Effect of Intra-Row Spacing and Cropping System with Sugar Beet on Growth,Yield and Quality of Two Garlic Cultivars

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ABSTRACT

A field experiment was carried out at Sakha Horticulture Research Station, Kafr El- Sheikh Governorate Egypt, during winter seasons of 2014/2015 and 2015/2016 to study the effect of two garlic cultivars, two intra-row spacing and three intercropping systems addition sole were used on growth, yield and quality of garlic and sugar beet, as well as to evaluate land equivalent ratio (LER) and economic return under different combinations. Variety Geloria sugar beet (a mono-germ variety) was used as the main crop. The experiment was laid out in a split-split plot arrangement in a randomized complete block design. Main plots contained garlic cultivars (Balady cv. and Sids-40 cv.), sub plots were devoted to intra-row spacing (10 cm and 15 cm) and sub-sub plots were assigned to intercropping system (one garlic row, two garlic rows and three garlic rows), pure stand of sugar beet and also pure stand of garlic. Results indicated that Balady cv. was surpasses Sids-40 of germination %, plant height, bulb diameter and clove number. Moreover, Sids-40 cv. gave the highest values for all the other studied characteristics (leaves number, fresh and cured bulb weight, clove weight and total yield per fed.) in two seasons. The 15 cm intra-row spacing superior over the 10 cm intra-row spacing in most characteristics. Also, one garlic row resulted the highest improvement of all characteristics except total yield per feddan of garlic and sugar beet. However, the pure stand of garlic and sugar beet had the highest values of total yield fed^{-1} and its components in comparison to intercropping system. The highest LER were obtained from Balady cv. at 10 cm intra-row spacing with three garlic rows, followed by the same cultivar at 15 cm intra- row spacing with two rows (1.55 and 1.51), respectively, as mean of both seasons. The highest net income was obtained from Sids-40 cv. (20052 L.E.) followed by Balady cv.(19355L.E) at 15cm intra row spacing with two rows as mean of both two seasons.

Keywords: Garlic, *Allium Sativum* l., Cultivar, Intra-Row Spacing, Intercropping, Sugar Beet, Productivity, Quality

INTRODUCTION

Garlic (*Allium Sativum L.*) is one of the most important vegetable crops in the world (Baghalian, 2005). It's belonging to family Alliaceae and Genus Allium (Dayi, 2008).As well as, have Anti-infective properties such as anti-bacterial, antifungal, anti-cancer, lowering blood sugar and blood lipids, power suppliers, also reduce blood platelet aggregation. In terms of production, garlic is coming second after onion, it is a bulbous plant, and produce a bulb which consists of bulblets called cloves (valadez, 1992). Garlic is a high value cash crop due to its various used in local consumption, food processing and exportation (AL-Otayk *et al*., 2008 & EL eshmwiy *et al.,* 2010). In Egypt, the cultivated area is about 20532 feddan with average yield of 9.7 ton/fed. in 2014 year (Bulletin of the Agriculture Statistics, Economic Affairs Sector. Part 1 winter crops. February 2013/2014 Ministry of Agriculture and Land Reclamation)

Garlic bulbs yield and quality are changed with cultural practices, climate and used varieties (Abdel-razzak & El sharkawy 2013). Nasser *et al.* (1972), stated that the Chinese cultivar proved to be of high yielding ability, more uniform cloves of heavier weight and fewer cloves number per bulb than local variety (Balady cv.). Moustafa *et al.* (2009), evaluated some new imported cultivar under the Egyptian conditions and showed that there were significant differences among the tested genotypes. Mohamed (2004) & Ammar (2007) found that, Balady cultivar significantly superior Sids-40 cultivar in plant height but Sids-40 cultivar produced more leaves. Hussein *et al.,* (1995), reflect to Chinese cultivars gave better bulb quality (bulb diameter, bulb weight). Significant variations were observed for various garlic characteristics as reported by Osman & Moustafa (2009) & Aly, Shreen (2010). Sandhu *et al.* (2015) reported that the analysis of variance showed significant difference among all the genotypes for all the characters under study.

Plant spacing influences the growth and yield of garlic. Yield of garlic is dependent on the number of plants accommodated per unit area of land (Alam *et al*., 2010). Several authors reported that, increasing the yield and improved the grade of garlic bulb due to proper plant spacing, wider spacing increased greater plant height and number of leaves (Purewal & Daragan, 1961; Om and Srivastava, 1977), increased the bulb size (Menezes *et al.* 1974) and reduced the yield of garlic (Rahim *et al*., 1984). The increased number of plant per unit area in closer spacing compensates the loss of reduced bulb sizes and ultimately increases the yield. Castellanos *et al.,* (2004), reported that, although plant yield increased when the higher plant density were used

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but the yield improvement increased plant stand is offset by the reduction in bulb size which severely affects quality and market value, when garlic is produced for fresh market. Castillo *et al*. (1996), recommended handling plant densities from 140000 to 180000 plants/ha to ensure a good bulb diameter. Olfati. *et al.,* (2016), showed that, moderate between row spacing and plant density for fresh market garlic and low between row spacing and high plant density for higher yield is proposed.

Intercropping is old practice of growing two or more crops simultaneously in the same piece of land. It is a technique of crop intensification in both space and time, the competition between crops may occur during a part or whole of crop growth period. The relationships of cooperation and competition are density dependent (Donald, 1963). At low densities, there is cooperation but, the active competition comes into existence at high densities. The competition between base and intercrops essentially depends on the maturity period, rooting habit, pattern of canopy spread, etc. It is proven fact that the utilization of natural resources viz. space, light, soil moisture, air, nutrient etc. were more efficient with intercropping than sole cropping (Lomte & Dabhade, 1990). Sarkar *et al*. (1995), showed that intercropping not only stabilizes crop production by reducing the impact of weather vagaries, but also increases cropping intensity considerably. In farming systems with low external inputs, intercropping became also appeared as an economically viable option for an integrated weed management (Teasdale, 1998, Schoofs & Entz, 2000 and Jabbar *et al*. 2010). The benefit of using garlic in mixed cropping is that it effectively repels harmful pests while retaining beneficial ones (Amin *et al*., 2011).

Sugar beet (*Beta vulgaris* L.), is the second source of sucrose all over the world and in Egypt. As well as, Sohier and Ouda (2001), revealed that the importance of sugar beet crop to agriculture is not confined only to sugar production, but also it is adapted to saline, calcareous and sodic soil. Moreover, as a short duration and quires less water to produce kilogram of sugar requires about 1.4 m^3 of water. It's a deep-rooting crop (up to 3 m) so the crops like Onion and garlic are very much suite to intercropping with sugar beet. Since these crops are shallow rooted bulbs and having low canopy, so they do not compete with space and deep-rooted long duration crop (El-Sarag, 2009; Mahmoud *et al*., 2012 & Masri *et al*., 2015). Toaima *et al*., (2000), reflect to the Intercropping patterns of sugar beet + garlic or sugar beet + onion improves the growth traits, yield and other components of sugar beet. The area of sugar beet production had increased in the recent years (16900 fed. in 1982 season to 450000 fed. in 2012 season), and the contribution of sugar beet to sugar production increased largely, as it reached 35.5% of the total sugar production in 2012 season (FAO, 2012).

In Egypt, the agricultural system has one of main problems. It's the low area of cultivated land per grower about 44% of the growers own or works in an area of one feddan or less (Ahmed *et al.*, 2009). In view of lessening resources like water, energy and arable of land for feed, there are a dire requirement new strategies and techniques of crop production to meet the needs of expanding for food, feed and fiber.

The objective of this study was to evaluate the impact of two garlic cultivars and two plant spacing under garlic intercropping system with sugar beet, as well as land equivalent ratio (LER) and monetary returns during garlic and sugar beet production and total income, under Egyptian conditions.

MATERIALS AND METHODS

A field experiment was carried out at Sakha Horticulture Research Station farm, Kafr El– Sheikh Governorate Egypt, during winter seasons of 2014/2015 and 2015/2016. Experiment location was in the middle Northern Part of Nile Delta region in along the western branch of the Nile **.** The site elevation of about 6 meters above mean sea level and it lies at 30.57N. Latitude, 31.07 E. longitudes. The experiment soil texture was clay loam in both seasons (Table a).

A split-split plot in a randomized complete block design arrangement with three replications was used. Garlic cultivars were allocated to main plots, meanwhile, the sub plots were assigned for two plant spacing as three intercropping systems with sole garlic and sugar beet were distributed at sub-sub plots. As follow:-

Main plots: garlic cultivars were Balady cv. and Sids-40 cv.

Sub plots : intra-row spacing were 10 and 15 cm.

Sub-sub plots: intercropping system were as follow:-

1- Sole garlic as monoculture.

2- Sole sugar beet as monoculture.

3- One garlic row was planted on the top of sugar beet bed.

4- Two garlic rows were planted on the top of sugar beet bed.

5- Three garlic rows were planted on the top of sugar beet bed.

Table a. Some properties of the experimental soil

Texture	Clay %	Silt %	Total sand %	EC dS.m^{-1}	PH
Clay loam	59.01	26.2	14.8	2.1	8.1

Each experimental plot includes five ridges 4m length and 1.20 m width with an area 24m^2. Sugar beet variety Geloria (a mono-germ variety) was used as main crop**.** Seeds of sugar beet (received from Sugar Crops Res. Inst.) were planted on 7th and 8th October for the 1st and 2nd seasons respectively. Garlic bulbs for each cultivar (obtained from Hort. Res. Institute, Agri. Res. Center, Giza), were carefully separated into individual cloves. Cloves were soaked overnight in tap water before planting. The principal target of water to enhance sprouting, then the cloves were sown on October 8th and 9th for the first and second seasons and they harvested on 28th April and 10th May for two seasons when older leaves turned yellowish green and had started withering. The land of the experimental field was prepared as recommended, and all the agricultural practices for sugar beet were applied according to the recommendations of the Egyptian Ministry of Agriculture.

Data record

a- Growth, yield and its components parameter of garlic plants:

1-Germination percentage of garlic plants: Germination percentage of garlic plants after 30 to 40 days from planting date were recorded. The percentage of germinated cloves were counted by using the following equation:

$$\text{Germination } \% = \frac{\text{Number of sprouted cloves/plot}}{\text{Number of planted cloves/plot}} \times 100$$

2. Plant height (cm): were taken randomly from average of ten plants/plots.

3. Leaves number plant^{-1}: number of leaves calculated as the average number of green leaves.

4- **Leaf area (cm^2):** The method calculates the leaf area as a product of leaf length, leaf width and a correction factor (0.72) according to the leaf parameter method by **Džamić *et al*. (2001**) and **Djordje M. *et al.* (2011)**.

5. Bulb diameter plant^{-1}: Average bulb diameters per plant in each treatment were measured in centimeters.

6. Fresh and curd bulb weight plant^{-1}: Average bulb weight per plant in each treatment was calculated in grams by the use of the following equation:

$$\text{Average bulb weight} = \frac{\text{Total weigth of bulbs}}{\text{Total number of bulbs}}$$

7- Number of cloves bulb^{-1}.

8- Average of clove weight.

9- Total yield (ton/fed.): After harvesting, the yield of each plot was left in the farm as intact plant (with tops and roots) for fifteen days until the curing process was completed. After wards the yield was weighted and expressed as ton/feddan.

B- Sugar beet growth, yield and its components parameters: It included leaves number/plant, leaf fresh weight/ plant (g), root fresh weight(g), root length (cm), root diameter (cm), root weight/ plant (g), and total root yield (ton/fed).

c- Sugar beet quality parameters: They included Sugar and purity (sucrose % and purity %) content in roots were determined using an automatic sugar polarimeter according to Le-Docte (1971) method as described by Mc Ginnus (1982).

Economic feasibility: Total yield of sugar beet of intercrops and garlic of intercrops, as compared with sole crop were recorded at harvest and cost benefit ratio worked out. Gross return (L.E. fed^{-1}): Gross return from each treatment was calculated in Egyptian pounds (L.E.).

Price of ton of sugar beet was obtained by Egyptian Sugar and Integrated Industries Company and price of ton of garlic was obtained by market search.

Land Equivalent Ratio: According to Willy and Osiru (1972), land Equivalent Ratio (LER) was determined as follows:

$$\text{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where:

Y_{aa} and Y_{bb} are the sole yield of a and b crops, respectively, ton/fed.

Y_{ab} is yield of the intercropped a crop, ton/fed.

Y_{ba} is yield of the intercropped b crop, ton/fed.

Statistical analysis:

The obtained data were submitted to analysis of variance according to the method described by Gomez and Gomez (1984). Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955).

RERSULTS AND DISCUSSION

***Performance of garlic:-**

Main effects:

1- Effect of garlic cultivars:

1-a- Germination percentage and some vegetative growth parameters:

Results in Table (1) showed the effect of garlic cultivars, plant spacing and cropping system on germination percentage and vegetative growth components of garlic in winter seasons of 2014/2015 and 2015/2016. The results revealed that garlic cultivars exhibited significant effect on germination percentage, leaves number and plant height traits. Balady cv. gave the highest values of germination % (82.28 and 80.67) and plant height (74.06 and 72.6) in two seasons respectively. On contrary, Sids-40 cv. gave the highest value of leaves number trait (9.67 and 8.78) in the two seasons respectively.

The obtained results are in harmony with those obtained by Moustafa *et al,* (2009) and Aly (2010) who indicated that the variation of different garlic cultivars in their emergence %. Also, agree with Al-Otayk *et al*. (2008), Anwar and Gouda (2012) and Abdel Razzak and El-Sharkawy (2013), Panse (2013), El Nagar and El-Zohiri (2015) and Azza and Naglaa (2016). On the other hand, two garlic cultivars recorded insignificant differences on leaf area trait in both seasons.

1-b- Yield and its components:

Data presented in table (2) showed the effect of garlic cultivars, plant spacing and cropping system on garlic yield and quality in seasons 2014/2015 and 2015/2016. Cultivars significantly differed in bulb diameter per plant (cm), fresh and cured bulb weight (g), cloves number per bulb, clove weight (g) and total yield (ton/fed.). The results indicated that, the highest values in bulb diameter per plant (5.64 and 5.59 cm/bulb) and cloves number per bulb (50.49 and 51.00) in two seasons respectively were recorded from Balady cultivar. On the other hand, Sids-40 cv. significantly surpassed Balady cv. in fresh bulb weight (66.61 and 64.67), cured bulb weight (30.28and 28.11 g/bulb), clove weight (3.34 and 3.31 g/clove) and total yield (4.94 and 4.79 ton/fed.) in two seasons respectively.

These results agree with those obtained by Hussein, *et al.*, (1995), Al-Otayk *et al., (*2008), abou el-magd *et al*., (2012) and Anwar and Gouda (2012) they found that the lowest bulb, cloves weight and total yield were obtained in Balady cultivar.

2- Effect of garlic plant spacing:

Plant density changed when garlic cultured with different intra-row spacing. Previous studies carried out on plant density indicate direct influence on growth, yield and its components as Castellanos *et al.,(*2004).

Table1. Effect of garlic cultivars, plant spacing and cropping system on garlic germination percentage and some vegetative growth components

Treatments		Germination %	leaves number plant^{-1}	Plant height(cm)	Leaf area (cm^2)
		2014/2015			
Cultivars	Balady	82.28^{a}	8.96^{b}	74.06^{a}	75.05^{a}
	Sids-40	80.64^{b}	9.67^{a}	66.49^{b}	79.62^{a}
Distances	10 cm	81.17^{b}	9.15^{b}	68.44^{b}	73.53^{b}
	15 cm	81.75^{a}	9.48^{a}	72.11^{a}	81.14^{a}
	Sole	82.16^{a}	10.6^{a}	79.26^{a}	96.44^{a}
Cropping system	One row	81.69^{ab}	9.85^{b}	73.93^{b}	85.11^{b}
	Two rows	81.42^{b}	8.82^{c}	66.98^{c}	69.77^{c}
	Three rows	80.58^{c}	8.01^{d}	60.93^{d}	58.02^{d}
		2015/2016			
Cultivars	Balady	80.67^{a}	8.15^{b}	72.60^{a}	62.03^{a}
	Sids-40	79.06^{b}	8.78^{a}	65.19^{b}	65.79^{a}
Distances	10 cm	79.58^{b}	8.32^{b}	67.10^{b}	60.77^{b}
	15 cm	80.15^{a}	8.62^{a}	70.69^{a}	67.06^{a}
	Sole	80.54^{a}	9.62^{a}	77.71^{a}	79.70^{a}
Cropping system	One row	80.09^{ab}	8.96^{b}	72.48^{b}	70.34^{b}
	Two rows	79.83^{b}	8.02^{c}	65.67^{c}	57.66^{c}
	Three rows	78.99^{c}	7.28^{d}	59.73^{d}	47.95^{d}

Means followed by the same letters were not significantly differed according to Duncan's multiple range test.

Table 2. Effect of garlic cultivars, plant spacing and cropping system on garlic yield and quality

Treatments		Bulb Diameter (cm)	Fresh bulb Weight (g)	Cured bulb Weight (g)	Cloves no. bulb^{-1}	Clove weight (g)	Yield ton/fed
2014/2015							
Cultivars	Balady	5.64^{a}	60.02^{b}	27.28^{b}	50.49^{a}	1.30^{b}	4.43^{b}
	Sids-40	5.11^{b}	66.61^{a}	30.28^{a}	14.31^{b}	3.34^{a}	4.94^{a}
Distances	10 cm	5.24^{b}	61.26^{b}	27.85^{b}	32.41a	2.26^{b}	4.96^{a}
	15 cm	5.50^{a}	65.35^{a}	29.7 ^{a}	32.40a	2.38^{a}	4.40^{b}
Cropping system	Sole	6.01^{a}	72.12^{a}	32.76^{a}	32.95a	2.79^{a}	6.52^{a}
	One row	5.63^{b}	66.9^{b}	30.4^{b}	32.70a	2.62^{b}	2.34^{d}
	Two rows	5.14^{c}	59.6^{c}	27.08^{c}	32.44a	2.31^{c}	4.22^{c}
	Three rows	4.71^{d}	54.7^{d}	24.88^{d}	31.52a	1.56^{d}	5.64^{b}
2015/2016							
Cultivars	Balady	5.59^{a}	58.27^{b}	25.33^{b}	51.00^{a}	1.28^{b}	4.30^{b}
	Sids-40	5.06^{b}	64.67^{a}	28.11^{a}	14.46^{b}	3.31^{a}	4.79^{a}
Distances	10 cm	5.19^{b}	59.48^{b}	27.58^{a}	32.74a	2.24^{b}	4.81^{a}
	15 cm	5.45^{a}	63.45^{a}	25.86^{b}	32.73a	2.35^{a}	4.28^{b}
Cropping system	Sole	5.95^{a}	70.0^{a}	30.43^{a}	33.29a	2.76^{a}	6.33^{a}
	One row	5.58^{b}	64.9^{b}	28.23^{b}	33.03a	2.59^{b}	2.28^{d}
	Two rows	5.09^{c}	57.8^{c}	25.14^{c}	32.77a	2.28^{c}	4.10^{c}
	Three rows	4.67^{d}	53.1^{d}	23.09^{d}	31.83a	1.55^{d}	5.48^{b}

Means followed by the same letters were not significantly differed according to Duncan's multiple range test.

2-a- Germination percentage and some vegetative growth components:

Data in Table (1) mentioned that all growth parameters as germination percentage of cloves (81.75and 80.15), leaves number per plant (9.48 and 8.62), plant height (72.11 and 70.69) and leaf area (81.14 and 67.06) increased significantly with higher intra-row spacing (15 cm), respectively in two seasons, while, the lowest values of all the above mentioned traits were obtained from 10 cm intra-row spacing. Similar results were also reported by Singh *et al.,* (1995). This might be due to the fact that wider row spacing facilitated less competition for space and more availability of light and nutrients to the plants. The increase in growth parameters due to wider spacing in garlic were also reported by Naruka and Dhaka (2001), Alam *et al*.,(2010), Moravcevic *et al* (2011) And Olfati *et al.*, (2016).

2-b- Yield and its components:

Results in table (2), revealed that garlic cultivars, plant spacing and cropping systems effect on garlic yield and its components in seasons 2014/2015 and 2015/2016. Intra-row spacing significantly differed in bulb diameter per plant (cm), fresh and cured bulb weight (g), number of cloves per bulb, clove weight (g) and total yield (ton/fed.). In the present research the yield increased when the lower row spacing were used but the yield improvement i.e bulb diameter, bulb weight, and clove weight, increased when the wider row spacing (15cm) was used. Results showed that yield parameters increased at wider row spacing, this might have been due to less number of plants in a given area with low competition for nutrients and sunlight, increasing food assimilatory efficiency and thereby more food reserve in bulbs thereby increasing bulb diameter, fresh weight of bulb and weight of cloves. But, increasing the intra- row spacing, decreased total yield significantly, it was perhaps due to reduction in number of bulbs harvested in a given area. The results obtained are in conformity with the findings of Singh *et al., (1995)*, Muro *et al*. (2000).Alam *et al*.,(2010), Moravcevic *et al* (2011), Olfati *et al.*, (2016) and Azza and Naglaa (2016).

3- Effect of garlic cropping system:

3- a- Germination percentage and some vegetative growth components:

Data presented in Table (1) showed that germination % and all vegetative growth characteristics were significantly affected by cropping systems during the two growing seasons**.** The highest significant values of germination % (82.16 and 80.54%), leaves number per plant (10.5 and 9.6), plant height (79.26 and 77.71) and leaf area (96.44 and 79.70) were recorded when garlic was grown as a sole crop, flowed by garlic cropped with sugar beet at one row (Table 1) during the first and second seasons, respectively. Meanwhile the lowest values of all the above characteristics were recorded when garlic was intercropped with sugar beet on three

rows. The previous results may be due to competition between plants of garlic and sugar beet for light. The obtained results were harmony with those showed by Abdel Motagally and Metwally (2014), who reflected that, significant decreased was observed by intercropping sugar beet with onion, compared to sole onion.

3- b- Yield and quality:

Data presented in Table 2 reported that characteristics of garlic yield and its components were significantly affected by intercropping systems, except cloves number per bulb in the two seasons. The previous characteristics gave the highest values when growing garlic in pure stand as sole crop. This may be due to the increase in number of garlic plants compared to intercrop. On the other hand, bulb diameter, fresh bulb weight, cured bulb weight and clove weight surpassed when intercropped one row of garlic on the back of sugar beet compared with the other intercropping systems. On the contrary, intercropping at three rows of garlic on the back of sugar beet gave the highest value compared with the others intercropping systems of total yield per feddan. The reduction in garlic yield in the intercrop associations may be due to the increase in number of garlic plants when compared with pure stand and the severe inter-specific and intra-specific competition between garlic and sugar beet plants, as well as between garlic plants and between sugar beet plants on water and nutrients. Similar results were obtained by Toaima (2006), Ibrahim *et al*. (2008),Abd El- Zaher *et al*. (2009) and Abdel Motagally and Metwally (2014).

Interaction effects:

1- Effect of the interaction between cultivars and intra-row spacing on growth, yield and its components:

Results in tables 3& 4 indicated the effect of interaction between garlic cultivars and intra-row spacing on mean of germination %, growth, yield and its components. Plant height, leaf area, bulb diameter, fresh bulb weight, curd bulb weight and total yield were significantly affected by the interaction between two varieties and plant spacing in both seasons.

Table 3. Interaction effect between cultivars and intra-row spacing on garlic growth traits

cultivars X Distances		Germination %	leaves number plant^{-1}	Plant height(cm)	Leaf area (cm^2)
		2014/2015			
Balady	10cm	82.02^{a}	8.82^{a}	71.36^{b}	70.07^{c}
	15cm	82.54^{a}	9.11^{a}	76.75^{a}	80.04^{ab}
Sids -40	10cm	80.33^{a}	9.48^{a}	65.53^{d}	77.00^{b}
	15cm	80.96^{a}	9.85^{a}	67.46^{c}	82.23^{a}
		2015/2016			
Balady	10cm	80.41^{a}	8.02^{a}	69.96^{b}	57.91^{c}
	15cm	80.92^{a}	8.28^{a}	75.25^{a}	66.15^{ab}
Sids -40	10cm	78.75^{a}	8.62^{a}	64.24^{d}	63.63^{b}
	15cm	79.38^{a}	8.96^{a}	66.14^{c}	67.96^{a}

Means followed by the same letters were not statistically significantly differed according to Duncan's multiple range test.

Table 4. Interaction effect between cultivars and intra-row spacing on garlic yield and quality traits

cultivars X Distances		Diameter of bulb^{-1} (cm)	Fresh bulb weight (g)	Cured bulb Weight (g)	cloves no. plant^{-1}	clove weight(g)	Total yield ton/fed.
			2014/2015				
Balady	10cm	5.45^{b}	58.95^{d}	27.77^{c}	50.42^{a}	1.27^{a}	4.82^{b}
	15cm	5.83^{a}	61.09^{c}	26.79^{d}	50.56^{a}	1.32^{a}	4.03^{c}
Sids-40	10cm	5.04^{d}	63.59^{b}	31.65^{a}	14.40^{a}	3.25^{a}	5.10^{a}
	15cm	5.18^{c}	69.62^{a}	28.91^{b}	14.23^{a}	3.44^{a}	4.77^{b}
			2015/2016				
Balady	10cm	5.40^{b}	57.23^{c}	25.78^{c}	50.93^{a}	1.26^{a}	4.68^{b}
	15cm	5.77^{a}	59.31^{d}	24.88^{d}	51.08^{a}	1.30^{a}	3.92^{c}
Sids-40	10cm	4.99^{d}	61.74^{b}	26.83^{b}	14.54^{a}	3.22^{a}	4.95^{a}
	15cm	5.12^{c}	67.59^{a}	29.39^{a}	14.38^{a}	3.40^{a}	4.63^{b}

Means followed by the same letters were not statistically significantly differed according to Duncan's multiple range test

The highest values of leaf area (82.23 and 67.96), fresh bulb weight (69.62 and 67.59) and curd bulb weight (31.91 and 29.39) resulted from Sids-40 cultivar with 15 cm intra-row spacing in the two seasons respectively. But the highest values of plant height (76.75and 75.25) as well as bulb diameter (5.83 and 5.7) resulted from Balady cultivar with 15 cm intra-row spacing in two seasons respectively. Sids-40 cultivar with 10 cm intra-row spacing gave the highest value of total yield (5.1 and 4.95 ton/fed.) in two seasons respectively

2- Effect of interaction between garlic cultivars and cropping system on growth, yield and its components:

Interactive effect of cultivars and cropping systems was significant affect for plant height, leaf area, bulb diameter, fresh bulb weight, curd bulb weight, clove weight and total yield in both two seasons (Tables 5 & 6).

Within the same garlic cultivar, plant height, leaf area, bulb diameter, fresh bulb weight, curd bulb weight, clove weight and total yield traits of sole crop were usually greater compared with the intercropped stands in two seasons. Within garlic cropping systems, all the previous traits from one row treatment of garlic gave the highest values compared with the others intercropping treatments except total yield. Total yield trait of three rows treatment of garlic gave the highest value compared with the others intercropping treatments.

3- Effect of the interaction between intra-row spacing and cropping system on growth, yield and its components:

Data in tables 7&8 indicated the effect of interaction between intra-row spacing and cropping system on garlic growth, yield and its components. Interactive effect of intra-row spacing and cropping systems was significant for plant height, leaf area, bulb diameter, fresh bulb weight, curd bulb weight and total yield in both two seasons (table7&8). Garlic as sole stand produced plant height, leaf area, bulb diameter, fresh bulb weight, curd bulb weight, clove weight and total yield higher when compared with the intercropped stands in two seasons.

Within intercropping system, one row at 15 cm intra-row spacing of garlic has the highest values for the previous characteristics except total yield. For total yield trait, three rows at 15cm intra-row spacing treatment of garlic gave the highest values compared with the others intercropping treatments.

Table 5. Interaction effect between cultivars and cropping system on garlic growth traits

Cultivars x cropping		Germination %	leaves no. plant^{-1}	Plant height (cm)	Leaf area (cm^2)
		2014/2015			
Balady	Sole	82.96^{a}	10.01^{a}	85.29^{a}	96.56^{a}
	One row	82.60a	9.48^{a}	78.91^{b}	85.28^{b}
	Two rows	82.30^{a}	8.57^{a}	68.91^{d}	64.62^{d}
	Three rows	81.24^{a}	7.79^{a}	63.11^{e}	53.76^{e}
Sids -40	Sole	81.35a	11.15^{a}	73.23^{c}	96.32^{a}
	One row	80.78^{a}	10.22^{a}	68.95^{d}	84.94^{b}
	Two rows	80.54^{a}	9.08^{a}	65.06^{e}	74.93^{c}
	Three rows	79.91^{a}	8.23^{a}	58.74^{f}	62.28^{d}
		2015/2016			
Balady	Sole	81.34^{a}	9.10^{a}	83.62^{a}	79.80^{a}
	One row	80.99^{a}	8.62^{a}	77.36^{b}	70.48^{b}
	Two rows	80.69^{a}	7.79^{a}	67.56^{d}	53.40^{d}
	Three rows	79.65^{a}	7.08^{a}	61.88^{e}	44.43^{e}
Sids -40	Sole	79.75^{a}	10.13^{a}	71.79^{c}	79.60^{a}
	One row	79.19^{a}	9.29^{a}	67.60^{d}	70.20^{b}
	Two rows	78.96^{a}	8.25^{a}	63.78^{e}	61.92^{c}
	Three rows	78.35^{a}	7.48^{a}	57.59^{f}	51.47^{d}

Means followed by the same letters were not statistically significantly differed according to Duncan's multiple range test.

Table 6. Interaction effect between cultivars and cropping system on garlic yield and quality traits

Cultivars X intercropping		Diameter of Bulb^{-1} (cm)	Fresh bulb weight (g)	Cured bulb Weight (g)	cloves no. plant^{-1}	clove weight (g)	Total yield ton/fed
			2014/2015				
Balady	Sole	6.44^{a}	66.3^{c}	30.13^{c}	51.3^{a}	1.47^{e}	6.00^{b}
	One row	5.99^{b}	62.5^{d}	28.4^{d}	50.96^{a}	1.40^{ef}	2.21^{f}
	Two rows	5.28^{d}	58.5^{ef}	26.6^{ef}	50.4^{ab}	1.22^{fg}	4.14^{d}
	Three rows	4.87^{e}	52.8^{g}	24^{g}	49.3^{a}	1.09^{g}	5.35^{c}
Sids -40	Sole	5.58^{c}	77.9^{a}	35.4^{a}	14.6^{a}	4.11^{a}	7.04^{a}
	One row	5.28^{d}	71.3^{b}	32.4^{b}	14.4^{a}	3.83^{b}	2.48^{e}
	Two rows	5.01^{e}	60.6^{de}	27.56^{de}	14.5^{a}	3.40^{c}	4.29^{d}
	Three rows	4.56^{f}	56.6^{f}	25.76^{f}	13.7^{a}	2.03^{d}	5.9^{b}
			2015/2016				
Balady	Sole	6.37^{a}	64.40^{c}	28^{c}	51.83^{a}	1.46^{e}	5.82^{b}
	One row	5.93^{b}	60.66^{d}	26.37^{d}	51.48^{a}	1.38^{ef}	2.14^{f}
	Two rows	5.23^{d}	56.79^{ef}	24.7^{ef}	50.87^{a}	1.20^{fg}	4.02^{d}
	Three rows	4.82^{e}	51.23^{g}	22.6 ^{g}	49.83^{a}	1.08^{g}	5.20^{c}
Sids -40	Sole	5.53^{c}	75.64^{a}	32.86^{a}	14.75^{a}	4.07^{a}	6.83^{a}
	One row	5.23^{d}	69.19^{b}	30.08^{b}	14.58^{a}	3.80^{b}	2.41^{e}
	Two rows	4.96^{e}	58.85^{de}	25.58^{de}	14.67^{a}	3.36^{c}	4.17^{d}
	Three rows	4.51^{f}	54.98^{f}	23.912^{f}	13.83^{a}	2.01^{d}	5.76^{b}

Means followed by the same letters were not significantly differed according to Duncan's multiple range test.

Table 7. Interaction effect between intra-row spacing and cropping system on garlic growth traits

Distances X cropping system	Germination %	leaves no. plant^{-1}	Plant height (cm)	Leaf area (cm^2)
		2014/2015		
Garlic sole	82.15a	10.6a	79.26a	96.44a
Gar.10cm*one row	81.34a	9.54a	71.82c	80.06c
Gar.10cm*two rows	81.14a	8.64a	64.35d	64.15e
Gar.10cm*three rows	80.05a	7.83a	58.35e	53.48f
Gar.15cm*one row	82.04a	10.1a	76.04b	90.16b
Gar.15cm*two rows	81.70a	9.01a	69.62c	75.39d
Gar.15cm*three rows	81.11a	8.1a	63.51d	62.56e
		2015/2016		
Garlic sole	80.54a	9.62a	77.71a	79.70a
Gar.10cm*one row	79.75a	8.68a	70.42c	66.16c
Gar.10cm*two rows	79.55a	7.86a	63.08d	53.02e
Gar.10cm*three rows	78.48a	7.12a	57.20e	44.20f
Gar.15cm*one row	80.43a	9.23a	74.55a	74.51b
Gar.15cm*two rows	80.10a	8.19a	68.26c	62.31d
Gar.15cm*three rows	79.52a	7.44a	62.27d	51.70e

Means followed by the same letters were not significantly differed according to Duncan's multiple range test.

Table 8. Interaction effect between intra-row spacing and cropping system on garlic yield and quality traits

Distances X Cropping system	Diameter Of Bulb^{-1} (cm)	Fresh bulb weight(g)	Cured bulb Weight (g)	Cloves no. plant^{-1}	Clove weight(g)	Total yield (ton/fed.)
2014/2015						
Garlic sole	6.01a	72.12a	32.76^{a}	33.17a	2.79a	6.52a
Gar.10cm*one row	5.48c	64.66c	29.38^{c}	33.08a	2.57a	2.51f
Gar.10cm*two rows	4.96d	56.24d	25.58^{d}	32.04a	2.14a	4.53d
Gar.10cm*three rows	4.53e	52.06e	23.68^{e}	31.35a	1.54a	6.26b
Gar.15cm*one row	5.78b	69.08b	31.42^{b}	32.32a	2.66a	2.17g
Gar.15cm*two rows	5.33c	62.88c	28.58^{c}	32.84a	2.47a	3.90e
Gar.15cm*three rows	4.90d	57.34d	26.08^{d}	31.68a	1.59a	5.02c
2015/2016						
Garlic sole	5.95a	70.02a	30.4^{a}	33.50a	2.76a	6.33a
Gar.10cm*one row	5.43c	62.78c	27.28^{c}	33.42a	2.55a	2.44f
Gar.10cm*two rows	4.91d	54.60d	23.73^{d}	32.37a	2.12a	4.40d
Gar.10cm*three rows	4.49e	50.54e	21.98^{e}	31.67a	1.52a	6.08b
Gar.15cm*one row	5.72b	67.07b	29.17^{b}	32.65a	2.63a	2.11g
Gar.15cm*two rows	5.28c	61.04c	26.56^{c}	33.17a	2.44a	3.79e
Gar.15cm*three rows	4.85d	55.67d	24.2^{d}	32.00a	1.57a	4.88c

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range

4- Effect of interaction between garlic cultivars, intra-row spacing and cropping system on garlic growth, yield and its components:

Data present in tables 9 and 10 indicated the effect of interaction between garlic cultivars, intra-row spacing and cropping system on garlic germination %, growth, yield and its components in two seasons. Generally, garlic as sole stand has the highest values for all characteristics in two seasons. The highest values of plant height (80.98 and 79.39) as well as bulb diameter (6.13 and 6.00) in two seasons respectively resulted from Balady cv. planted at 15 intra-row spacing with one row. Meanwhile, Sids-40 cv. planted at 15cm intra-row spacing with one row gave the highest values of fresh bulb weight (73.39 and 71.25), curd bulb weight (33.36 and 31.00) in two seasons respectively. Sids-40 cv. x 15 cm intra-row spacing x three rows have the highest value for total yield (6.26 and 6.08) respectively in two seasons. The previous results may be due to the intra specific competition between garlic plants, as well as inter competition between garlic plants and sugar beet plants for light, water, solar radiation, moisture and nutrients (Masri and Safina 2015).

***Performance of sugar beet:-**

Main effects:

Data presented in Tables 11 &12 showed the effected of cultivars, intra- row spacing and cropping system of garlic on sugar beet traits in 2014/2015 and 2015/2016 seasons.

1- Effect of garlic cultivars on sugar beet quality:

The results revealed that there are insignificant effects on leaves number, leaves weight (g), root weight (g), root length (cm), yield weight (ton/fed.), sucrose percentage and purity percentage in both seasons. Meanwhile, garlic cultivars gave significant effect on root diameter in two seasons. Balady cv. gave the highest value of root diameter (23.06 and 21.67) in both seasons respectively. There results agreed with those reported by Hussein and Metwally (2012), El-Shamy *et al.* (2015).

2- Effect of garlic plant spacing on sugar beet quality:

Sugar beet was significantly influenced by the different plant spacing of garlic intercropped with sugar beet in two seasons.

Intra-row spacing at 15cm gave the highest values of leaves number (31.04 and 28.54), leaves weight (296.3and 297.6), root weight (702.1 and 665.8), root diameter (22.60 and 21.21), yield weight (25.43 and 24.64 ton/fed.), sucrose (16.34and 16.13%) and purity (68.63 and 68.15 %) in two seasons respectively. On contrary, root length trait of sugar beet increased with decreased the intra-row spacing, as 10cm intra –row spacing gave the highest values in two seasons (16.92 and 16.08 cm) respectively.). These results are in accordance with those obtained by Abdel Motagally and Metwally (2014).

3- Effect of garlic cropping system on sugar beet quality:

The data of leaves number, leaves weight, root weight, root diameter, root length, yield weight (ton/fed.), sucrose % and purity% of sugar beet differed significantly due to row proportion of garlic intercropped with sugar beet in two seasons.

Sole sugar beet recorded significantly higher leaves number (33.00and 30.33), leaves weight (383.3 and 358.3), root weight(833.3 and 800.0), root diameter(26.73 and25.3), yield weight (29.00 and 28.16 ton/fed.), sucrose (16.8 and 16.6 %) and purity (73.38 and 72.7%) respectively in two seasons compared to other treatments. But, sole sugar beet recorded significantly lower root length compared to the other treatments. In general, increase in the row ratios of garlic resulted in gradual reduction of sugar beet characteristics except root length parameter. Growing of garlic in one row recorded significantly higher for all characteristics than two and three row. And lower sugar beet for all characteristics were recorded under three row of garlic. On the contrary, significantly lower root length was recorded by sugar beet growing with three row of garlic in two seasons (15.5 and 14.5 cm respectively) compared to other treatments. These results are in a great agreement with those obtained by *Hussein and* Metwally (2012), Abou Khadra et al. (2013) and Abdel Motagally and Metwally (2014).

Table 9. Interaction effect between garlic cultivars, intra-row spacing and cropping system on garlic growth traits

Cultivars X Distance X Cropping system			Germination %	Leaves no. plant^{-1}	Plant height (cm)	Leaf area (cm^2)
			2014/2015			
		Sole	82.96a	10.0a	85.29a	96.56a
	10 cm	One row	82.42a	9.29a	76.84d	80.84a
		Two rows	82.15a	8.30a	64.94fg	56.65a
Balady		Three rows	80.54a	7.67a	58.36h	46.22a
	15 cm	One row	82.79a	9.68a	80.98b	89.72a
		Two rows	82.45a	8.85a	72.88d	72.59a
		Three rows	81.95a	7.91a	67.86ef	61.29a
		Sole	81.35a	11.2a	73.23d	96.32a
	10 cm	One row	80.27a	9.80a	66.81fg	79.28a
		Two rows	80.13a	8.98a	63.75g	71.66a
Sids-40		Three rows	79.56a	7.99a	58.33h	60.73a
	15 cm	One row	81.29a	10.6a	71.09de	90.60a
		Two rows	80.95a	9.17a	66.37fg	78.19a
		Three rows	80.27a	8.46a	59.16h	63.82a
			2015/2016			
		Sole	81.34a	9.10a	83.62a	79.80a
	10 cm	One row	80.80a	8.44a	75.33d	66.81a
		Two rows	80.54a	7.54a	63.67fg	46.81a
Balady		Three rows	78.96a	6.98a	57.22h	38.20a
	15 cm	One row	81.17a	8.80a	79.39b	74.15a
		Two rows	80.83a	8.04a	71.45d	59.99a
		Three rows	80.35a	7.19a	66.53ef	50.66a
		Sole	79.75a	10.1a	71.79d	79.60a
	10 cm	One row	78.69a	8.91a	65.50fg	65.52a
		Two rows	78.56a	8.17a	62.50g	59.22a
Sids-40		Three rows	78.00a	7.27a	57.18h	50.19a
	15 cm	One row	79.69a	9.67a	69.70de	74.88a
		Two rows	79.37a	8.33a	65.07fg	64.62a
		Three rows	78.69a	7.69a	58.00h	52.74a

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

Table 10. Interaction effect between garlic cultivars, intra-row spacing and cropping system on garlic yield and quality traits

Cultivars	X Distances	X Cropping system	Bulb Diameter (cm)	Fresh bulb weight (g)	Cured bulb Weight (g)	cloves no. plant^{-1}	clove weight (g)	Total yield ton/fed
				2014/2015				
		Sole	6.44a	66.33cd	30.13cd	51.5a	1.47a	6.00b
	10 cm	One row	5.84c	60.17fg	27.33fg	51.80a	1.37a	2.39g
		Two rows	5.00fg	57.24gh	26.03gh	49.90a	1.17a	4.62d
Balady		Three rows	4.53h	52.04h	23.66i	48.50a	1.08a	6.26b
	15 cm	One row	6.13b	64.78de	29.46de	50.13a	1.43a	2.03h
		Two rows	5.56d	59.75fg	27.16fg	50.80a	1.26a	3.66f
		Three rows	5.20ef	53.49h	24.33hi	50.16a	1.10a	4.45ge
		Sole	5.58cd	77.9a	35.4 a	14.9a	4.11a	7.04a
	10 cm	One row	5.13fg	69.15c	31.4 c	14.4a	3.78a	2.64g
		Two rows	4.91g	55.23h	25.13hi	14.2a	3.11a	4.45de
Sids-40		Three rows	4.53h	52.08i	23.7 i	14.2a	1.99a	6.27b
	15 cm	One row	5.43de	73.39b	33.36 b	14.5a	3.9a	2.32gh
		Two rows	5.10fg	66.00cd	30 cd	14.9a	3.68a	4.14e
		Three rows	4.59h	61.19ef	27.83ef	13.2a	2.08	5.60c
				2015/2016				
		Sole	6.37a	64.4cd	28cd	52.00a	1.46a	5.82b
	10 cm	One row	5.7c	58.4fg	25.4fg	52.33a	1.35a	2.32g
		Two rows	8.95fg	55.6gh	24.16h	50.40a	1.16a	4.49d
Balady		Three rows	4.49h	50.5h	21.96i	49.00a	1.07a	6.08b
	15 cm	One row	6.07b	62.9de	27.33de	50.63a	1.42	1.97h
		Two rows	5.50d	58.0fg	25.23fg	51.33a	1.25a	3.56f
		Three rows	5.15ef	51.9h	22.56hi	50.67a	1.09a	4.32ge
		Sole	5.53cd	75.64a	32.86a	14.50a	4.07a	6.83a
	10 cm	One row	5.08fg	67.13c	29.16c	14.50a	3.74a	2.56g
		Two rows	4.86g	53.62h	23.3hi	14.33a	3.08a	4.32de
Sids-40		Three rows	4.48h	50.56i	22.0i	14.33a	1.97a	6.08b
	15 cm	One row	5.38de	71.25b	31.0 b	14.67a	3.85a	2.25gh
		Two rows	5.05fg	64.07cd	27.86cd	15.00a	3.64a	4.02e
		Three rows	4.54h	59.41e	25.83ef	13.33a	2.06a	5.43c

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

Table 11. Mean effect of garlic cultivars, plant spacing and cropping system on sugar beet growth components

Treatments		Leaves number plant ^{1}	Leaves weight plant $^{-1}$	Root weight plant $^{-1}$	Root diameter
			2014/2015		
cultivars	Balady	30.08^{a}	291.7^{a}	679.2^{a}	22.67^{a}
	Sids-40	30.25^{a}	273.3^{a}	670.8^{a}	21.71^{a}
Distances	10 cm	29.29^{a}	268.8^{b}	647.9^{b}	21.67^{b}
	15 cm	31.04^{b}	296.3^{a}	702.1^{a}	22.71^{a}
Cropping system	Sole	33.00^{a}	383.3^{a}	833.3^{d}	26.00^{a}
	One row	31.75^{b}	317.5^{b}	754.2^{e}	23.75^{b}
	Two rows	28.83^{c}	237.5^{c}	645.8^{f}	21.75^{c}
	Three rows	27.08^{d}	191.7^{d}	466.7^{g}	17.25^{d}
			2015/2016		
cultivars	Balady	28.00a	275.3a	645.8a	21.67a
	Sids-40	27.58a	275.1a	632.8a	20.13a
Distances	10 cm	27.04a	252.8b	612.9b	20.58b
	15 cm	28.54b	297.6a	665.8c	21.21a
Cropping system	Sole	30.33a	358.3a	800.0d	25.3a
	One row	28.80b	324.1b	700.4e	21.8b
	Two rows	26.92c	240.4c	620.8f	20.1c
	Three rows	25.08d	177.9d	436.0g	16.3d

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range

Table 12. Effect of garlic cultivars, plant spacing and cropping system on sugar beet quality

Treatments		Root length (cm)	Yield weight fad $^{-1}$ (ton)	Sucrose %	Purity %
			2014/2015		
cultivars	Balady	15.88^{a}	24.93^{a}	16.10^{a}	68.68^{a}
	Sids-40	15.79^{a}	25.06^{a}	15.94^{a}	67.70^{a}
Distances	10 cm	16.92^{a}	24.56^{a}	15.69^{a}	67.74^{b}
	15 cm	14.75^{a}	25.43^{a}	16.34^{a}	68.63^{a}
Cropping system	Sole	15.33^{bc}	29.00^{c}	16.80^{b}	73.38^{a}
	One row	14.25^{bc}	25.07^{c}	16.52^{b}	68.71^{b}
	Two rows	15.67^{cd}	23.88^{d}	15.71^{c}	66.21^{c}
	Three rows	18.08^{d}	22.02^{d}	15.04^{c}	64.44^{d}
			2015/2016		
cultivars	Balady	14.88a	24.34a	15.83a	67.97a
	Sids-40	15.17a	24.30a	15.71a	67.28a
Distances	10 cm	16.08a	23.99a	15.41a	67.08b
	15 cm	13.96a	24.64a	16.13a	68.15a
Cropping system	Sole	14.00bc	28.16c	16.60b	72.70a
	One row	14.50bc	24.36c	16.12b	67.89b
	Two rows	15.12cd	23.26d	15.49c	65.79c
	Three rows	16.45d	21.47d	14.83c	64.04d

Means followed by the same letters were not significantly differed according to Duncan's multiple range test

Interaction effects:

1- Effect of the interaction between varieties and intra-row spacing on sugar beet quality:

The results in Tables 13 and 14 indicated that the effect of interaction between cultivars and intra-row spacing of garlic on sugar beet growth, yield and its components in 2014/2015 and 2015 /2016. There were insignificant effects on all growth, yield and its components except, total yield / fed. and purity in two seasons. Balady cv. at 15 cm intra –row spacing was recorded higher for yield weight (25.48 and 25.08) and purity % (69.97 and 68.98) compared with the other treatments in two seasons respectively irrespective of various row proportion tested.

2- Effect of the interaction between garlic cultivars and cropping system on sugar beet quality:

The results in Tables 15 and 16 showed that the effect of interaction between cultivars and cropping systems of garlic on sugar beet growth, yield and its components in 2014/2015and 2015 /2016. There were no significant effects on all growth, yield and its components in two seasons except, leaves number and leaves weight were significantly influenced in 2nd seasons also, root diameter/plant were significantly influenced in two seasons. Sole sugar beet recorded higher leaves number (30.33), leaves weight per plant (358.3) and root diameter (2673 and 25.33) compared with the other treatments. While, sugar beet gave the highest values when intercropped with garlic at one row irrespective of different intra spacing examined.

3- Effect of the interaction between intra-row spacing and cropping system on sugar beet quality:

The data on leaves number per plant, leaves weight per plant, root weight, root diameter, root length, yield weight per fed. sucrose % and purity % of sugar beet differed significantly due to interaction between intra row spacing and cropping systems of garlic (Table17 and 18).

Sole sugar beet recorded significantly higher values of all growth, yield and its components (leaves number, leaves weight, root weight, root diameter, yield weight per fed. and purity %) except, root length and sucrose % compared to other treatments. However, growing of sugar beet intercropped with garlic at 15 cm intra-row spacing one garlic row recorded higher values for leaves number(33 and 30.17), leaves weight(370.8 and 345), root weight(800 and 756.67), root diameter(24.33 and 22.17), yield weight (25.65 and 24.82), sucrose(17.04 and 16.77%) and purity (69.62 and 68.64%) respectively in two seasons.

Table 13. Interaction Effect between cultivars and intra-row spacing on sugar beet growth traits

cultivars X Distances		Leave number plant $^{-1}$	Leave weight plant $^{-1}$	Root weight plant $^{-1}$	Root diameter plant $^{-1}$
		2014/2015			
Balady	10 cm	29.33^{a}	266.67^{a}	650.00^{a}	22.65^{a}
	15 cm	30.83^{a}	316.67^{a}	708.33^{a}	23.32^{a}
Sids-40	10 cm	29.25^{a}	270.83^{a}	645.83^{a}	21.32^{a}
	15 cm	31.25^{a}	320.8^{a}	695.83^{a}	21.73^{a}
		2015/2016			
Balady	10 cm	27.08^{a}	256.25^{a}	619.75^{a}	21.25^{a}
	15 cm	28.92^{a}	294.33^{a}	671.92^{a}	22.08^{a}
Sids-40	10 cm	27.00^{a}	249.33^{a}	606.00^{a}	19.92^{a}
	15 cm	28.17^{a}	300.83^{a}	659.58^{a}	20.33^{a}

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

Table 14. Interaction Effect between cultivars and intra-row spacing on sugar beet yield quality traits

Cultivars X Distances		root length (cm)	yield weight(ton)	Sucrose%	Purity %
		2014/2015			
Balady	10 cm	16.73^{a}	24.38^{b}	15.77^{a}	67.91^{b}
	15 cm	14.00^{a}	25.48^{a}	16.42^{a}	69.97^{a}
Sids-40	10 cm	17.93^{a}	24.73^{b}	15.61^{a}	68.24^{b}
	15 cm	14.89^{a}	25.39^{a}	16.26^{a}	68.31^{b}
		2015/2016			
Balady	10 cm	15.75^{a}	23.59^{a}	15.41^{a}	66.91^{b}
	15 cm	14.00^{a}	25.08^{b}	16.25^{a}	68.98^{a}
Sids-40	10 cm	16.42^{a}	24.39^{c}	15.41^{a}	67.25^{b}
	15 cm	13.92^{a}	24.20^{d}	16.01^{a}	67.32^{b}

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

Table 15. Interaction effect between cultivars and cropping system on sugar beet growth traits

Cultivars X Cropping system		Leaves number plant $^{-1}$	Leaves weight plant $^{-1}$	Root weight plant $^{-1}$	Root diameter plant $^{-1}$
		2014/2015			
	Sole	33.00a	383.3a	833.3a	26.73a
	One row	31.67^{a}	345.8^{a}	766.7^{a}	24.4^{b}
Balady	Two rows	28.67^{a}	262.5^{a}	650.0^{a}	22.4^{c}
	Three rows	27.00^{a}	175.0^{a}	466.7^{a}	18.23^{e}
Sids-40	One row	31.83^{a}	341.0^{a}	741.7^{a}	22.07^{c}
	Two rows	29.00^{a}	250.0^{a}	641.7^{a}	20.57^{d}
	Three rows	27.17^{a}	208.3^{a}	466.6^{a}	16.73^{f}
		2015/2016			
	Sole	30.33a	358.3a	800	25.33a
	One row	29.33^{b}	339.7^{a}	719.2^{a}	23.00^{b}
Balady	Two rows	26.83^{d}	247.0^{c}	625.0^{a}	21.00^{c}
	Three rows	25.50e	156.7^{b}	439.2^{a}	17.33^{e}
Sids-40	One row	28.33^{c}	309.0^{b}	681.7^{a}	20.67^{c}
	Two rows	27.00^{d}	233.8^{ab}	616.7^{a}	19.17^{d}
	Three rows	24.67^{f}	199.2^{b}	432.8^{a}	15.33^{f}

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

Table 16. Interaction effect between cultivars and cropping system on sugar beet yield quality traits

Cultivars X Cropping system		root length (cm)	yield weight (ton)	Sucrose%	Purity %
		2014/2015			
	Sole	14.98	29.00	16.80	73.71a
	One row	14.98^{a}	25.14^{a}	16.65^{a}	69.18^{a}
Balady	Two rows	15.81^{a}	23.81^{a}	15.78^{a}	67.3^{a}
	Three rows	17.64^{a}	21.76^{a}	15.17^{a}	65.5a
Sids-40	One row	14.98^{a}	25.01^{a}	16.40^{a}	68.59^{a}
	Two rows	16.31^{a}	23.96^{a}	15.64^{a}	66.27^{a}
	Three rows	17.2^{a}	22.29^{a}	14.92^{a}	64.52^{a}
		2015/2016			
	Sole	14.00a	28.17a	16.62a	72.73a
	One row	14.00^{a}	24.41^{a}	16.13^{a}	68.19^{a}
Balady	Two rows	14.83^{a}	23.40^{a}	15.55^{a}	66.31^{a}
	Three rows	16.67^{a}	21.37^{a}	15.00^{a}	64.56^{a}
Sids-40	One row	15.03^{a}	24.32^{a}	16.11^{a}	67.60^{a}
	Two rows	15.41^{a}	23.12^{a}	15.44^{a}	65.28^{a}
	Three rows	16.23^{a}	21.58^{a}	14.67^{a}	63.53^{a}

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

Table 17.Interaction effect between intra-row spacing and cropping system on sugar beet growth traits

Distances X Cropping system		Leaves number plant $^{-1}$	Leaves weight plant^{-1}	Root weight plant $^{-1}$	Root diameter plant $^{-1}$
		2014/2015			
	Sole	33.0a	383.33a	833.3a	26.0a
10 cm	One row	30.50^{b}	316.67^{b}	708.33^{b}	23.17^{b}
	Two rows	27.83^{c}	233.33^{c}	625.00^{c}	21.50^{c}
	Three rows	25.83^{d}	141.67^{e}	425.00^{e}	16.00^{d}
15 cm	One row	33.00^{a}	370.8^{a}	800.00^{a}	24.33^{ab}
	Two rows	29.83^{b}	279.17^{b}	666.67^{b}	22.00^{abc}
	Three rows	28.33^{c}	241.67^{c}	508.33^{c}	18.50^{d}
		2015/2016			
	Sole	30.33a	358.33a	800a	28.33a
10 cm	One row	27.50^{b}	303.17^{b}	644.17^{b}	21.50^{b}
	Two rows	26.50^{c}	218.83^{c}	600.83^{c}	20.33^{c}
	Three rows	23.83^{d}	130.83^{e}	406.50^{e}	15.17d
15 cm	One row	30.17^{a}	345.00^{a}	756.67^{a}	22.17^{b}
	Two rows	27.33^{b}	262.00^{b}	640.83^{bc}	19.83^{b}
	Three rows	26.33^{c}	225.00^{c}	465.5^{d}	17.50^{c}

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

Table 18. Interaction effect between intra-row spacing and cropping system on sugar beet yield quality traits

Distances X Cropping system		root length(cm)	yield weight(ton)	Sucrose%	Purity %
		2014/2015			
	Sole	14.98	29	16.80	73.71
	One row	15.83^{a}	24.50^{a}	16.00^{a}	68.14^{b}
10 cm	Two rows	17.33^{b}	23.47^{b}	15.24^{b}	65.84^{b}
	Three rows	19.17^{b}	21.25^{b}	14.73^{b}	64.58^{b}
	One row	12.67^{a}	25.65^{a}	17.04^{a}	69.62^{b}
15 cm	Two rows	14.00^{b}	24.29^{b}	16.17^{b}	67.73^{b}
	Three rows	17.00^{b}	22.80^{b}	15.35^{b}	65.48^{b}
		2015/2016			
	Sole	14	28.17	16.62	72.73
10 cm	One row	15.83a	23.91^{b}	15.47^{a}	67.15^{b}
	Two rows	16.67^{b}	23.01^{b}	15.00^{b}	64.86^{b}
	Three rows	17.83^{b}	20.88^{c}	14.54^{b}	63.59^{b}
15 cm	One row	13.20^{a}	24.82^{b}	16.77^{a}	68.64^{b}
	Two rows	13.58^{b}	23.51^{b}	16.00^{b}	66.74^{b}
	Three rows	15.07^{b}	22.07^{c}	15.13^{b}	64.49^{b}

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

On the other hand the higher value of root length parameter was obtained from sugar beet intercropped with garlic at 10 cm intra- row spacing three garlic rows (19.17 and 17.83) in two seasons respectively compared with sole sugar beet and intercropped treatment irrespective of garlic cultivars tested.

4- Effect the interaction between garlic cultivars, intra-row spacing and cropping system:

The results in Tables 19 &20 showed that, effect of the interaction between garlic cultivars, intra-row spacing and cropping systems on growth, yield and quality of sugar beet in 2014/2015and 2015/2016. There were no significant effects on all growth, yield and its components of Sugar beet in two seasons except, root length and purity % in two seasons and yield weight in

2nd season. Sole sugar beet accounted significantly higher in yield weight (29 and 28.17) and purity (73.71 and 72.73%) respectively in two seasons compared to other treatments followed by sugar beet intercropped with Balady cv. at 15 cm intra-row spacing in one row for yield weight(25.93and 25.47) and purity (70.05 and 69.54%), respectively in two seasons. Meanwhile sugar beet intercropped with Sids-40cv. at 10 cm intra-row spacing in three rows significantly lower in yield weight (21.51and 21.40). While, sugar beet intercropped with Sids-40cv. at 15 cm intra-row spacing three rows significantly lower in purity (63.39 and 63.21%) respectively in two seasons. Root length of sugar beet intercropped with Sids-40 cv. at 10 cm in three rows recorded higher value (19.33 and 18.67) compared to other treatments, meanwhile, lower value (13.31 and 12.33) was obtained from sugar beet intercropped with Balady cv. at 15 cm intra-row spacing one row respectively in two seasons the rest of treatments were intermediate.

***Land equivalent ratio (LER):**

Data in table 21 showed the treatments effect on land use efficiency of garlic intercropped with sugar beet. The data revealed that the highest value of LER was obtained from intercropping garlic Cultivar Balady at 10 cm intra-plant spacing with three rows on the top of sugar beet bed flowed with the same cultivars at 15cm intra-row spacing with two rows intercropped as mean of two seasons. On the other hand, the lowest value of LER was obtained when Sids-40 at 15 cm and planted at one row on the top of sugar beet bed as mean of two seasons. These results were in the same line with those obtained by Abou Khadra *et al.* (2013*)*, and El-Shereif (2013) who stated that intercropping system recorded higher LER over sole cropping.

Table 19. Interaction effect between garlic cultivars, intra-row spacing and cropping system on sugar beet growth traits

Cultivars X Distances X Cropping system			Leaves number plant $^{-1}$	Leaves weight plant $^{-1}$	Root weight plant $^{-1}$	Root diameter plant $^{-1}$
			2014/2015			
		Sole	33.00a	383.3a	833.33a	26.00a
		One row	30.67a	316.7a	716.67a	24.00a
	10 cm	Two rows	27.67a	233.3a	633.33a	21.33a
		Three rows	26.00a	133.3a	416.67a	16.33a
Balady		One row	32.67a	375.0a	816.67a	25.33a
	15 cm	Two rows	29.67a	291.7a	666.67a	23.00a
		Three rows	28.00a	216.7a	516.67a	19.33a
		One row	30.33a	316.7a	700.00a	22.33a
	10 cm	Two rows	28.00a	233.3a	616.67a	21.67a
		Three rows	25.67a	150.0a	433.33a	15.67a
Sids-40		One row	33.33a	261.7a	783.33a	23.33a
	15 cm	Two rows	30.00a	191.7a	666.67a	21.00a
		Three rows	28.67a	266.7a	500.00a	17.67a
			2015/2016			
Sole			30.33a	358.3a	800.00a	25.33a
		One row	28.00a	328.3a	671.60a	22.67a
	10 cm	Two rows	26.00a	220.0a	608.30a	21.00a
		Three rows	24.00a	118.3a	399.00a	16.00a
Balady		One row	30.67a	350.0a	766.60a	23.33a
	15 cm	Two rows	27.67a	274.0a	641.60a	21.00a
		Three rows	27.00a	195.0a	479.30a	18.67a
		One row	27.00a	278.0a	616.60a	20.33a
	10 cm	Two rows	27.00a	217.6a	593.30a	19.67a
		Three rows	23.67a	143.3a	414.00a	14.33a
Sids-40		One row	29.67a	340.0a	746.60a	21.00a
	15 cm	Two rows	27.00a	250.0a	640.00a	18.67a
		Three rows	25.67a	255.0a	451.60a	16.33a

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

Table 20. Interaction effect between garlic cultivars, intra-row spacing and row cropping system on sugar beet yield and quality traits

Cultivars x Distances x Cropping system			Root length (cm)	Yield weight fad $^{-1}$(ton)	Sucrose%	Purity%
			2014/2015			
		Sole	14.98a	29.00a	16.80a	73.71a
	10 cm	One row	16.65a	24.35d	16.04a	67.82cd
		Two rows	17.3a	23.17efg	15.34a	65.74ef
		Three rows	17.98a	20.99h	14.90a	64.32g
Balady	15 cm	One row	13.31a	25.93b	17.26a	70.53b
		Two rows	14.31a	24.44cd	16.21a	68.85c
		Three rows	17.33a	22.53g	15.43a	66.77de
	10 cm	One row	16.98a	24.65cd	15.96a	68.46c
		Two rows	17.98a	23.78def	15.14a	65.95e
		Three rows	19.64a	21.51h	14.56a	64.83fg
Sids-40	15 cm	One row	15.04a	25.36bc	16.83a	68.72c
		Two rows	14.79a	24.14de	16.13a	66.6e
		Three rows	14.78a	23.07fg	15.27a	64.2g
			2015/2016			
		Sole	14.00a	28.17a	16.62a	72.73a
		One row	15.67a	23.35d	15.22a	66.83cd
	10 cm	Two rows	16.33a	22.50efg	15.01a	64.75ef
		Three rows	17.00a	20.36h	14.76a	63.34g
Balady		One row	12.33a	25.47b	17.03a	69.54b
	15 cm	Two rows	13.33a	24.30cd	16.09a	67.86c
		Three rows	16.33a	22.37f	15.24a	65.78de
		One row	16.00a	24.47cd	15.72a	67.47c
	10 cm	Two rows	17.00a	23.52def	14.98a	64.96e
		Three rows	18.67a	21.40h	14.31a	63.84fg
Sids-40		One row	14.06a	24.17bc	16.50a	67.73c
	15 cm	Two rows	13.82a	22.72de	15.91a	65.61e
		Three rows	13.80a	21.76fg	15.02a	63.21g

Means followed by the same letters were not statistical significantly differed according to Duncan's multiple range test.

*** Economic evaluation:-**

The economic study of various treatment combinations are given in Table 21. The highest total gross return from Sids-40 cv. at 15 cm intra-row spacing with two rows of garlic intercropped with sugar beet (27992 L.E/ fed.) closely followed by Balady cv (25995 L.E./ fed.) at 15 cm intra-row spacing and two rows on the top of sugar beet bed as mean of two seasons with a net income (20052 and 19395 L.E. / fed) respectively.

These results agree with Castellanos *et al.,* (2004)**.** Who said that, although plant yield increased when the higher plant density were used but the yield improvement increased plant stand is offset by the reduction in bulb size which severely affects quality and market value.

CONCLUSION

Eventually, Garlic cultivar (Balady or Sids-40) when planted at the intra-row spacing 15 cm and intercropping two garlic rows on the top of sugar beet bed could be the appropriate suggestion for increasing net income of farmers in North Middle Nile Delta region, Egypt.

Table 21. Effects of garlic cultivars and intra-row spacing intercropped with sugar beet on LER and economic values

Treatments			Relative yield (RY)		LER	Gross income for garlic	Gross income for sugar beet	Total income L.E/fed.)	Total Cost L.E./ fed.	Net income
Cultivars	Distances	Cropping system	garlic	sugar beet						
Balady	10 cm	One row	0.398	0.900	1.298	14340	9506	23846	6830	17016
		Two rows	0.770	0.722	1.492	20790	7623	26104	7680	18424
		Three rows	1.043	0.509	1.553	18780	5381	24161	8520	15641
	15 cm	One row	0.338	0.975	1.313	12180	10300	22481	6640	15841
		Two rows	0.610	0.902	1.512	18300	9525	25995	6640	19355
		Three rows	0.742	0.599	1.341	13350	6326	19676	7280	12396
Sids-40	10 cm	One row	0.377	0.940	1.317	15840	9926	25766	7250	18516
		Two rows	0.636	0.870	1.506	20025	9195	26995	8500	18495
		Three rows	0.896	0.547	1.442	18810	5775	24585	9750	14835
	15 cm	One row	0.331	0.929	1.260	13920	9813	23734	6940	16794
		Two rows	0.591	0.886	1.478	20700	9362	27992	7940	20052
		Three rows	0.800	0.577	1.377	16800	6097	22898	8900	13998

Total income for solid crops: Sugar beet: LE 10875 Garlic LE 30000

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الملخص العربي

تاثير مسافات الزراعة ونظم التحميل مع بنجر السكر على النمو والمحصول والجودة في صنفين من اصناف الثوم

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أجريت تجربه حقليه بمزرعه محطة بحوث البساتين بسخا خلال موسمى النمو ٢٠١٥/٢٠١٤ ، ٢٠١٦/٢٠١٥ وذلك بهدف دراسة تاثير صنفين من اصناف الثوم (البلدى & سدس-٤٠) زرعوا على مسافتين زراعيتين (١٠& ١٥ سم) تحت ثلاث نظم تحميل(تحميل ثوم مع بنجر السكر بحيث يزرع سطر واحد فقط من الثوم & تحميل سطرين من ثوم & تحميل ثلاثه اسطر من الثوم على ظهر المصطبة مع بنحر السكر بحيث يكون بنجر السكر منزرع بالمعدل الموصى به) كذلك زراعة بنجر السكر والثوم منفرد بالمعدل الموصى به على النمو الخضرى والمحصول وجودته لكل من الثوم والبنجر كذلك تقييم المكافئ الارضى وحساب العائد الاقتصادى تحت ظروف التجربه. الصنف جلوريا كان الصنف المستخدم للمحصول الرئيسى (بنجر السكر) تم ترتيب المعاملات فى نظام القطع المنشقه – المنشقه فى تصميم القطاعات الكامله العشوائيه و قد خصصت القطع الرئيسيه لاصناف الثوم و القطع المنشقه لمسافات الزراعه و القطع تحت االمنشقه الى نظم التحميل

أهم النتائج يمكن تلخيصها كما يلى:

اظهر الصنف البلدى للثوم تفوق فى صفات نسبة الانبات، وارتفاع النبات، وقطر الراس وعدد الفصوص. بينما اعطى الصنف سدس ٤٠ اعلى القيم فى باقى الصفات المدروسة فى كلا الموسمين. واظهرت مسافة الزراعة ١٥ سم بين نباتات الثوم داخل نفس الخط تفوق فى معظم الصفات وكان نظام التحميل سطر واحد للثوم على مصطبة البنجر هو الافضل بالنسبه لكل الصفات ماعدا محصول الكلى للفدان فى كل من الثوم وبنجر السكر. كانت اعلى متوسط لقيمه المكافئ الارضى هى(١,٥٥) مع الصنف الثوم البلدى على مسافة زراعة١٠ سم فى ثلاثه صفوف يليه نفس الصنف ولكن على ١٥ سم و الزراعه فى صفين (١,٥١) وذلك كمتوسط عام للموسمين. كذلك الحصول على اعلى صافى للدخل مع الصنف سدس-٤٠(٢٠٠٥٢ جنيه) على مسافه ١٥ سم مع معامله الصفين يليه الصنف البلدى(١٩٣٥٥جنيه) على نفس المسافه مع الصفين ايضا وذلك كمتوسط عام للموسمين.

توصيات البحث:

زراعه اى من صنفين الثوم سدس-٤٠ أوالبلدى على مسافات زراعيه ١٥سم وبمعدل سطرين على مصطبة بنجر السكر يعطى أعلى عائد اقتصادى وهذا يؤدى لزيادة دخل المزارع في منطقة شمال الدلتا.