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# EFFECT OF PLANT DENSITY ON GROWTH AND YIELD OF TWO GARLIC CULTIVARS UNDER SOHAG CLIMATIC CONDITIONS

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## ABSTRACT

*One field experiment was carried out during the two successive winter seasons of 2014/2015 and 2015/2016 at a Private Farm at Sohag Governorate, to study the effect of two cultivars (Balady and Sids 40) and three plant densities (one, two and three rows in ridge) on growth, yield and bulb quality of garlic, these treatments were arranged in a split plot design with three replicates, garlic cultivars were arranged in the main plot, while plant densities were arranged in the sub plot.*

*The obtained results could be summarized as follows: The interaction between Balady cultivar and planting in one row/ ridge recorded the tallest plants in both seasons. The percentages of dry matter of both leaves/plant and bulb, both bulb diameter and weight as well as clove weight were the highest with the interaction between Sids 40 and planting in one row/ ridge in both seasons. While, the highest total fresh (15.96 and 14.03 ton/fed.) and cured yield (10.02 and 8.80 ton/fed.) were obtained with the interaction between Sids 40 cultivar and planting in three rows/ ridge in the 1$^{st}$ and 2$^{nd}$ seasons, respectively, this treatment recorded relative increases in total fresh yield /fed. were about 56.31 and 58.89 % and total cured yield /fed were about 40.33 and 43.08 % over the interaction between Balady cultivar and planting in one row/ ridge. in the 1$^{st}$ and 2$^{nd}$ seasons, respectively.*

***Conclusively,** under the conditions of this study, cultivated garlic cv Sids 40 in three rows / ridge for the best interaction treatment for increasing the productivity of garlic yield under Sohag climatic conditions.*

**Key words:** Garlic, plant density, plant growth, yield**.**

## INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most important and widely consumed bulbous spice crops belongs to the family *Alliaceae*. West Asia and Mediterranean region is considered to be the center of origin of garlic. It is cultivated throughout India for its bulb which forms an integral part of Indian culinary. The bulb can be consumed as spice or condiment in the form of garlic paste, pickle, chutney, curried vegetables, curry powders and meat preparation, etc. value added products of garlic are represented by garlic powder. It is the second most widely cultivated crop after onion (Hamma *et al.,* 2013).

There were a significant differences between garlic cultivars concerning plant growth, yield and its components as well as bulb quality (Halim 2000, Azad 2002, Islam *et al.*, 2004 , Rahman *et al.*, 2005, Mohsen 2012, Youssef and Tony 2014 , Zaki *et al*., 2014, Hassan 2015 and Hassan *et al*. 2016 and Usman *et al.* (2016).

They concluded that there were a different characters between the cultivars of garlic.

For increasing garlic production there is a need to check the optimum density of garlic (Khodadadi and Nosrati, 2012). Planting density decrease competition for light, water and nutrient in plants. Without wastage optimum plant population ensures effective use of available cropland (Geremew *et al*., 2010).

Plant growth, yield and bulb quality had affected by plant densities (Abubakar, 2001, Jamroz *et al.,* (2001), Castellanos *et al.,* 2004, Singh and Singh 2004, Dawar *et al.*, 2005, Sirohi 2005, Adekpe *et al.,* 2007, Gautam *et al.*, 2007, Kilgori *et al.,* 2007, Rekowska and Skupien (2008) Fikreyohannes *et al*. 2008, El-Shal *et al.* 2011 and Nagina *et al.* 2017).

Therefore, the aim of the present experiment was to determine the suitable plant density and best cultivar of garlic for increasing productivity and bulb quality of garlic under Sohag climatic conditions, Egypt .

## MATERIALS AND METHODS

One field experiment was carried out during the two successive winter seasons of 2014/2015 and 2015/2016 at a Private Farm at Sohag Governorate, Egypt to study the effect of two cultivars (Balady and Sids 40) and three plant densities (one, two and three rows in ridge) on growth, yield and bulb quality of garlic. The meteorological data according to Sohag meteorological station is listed in Table A.

**Table (A).** Average monthly temperature and relative humidity at Sohag during the tow studies seasons*:

| Seasons | 2014/2015 | | | 2015/2016 | | |
|---|---|---|---|---|---|---|
| **Month** | **Temperature Cº** | | **Relative Humidity (%)** | **Temperature Cº** | | **Relative Humidity (%)** |
| | **Max.** | **Min.** | | **Max.** | **Min.** | |
| **September** | 35.7 | 24.2 | 32.8 | 38.3 | 23.6 | 37.5 |
| **October** | 30.9 | 16.7 | 35.5 | 32.7 | 19.4 | 50.5 |
| **November** | 26.2 | 21.1 | 44.3 | 25.2 | 21.7 | 58.8 |
| **December** | 22.8 | 8.3 | 47.1 | 20.2 | 7.1 | 62.9 |
| **January** | 20.1 | 5.2 | 43.3 | 18.2 | 5.0 | 59.9 |
| **February** | 22.7 | 7.5 | 37.7 | 24.4 | 8.2 | 50.8 |
| **March** | 26.8 | 11.6 | 33.4 | 27.8 | 13.2 | 40.3 |
| **April** | 29.3 | 14.2 | 24.0 | 34.7 | 17.1 | 31.9 |
| **May** | 34.9 | 19.5 | 26.1 | 35.9 | 20.0 | 27.5 |

(*) Source: Sohag meteorological station.

These treatments were arranged in a split plot design with three replicates, garlic cultivars were arranged in the main plot, while plant densities were arranged in the sub plot.

The experimental area was 10.5 $m^2$ (1/400 fed.) it was consisted of 5 ridges, 60 cm width and 3.5 m length.

Garlic cloves were selected for uniformity in shape and size and were planted of October $11^{th}$ and $15^{th}$ in 2014/2015 and 2015/2016 seasons, respectively. Cloves were planted with top of ridges at 10 cm apart.

All experimental units were fertilized with 120, 60 and 48 kg/fed N, P and K in the form of ammonium nitrate (33.5%), super phosphate (15.5% $P_2O_5$) and potassium sulphate (48% $K_2O$), respectively. These fertilizers were added on three equal portions at 30, 60 and 90 days after planting.

The normal cultural practices have been followed according to the usual methods being adapted for garlic crop.

A month before harvest, ten plants were randomly taken from each plot to determine plant height, number of leaves/plant, dry matter of leaves and bulb percentage its were determined by drying 100 g of grated leaves tissues and bulbs at 105 $^0$C till constant weight, and then DM (%) was calculated.

Garlic plants were harvested on April 3$^{rd}$ and 4$^{th}$ in the first and second seasons, respectively, and fresh yield per plot was recorded and converted to fresh yield (ton/fed.).

Then, the harvested plants were left in the field to cured for 15 days in the two seasons, then the cured yield (ton/fed.) was determined. After that, ten plants from each sub-plot were randomly taken to Bulb diameter with the help of Verniercalliper, bulb and clove weights were measured with the help of electric balance.

***Statistical analysis***

Statistical analysis was conducted for all collected data. The analysis of variance was calculated according to Steel *et al.* (1997) and means separation were done according to LSD at 0.05 probability level.

## RESULTS AND DISCUSSION

### 1. *Effect of garlic cultivars*

Data in Table 1 indicated that, there were significant differences between the two garlic cultivars regarding plant growth , yield and bulb quality in most cases in both seasons. Balady cultivar gave the tallest plants than Sids 40 in both seasons. While Sids 40 gave the highest values of dry matter of leaves and bulb percentage, total fresh yield and weight of clove in both seasons, cured yield and bulb weight in the 1$^{st}$ season only. On the other side, three were no significant differences between two

**Table (1):** Effect of garlic cultivars on plant growth, yield and bulb quality during 2014/2015 and 2015/2016 seasons

| Traits | Plant growth | | | Yield (ton/fed) | | | Bulb quality | | |
|---|---|---|---|---|---|---|---|---|---|
| Cultivars | Plant height (cm) | No. of leaves/ plant | Dry matter leaves % | Dry matter bulbs % | Fresh yield | Cured yield | Bulb diameter (cm) | Bulb weight (g) | Weight of cloves (g) |
| | 2014/2015 season | | | | | | | | |
| **Balady** | 89.7. | 11.1 | 13.7 | 21.6 | 12.70 | 8.61 | 4.9 | 49.9 | 1.8 |
| **Sids40** | 65.1 | 11.9 | 18.3 | 26.6 | 14.24 | 9.23 | 5.2 | 54.1 | 3.5 |
| **LSD $_{0.05}$** | **5.3** | **NS** | **1.7** | **2.1** | **1.06** | **0.42** | **NS** | **3.2** | **0.9** |
| | 2015/2016 season | | | | | | | | |
| **Balady** | 82.3 | 10.9 | 12.0 | 18.7 | 11.19 | 7.33 | 4.5 | 43.7 | 1.4 |
| **Sids40** | 61.2 | 12.6 | 16.2 | 24.6 | 11.78 | 7.65 | 4.9 | 45.2 | 3.0 |
| **LSD $_{0.05}$** | **3.9** | **NS** | **1.3** | **1.7** | **0.45** | **NS** | **NS** | **NS** | **0.4** |

cultivars concerning number of leaves / plant and bulb diameter in both seasons, cured yield and bulb weight in the 2nd season .

The relative increases in total fresh yield /fed. were about 12.12 and 5.27 % and total cured yield /fed were about 7.20 and 4.36 % for Sids 40 cultivar than Balady cultivar in the 1st and 2nd seasons, respectively.

The differences between garlic cultivars could be attributed to the genetic differences between cultivars .These results are in agreement with (Halim 2000, Azad 2002, Islam *et al.*, 2004, Rahman *et al.*, 2005, Mohsen 2012, Youssef and Tony 2014 , Zaki *et al*., 2014, Hassan 2015 and Hassan *et al*. 2016 and Usman *et al.*, 2016). They concluded that there were a different characters between the cultivars of garlic.

**2.** ***Effect of plant density***

Data in Table (2) show that, plant growth, yield and bulb quality of garlic grown under Sohag conditions had affected by plant density in both seasons.

Planting of garlic in one row/ ridge had significantly increased plant growth such as plant height the percentages of dry matter of both leaves and bulb, both bulb diameter and weight as well as clove weight than other densities (two or three rows/ ridge) in both seasons. While, garlic planting in three rows /ridge recorded the highest values of both total fresh and curd yield/fed. than other densities in both seasons. Plant densities did not

**Table (2):** Effect of plant density on plant growth, yield and bulb quality during 2014/2015 and 2015/2016 seasons

| Traits | Plant growth | | | | Yield (ton/fed) | | Bulb quality | | |
|---|---|---|---|---|---|---|---|---|---|
| | Plant height (cm) | No. of leaves / plant | Dry matter leaves % | Dry matter bulbs % | Fresh yield | Cured yield | Bulb diameter (cm) | Bulb weight (g) | Weight of cloves (g) |
| **Density** | **2014/2015 season** | | | | | | | | |
| **1 row** | 82.5 | 12.2 | 17.8 | 26.5 | 11.07 | 7.62 | 6.1 | 59.6 | 3.3 |
| **2 rows** | 77.3 | 11.6 | 16.1 | 24.5 | 14.08 | 9.20 | 5.2 | 48.1 | 2.6 |
| **3 rows** | 72.5 | 10.8 | 14.1 | 21.4 | 15.34 | 9.94 | 4.0 | 35.6 | 2.3 |
| **LSD 0.05** | **3.1** | **NS** | **1.3** | **1.8** | **1.32** | **0.52** | **0.4** | **5.6** | **0.5** |
| | **2015/2016 season** | | | | | | | | |
| **1 row** | 76.8 | 12.7 | 15.7 | 24.2 | 8.94 | 6.24 | 5.6 | 62.3 | 2.8 |
| **2 rows** | 71.4 | 12.4 | 14.7 | 22.4 | 11.97 | 7.80 | 4.9 | 40.8 | 2.2 |
| **3 rows** | 67.2 | 10.3 | 12.0 | 18.5 | 13.52 | 8.45 | 3.7 | 30.4 | 1.8 |
| **LSD 0.05** | **2.1** | **NS** | **1.1** | **1.5** | **0.73** | **0.26** | **0.2** | **5.1** | **0.3** |

reflect any significant effect on number of leaves/ plant in both seasons. On the other side, planting of garlic in two rows/ ridge gave the intermediate values of plant growth, yield and bulb quality between planting in one or three rows/ ridge in both seasons.

The relative increases in total fresh yield /fed. were about 38.57 and 51.23 % and total cured yield /fed. were about 30.44 and 35.41 % for planting in three rows/ ridge than planting in one row/ ridge in the 1$^{st}$ and 2$^{nd}$ seasons, respectively.

The reduction in growth characters of plants in the case of increased plant density may be due to increased competition among crop plants and the struggle in an enforced sharing of light, nutrients and water supplies as well as space of the surrounding media. (Ara *et al.,* 2007).

Light is critical source of photosynthesis for plant growth, large spaced plant gets proper light intensity and nutrient as compare to the small spaced plant that's why leaf area of wider spaced plant is more leaf length increase as we increase plant spacing, plants spread more and leaf area increases due to moisture availability, nutrients and additional light intensity all these lead to more increased in plant growth. More bulb diameter, weight and increased for weight of cloves obtained from wider spacing may be due to vigorous plant (Biru, 2015).

The productivity of unit area greatly influenced by the number of plants in units area. However, total yield is associated strongly by the number of growing plants in unit area, on the other side, the yield quality such as bulb diameter and weight response negatively (Rekowska and Skupien, 2008). These results are in agreement with the results of Rahman and Talukdar (2003), Castellanos *et al.* (2004), Singh and Singh (2004), Dawar *et al.* (2005), Sirohi (2005), Adekpe *et al.*, (2007), Gautam *et al.* (2007), Kilgori *et al*, (2007), Rekowska and Skupien (2008) and Fikreyohannes *et al*. (2008).

**3.** ***Effect of the interaction between cultivars and plant densities***

The interactions between garlic cultivars and plant densities had significant effect on plant growth , yield and bulb quality of garlic under Sohag conditions in both seasons , except number of leaves / plant in both seasons.

The interaction between Balady cultivar and planting in one row/ ridge recorded the tallest plants (95.2cm and 90.3cm) in the 1st and 2nd seasons respectively. The percentages of dry matter of both leaves/plant and bulb, both bulb diameter and weight as well as clove weight were the highest with the interaction between Sids 40 and planting in one row/ ridge in both seasons. While the highest total fresh (15.96 and 14.03 ton/fed.) and cured yield ( 10.02 and 8.80 ton/fed.) were obtained with the interaction between Sids 40 cultivar and planting in three rows/ ridge in the 1st and 2nd seasons , respectively.

The relative increases in total fresh yield /fed. were about 56.31 and 58.89 % and total cured yield /fed were about 40.33 and 43.08 % for the interaction between Sids 40 cultivar and planting in three rows/ ridge than the interaction between Balady cultivar and planting in one row/ ridge in the 1st and 2nd seasons, respectively.

These results are in agreement with those reported with Alam *et al*. (2010) and Abdalla *et al.* (2011) found that there were significant differences with the interaction between garlic cultivars and plant densities.

**Table (3):** Effect of the interaction between garlic cultivars and plant density on plant growth, yield and bulb quality during 2014/2015 and 2015/2016 seasons

| Traits | | Plant growth | | | | Yield ( ton/fed.) | | Bulb quality | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant height (cm) | No. of leaves /plant | Dry matter leaves % | Dry matter bulbs % | Fresh yield | Cured yield | Bulb diameter (cm) | Bulb weight (g) | Weight of cloves (g) |
| **Cultivars** | **Plant Density** | ***2014/2015 season*** | | | | | | | | |
| **Balady** | **1 row** | 95.2 | 11.3 | 14.6 | 23.5 | 10.21 | 7.14 | 5.7 | 69.3 | 2.3 |
| | **2 rows** | 89.3 | 11.1 | 13.9 | 21.7 | 13.32 | 8.84 | 5.1 | 45.5 | 1.8 |
| | **3 rows** | 84.5 | 10.8 | 12.5 | 19.5 | 14.71 | 9.85 | 4.0 | 34.8 | 1.4 |
| **Sids40** | **1 row** | 69.7 | 13.1 | 20.9 | 29.4 | 11.93 | 8.10 | 6.4 | 75.3 | 4.3 |
| | **2 rows** | 65.2 | 12.0 | 18.3 | 27.3 | 14.83 | 9.56 | 5.2 | 50.6 | 3.6 |
| | **3 rows** | 60.4 | 10.7 | 15.7 | 23.2 | 15.96 | 10.02 | 4.0 | 36.3 | 2.9 |
| **LSD $_{0.05}$** | | **4.2** | **NS** | **1.7** | **1.9** | **1.41** | **0.71** | **0.6** | **7.1** | **0.7** |
| | | ***2015/2016 season*** | | | | | | | | |
| **Balady** | **1row** | 90.3 | 11.3 | 13.1 | 21.5 | 8.83 | 6.15 | 5.3 | 61.2 | 1.9 |
| | **2 rows** | 81.4 | 11.2 | 12.2 | 19.4 | 11.73 | 7.76 | 4.6 | 40.3 | 1.3 |
| | **3 rows** | 75.2 | 10.3 | 10.7 | 15.3 | 13.01 | 8.09 | 3.5 | 29.7 | 1.1 |
| **Sids40** | **1 row** | 63.2 | 14.1 | 18.3 | 26.9 | 9.09 | 6.32 | 5.8 | 63.3 | 3.7 |
| | **2 rows** | 61.4 | 13.5 | 17.1 | 25.3 | 12.21 | 7.84 | 5.1 | 41.2 | 3.1 |
| | **3 rows** | 59.1 | 10.2 | 13.3 | 21.7 | 14.03 | 8.80 | 3.9 | 31.1 | 2.5 |
| **LSD $_{0.05}$** | | **2.9** | **NS** | **1.6** | **2.0** | **0.83** | **0.34** | **0.4** | **5.9** | **0.4** |

***Conclusively,*** under the conditions of this study, cultivated garlic cv sids 40 in three rows / ridge for the best interaction treatment for increasing the productivity of garlic yield under Sohag climatic conditions.

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# تاثير الكثافة النباتية علي نمو وانتاج صنفين من الثوم تحت الظروف المناخية لسوهاج

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معهد بحوث البساتين – مركز البحوث الزراعية – جيزة – مصر.

اجريت هذه التجربة فى مزرعة خاصة بمحافظة سوهاج خلال موسمى الزراعة ٢٠١٥/٢٠١٤ و ٢٠١٦/٢٠١٥ وذلك لدراسة تاثير كلا من الصنف و الكثافة النباتية (خط واحد وخطين وثلاثة خطوط على الريشة الواحدة) على النمو والمحصول والجوده لصنفى الثوم (البلدى و سدس٤٠). وتم توزيع المعاملات فى التجربة فى تصميم القطع المنشقة فى ثلاثة مكررات حيث وزعت الاصناف فى القطع الرئيسيه والكثافة النباتية فى القطع تحت الرئيسيه .
وتم تلخيص نتائج التجربة كما يلى:- سجلت معامله التفاعل بين زراعة الصنف البلدى على خط واحد اطول النباتات خلال موسمى التجربة. ولوحظ أعلى القيم للنسبة المئوية للمادة الجافة من اوراق النبات والبصله وقطر ووزن البصلة وكذلك وزن الفص وذلك بمعاملة لتفاعل بين زراعة الصنف سدس ٤٠ على خط واحد على الريشة وذلك خلال موسمى التجربة. بينما كانت أعلى النتائج لمحصول الفدان الطازج (١٥.٩٦ و ١٤.٠٣ طن للفدان) و المحصول بعد العلاج التجفيفى (١٠.٠٢ و ٨.٨٠ طن للفدان) وذلك عند زراعة الصنف سدس ٤٠ على ثلاثة خطوط على الريشة الواحدة فى موسمى الزراعة الاول و الثانى على التوالى ، وكانت هذه الزياده فى المحصول الكلى الطازج حوالى ٥٦.٣١ و ٥٨.٨٩ % و زيادة فى المحصول الكلى بعد العلاج التجفيفى كانت حوالى ٤٠.٣٣ و ٤٣.٠٨ % عن معامله التفاعل بين زراعة الصنف البلدى على خط واحد على الريشة الواحدة خلال الموسم الاول و الثانى على التوالى.
**التوصيه :** يمكن ان نوصى من خلال هذه الدراسة تحت ظروف التجربة بزراعة الصنف سدس٤٠ على ثلاثة خطوط على الريشة الواحدة وذلك لزيادة انتاجية الثوم تحت الظروف المناخيه لسوهاج.