# Effect of Foliar Application by Chitosan on Five Garlic Genotypes in Aswan the Southern Egypt

Mohamed, I. H[1].; Abdelrasheed, K. G. [1]; Hassan S. Abbas [2] and Mona N. Shehata1

[1] Horticulture Department, Faculty of Agriculture and Natural Resources, Aswan University, Egypt
[2] Vegetable Crops Department, Faculty of Agriculture, Assiut University, Assiut, Egypt

## Abstract

A field experiment was carried out during the two consecutive winter seasons of 2018/2019 and 2019/2020 in the Experimental Farm, Faculty of Agriculture and Natural Resources, Aswan University, Egypt. The objective of study was to evaluate the response of five garlic genotypes, (**Egaseed1, Sids40, Clone 3, Clone 4 and Clone 5**) to the foliar application of chitosan (**0 , 1.5 , 2 and 2.5 cm/L**).

The results showed that the highest leave number was obtained by Clone 4 and Clone 5 in both seasons respectively. Whereas the highest leave number was obtained by control and 1.5 cm/L respectively. Through highest plant was Clone 3, Clone 5 respectively**.** While the highest plants were obtained by 1.5 cm/L**.** The highest fresh and cured yield ton / fed were obtained by Clone 4 and Clone 5 in both seasons respectively. While the highest fresh and cured yield ton / fed were obtained by 2 cm/L and control respectively. Meanwhile the highest Garlic bulb diameter after curing was obtained by Clone 5 and sids40 in both seasons respectively. While the highest Garlic bulb diameter after curing was obtained by 2cm/L**.** Meantime highest Average clove weight after curing was obtained by Clone 3 and sids40 respectively. While highest Average clove weight after curing was obtained by 2 cm/L and control respectively. Meanwhile highest T.S.S after curing was Egaseed1, Clone 4 respectively. While the highest T.S.S after curing was obtained by 2.5 cm/L respectively. Meanwhile lowest Weight loss percentage after curing was sids40, Clone 5 respectively. While the lowest Weight loss percentage after curing was obtained by 2cm/L and 2.5 cm/L respectively.

***Keywords*:** Garlic; Genotype; Chitosan

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## INTRODUCTION

Garlic (*Allium sativum* L.; Family: *Amaryllidaceae*) is an aromatic herbaceous annual spice and one of the oldest authenticated and most important herbs that have been used from ancient times as traditional medicine [1, 2].

Garlic is one of the most important bulb crops in Egypt, which is cultivated for both local consumption and export. It is often used as a spice or condiment as well as for medical purposes. In Egypt, the total area devoted for production was 16757 ha, which produced 348230.7 ton in 2021 season [3].

Chitosan is a cationic polysaccharide, produced by the alkaline deacetylation of chitin, which is present in shells of insects and marine crustaceans. It has many favorable properties such as availability, biodegradability, biocompatibility, bioactivity, non-toxicity and has good adhesion and sorption may be the reasons for its wide applications [4, 5].

Many investigators reported that using chitosan as foliar spray with chitosan increased vegetative growth, yield and quality of vegetable crops [6-8]. Chitosan also promoted growth of various crops such as soybean sprouts [9], sweet basil [10], strawberry [6] and sweet pepper plants [7]. Several experiments studied the effects of concentration and frequency of chitosan application on various crops such as chili, Chinese cabbage, celery and bitter cucumber [11, 12]. Chitosan concentration and frequency of application significantly increased growth rates of chili and the harvest yield of Chinese cabbage [11]**.** It was found that chitosan treatment increases the yield and marketability of soybean sprouts. However, the mechanism of action of chitosan on plant growth remains unclear [9].

This work was carried out during the two consecutive winter seasons of 2018/2019 and 2019/2020 in the Experimental Farm, Faculty of Agriculture and Natural Resources, Aswan University, Egypt on a sandy soil. The aim of this study was to investigate the influence of four levels of Chitosan on growth, yield, and storability of garlic "*Allium sativum* L." under Aswan condition.

**Table (1): Means of the mechanical and chemical analysis of the soil before garlic planting in the autumn seasons of 2018/2019 and 2019/2020.**

| Soil property | Season | |
|---|---|---|
| | 2018 | 2018 |
| **1. Physical properties:-** | | |
| Clay (%) | 3.00 | 3.50 |
| Silt (%) | 0.00 | 0.00 |
| Sandy (%) | 97.00 | 96.50 |
| Textural class | Sandy | Sandy |
| **2. Chemical properties:-** | | |
| **a) Soluble cations in (1:1) soil to water extract moll/L)** | | |
| $Ca^{++}$ | 3.06 | 3.10 |
| $Mg^{++}$ | 1.02 | 1.05 |
| $K^{+}$ | 0.83 | 0.85 |
| $Na^{+}$ | 0.76 | 0.80 |
| **b) Soluble anions in (1:1) soil to water extract(moll/L):-** | | |
| $CO_3^{--}$ | 0.00 | 0.00 |
| $HCO_3^{-}$ | 7.10 | 7.06 |
| $Cl^{-}$ | 3.06 | 3.57 |
| $SO_4^{--}$ | 0.40 | 0.44 |
| PH (1:1 soil suspension) | 7.64 | 7.70 |
| EC (ds/cm) at 25°C | 0.33 | 0.32 |
| Available N (mg/kg soil) | 128.31 | 130.00 |
| Available P (mg/kg soil) | 8.00 | 10.00 |
| Available K (mg/kg soil) | 175.00 | 180.00 |

## MATERIALS AND METHODS

*The analyses were carried out at natural resources Department, Faculty of Agriculture and Natural Resources, Aswan University, Egypt

# Treatments:

1. **Genotypes**

Five cloned genotypes of garlic CVs. (**Egaseed1, Sids40, Clone 3, Clone 4 and Clone 5**) were randomly arranged in the main plots. The origin and bulb color of these genotypes were listed in Table (2) as follow:

**Table (2): Source and bulb color of garlic genotypes.**

| Genotype | Source | Bulb color |
|---|---|---|
| **Egaseed1** | The Agricultural Egyptian Company for Seed Production | **Slightly red** |
| **Sids40** | Sids Horticulture Research Station, The Agricultural Research center | **Slightly red** |
| **Clone 3** | Department of horticulture, the faculty of agriculture, Aswan university | **Red** |
| **Clone 4** | Department of horticulture, the faculty of agriculture, Aswan university | **Red** |
| **Clone 5** | Department of horticulture, the faculty of agriculture, Aswan university | **Red** |

**2. Chitosan**

Four treatments of chitosan (**0, 1.5, 2 and 2.5 cm/L**) were randomly arranged in the sub - plots.

Plants were sprayed with chitosan as foliar application with aqueous solution three times after 105,120 and 135 days from planting. While control treatment was sprayed with distilled water.

**Experimental layout**

The experimental layout was a Factorial Experiments in a Randomized Complete Blocks Design with three replications. Each experiment included 20 treatments. Which were the combinations of four levels of Chitosan foliar application and five garlic genotype. Each experimental four rows of 10 m length and 0.80 m width

**Data were recorded for the following plant characteristics:**

**1 Vegetative Growth characteristics**

1-1 Plant height (cm) after 105 days from planting, 5 guarded plants/plot was measured as the height of the plant vegetative growth from the true stem to the terminal point of the tallest leaf and average was used.

1-2 Leaves number per plant after 105 days dry and green leaves) was counted of the same sample and their average was used.

**2 Bulb characteristics**

2-1 Cured bulb diameter (mm) was estimated as beforehand mentioned.

2-2 Bulbing ratio at harvesting was calculated using equation [13].

$$\boldsymbol{Bulbing\ ratio} = \frac{\textbf{(Neck diameter (mm)}}{\textbf{(Bulb diameter (mm)}}$$

2-3 Cured bulbing ratio was measured as mentioned in bulbing ratio at harvesting.

2-4 Number of cured cloves per bulb was recorded as the average of cloves of 5 bulbs taken randomly from each plot.

2-5 Average weight of single cured clove (g). It was calculated as the average weight of cloves of the previous 5 bulb using the following formula:

$$\boldsymbol{Average\ clove\ weight} = \frac{(\textbf{Average cloves weight (g) of the 5 cured bulbs})}{(\textbf{Average clove numbers of these 5 bulbs})}$$

3 **Bulb quality**

To estimate total soluble solids (TSS) of bulb characters, 5 fully ripened bulbs were used to extract their juice by using the refract meter according to the method of [14].

**4 Yield and its components**

4-1 Fresh and cured yield (ton/fed): garlic plants were harvested on March 17th and 23th in the first season and April 5th and 6th in the second season. Fresh yield (kg/plot) of whole plants was determined. Data were rated and converted as ton/fed. After that, the harvested plants were cured in the field for 21 days and then weighted. The cured yield was estimated as ton/fed.

4-2 Percentage of fresh and dry mater: Bulb slices were oven dried at 70 C° for two days until it reaches constant weight and then the dry mater were calculated as follows:

$$\boldsymbol{Dry\ mater\ (D.M.)\%} = \mathbf{100} - \frac{(\textbf{Weight before dring} - \textbf{Weight after dring})}{(\textbf{Weight before dring})}\boldsymbol{x}\mathbf{100}$$

5 **Weight loss percentage** "Characteristics during curing and storage periods"

Yield losses of the tested materials, **cv. "Egaseed1", "Grower's Clones" and cv. "Sids-40**" were determined during the curing process in the open field for 21 days. Also, the percentages of weight loss during storage under the room conditions were estimated after 8 months from the starting date of storage (**May, 2019 and May, 2020**) as follows:

5-1 Weight loss percentage after curing: the total loss during the curing process was estimated using the following formula:

$$\boldsymbol{Weight\ loss}\ \% = \frac{(\textbf{Fresh weight} - \textbf{cured weight})}{(\textbf{Fresh weight})}\boldsymbol{x}\ \mathbf{100}$$

5-2 Weight loss percentage after Eight months from storage: random samples of cured bulbs were taken from each plot in both seasons and packed in small nylon net bags. These samples were stored under the room condition. The weight loss in the storage at room temperature was estimated after Eight months from using the following formula: [15]

$$\boldsymbol{Weight\ loss}\ \% = \frac{(\textbf{Initial weight of cured sample}) - (\textbf{actual weight at the specific time of storage})}{(\textbf{Initial weight of cured sample})}\ \boldsymbol{x}\ \mathbf{100}$$

**1. Statistical analysis**

Data were subjected to analysis of variance procedures and means were compared using L. S. D. test according to [16].

**RESULTS AND DISCUSSION**

**1. Vegetative Growth characteristics**

**1.1. Number of leaves at 105 days**

Data in table (3) showed that there were significant differences between the five genotypes in the first season. Clone4 showed the highest result with (9.67) and the lowest result was recorded in Clone5 by (9.28). While in the second season, Clone5 showed the highest result with (8.43) and the lowest result was recorded in Clone4 by (7.80).

There was insignificant difference in number of leaves between the four treatments of chitosan, however in the first season chitosan treatment at control showed result with (9.49) and result was recorded at chitosan at 2 cm/L by (9.33). While in the second season, chitosan treatment at 1.5 cm/L showed result with (8.41) and result was recorded at chitosan treatment at 2.5 cm/L by (8.09).

The interaction effect between treatment and garlic genotypes was significant. In both seasons, untreated garlic clone 4 had the highest result by (10.00) and garlic Clone 5 treated with 2cm/L chitosan had the lowest result by (8.93). While in the second season, the highest result was garlic clone 5 treated with (1.5 cm/L) by (8.73) and lowest result by garlic clone 4 with chitosan treatment of 2.5 cm/L by (7.73).

It is illustrated that application of chitosan at (300 mm) considerably augmented the plant height and number of leaves of garlic in garlic plants in drought conditions [17]. This increase may have been due to the synergistic role of chitosan in stimulating growth compared with untreated plants. The enhancement of garlic growth characters by foliar application of chitosan are in accordance with those found on squash [18], strawberry [6], sweet pepper [7], radish [19], garlic [8], strawberry [20] and on mung bean [21]. On cucumber, it was found

that foliar application of chitosan at rate of 4 ml/L was recorded the highest vegetative growth [22]. Furthermore, most of the morphological characters in okra were increased with increasing chitosan concentration up to 25 ppm

[9]. In addition, foliar-applied chitosan in particular 200 mg/L increased the common bean plant growth as compared to control plants [23].

There was a significant difference among the four cultivars (Balady, Sids-40, Eggaseed-1 and Eggaseed-2) and Egyptian genotype (Sids50) respecting plant height [24]. The previous significant differences on growth characters among various garlic cvs were confirmed by the previous results [25-31]. It is reported that the number of leaves per plant was significantly affected by garlic ecotypes compared with ecotypes from Balady [32].

**Table (3): Effect of foliar spray with chitosan on number of leaves at 105 days in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 9.00 | 8.20 | 9.47 | 8.27 | 9.60 | 8.60 | 10.00 | 7.80 | 9.40 | 8.00 | **9.49a** | **8.17b** |
| Chitosan 1.5 cm/L | 9.47 | 8.67 | 9.40 | 8.53 | 9.40 | 8.47 | 9.80 | 7.67 | 9.33 | 8.73 | **9.48a** | **8.41a** |
| Chitosan 2 cm/L | 9.27 | 8.33 | 9.67 | 8.00 | 9.33 | 7.93 | 9.47 | 8.00 | 8.93 | 8.67 | **9.33a** | **8.19ab** |
| Chitosan 2.5 cm/L | 9.93 | 7.80 | 9.20 | 8.40 | 9.13 | 8.20 | 9.40 | 7.73 | 9.47 | 8.33 | **9.43a** | **8.09b** |
| **Mean** | **9.42ab** | **8.25a** | **9.43ab** | **8.30a** | **9.37b** | **8.30a** | **9.67a** | **7.80b** | **9.28b** | **8.43a** | | |

| L.S. D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | First | 0.52 | 0.29 | 0.78 |
| | Second | 0.28 | 0.32 | 0.64 |

### 1.2. Plant height at 105 days

Data in table (4) showed that there were significant differences in both seasons. Clone3 showed the highest result with (52.97 cm) and the lowest result was recorded in Egaseed1 by (49.02 cm). While in the second season, Clone5 showed the highest result with (51.30 cm) and the lowest result was recorded in Clone4 by (45.70 cm).

There was insignificant difference in plant height between the four treatments of chitosan in the both seasons. In the first season, chitosan treatment at 1.5 cm/L showed result with (51.72 cm) and the short plant was recorded at chitosan at 2.5 cm/L by (49.03 cm). While in the second season, chitosan treatment at 1.5 cm/L showed result with (49.32 cm) and the short plant was recorded at chitosan treatment at 2.5 cm/L by (47.36 cm).

The interaction effect between treatment and garlic genotypes was insignificant. In the first season, garlic clone 3 with control had result by (54.27 cm) and garlic Sids40 with chitosan of 2.5cm/L had result by (46.70 cm).

While in the second season, plant was garlic clone 5 with (chitosan of 1.5 cm/L) by (51.93 cm) and the result of garlic clone 4 with chitosan treatment of 2.5 cm/L by (43.33 cm).

The latter authors reported that Chitosan application proved to stimulate early growth stages of lettuce, soybean, and upland rice. More recently, improvement effects were shown on strawberry growth because of Chitosan application [6]. Nevertheless, the exact mechanism(s) of Chitosan effects on plant growth is not yet determined. Similar effects of Chitosan were recorded by [7] on sweet pepper plant behavior. Positive effects of Chitosan incorporated into the soil on early growth stages of soybean, mini-tomato, upland rice, and lettuce [33]. The degree of responses differed according to the applied concentration of Chitosan. This was also reported to differ by the crop and concentration [33]. The increment in total N content in the leaves maybe brought about by the amino components in chitosan and or higher ability of the plant to absorb N from the soil when Chitosan was degraded.

The nature and extent of genetic variability is one of the most important and essential criteria in any breeding programmer. The knowledge of various parameters of variability i.e., phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), general mean, variation in range, genetic gain and heritability in broader sense are very much helpful in predicting the amount of variation present in each set of genetic material. For all the observed characters, the estimates of PCV and GCV were worked out. The variation in coefficients of variability varies from character to character, either low or moderate and these are helpful in determining the extent of genetic diversity present among the genotypes. Extensive sense, heritability is the parameter of tremendous significance to the breeder as its magnitude indicates the reliability with which a genotype can be recognized by its phenotypic expression. For estimating the real effects of selection, it is more important to study genetic advance along with heritability since only heritability is not enough reported that by [34].

Similarly high amount of phenotypic and genotypic coefficients of variation for purple blotch and clove weight were also observed by [35]**.** Heritability is defined as the ability of a particular trait to get transmitted from one generation to another. The magnitude of heritability indicates the reliability with which a genotype can be recognized by its phenotypic expression thus making heritability a parameter of utmost significance to breeders. Higher the variation in heritability among the different genotypes for a particular trait greater will be the chances for its improvement by selection. Hence heritability studies are of great significance to know whether the variability for a particular trait is heritable or the extent to which it is being affected by the environmental factors**.** **[35]**

**[30]** Show clearly that there was a significant difference among the four cultivars (Balady, Sids-40, Eggaseed-1 and Eggaseed-2) and Egyptian genotype (Sids -50) respecting plant height, in both growing seasons. The previous significant differences on growth characters among various garlic cvs were confirmed by the results of, **[25-32]**

who reported that the plant height per plant was significantly affected by garlic ecotypes Compared with ecotypes from Balady.

**Table (4): Effect of foliar spray with chitosan on plant height at 105 days in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 48.07 | 50.67 | 51.67 | 47.33 | 54.27 | 48.60 | 49.87 | 45.73 | 51.27 | 50.60 | **51.03a** | **48.59a** |
| Chitosan 1.5 cm/L | 50.53 | 51.13 | 52.80 | 49.47 | 52.27 | 49.40 | 51.07 | 44.67 | 51.93 | 51.93 | **51.72a** | **49.32a** |
| Chitosan 2 cm/L | 50.20 | 47.80 | 48.60 | 47.07 | 53.27 | 45.87 | 50.40 | 49.07 | 49.73 | 51.20 | **50.44a** | **48.20a** |
| Chitosan 2.5 cm/L | 47.27 | 47.47 | 46.70 | 48.27 | 52.07 | 46.27 | 49.80 | 43.33 | 49.33 | 51.47 | **49.03a** | **47.36a** |
| **Mean** | **49.02b** | **49.27ab** | **49.94b** | **48.03bc** | **52.97a** | **47.53bc** | **50.28b** | **45.70c** | **50.57ab** | **51.30a** | | |
| **L.S. D** | **Seasons** | | **Treatments** | | **Genotypes** | | **Interaction** | | | | | |
| | **First** | | 2.81 | | 6.68 | | 6.52 | | | | | |
| | **Second** | | 3.31 | | 2.59 | | 6.60 | | | | | |

## 2. Bulb characteristics

### 2.1. Garlic bulb diameter after curing

Data in table (5) showed that was insignificant difference in the first season however in first season (Sids40) showed the result by (48.13) Mm and the result was recorded in (Egaseed1) by (41.05) Mm while in the second season was significant (clone 5) showed the high result by (46.38a) Mm and clone 4 showed the lowest result by (37.52c) Mm.

There was significant difference in between the four treatments of chitosan the first season however in the first season chitosan treatment at 2cm/L showed the highest result with (48.84a) Mm and the lowest result was recorded at chitosan at control by (38.65b) Mm while in the second season There was insignificant difference however chitosan treatment at 2cm/L showed the result with (42.49a) Mm and the result was recorded at chitosan treatment at 2.5 cm/L by (40.73a) Mm.

The interaction effect between treatment and garlic genotypes was significant in the first season however in the first season garlic Sids40 with chitosan at 2cm/L had the highest result by (68.20) Mm and garlic Sids40 with chitosan treatment at control had the lowest result by (38.47) Mm while The interaction effect between treatment and garlic genotypes was significant in the second season the high result was garlic clone5 with chitosan at 2.5cm/L by (50.07) Mm and lowest result by garlic clone4 with chitosan treatment of 2.5cm/L by (37.52) Mm.

Application of chitosan at (300 mM) considerably significantly increases of the bulb diameter (cm) of garlic in garlic plants in drought conditions. [17]

There was significantly increased bulb diameter in Sids-50 genotype without significant differences with Balady and Eggaseed-1 in the 2nd season revealed that by [24]

**Table (5): Effect of foliar spray with chitosan on garlic bulb diameter after curing from planting in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 38.53 | 42.27 | 38.47 | 41.27 | 38.60 | 40.47 | 39.00 | 39.20 | 38.67 | 45.93 | **38.65b** | **41.83a** |
| Chitosan 1.5 cm/L | 39.80 | 41.33 | 42.47 | 44.13 | 44.60 | 44.60 | 41.67 | 37.87 | 42.93 | 42.40 | **42.29ab** | **42.07a** |
| Chitosan 2 cm/L | 44.67 | 45.67 | 68.20 | 40.30 | 43.80 | 40.80 | 43.53 | 38.53 | 44.00 | 47.13 | **48.84a** | **42.49a** |
| Chitosan 2.5 cm/L | 41.20 | 40.53 | 43.40 | 40.40 | 42.60 | 38.20 | 43.27 | 34.47 | 43.27 | 50.07 | **42.75ab** | **40.73a** |
| **Mean** | **41.05a** | **42.45b** | **48.13a** | **41.53b** | **42.40a** | **41.02bc** | **41.87a** | **37.52c** | **42.22a** | **46.38a** | | |

| L.S. D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | first | 8.80 | 7.80 | 18.81 |
| | second | 5.10 | 3.79 | 9.67 |

## 2.2. Fresh garlic bulbing ratio

Data in table (6) showed that was significant difference in the first season however in first season (clone 3) showed the high result by (0.25a) and the lowest result was recorded in (clone 5) and (Sids40) by (0.23ab) while in the second season was insignificant (Sids40), (clone 3) and (clone 5) showed the high result by (0.21a) and Egaseed1 and (clone 4) showed the lowest result by (0.20a).

There was insignificant difference in between the four treatments of chitosan the first season however in the first season chitosan treatment at( 1.5cm/L , 2.5cm/L and control )showed the result with (0.24a) and the result was recorded at chitosan at 2 cm/L by ( 0.23a) while in the second season There was significant difference however chitosan treatment at 1.5 cm/L showed the highest result with ( 0.22a ) and the lowest result was recorded at chitosan treatment at 2.5cm/L and 2cm/L by (0.18b).

he interaction effect between treatment and garlic genotypes was insignificant in the first season however in the first season garlic (Egaseed1 with chitosan (1.5cm/L and 2cm/L), clone3 with chitosan of (control , 2cm/L and 2.5cm/L), clone4 with chitosan 1.5cm/L and clone 5 with chitosan of 2.5 cm/L ) had the result by (0.25) and garlic (clone5 with chitosan of 2cm/L) had the result by ( 0.21) while The interaction effect between treatment and garlic genotypes was significant in the second season the high result was garlic ( Sids40 with control, Clone 3 with chitosan of 1.5cm/L and clone3 with chitosan 2cm/L ) by ( 0.23) and lowest result by garlic (Egaseed 1 and clone 4 with chitosan at 2.5 cm/L ) by (0.17).

There were significant differences in bulbing ratio among cultivars and the genotype; Eggaseed-2 cv. gave the highest bulbing ratio than that of other cultivars (Egyptian (Balady) and Sids-50 (soft neck garlic white), Sids-40, Eggaseed-1) resulted that by [24]

**Table (6): Effect of foliar spray with chitosan on fresh garlic bulbing ratio in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 0.24 | 0.20 | 0.23 | 0.23 | 0.25 | 0.21 | 0.24 | 0.19 | 0.22 | 0.21 | **0.24a** | **0.21a** |
| Chitosan 1.5 cm/L | 0.25 | 0.22 | 0.22 | 0.22 | 0.24 | 0.23 | 0.25 | 0.21 | 0.22 | 0.22 | **0.24a** | **0.22a** |
| Chitosan 2 cm/L | 0.25 | 0.21 | 0.23 | 0.21 | 0.25 | 0.19 | 0.23 | 0.22 | 0.21 | 0.23 | **0.23a** | **0.21a** |
| Chitosan 2.5 cm/L | 0.22 | 0.17 | 0.23 | 0.18 | 0.25 | 0.19 | 0.23 | 0.17 | 0.25 | 0.18 | **0.24a** | **0.18b** |
| **Mean** | **0.24ab** | **0.20a** | **0.23ab** | **0.21a** | **0.25a** | **0.21a** | **0.24ab** | **0.20a** | **0.23b** | **0.21a** | | |

| L.S.D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | first | 0.04 | 0.02 | 0.04 |
| | second | 0.02 | 0.02 | 0.05 |

### 2.3. Garlic bulbing ratio after curing

Data in table (7) showed that was significant difference in the first season however in first season (Sids40 and clone 4) showed the high result by (0.14a) and the lowest result was recorded in (clone 3) by (0.12a) while in the second season was significant (Sids40) and (clone 5) showed the high result by (0.20a) and Egaseed1 showed the lowest result by (0.17b).

There was significant difference in between the four treatments of chitosan the first season however in the first season chitosan treatment at 2.5cm/L showed the highest result with (0.15a) and the lowest result was recorded at chitosan at 1.5cm/L by (0.10b) while in the second season There was significant difference however chitosan treatment at 1.5cm/L showed the highest result with (0.21a) and the lowest result was recorded at chitosan treatment at 2.5cm/L by (0.17c).

The interaction effect between treatment and garlic genotypes was significant in the first season however in the first season garlic (Sids40 with chitosan control, clone 3 with chitosan of 2 cm/L and clone 5 with chitosan of 2.5 cm/L) had the highest result by (0.16) and garlic (Egaseed 1 with chitosan 1.5 cm/L and clone 3 with chitosan of control ) had the lowest result by (0.09) while The interaction effect between treatment and garlic genotypes was significant in the second season the high result was garlic (Clone 3 with chitosan of 1.5 cm/L and clone 5 with chitosan control ) by (0.22) and lowest result by garlic (Egaseed 1 with chitosan of control and clone 5 with chitosan at 2.5 cm/L ) by (0.15).

There were significant differences in bulbing ratio among cultivars and the genotype, Eggaseed-2 cv. gave the highest bulbing ratio than that of other cultivars (Egyptian (Balady) and Sids-50 (soft neck garlic white), Sids-40, Eggaseed-1) Resulted by [24]

**Table (7): Effect of foliar spray with chitosan on garlic bulbing ratio after curing in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 0.14 | 0.15 | 0.16 | 0.21 | 0.09 | 0.18 | 0.10 | 0.18 | 0.10 | 0.22 | **0.11b** | **0.19bc** |
| Chitosan 1.5 cm/L | 0.09 | 0.20 | 0.10 | 0.20 | 0.10 | 0.22 | 0.10 | 0.21 | 0.15 | 0.21 | **0.10b** | **0.21a** |
| Chitosan 2 cm/L | 0.15 | 0.19 | 0.13 | 0.21 | 0.16 | 0.18 | 0.15 | 0.19 | 0.13 | 0.21 | **0.14a** | **0.20ab** |
| Chitosan 2.5 cm/L | 0.14 | 0.16 | 0.15 | 0.17 | 0.14 | 0.17 | 0.16 | 0.17 | 0.16 | 0.15 | **0.15a** | **0.17c** |
| **Mean** | **0.13a** | **0.17b** | **0.14a** | **0.20a** | **0.12a** | **0.19ab** | **0.12a** | **0.19ab** | **0.13a** | **0.20a** | | |

| L.S.D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | first | 0.02 | 0.02 | 0.05 |
| | second | 0.02 | 0.02 | 0.06 |

### 2.4. Average number of cloves after curing

Data in table (8) showed that was significant difference in the first season however in first season (Clone5) showed the high result by (16.13a) and the lowest result was recorded in (Clone3) by (12.58b) while in the second season was significant (clone5) showed the high result by (12.43a) and Clone3 showed the lowest result by (10.00b).

There was insignificant difference in between the four treatments of chitosan the first season however in the first season chitosan treatment at chitosan at 2cm/L showed the result with (14.41) and the result was recorded at chitosan at control by (13.75) while in the second season There was insignificant difference however chitosan treatment at 2.5 cm/L showed the result with (11.84) and the result was recorded at chitosan treatment at control by (10.68).

The interaction effect between treatment and garlic genotypes was significant in both seasons however in the first season garlic Clone 5 with chitosan 1.5 cm/L had the highest result by (18.60) and garlic Clone 3 with chitosan treatment at Control had the lowest result by (12.07) while the second season the high result was garlic (Clone 5 with chitosan of 1.5 cm/L) by (13.40) and lowest result by garlic Sids 40 with chitosan treatment of Control by (9.07).

Baldy cultivar recorded the highest number of cloves/ bulbs in both seasons and the relative increases in cured yield due to Sids 50 genotype were about (6.15 and 22.58 %) over Baldy cultivar, (30.18 and 31.03 %) over Sids 40, (15.0 and 24.59 %) over Eggaseed-1 and (68.29 and 80.95 %) over Eggaseed-1 in the 1st and 2nd seasons, respectively resulted by **[30]** .

**Table (8): Effect of foliar spray with chitosan on Average number of cloves After Curing in both seasons in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 13.00 | 11.40 | 14.87 | 9.07 | 12.07 | 9.73 | 13.73 | 10.13 | 15.07 | 13.07 | **13.75a** | **10.68a** |
| Chitosan 1.5 cm/L | 14.27 | 11.80 | 13.93 | 9.87 | 12.47 | 9.53 | 12.53 | 12.20 | 18.60 | 13.40 | **14.36a** | **11.36a** |
| Chitosan 2 cm/L | 15.47 | 11.13 | 14.27 | 10.00 | 12.60 | 10.60 | 13.67 | 12.60 | 16.07 | 10.80 | **14.41a** | **11.03a** |
| Chitosan 2.5 cm/L | 14.40 | 12.07 | 15.07 | 13.07 | 13.20 | 10.13 | 14.00 | 11.47 | 14.80 | 12.47 | **14.29a** | **11.84a** |
| **Mean** | **14.28ab** | **11.60ab** | **14.53ab** | **10.50b** | **12.58b** | **10.00b** | **13.48b** | **11.60ab** | **16.13a** | **12.43a** | | |

| L.S.D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | first | 1.30 | 2.02 | 4.87 |
| | second | 1.31 | 1.65 | 3.91 |

## 2.5. Average clove weight after curing.

Data in table (9) showed that was significant difference in the first season however in first season (Clone 3) showed the high result by (2.25a) gm and the lowest result was recorded in (Clone 5) by (1.77b) gm while in the second season was significant (Sids 40) showed the high result by (2.88a) gm and Clone4 showed the lowest result by (2.25c) gm.

There was insignificant difference in between the four treatments of chitosan the first season however in the first season chitosan treatment at chitosan at 2 cm/L showed the result with (2.06) gm and the result was recorded at chitosan at control and 2.5 cm/L by (1.97) gm while in the second season There was significant difference however chitosan treatment at Control showed the highest result with (2.84a) gm and the lowest result was recorded at chitosan treatment at 2 cm/L by (2.47b) gm.

The interaction effect between treatment and garlic genotypes was significant in first season however in the first season garlic Clone 4 with chitosan 2 cm/L had the highest result by (2.49) gm and garlic Clone 5 with chitosan treatment at 1.5 cm/L had the lowest result by (1.47) gm while the second season was insignificant However the result was garlic (Sids 40 with chitosan of Control) by (3.81) gm and result by garlic Clone 4 with chitosan treatment of 2.5 cm/L by (2.00) gm.

**Table (9): Effect of foliar spray with chitosan on Average clove weight after curing in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 1.79 | 2.44 | 1.83 | 3.81 | 2.05 | 2.89 | 2.21 | 2.90 | 1.96 | 2.18 | **1.97a** | **2.84a** |
| Chitosan 1.5 cm/L | 2.06 | 2.43 | 1.89 | 2.88 | 2.21 | 2.74 | 2.40 | 2.08 | 1.47 | 2.65 | **2.01a** | **2.56ab** |
| Chitosan 2 cm/L | 1.95 | 2.44 | 1.87 | 2.40 | 2.26 | 2.46 | 2.49 | 2.02 | 1.72 | 3.04 | **2.06a** | **2.47b** |
| Chitosan 2.5 cm/L | 1.94 | 2.32 | 1.70 | 2.43 | 2.47 | 3.08 | 1.78 | 2.00 | 1.94 | 2.71 | **1.97a** | **2.51ab** |
| **Mean** | **1.94ab** | **2.41bc** | **1.82b** | **2.88a** | **2.25a** | **2.79ab** | **2.22a** | **2.25c** | **1.77b** | **2.65abc** | | |

| L.S.D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | **first** | 0.24 | 0.39 | 0.89 |
| | **second** | 0.34 | 0.43 | 1.03 |

## 3. Bulb quality

### 3.1. T.S.S after curing

Data in table (10) showed that was insignificant difference in the first season however in first season (Clone4) showed the result by (42.67) and the result was recorded in (Sids40) by (40.75) while in the second season was significant (Egaseed1) showed the high result by (38.92a) and Clone 3 showed the lowest result by (36.50b).

There was insignificant difference in between the four treatments of chitosan the first season however in the first season chitosan treatment at chitosan at 2.5 cm/L showed the result with (42.97) and the result was recorded at chitosan at 2 cm/L by (40.31) while in the second season There was insignificant difference however chitosan treatment at 2.5 cm/L and 1.5 cm/L showed the result with (38.00) and the result was recorded at chitosan treatment at Control by (35.47).

The interaction effect between treatment and garlic genotypes was insignificant in first season however in the first season garlic Clone4 with chitosan Control had the result by (48.17) and garlic Clone 4 with chitosan treatment at Control had the result by (35.60) while the second season was insignificant However the result was garlic (Egaseed1 with chitosan of 1.5 cm/L) by (41.00) and result by garlic Clone 4 with chitosan treatment of Control by (34.00).

The significant effect of foliar spray of chitosan might be due to that chitosan is a new plant growth promoter such as GA3 that may have effect on the plant growth and yield [16]. Also, chitosan is a strong inducer of many secondary metabolites such as phenolic compounds in plants under stress [37] on Barley Plants, [38] and [39].

Similar results were also obtained by [18] reported that foliar application of chitosan at rates of 0.10 g/l gave the highest contents of T.S.S in fruits squash plants, [23] on common bean, [20] on strawberry found that there was no significant effect for the tested treatments on most of fruit quality characters, the most effective treatment in fruit quality was found to be 5.0 ml/l chitosan, [6] on strawberry found that total soluble solids showed tendency to increase in response to chitosan application, [7] on sweet pepper and [8] on cucumber they found that foliar applications with chitosan improved fruit quality of plants,.

**Table (10): Effect of foliar spray with chitosan on T.S.S after curing in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 41.17 | 36.33 | 40.67 | 36.33 | 35.60 | 33.67 | 48.17 | 34.00 | 37.00 | 37.00 | **40.52a** | **35.47a** |
| Chitosan 1.5 cm/L | 41.67 | 41.00 | 38.67 | 36.67 | 41.33 | 37.33 | 41.50 | 37.33 | 44.67 | 37.67 | **41.57a** | **38.00a** |
| Chitosan 2 cm/L | 42.50 | 40.00 | 39.17 | 39.00 | 43.00 | 35.33 | 37.67 | 38.67 | 39.20 | 36.00 | **40.31a** | **37.80a** |
| Chitosan 2.5 cm/L | 38.17 | 38.33 | 44.50 | 37.33 | 46.17 | 39.67 | 43.33 | 36.33 | 42.67 | 38.33 | **42.97a** | **38.00a** |
| **Mean** | **40.88a** | **38.92a** | **40.75a** | **37.33ab** | **41.53a** | **36.50b** | **42.67a** | **36.58b** | **40.88a** | **37.25ab** | | |

| L.S.D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | First | 5.03 | 3.03 | 8.06 |
| | second | 4.00 | 1.96 | 5.57 |

## 4. Yield and its components characters

### 4.1. Fresh yield ton/feddan

Data in table (11) showed that was significant difference in the first season however in first season (Clone4) showed the high result by (5.85a) tons and the lowest result was recorded in (clone 5) by (5.08b) tons while in the second season was significant (clone 5) showed the high result by (6.54a) tons and clone 4 showed the lowest result by (4.93c) tons.

There was insignificant difference in between the four treatments of chitosan the first season however in the first season chitosan treatment at chitosan at 2 cm/L showed the result with (5.84a) tons and the result was recorded at chitosan at 1.5 cm/L by (5.00a) tons while in the second season There was insignificant difference however chitosan treatment at control showed the result with (6.40a) tons and the result was recorded at chitosan treatment at 2 cm/L by (5.31a) tons.

The interaction effect between treatment and garlic genotypes was insignificant in first season however in the first season garlic Egaseed1 with chitosan 2 cm/L had the result by (6.22) tons and garlic Clone 5 with chitosan treatment at 1.5 cm/L had the result by (4.10) tons while the second season was significant however the result was

garlic (clone 5 with chitosan of 2.5 cm/L ) by (7.53) tons and result by garlic clone 4 with chitosan treatment of 2.5 cm/L by (4.93) tons.

**Table (11): Effect of foliar spray with chitosan on Fresh yield ton/feddan in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 5.58 | 6.12 | 5.65 | 6.31 | 5.36 | 7.18 | 6.03 | 5.51 | 5.65 | 6.86 | **5.65a** | **6.40a** |
| Chitosan 1.5 cm/L | 4.67 | 5.87 | 4.27 | 5.91 | 5.88 | 6.26 | 6.06 | 5.00 | 4.10 | 5.72 | **5.00a** | **5.75a** |
| Chitosan 2 cm/L | 6.22 | 5.60 | 5.75 | 5.02 | 5.97 | 4.76 | 5.89 | 5.09 | 5.38 | 6.06 | **5.84a** | **5.31a** |
| Chitosan 2.5 cm/L | 4.98 | 4.36 | 5.78 | 5.46 | 5.58 | 5.17 | 5.42 | 4.13 | 5.17 | 7.53 | **5.39a** | **5.33a** |
| **Mean** | **5.36ab** | **5.49bc** | **5.36ab** | **5.67b** | **5.70ab** | **5.84b** | **5.85a** | **4.93c** | **5.08b** | **6.54a** | | |

| L.S.D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | first | 3.54 | 0.73 | 3.71 |
| | second | 1.29 | 0.67 | 1.94 |

## 4.2. Cured yield ton/feddan

Data in table (12) showed that was significant difference in the first season however in first season (Clone 4) showed the high result by (3.70a) tons and the lowest result was recorded in (clone 5) by (3.17b) tons while in the second season was significant (clone 5) showed the high result by (5.07a) tons and clone 4 showed the lowest result by (3.69c) tons.

There was insignificant difference in between the four treatments of chitosan the first season however in the first season chitosan treatment at chitosan at 2 cm/L showed the result with (3.80a) tons and the result was recorded at chitosan at control by (3.18a) tons while in the second season There was insignificant difference however chitosan treatment at control showed the result with (4.55a) tons and the result was recorded at chitosan treatment at 2 cm/L by (4.13a) tons.

The interaction effect between treatment and garlic genotypes was insignificant in first season however in the first season garlic Clone 4 with chitosan 2 cm/L had the result by (3.98) tons and garlic Clone 5 with chitosan treatment at 1.5 cm/L had the result by (2.77) tons while the second season was significant however the result was garlic (Clone 5 with chitosan of 2.5 cm/L) by (6.11) tons and result by garlic Clone 4 with chitosan treatment of 2.5 cm/L by (3.69) tons.

[13] Decided that the application of chitosan at (300 mm) considerably catalyst the total yield (ton $ha^{-1}$) and total cured yield (ton $ha^{-1}$) of garlic in garlic plants in drought conditions.

the highest garlic yield and its components can be achieved from Sids-50 garlic cultivar followed by cv. Balady, and Eggaseed-1 (purple) cleared that by [30].

These results agree with those obtained by [30] who found that the genotype Yamuna Safed-3 recorded maximum bulb yield per hectare (14.51 t/ha). On the basis of growth and yield parameters Yamuna Safed-3, Yamuna Safed-2, Yamuna Safed-9 and Yamuna Safed-5 produced highest yield when grown under Eastern Dry Zone of Karnataka. [31] Reported that best results were recorded on all the parameters in variety KS–2 followed by variety G–4 and the minimum were recorded with the genotype Agri found White. Best results on quality parameters were also recorded in KS–2. indicated that the NARC-G1 cultivar gave maximum fresh yield (25.6 t/ha), followed by Cultivar Italian, which gave (22.4 t/ha), while cultivar the bottom and gave (15.2 t/ha). Hence, NARC-G1 cultivar could be utilized in term of better yield and as well as industrial use for value addition purposes. [40] Stated that the genotype Yamuna safed-3 recorded a highest yield of 1.19 Kg/2 m2 followed by local cultivar and Ooty-1 (0.90 Kg/2 m2 and 0.89 Kg/2 m2 respectively). While considering both yield and quality aspects in trade, local cultivar, Yamuna Safed 3 and Ooty-1 were found to be the promising genotypes.

The significant effect of chitosan on yield and its components might be due to chitosan have the simulative effect on physiological processes and improved the transportation of nitrogen in the functional leaves which improved vegetative growth and development [33]; [41].

These results are agreeable with those reported by [18] on squash, [25] on okra, [22] on cucumber, [23] on common bean and [20] on strawberry.

**Table (12): Effect of foliar spray with chitosan on Cured yield ton/fadden in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 3.34 | 4.73 | 3.26 | 4.14 | 3.06 | 5.31 | 3.18 | 3.71 | 3.06 | 4.86 | **3.18a** | **4.55a** |
| Chitosan 1.5 cm/L | 3.16 | 4.55 | 2.90 | 4.74 | 3.71 | 4.75 | 3.84 | 3.63 | 2.77 | 4.48 | **3.28a** | **4.43a** |
| Chitosan 2 cm/L | 3.95 | 3.75 | 3.82 | 3.83 | 3.76 | 4.14 | 3.98 | 4.11 | 3.49 | 4.83 | **3.80a** | **4.13a** |
| Chitosan 2.5 cm/L | 3.49 | 3.66 | 3.79 | 4.44 | 3.63 | 4.18 | 3.82 | 3.30 | 3.34 | 6.11 | **3.61a** | **4.34a** |
| **Mean** | **3.49ab** | **4.17bc** | **3.44ab** | **4.29bc** | **3.54ab** | **4.59ab** | **3.70a** | **3.69c** | **3.17b** | **5.07a** | | |
| **L.S.D** | **Seasons** | | **Treatments** | | **Genotypes** | | **Interaction** | | | | | |
| | **First** | | 2.12 | | 0.53 | | 2.40 | | | | | |
| | **Second** | | 1.00 | | 0.66 | | 1.72 | | | | | |

Similar results to present study were also reported by [42] who recorded high phenotypic and genotypic coefficients of variation for different characters like number of cloves per bulb and bulb yield per plot. [43], [35], [44], [45] and [46] reported moderate estimates of phenotypic and genotypic coefficients of variation for number of cloves per bulb.

### 4.3 Dry matter percentage after curing

Data in table (13) showed that was significant difference in the first season however in first season the lowest result was recorded in (Egaseed 1) by (44.16b) and (Sids 40) showed the high result by (50.36a) while in the second season was significant Egaseed 1 showed the lowest result by (52.46c) and (Clone 5) showed the high result by (57.23a).

There was insignificant difference in between the four treatments of chitosan the first season however in the first season the result was recorded at chitosan at 2.5 cm/L by (44.82a) and chitosan treatment at chitosan at 1.5 cm/L showed the result with (48.93a) while in the second season There was significant difference however the lowest result was recorded at chitosan treatment at 2 cm/L by (52.23b) and chitosan treatment at 2.5 cm/L showed the highest result with (58.94a).

The interaction effect between treatment and garlic genotypes was significant in first season however in the first season garlic Egaseed 1 with chitosan treatment at Control had the lowest result by (33.24) and garlic Clone 3 with chitosan Control had the highest result by (52.51) while the second season was significant However lowest result by garlic Egaseed1 with chitosan treatment of 2 cm/L by (44.64) and the high result was garlic (Clone 5 with chitosan of 2.5 cm/L) by (59.47).

**Table (13): Effect of foliar spray with chitosan on dry matter percentage after curing in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 33.24 | 53.26 | 50.82 | 54.85 | 52.51 | 53.53 | 45.79 | 55.81 | 46.62 | 54.71 | **45.80a** | **54.43b** |
| Chitosan 1.5 cm/L | 47.97 | 53.70 | 50.07 | 55.42 | 48.19 | 54.28 | 47.53 | 53.82 | 50.87 | 56.21 | **48.93a** | **54.69ab** |
| Chitosan 2 cm/L | 50.04 | 44.64 | 50.05 | 51.79 | 47.69 | 56.13 | 44.87 | 50.06 | 43.53 | 58.55 | **47.23a** | **52.23b** |
| Chitosan 2.5 cm/L | 45.39 | 58.23 | 50.51 | 59.24 | 40.85 | 59.11 | 42.75 | 58.66 | 44.57 | 59.47 | **44.82a** | **58.94a** |
| **Mean** | **44.16b** | **52.46c** | **50.36a** | **55.32ab** | **47.31ab** | **55.76ab** | **45.24b** | **54.59bc** | **46.40ab** | **57.23a** | | |
| **L.S.D** | **Seasons** | | **Treatments** | | **Genotypes** | | **Interaction** | | | | | |
| | **First** | | 4.95 | | 4.88 | | 11.6 | | | | | |
| | **Second** | | 4.30 | | 2.59 | | 7.13 | | | | | |

## 5. Weight loss percentage

### 5.1. Weight loss percentage after curing

Data in table (14) showed that was significant difference in the first season however in first season the lowest result was recorded in (Clone 5) by (29.67b) and (Clone 3) showed the high result by (38.36a) while in the second season was significant Sids40 showed the lowest result by (17.87b) and (Egaseed 1) showed the high result by (30.50a).

There was significant difference in between the four treatments of chitosan the first season however in the first season the lowest result was recorded at chitosan at 2 cm/L by (28.36b) and chitosan treatment at chitosan at Control showed the highest result with (38.91a) while in the second season there was significant difference however the lowest result was recorded at chitosan treatment at 2.5 cm/L by (14.87b) and chitosan treatment at 1.5 cm/L showed the highest result with (28.86a).

The interaction effect between treatment and garlic genotypes was significant in first season however in the first season garlic Egaseed 1 with chitosan treatment at 1.5 cm/L had the lowest result by (20.41) and garlic Clone 4 with chitosan Control had the highest result by (43.89) while the second season was significant However lowest result by garlic Sids40 with chitosan treatment of 2.5 cm/L by (4.14) and the high result was garlic (Egaseed1 with chitosan of Control) by (35.20).

**Table (14): Effect of foliar spray with chitosan on weight loss percentage after curing in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 38.39 | 35.20 | 39.85 | 32.26 | 42.85 | 21.37 | 43.89 | 32.61 | 29.55 | 22.79 | **38.91a** | **28.85a** |
| Chitosan 1.5 cm/L | 36.78 | 41.08 | 36.80 | 18.76 | 36.98 | 26.24 | 34.57 | 30.08 | 34.27 | 28.17 | **35.88ab** | **28.86a** |
| Chitosan 2 cm/L | 20.41 | 19.94 | 33.63 | 16.34 | 40.88 | 17.54 | 23.56 | 8.50 | 23.32 | 14.20 | **28.36c** | **15.30b** |
| Chitosan 2.5 cm/L | 27.85 | 25.79 | 32.46 | 4.14 | 32.73 | 21.24 | 34.69 | 8.82 | 31.53 | 14.35 | **31.85bc** | **14.87b** |
| **Mean** | **30.86ab** | **30.50a** | **35.68ab** | **17.87b** | **38.36a** | **21.60ab** | **34.18ab** | **20.00b** | **29.67b** | **19.88b** | | |

| L.S.D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | First | 4.57 | 6.82 | 20.47 |
| | second | 8.99 | 9.20 | 23.31 |

5.2. **Weight loss percentage after eight months**

Data in table (15) showed that was significant difference in the first season however in first season the lowest result was recorded in (Clone 4) by (58.08b) and (Clone 5) showed the high result by (67.78a) while in the second season was significant Egaseed1 showed the lowest result by (63.96b) and (Sids 40) showed the high result by (71.61a).

There was insignificant difference in between the four treatments of chitosan the first season however in the first season the result was recorded at chitosan at 1.5 cm/L by (62.31a) and chitosan treatment at chitosan at Control showed the result with (67.73a) while in the second season There was insignificant difference however the result was recorded at chitosan treatment at 1.5 cm/L and 2 cm/L by (67.86a) and chitosan treatment at control showed the result (71.29a).

The interaction effect between treatment and garlic genotypes was significant in first season however in the first season garlic Clone4 with chitosan treatment at 1.5 cm/L had the lowest result by (52.13) and garlic Clone 3 with chitosan Control had the highest result by (75.74) while the second season was insignificant However the result of garlic Egaseed1 with chitosan treatment of 1.5 cm/L by (62.24) and the result was garlic (Clone 5 with chitosan of Control) by (78.78).

**Table (15): Effect of foliar spray with chitosan on weight loss percentage after eight months in five garlic genotypes at two successive seasons 2018/2019 and 2019/2020.**

| Genotypes / Treatments | Egaseed1 | | Sids40 | | Clone3 | | Clone4 | | Clone5 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Control | 70.01 | 63.82 | 59.47 | 67.31 | 75.74 | 74.19 | 62.29 | 72.34 | 71.11 | 78.78 | **67.73a** | **71.29a** |
| Chitosan 1.5 cm/L | 68.83 | 62.24 | 72.57 | 78.70 | 52.30 | 66.92 | 52.13 | 65.50 | 65.73 | 65.93 | **62.31a** | **67.86a** |
| Chitosan 2 cm/L | 66.06 | 63.96 | 63.55 | 70.27 | 61.39 | 67.52 | 59.48 | 67.81 | 68.28 | 69.76 | **63.75a** | **67.86a** |
| Chitosan 2.5 cm/L | 65.03 | 65.81 | 68.15 | 70.17 | 61.72 | 68.74 | 58.44 | 71.76 | 65.98 | 68.66 | **63.86a** | **69.03a** |
| **Mean** | **67.48a** | **63.96b** | **65.93a** | **71.61a** | **62.79ab** | **69.34ab** | **58.08b** | **69.35ab** | **67.78a** | **70.78ab** | | |

| L.S.D | Seasons | Treatments | Genotypes | Interaction |
|---|---|---|---|---|
| | First | 6.78 | 6.75 | 16.28 |
| | second | 6.15 | 7.45 | 17.71 |

## CONCLUSION

From the results obtained in this study, it can be concluded that:

The best genotype of Garlic under Aswan weather conditions was Clone 5 with a Foliar Application by Chitosan at 2.5 cm/L.

* Finally, the effect of chitosan on the growth, yield and quality of some garlic genotypes may require further research under Aswan conditions.

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