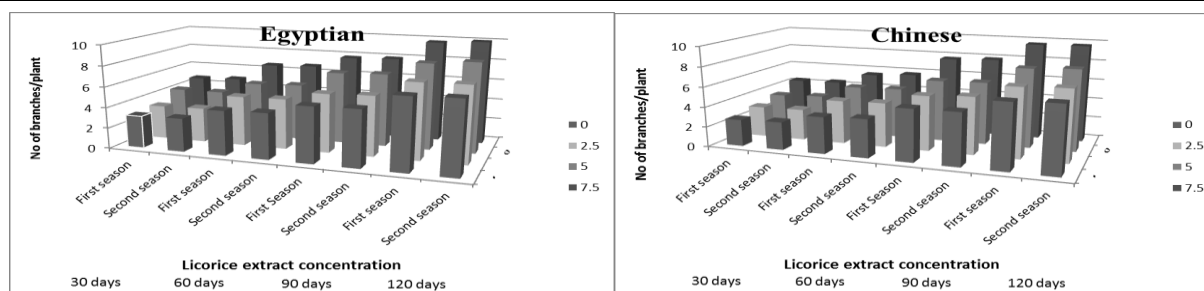


Fig. 4. Effect of interaction between garlic varieties and Licorice root extract on garlic Number of leaves/plant of garlic plants at 30, 60, 90 and 120 days after planting during winter seasons of 2018/2019 and 2019/2020

4.Plant fresh weight

This character showed that plants of the Egyptian cultivar had higher values of fresh weight at the age of 120 days from planting garlic cloves (76.18 and 77.08 g) than that of the Chinese cultivar (66.43 and 67.22 g) under the conditions of these experiments (soil properties are not suitable enough for garlic production) although the values were almost similar along with the growing seasons (after 30, 60, and 90 days from planting garlic cloves). Treating

garlic cloves before plantation and spraying the plants with licorice root extract significantly these values to reach 92.95 and 95.07 g after 120 days from planting the cloves in the first and second seasons, respectively (Table 7). The effect of the interaction of cultivars and treatments was higher in the Egyptian cultivar (99.93 and 101.91 g) than that of the Chinese cultivar (85.96 and 88.24 g) in the first and second seasons, respectively as shown in Table 7 and Fig 5.

Table 7A. Effect of garlic varieties and Licorice root extract on garlic Fresh weight (bulb + leaves)/plant (g) at 30, 60, 90 and 120 days after transplanting during winter seasons of 2018/2019 and 2019/2020.

Treatments	Fresh weight (bulb + leaves)/plant (g)							
	Days after planting							
	30		60		90		120	
	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season	1 st Season	2 nd Season
Garlic varieties								
Egyptian	8.30 a	8.47 a	17.58 a	18.19 a	36.95 a	37.44 a	76.18 a	77.08 a
Chinese	7.72 a	8.11 a	17.20 a	17.42 a	36.23 a	36.40 a	66.43 b	67.22 b
Licorice concentrations (g/l)								
0	5.93 c	6.18 d	14.92 d	15.28 d	25.59 d	25.91 d	54.38 d	54.65 d
2.5	7.37 bc	7.91 c	16.61 c	17.19 c	31.69 c	31.78 c	63.95 c	64.26 c
5	8.56 ab	8.78 b	18.14 b	18.62 b	41.00 b	41.76 b	73.94 b	74.63 b
7.5	10.20 a	10.30 a	19.90 a	20.11 a	48.08 a	48.23 a	92.95 a	95.07 a

Table 7B. Effect of interaction between garlic varieties and Licorice root extract on garlic Fresh weight (bulb + leaves)/plant (g) at 30, 60, 90 and 120 days after plantation during winter seasons of 2018/2019 and 2019/2020.

Treatments		Fresh weight (bulb + leaves)/plant (g)							
		Days after planting							
		30		60		90		120	
		1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Interaction									
Egyptian	control	6.02 b	6.22 d	14.93 e	15.53 c	25.95 e	26.51 cd	55.93 f	56.15 ef
	2.5	7.89 ab	8.03 c	16.98 cd	17.87 ab	31.90 d	32.00 c	68.91 d	69.25 d
	5	8.92 ab	9.07 bc	18.51 b	19.11 a	41.02 c	42.18 b	79.95 c	81.03 c
	7.5	10.39 a	10.56 a	19.90 a	20.24 a	48.94 a	49.07 a	99.93 a	101.91 a
Chinese	control	5.84 b	6.13 d	14.90 e	15.04 c	25.23 e	25.32 d	52.83 g	53.15 f
	2.5	6.85 ab	7.80 c	16.24 d	16.51 bc	31.48 d	31.57 c	58.98 e	59.28 e
	5	8.20 ab	8.49 c	17.77 bc	18.13 ab	40.98 c	41.35 b	67.93 d	68.24 d
	7.5	10.01 a	10.03 ab	19.90 a	19.98 a	47.23 b	47.39 a	85.96 b	88.24 b

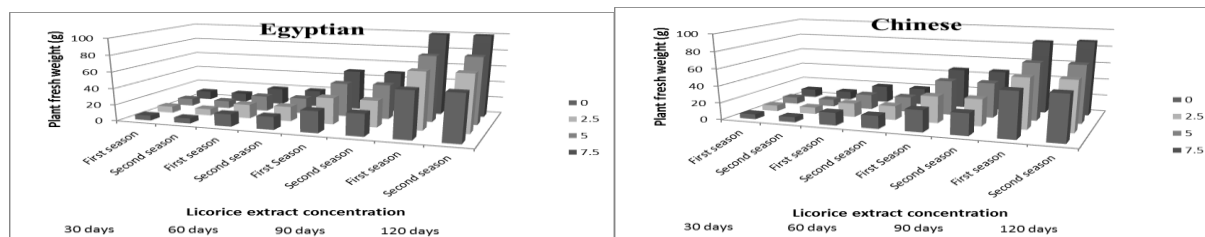


Fig. 5. Effect of interaction between garlic varieties and Licorice root extract on garlic Fresh weight (bulb + leaves)/plant (g) at 30, 60, 90 and 120 days after plantation during winter seasons of 2018/2019 and 2019/2020.

Bulb characters

1.Bulb fresh weight (g) and bulb dry weight (g)

This character was significantly affected by garlic cultivars and licorice roots extract treatments as described in Table 8 and Fig 6. The Egyptian cultivar produced bulbs with higher fresh weight values (69.98 and 70.59 g) than those of the Chinese one (66.26 and 66.83 g) and these differences were significant in the second season. Moreover, treating garlic cloves or plants with licorice roots extract significantly increased bulbs fresh weight from 50.59 and 51.21 g (control) to 88.82 and 89.28 g (7.5 g/L of the

treatment) in the first and second seasons, respectively. Regarding the interaction between cultivars and treatments, the Egyptian cultivar responded to the licorice roots extract treatment more than the Chinese cultivar and gave bulbs with higher fresh weight values especially with the treatment of 7.5 g/L (92.80 and 93.71 g) for the Egyptian cultivar and (84.84 and 84.85 g) in the first and second seasons, respectively. Bulbs dry weight character was somehow similar to bulb fresh weight character as shown in Table 8 and Fig 6.

Table 8A. Effect of garlic varieties and licorice root extract on bulb fresh weight, bulb diameter, bulbing ratio and bulb dry matter of garlic plants at harvesting date during winter seasons of 2018/2019 and 2019/2020

Treatments	Bulb fresh weight (g)		Bulb diameter (cm)		Bulbing ratio		Bulb dry matter (%)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Garlic varieties								
Egyptian	69.98 a	70.59 a	4.16 a	4.36 a	0.31 a	0.33 a	27.96 a	28.67 a
Chinese	66.26 a	66.83 b	4.01 a	4.12 a	0.29 b	0.29 a	27.59 a	28.13 a
Licorice concentrations (g/l)								
control	50.59 d	51.21 d	2.77 d	2.90 d	0.18 d	0.20 c	25.15 d	25.33 c
2.5	59.17 c	60.10 c	3.54 c	3.72 c	0.21 c	0.22 c	26.85 c	28.04 b
5	73.90 b	74.24 b	4.53 b	4.72 b	0.36 b	0.37 b	28.42 b	28.66 b
7.5	88.82 a	89.28 a	5.50 a	5.61 a	0.44 a	0.44 a	30.69 a	31.57 a

Table 8B. Effect of interaction between garlic varieties and licorice root extract on bulb fresh weight, bulb diameter, bulbing ratio and bulb dry matter of garlic plants at harvesting date during winter seasons of 2018/2019 and 2019/2020.

Treatments	Bulb fresh weight (g)		Bulb diameter (cm)		Bulbing ratio		Bulb dry matter(%)		
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	
Garlic varieties licorice concentrations (g/l)									
Egyptian	0	51.49 d	51.93 d	2.78 d	2.98 d	0.19 d	0.22 cd	25.36 d	25.36 b
	2.5	59.61 d	60.59 cd	3.64 c	3.88 c	0.23 c	0.25 c	26.90 c	28.72 ab
	5	76.02 c	76.11 b	4.67 b	4.82 b	0.37 b	0.39 b	28.69 b	29.01 ab
	7.5	92.80 a	93.71 a	5.58 a	5.75 a	0.45 a	0.46 a	30.91 a	31.58 a
Chinese	0	49.68 d	50.49 d	2.76 d	2.82 d	0.18 d	0.18 d	24.95 d	25.29 b
	2.5	58.73 d	59.61 cd	3.45 c	3.57 c	0.19 d	0.20 d	26.80 c	27.36 ab
	5	71.78 c	72.37 bc	4.40 b	4.62 b	0.36 b	0.36b	28.16 b	28.31 ab
	7.5	84.84 b	84.85 ab	5.43 a	5.46 a	0.42 a	0.43 a	30.48 a	31.56 a

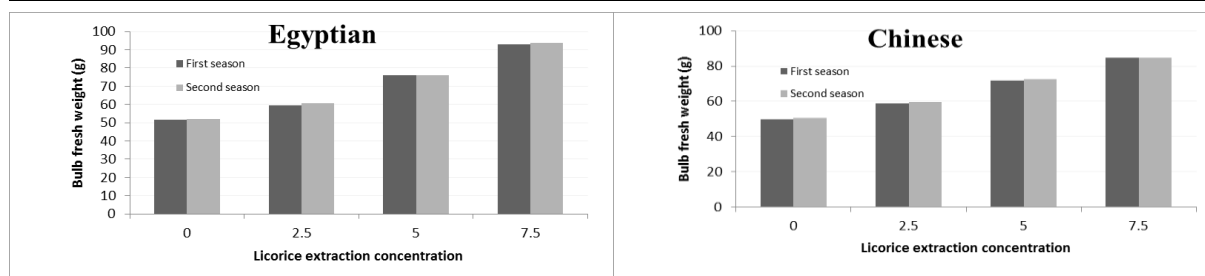


Fig. 6. Effect of interaction between garlic varieties and licorice root extract on bulb fresh weight of garlic plants at harvesting date during winter seasons of 2018/2019 and 2019/2020.

2. Bulb diameter (cm) and bulbing ratio

Bulb diameter was almost similar in both Egyptian and Chinese cultivars in the control treatment Table (8) and Fig 7 but treating garlic cloves and plants with licorice roots extract increased bulbs diameter from 2.77 and 2.90 cm (control “0.0” treatment) to 5.50 and 5.61 cm (7.5 g/L treatment). The effect of interaction

between treatments and cultivars on this character was insignificant (table 8). Regarding the bulbing ratio, it took the same trend like bulb diameter as neck diameter but did not differ significantly between the used two cultivars but as the neck diameter increased by licorice treatment the bulbing ratio increased Table (8) and Fig 8-9.

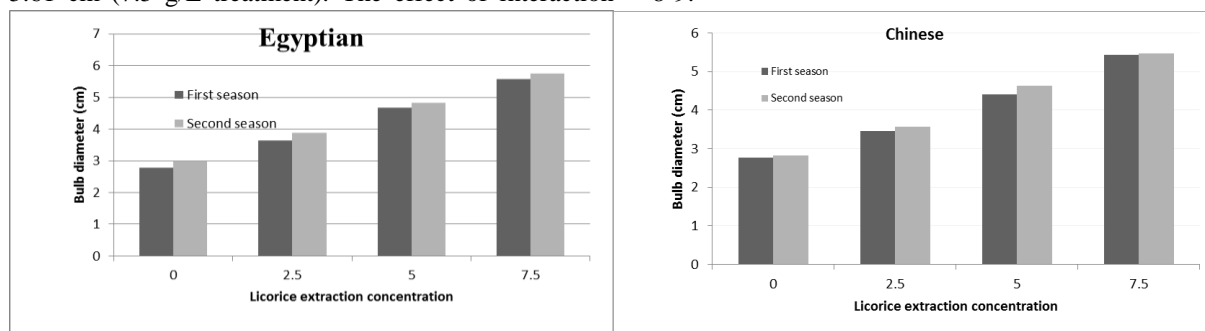


Fig. 7. Effect of interaction between garlic varieties and licorice root extract on bulb diameter of garlic plants at harvesting date during winter seasons of 2018/2019 and 2019/2020

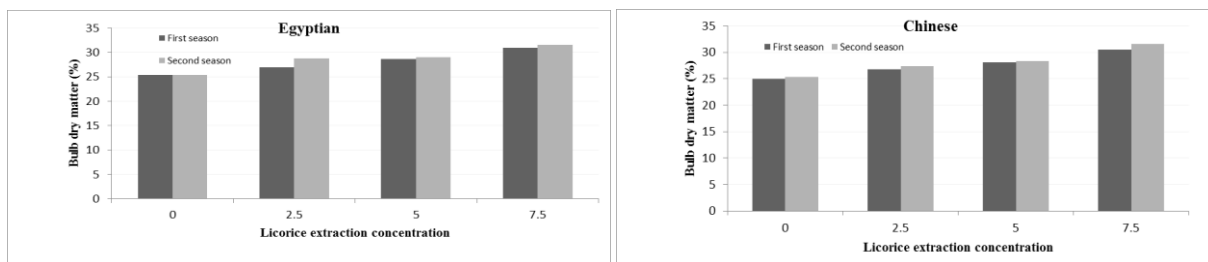


Fig. 8 : Effect of interaction between garlic varieties and licorice root extraction dry matter of garlic plants at harvesting date during winter seasons of 2018/2019 and 2019/2020.

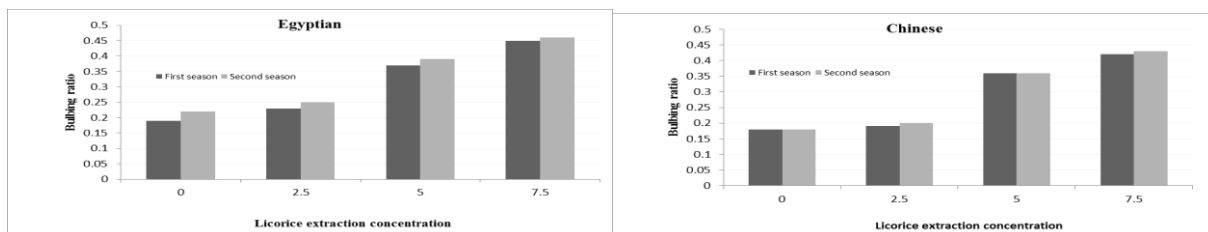


Fig. 9 : Effect of interaction between garlic varieties and licorice root extract bulb ratio of garlic plants at harvesting date during winter seasons of 2018/2019 and 2019/2020

Table 9A. Effect of garlic varieties and licorice root extract and on total yield during winter seasons of 2018/2019 and 2019/2020.

Treatments	Total yield (ton/fed.)		Relative total yield (%)	
	1 st season	2 nd season	1 st season	2 nd season
	Garlic varieties			
Egyptian	5.74 a	6.07 a	100	100
Chinese	4.42 b	4.82 b	77.00	79.40
	Licorice concentrations (g/l)			
control	3.72 d	3.90 d	100	100
2.5	4.62 c	4.95 c	124.19	126.92
5	5.28 b	5.65 b	141.93	144.87
7.5	6.70 a	7.28 a	180.10	186.66

Table 9B. Effect of interaction between garlic varieties and licorice root extract on total yield during winter seasons of 2018/2019 and 2019/2020.

Treatments		Total yield (ton/fed.)		Relative total yield (%)	
		1 st Season	2 nd Season	1 st Season	2 nd Season
		Interaction			
Egyptian	control	4.08 de	4.18 d	100	100
	2.5	5.23 c	5.53 bc	128.18	132.29
	5	6.16 b	6.44 b	150.98	154.06
	7.5	7.50 a	8.12 a	183.82	194.25
Chinese	control	3.36 e	3.62 d	100	100
	2.5	4.02 de	4.38 cd	119.64	120.99
	5	4.41 d	4.86 cd	121.48	134.25
	7.5	5.90 bc	6.43 b	175.59	177.52

3. Total yield(fed) and relative total yield (%)

The results of yield and its components, i.e., marketable yield, non -marketable yield and total yield (ton/fed.) during 2018/2019 and 2019/2020 seasons are presented in Tables 9 and 10. One Feddan produced 5.74 and 6.07 ton from Egyptian cultivar while the production of were Chinese cultivar 4.42 and 4.82 ton under the conditions of the experiments in the first and second season, respectively as shown in table 9. On the other hand, applying the treatments of the licorice root extract increased garlic total yield values to reach 6.70 and 7.28 ton/fed compared to control (3.72 and 3.90 ton/fed) in the first and second seasons, respectively . For the interaction between garlic cultivars and treating garlic cloves and plants with licorice root extract The best values of total yield/fed were obtained by treating garlic cloves and plants with at concentration 7.5 g/L of licorice root extract 7.50 and 8.12 ton/fed for Egyptian cultivar and 5.90 and 6.43 ton/fed for the Chinese cultivar in the first and second season, respectively (Table 9) and Fig 10. Regarding the relative total

yield, data in the same table showed that soaking garlic cloves before plantation and foliar spraying garlic plants with licorice roots extract with different ascending concentrations increased the relative total yield percentage to reach 180.10 and 186.66 % with the concentration of 7.5 g/L and the increases in total yield were about 80.10 and 86.66% over control treatment (control) and yield of Chinese cultivar decreased by 13.20 % compared to Egyptian cultivar in the first and second season respectively Table 9(B) and Fig 11.

In general, marketable yield was more than non-marketable yield of garlic plants. In addition, the highest values for marketable yield and the lowest values for non-marketable yield were recorded with application of at concentration 7.5 g/L of licorice root extract in both seasons. Treating garlic cloves and plants with licorice roots extract increased the highest values for marketable yield from 2.67 and 2.78(control treatment) to 6.25 and 6.79 (at concentration 7.5 g/L of licorice root extract) ,Table (10) and Fig 12 ,13.

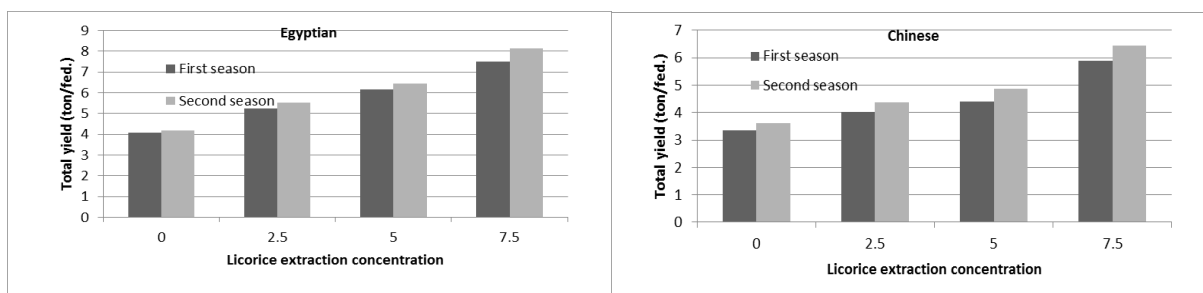


Fig. 10. Effect of garlic varieties and licorice root extract on total yield during winter seasons of 2018/2019 and 2019/2020.

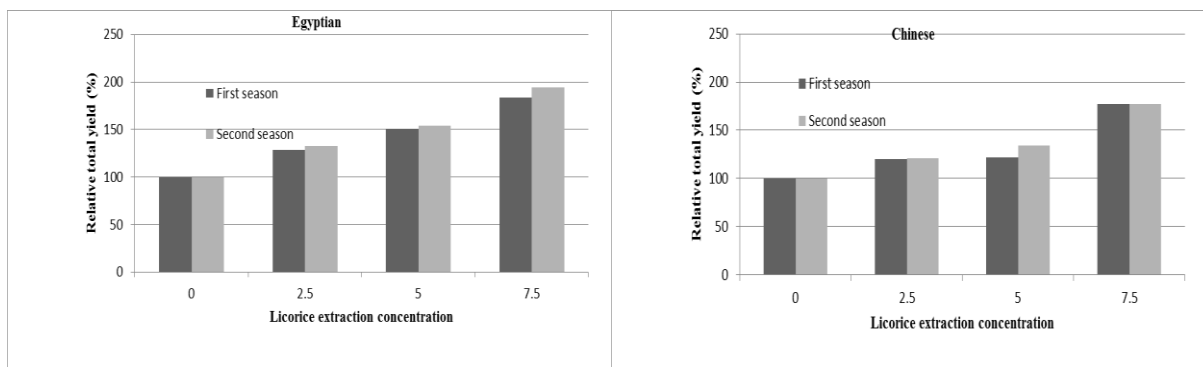


Fig. 11 . Effect of garlic varieties and licorice root extract on Relative total yield during winter seasons of 2018/2019 and 2019/2020.

Table 10A. Effect of garlic varieties and licorice root extract on marketable yield and non-marketable yield during winter seasons of 2018/2019 and 2019/2020.

Treatments	Marketable yield (ton/fed)		Non-marketable yield (ton/fed)	
	1 st Season	2 nd Season	1 st Season	2 nd Season
	Garlic varieties			
Egyptian	5.03 a	5.32 a	0.71 a	0.75 a
Chinese	3.66 b	4.00 b	0.76 a	0.81 a
	Licorice concentrations (g/l)			
control	2.67 d	2.78 d	1.05 a	1.12 a
2.5	3.83 c	4.10 c	0.80 b	0.85 b
5	4.63 b	4.98 b	0.65 c	0.67 c
7.5	6.25 a	6.79 a	0.44d	0.48 d

Table 10B. Effect of interaction between garlic varieties and Licorice root extraction on marketable yield and non-marketable yield during winter seasons of 2018/2019 and 2019/2020.

Treatments		Marketable yield (ton/fed)		Non-marketable yield (ton/fed)	
		1 st season	2 nd season	1 st season	2 nd season
		Interaction			
Egyptian	control	3.04 d	3.10 ef	1.04 a	1.08 a
	2.5	4.48 c	4.70 c	0.75 b	0.83 b
	5	5.54 b	5.82 b	0.62 bc	0.62 bc
	7.5	7.06 a	7.65 a	0.44 c	0.47 c
Chinese	control	2.30 e	2.46 f	1.06 a	1.16 a
	2.5	3.17 d	3.51 de	0.85 ab	0.87 b
	5	3.73 d	4.13 cd	0.68 bc	0.73 bc
	7.5	5.45 b	5.93 b	0.45 c	0.50 c

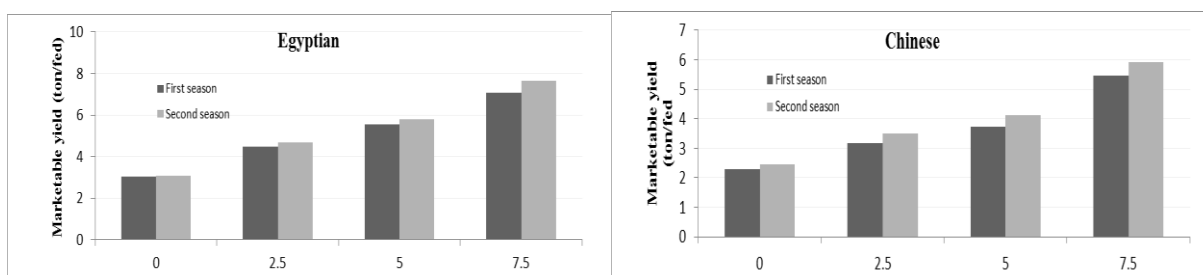


Fig. 12. Effect of interaction between garlic varieties and Licorice root extraction on marketable yield during winter seasons of 2018/2019 and 2019/2020.

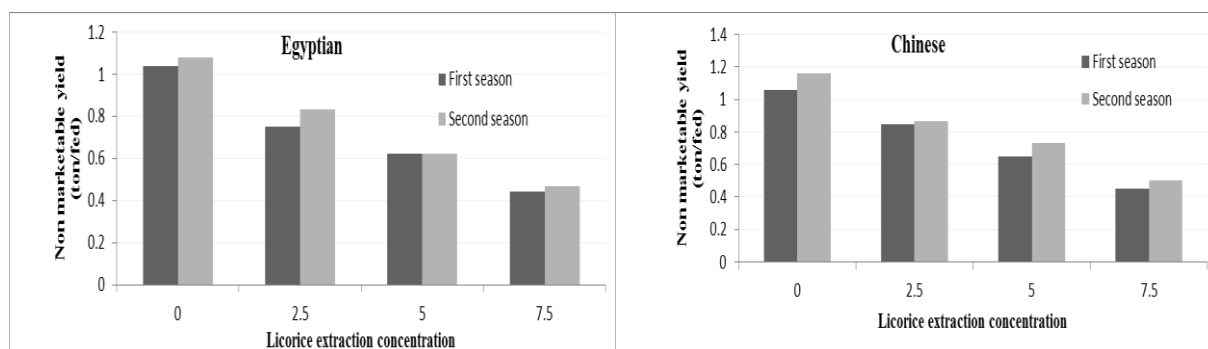


Fig. 13. Effect of interaction between garlic varieties and Licorice root extract on non-marketable yield during winter seasons of 2018/2019 and 2019/2020.

DISCUSSION

As the Ministry of Agriculture in Egypt is following a new strategy to spread vegetables cultivation in new reclaimed lands this study was conducted in a poor new reclaimed soil in the New Valley governorate to study the effect of garlic cultivars (two different cultivars were used; Egyptian and Chinese) as the first factor and four concentrations of licorice root extract (control, 2.5, 5.0, and 7.5 g/L) were used as the second factor. Results showed that these two cultivars differed in their growth and production behavior under these environmental conditions. The Egyptian cultivar behaved better than the Chinese one as it is good adapted to the Egyptian environment. Most of the recorded data e.g., plant height, plant fresh weight, bulb fresh weight and yield components (total yield, marketable yield, and non-marketable yield) These results are in agreement with those of (Osman and Moustafa 2009; Moustafa, 2011; Gad El-Hak *et al.*, 2011 and 2012; Hammdi and Abbass, 2012; Fathel *et al.*, 2015; Abdel Rasheed *et al.*, 2016 a & b; Frattaroulo *et al.*, 2019).

As for foliar spraying with natural extracts e.g., licorice root extract many researches showed that spraying onion plants with licorice root extract significantly promoted vegetative growth and bulb production. Other studies reported that spraying forwarded the process of flowering, increased flower set, the number of flowers/umbel, umbel diameter, and production of seeds (Hussein, 2020; Moses *et al.*, 2002; Al-Ajeeli, 2005; Moustafa *et al.*, 2009; Sabry *et al.*, 2009). Licorice extract is rich in amino acids, vitamins and growth stimulating photo-hormones that increases the activity of apical meristem tissue resulting in cell division and elongation (Alabady, 2002; Al-Ajeeli, 2005; Khan *et al.*, 2009; Lazim and Ahmed, 2013). In this study, licorice root extract had significant effects on garlic growth and production along with the quality of obtained bulbs and decreased the percentage of non-marketable bulbs and increased that of marketable bulbs under these conditions of poor newly reclaimed soils. Meanwhile, by using these treatments garlic plantations could be horizontally spread in the New Valley governorate as it is very vast and records about 64% of total area of Egypt.

CONCLUSION

These experiments were conducted in a very poor sandy soil of the New Valley located in the South-West of Upper Egypt. This kind of soil is not good for garlic production. But results of this study are very promising as different

concentrations of licorice root extract increased garlic plant growth, yield, and yield components along with the chemical compositions of garlic bulbs of both Egyptian and Chinese cultivars. These results can increase the amount and quality of garlic bulbs (green or dry) supposed to be exported abroad.

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تأثير الرش الورقي بمستخلص جذور العرقسوس علي الإنتاج والجودة في الثوم المصري والصيني
محمد حمام زين العابدين الدقيشي¹ ، ياسر محمود محمد مصطفى² ، محمد أحمد محمد علي³ و أسماء صلاح حسن صالح³.
¹ قسم الخضر – كلية الزراعة – جامعة أسيوط.
² قسم الخضر – كلية الزراعة – جامعة المنيا.
³ قسم البساتين – كلية الزراعة – جامعة الوادي الجديد.

أجريت هذه التجارب في المزرعة البحثية بكلية الزراعة – جامعة الوادي الجديد بالخارجة بجمهورية مصر العربية بغرض دراسة تأثير تركيزات مختلفة من مستخلص جذور العرقسوس هي (0.0 و 2.5 و 5.0 و 7.5 جرام لكل لتر) علي صنفين من الثوم هما الصنف المصري (البلدي) وصنف صيني (أيجاسيد 1) المنزرع في أرض رملية علي النمو والمحصول والجودة. أظهرت الدراسة أن صنف الثوم البلدي نما جيداً تحت هذه الظروف السيئة من التربة بالمقارنة بالصنف الصيني وكذلك كان لمعاملات مستخلص العرقسوس تأثيراً إيجابياً ومعنوياً علي كل الصفات المدروسة خصوصاً التركيزات العالية منه وهي 5.0 و 7.5 جرام لكل لتر. وهذه النتائج مبشرة جداً وتمكننا من التوصية بزراعة الثوم في الأراضي المستصلحة حديثاً مع استخدام التركيز 7.5 جرام لكل لتر من مستخلص جذور العرقسوس بنقع فصوص الثوم به ورش النباتات بهذا المستخلص بالإضافة الي استخدام كميات الأسمدة المختلفة الموصي بها من وزارة الزراعة المصرية لإنتاج الثوم في الأراضي الجديدة.