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Improving yield and quality of garlic (*Allium sativum* L.) under water stress conditions

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ABSTRACT

Water deficit represents one of the most abiotic stress type that controls crop productivity and quality all over the world. In an attempt to find a way to minimize its effects, a field experiment was executed during the two growing seasons of 2016 and 2017 at the experimental farm, Faculty of Agriculture, Ain Shams University, Qalubia governorate, Egypt. The experiment was laid out in a split-split-plot design to assess the response of two garlic cultivars (Balady and Sids-40) to foliar spraying of selenium (Se) and silicon (Si) under three irrigation levels (60, 80 and 100% of irrigation requirements, IR). Obtained results showed that the studied parameters of growth and yield of garlic were significantly increased with increasing irrigation water level up to full requirements. The Balady cultivar showed significant improvement in all the studied parameters as compared to Sids-40. Foliar spraying with Se showed better influence on the studied parameters than Si. Regarding the interaction between irrigation water levels and cultivars, the treatment of full irrigation level with Balady cultivar showed significant increase of the studied parameters, followed by 80% irrigation level with Balady cultivar. Also, irrigation levels with foliar treatments showed in general that the treatment of full irrigation level with Se enhanced the growth and yield parameters of garlic, followed by the treatment of full irrigation with Si and 80% irrigation level with Se. As for the interaction between cultivars and foliar treatments, Balady cultivar with Se gave the highest values, followed by the same cultivar with Si, compared to the other treatments. Concerning the interaction among all treatments, the treatment of full irrigation with Balady cultivar and spraying with Se was superior in giving high values of the studied parameters, followed by spraying with Si with the same other treatments, and the treatment of 80% irrigation level with Balady cultivar and spraying Se came in the third order. The foliar spray with Se followed by Si enhanced all vegetative growth, yield and quality parameters of garlic under water stress conditions as well as increasing the water use efficiency.

Keywords: Garlic, cultivars, drought stress, selenium, silicon.

Introduction

Garlic (*Allium sativum* L.) is an export crop has many benefits due to its richness of total phenolic and sulphuric compounds, besides containing considerable amounts of different nutrients, vitamins, antibiotics, enzymes and amino acids. It is used as vegetable, spices and medicine (Diriba-Shiferaw, 2017; Martins *et al*., 2016). Garlic is sensitive to water limitation and drought stress, and maximization yield of garlic bulb depends mainly on well-managed irrigation (Abd-Elhady and Eldardiry, 2016). Drought, as an abiotic stress increased mainly in arid and semi-arid regions like Egypt, cause direct decline in crop growth may be across either decrease in cell elongation, cell turgor or cell volume (Banon *et al*., 2006), and/or due to covering of xylem and phloem vessels thus obstruction any translocations (Lavisolo and Schuber, 1998).

However, attempts to improve yield under stress conditions by adding the fertilization requirements from essential elements have been largely unsuccessful, therefore, a well-focused approach combining the molecular, physiological, biochemical and metabolic aspects of drought and salt tolerance is essential to develop crop varieties to be more tolerant. One of the protective methods is the use of selenium (Se), which can increase stress resistance by improving growth, thereby reducing the harmful effects of abiotic stresses (Astaneh *et al*., 2018). Selenium is a trace element that can function as a benefit nutrient for humans and animals or as an environmental toxicant; the boundary between the two is narrow and depends on its chemical form, concentration, and other

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environmentally regulating variables (Fan *et al*., 2002; Shardendu *et al*., 2003). Kuznetsov *et al*. (2003) reported that Se had the ability to regulate the water status of plants under drought stress conditions. Kong *et al*. (2005) demonstrated that Se application maintained chloroplast and mitochondria ultra-structures, thereby improving photosynthesis and enhancing salt tolerance in sorrel seedlings. The positive effect of Se in plants is believed to be related to the regulation of antioxidant defense systems and photosynthesis. Hawrylak-Nowak (2009) found that the growth rate, photosynthetic pigment and proline content of cucumber were increased by exogenous selenium application under salt stress conditions. This application has protected the cell membrane and enhanced the salt tolerance of the plants.

Also, silicon (Si) is considered as a growth regulator, which participates in the regulation of physiological processes in plants including seed germination, stomatal closure, ion uptake and transport, membrane permeability, photosynthesis and plant growth rate (Aftab *et al*., 2010). On garlic, Mustafa *et al*. (2017) and Bideshki and Arvin (2010) found that there were enhancement in growth and yield parameters such as fresh and dry weights of whole plant, bulb diameter and yield production when the plants were treated with Si under water stress conditions.

Thus, the main objective of this study was to determine the influence of foliar spraying with Se and Si solutions on growth and yield of two different garlic cultivars under water stress conditions.

Materials and Methods

Field Experiment

A field experiment was conducted during the two successive seasons of 2016/2017 and 2017/2018 at the experimental farm, Faculty of Agriculture, Ain Shams University, Qalubia governorate, Egypt. The average temperature was 21±3.7ºC, the relative humidity was 61±8% and the evapotranspiration rate ET_o was 3.3±1.7 mm day^{-1}. The investigated soil was a clayey one (*Vertic Torrifluvents*) and its physical and chemical properties were determined, before cultivation, by the standard methods outlined by Klute (1986) and Page *et al.* (1982) and the obtained results are shown in Table 1.

Table 1: Some physical and chemical properties of the studied soil (0-30 cm).

Particle size distribution, %		**Soluble ions, $mmol_c$ L^{-1}**	
Sand	22.7	**Ca^{2+}**	3.04
Silt	25.1	**Mg^{2+}**	2.92
Clay	52.2	**Na^{+}**	1.12
Textural class	Clay	**K^{+}**	0.80
Field capacity, %	45.5	**HCO_3^-**	2.49
Wilting point, %	4.01	**Cl^-**	1.38
$CaCO_3$, g kg^{-1}	10.5	**SO_4^{2-}**	2.06
OM, g kg^{-1}	9.50	**Total macronutrient, %**	
CEC, $cmol_c$ kg^{-1}	42.3	**N**	0.16
pH (1:2.5)	7.41	**P**	0.02
EC_e, dS m^{-1}	0.49	**K**	1.42

Carbonate ions were not detected.

Applied Treatments

The experimental plot area was 10.5 m^2 containing 3 ridges, 5 m length and 0.7 m width. Cloves of garlic cultivars, i.e. Balady and Sids-40 were planted (at the end of September in 2016 and 2017) on both sides of the ridges, 10 cm apart. The experiment was laid out in split-split-plot design with three replications. The main plots were assigned to the irrigation treatments (60, 80 and 100% of IR) and the subplots were occupied by the two tested cultivars (as the most two common cultivars in Egyptian market), while the foliar applications (1.5 mM potassium silicate [K_2SiO_3] and 0.03 mM sodium selenite [Na_2SeO_3]), in addition to check (without spraying) distributed in the sub-subplots. Each of Se and Si sprayed on the plant leaves three times, at 3, 5 and 15 weeks from cultivation, at a rate of 50 ml per plant for each. All plants received the recommended doses of N, P and K fertilizers according to the Egyptian Ministry of Agriculture, *i.e.* ordinary superphosphate 15.5% P_2O_5 was added in soil before one week of planting and potassium sulphate 48% K_2O was added in soil during the vegetative growth stage (60 days after cultivation) at a rate of 50 kg ha^{-1} for both fertilizers. While N was added in the form of ammonium nitrate 33.5% N at a rate of 100 kg ha^{-1} in two equally separated doses, one at the time of planting and the other during the vegetative growth stage (75 days after cultivation).

The total applied water volumes of 60, 80 and 100% of irrigation water requirement in the experimental area were 1311, 2184 and 2731 m^3/feddan, respectively, during the tested season of 2016/2017 and 1216, 2027 and 2534 m^3/feddan, respectively, during the tested season of 2017/2018. The irrigation water requirement was calculated according to Food and Agricultural Organization (FAO), Penman- Monteith (PM) procedure (Allen *et al*., 1998). The first step was to calculate the potential evapotranspiration as following equation:

$$ET_o = \frac{0.408\Delta\ (R_n - G)\ +\ \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34\ u_2)}$$

Where: ET_o = The daily reference evapotranspiration (mm day^{-1}), Rn = Net radiation at the crop surface (MJ m^{-2} day^{-1}), G = Soil heat flux density (MJ m^{-2} day^{-1}), T = Mean daily air temperature at 2 m height (°C), U_2 = Wind speed at 2 m height (m s^{-1}), e_s = Saturation vapor pressure (kPa), e_a = Actual vapor pressure (kPa), Δ = The slope of vapor pressure curve (kPa $°C^{-1}$), γ = The psychometric constant (kPa $°C^{-1}$).

The second step was to obtain values of irrigation requirements (ET_{crop}) as following (Doorenbos and Pruitt, 1977):

$$IR = ET_o * K_c * 4.2 \quad \ldots\ldots\ldots \quad (m^3/\ feddan/\ day)$$

Where:
IR = Irrigation requirement for crop [m^3/ feddan/ day].
K_c = Crop coefficient [dimensionless].
ET_o = Reference crop evapotranspiration [mm/day].

Measurements

A sample of three plants from each plot were collected after 150 days of planting to assess number of leaves per plant, plant height, leaf fresh and dry weights. The collected plant leaves were sampled and separated into two groups, one was kept fresh to determine proline content according to the method of Troll and Lindsley (1955) modified by Petters *et al*. (1997). The other group was oven dried at 70°C for 48 h, and digested by H_2SO_4/H_2O_2 mixture according to the method described by Chapman and Pratt (1961). Total nitrogen in leaves was determined using Kjeldahl method according to the procedure described by Chapman and Pratt (1961), total phosphorus was determined using Spectrophotometer according to Watanabe and Olsen (1965) and total potassium in plant leaves was determined using Flame photometer as described by Jackson (1958).

The bulbs were harvested at full maturity stage (190 days from the clove sowing) with three samples of each experimental plot, to determine the yield and its component characters, *i.e.* total yield, bulb diameter, bulb neck diameter, average clove weight and number of cloves per bulb. Ascorbic acid (vitamin C) was determined in the fresh bulbs following 2, 6, dichlorophenol indophenol visual titration method (A.O.A.C., 1980). Total soluble solids (TSS) in the juice extracted from ground bulbs expressed as Brix value were determined by digital refractometer (A.O.A.C., 1980). Pungency was determined as pyruvic acid (PA) according to the method described by Ketter and Randle (1998). Protein content was calculated by multiplying the factor 6.25 (protein factor) with total nitrogen content in bulbs. Total nitrogen content in bulbs was determined by Kjeldahl method as outlined by Chapman and Pratt (1961). Total carbohydrates in bulbs were determined as glucose after acid hydrolysis and spectrophotometrically determined (Dubois *et al*., 1956).

Water use efficiency (WUE) was calculated according to FAO (1982) as follows; the ratio of crop yield (y) to the total amount of irrigation water used in the field for the growth season (IR):

$$WUE\ (kg/m^3) = Y\ (kg)/\ IR\ (m^3)$$

Statistical Analysis

The obtained data were then statistically analyzed using SAS software package. The means that were significant were separated using Duncan's multiple range test at P≤0.05 (SAS, 2000).

Results and Discussion

Vegetative Growth Parameters of Garlic

Data in Table 2 show that the studied vegetative growth parameters, *i.e.* number of leaf per plant, plant height, leaves fresh and dry weights, increased significantly with increasing irrigation water level up to full requirements. The cultivar Balady showed significant improvement in all the studied parameters as compared to Sids-40. A foliar spraying of Se showed better influence on the studied parameters than Si, compared to check treatment.

The treatment of 100% irrigation level with Balady cultivar showed the highest significant increase of the studied parameters, followed by 80% irrigation level with Balady cultivar. In general, the treatment of 100% irrigation level with foliar application of Se showed the highest significant increase of the studied parameters, followed by the treatment of 100% irrigation level with Si and the treatment of 80% irrigation level with foliar application of Se. Balady cultivar with foliar spraying of Se gave the highest values of growth parameters, followed by the same cultivar with foliar spraying of Si, compared to the other cultivar and check treatment (without any spraying). Regarding the interaction among all treatments, the treatment of full irrigation with Balady cultivar and spraying Se was the superior in giving the highest values of vegetative growth parameters, followed by spraying Si with the same other treatments, and the treatment of 80% irrigation level with Balady cultivar and spraying Se came in the third order. These results might be expected based on the genetic structure that characterized each garlic cultivar and the differences between each genotype. Selenium encouraged growth of garlic as considered growth regulator, followed by Si with the same role, as compared to check especially under decreasing irrigation water level. Several studies confirmed the role of Se and Si in increasing plant tolerance to face the stress (Astaneh *et al*., 2018; Mustafa *et al*., 2017; Bideshki and Arvin, 2010; Hawrylak-Nowak, 2009; Kong *et al*., 2005; Kuznetsov *et al*., 2003).

Chemical Components of Garlic Leaves

Data in Table 3 show that values of chemical components under investigation, except K, increased with increasing drought stress. It may be due to concentration effect which increase osmotic potential inside plant cells to face the stress. Balady cultivar showed higher values of the studied components in plant leaves than Sids-40 cultivar, due to the genetic differences between them. Selenium increased N, P and proline content of garlic leaves during the two tested seasons, while Si increased K as added by spraying on leaves in the form of potassium silicate. It may be due to their role in encouraging the growth.

Values of N, P and proline increased in Sids-40 more than Balady under drought stress (60% of IR), indication on that the plant was exposed to stress and Sids-40 cultivar was more affected than Balady cultivar. While, these concentrations increased in Balady cultivar than Sids-40 with increasing irrigation water levels. Potassium percent took a trend from first that increased in Balady cultivar with increasing irrigation water level. The interaction between irrigation water levels and foliar spray treatments showed that chemical components under investigation, except K, gave the highest values in check treatment at 60% irrigation level of IR, followed by the effect of Si and Se, respectively. Also, these components were improved by Se and increasing irrigation water level compared to check treatment. In fact, Se have a protective effect against the stress and its bad effect on cells and their vital components (Abul-Soud and Abd-Elrahman, 2016). Regarding the interaction between the studied cultivars and foliar addition of treatments obtained data showed an increase in all the studied parameters due to these additions, with Se higher than Si, and in Balady cultivar more than Sids-40, as compared to check treatment. Regarding the interaction among all the studied treatments, results showed that the treatment of 80% irrigation water with foliar addition of Se in Balady cultivar was better in giving suitable values of chemical components under investigation in garlic leaves. Selenium

Table 2: Effect of irrigation water levels, cultivars and spraying with Se and Si on vegetative growth parameters of garlic during the two tested seasons of 2016/2017 and 2017/2018.

Season		2016/2017				2017/2018			
Treatments		No. of leaves/plant	Plant height (cm)	Leaf fresh weight (g/plant)	Leaf dry weight (g/plant)	No. of leaves/plant	Plant height (cm)	Leaf fresh weight (g/plant)	Leaf dry weight (g/plant)
Irrigation	60% of IR	11.8 C	57.2 C	69.7 B	10.3 C	11.7 B	56.8 C	70.2 C	10.4 C
	80% of IR	12.0 B	59.0 B	72.4 B	11.8 B	12.0 A	59.9 B	74.9 B	11.4 B
	100% of IR	12.2 A	60.2 A	82.9 A	12.2 A	12.1 A	62.1 A	81.1 A	12.0 A
Cultivar	Sids 40	11.6 B	50.7 B	69.9 B	9.80 B	11.7 A	53.5 B	67.5 B	9.31 B
	Balady	12.4 A	67.0 A	80.1 A	13.0 A	12.4 A	65.7 A	83.3 A	13.3 A
Fertilizer	Se	12.4 A	59.6 A	77.7 A	11.3 B	12.5 A	60.9 A	76.4 A	11.7 A
	Si	11.8 B	59.1 A	74.2 B	11.8 A	12.0 B	59.6 B	75.3 AB	11.7 A
	Check	11.7 B	57.8 B	73.1 B	11.2 B	11.5 C	58.3 C	74.5 B	10.5 B
60%	Sids 40	11.3 e	49.6 d	64.3 e	8.93 e	11.4 d	51.1 f	51.1 e	8.77 e
	Balady	12.3 c	64.8 b	75.1 c	11.7 c	12.6 a	62.4 c	72.3 c	12.0 c
80%	Sids 40	11.7 d	50.4 d	68.0 d	10.5 d	12.0 b	53.6 e	66.9 d	9.33 d
	Balady	12.3 b	67.7 a	76.8 bc	13.0 b	12.0 b	66.2 b	83.0 b	13.6 b
100%	Sids 40	11.7 d	52.1 c	77.4 b	10.0 d	11.7 c	55.8 d	67.6 d	9.83 d
	Balady	12.6 a	68.4 a	88.5 a	14.4 a	12.5 a	68.5 a	94.5 a	14.2 a
60%	Se	12.1 b	58.1 d	71.5 d	10.1 h	12.4 a	58.8 d	70.6 f	10.3 f
	Si	11.8 d	56.8 e	69.8 ef	11.0 g	12.0 c	56.8 e	69.4 g	10.8 e
	Check	11.6 f	56.6 e	67.8 f	9.87 i	11.6 e	54.6 f	70.4 f	9.97 g
80%	Se	12.6 a	59.3 c	75.4 c	11.7 ef	12.4 a	61.2 b	75.5 d	12.0 c
	Si	11.7 e	61.1 b	70.8 e	11.9 de	12.1 b	59.3 c	75.0 de	11.9 c
	Check	11.7 e	56.7 e	70.7 e	11.6 f	11.7 e	59.0 c	74.3 e	10.4 f
100%	Se	13.0 a	61.4 a	86.2 a	12.2 b	12.5 a	62.7 a	83.0 a	12.7 a
	Si	11.9 c	59.3 c	81.9 b	12.6 a	11.9 d	62.8 a	81.4 b	12.3 b
	Check	12.0 b	60.1 c	80.8 b	12.0 d	11.8 d	61.0 b	78.7 c	11.0 d

Table 2: Continued.

Season			2016/2017				2017/2018			
Treatments			No. of leaves/plant	Plant height (cm)	Leaf fresh weight (g/plant)	Leaf dry weight (g/plant)	No. of leaves/plant	Plant height (cm)	Leaf fresh weight (g/plant)	Leaf dry weight (g/plant)
Sids 40	Se		12.0 c	51.7 c	72.8 c	10.4 c	12.1 b	54.5 c	65.4 e	9.33 de
	Si		11.7 d	50.9 d	66.6 d	9.98 c	11.7 c	53.9 c	65.5 e	10.0 d
	Check		11.3 d	49.4 e	70.2 c	9.11 d	11.2 d	52.1 d	71.7 d	8.57 e
Balady	Se		12.8 a	67.5 a	82.6 a	12.2 b	12.9 a	67.3 a	87.4 a	14.0 a
	Si		12.3 b	67.2 a	81.7 a	13.6 a	12.3 b	65.3 b	85.1 b	13.4 b
	Check		12.2 b	66.2 b	76.1 b	13.2 a	12.1 b	64.5 b	77.3 c	12.4 c
60%	Sids 40	Se	11.8 g	50.3 j	67.2 k	9.21 l	11.9 h	52.8 j	64.6 l	8.45 m
		Si	11.4 j	49.7 kl	63.4 l	9.52 k	11.4 k	51.5 k	68.2 j	9.54 k
		Check	10.8 l	48.7 m	62.2 m	8.05 m	10.6 l	49.1 l	71.3 g	8.32 m
	Balady	Se	12.3 c	65.8 d	75.8 f	10.9 h	12.9 a	64.9 c	76.6 e	12.2 f
		Si	12.3 c	64.0 f	76.1 ef	12.4 e	12.5 b	62.0 d	70.7 h	12.2 f
		Check	12.4 b	64.6 e	73.4 h	11.9 f	12.4 c	60.2 e	69.6 i	11.6 g
80%	Sids 40	Se	12.1 e	51.3 j	70.8 ij	11.7 fg	12.5 b	54.7 h	65.3 kl	9.72 j
		Si	11.2 k	50.4 j	61.7 m	10.2 j	12.0 fg	52.9 j	62.9 m	9.92 i
		Check	11.6 h	49.4 l	71.4 i	9.59 k	11.5 b	53.3 ij	72.5 f	8.34 m
	Balady	Se	13.1 a	70.0 b	84.5 c	14.3 b	12.2 e	68.0 b	86.2 cd	14.3 b
		Si	12.2 d	71.8 a	80.0 d	13.6 d	12.1 f	65.6 c	87.1 c	13.9 c
		Check	11.7 g	64.0 f	70.2 j	13.7 d	11.6 i	65.3 c	76.1 e	12.5 e
100%	Sids 40	Se	12.1 f	53.3 g	80.5 d	10.2 j	12.0 g	56.0 g	66.3 k	9.83 ij
		Si	11.5 i	52.7 h	74.7 g	10.3 i	11.5 j	57.3 f	65.3 kl	10.6 h
		Check	11.9 h	50.2 jk	77.0 e	9.69 k	11.5 k	54.0 hi	71.2 gh	9.04 l
	Balady	Se	13.1 a	69.4 b	91.9 a	14.2 c	13.0 a	69.3 a	99.8 a	15.6 a
		Si	12.3 c	65.8 d	89.1 b	14.9 a	12.3 a	68.2 b	97.6 b	14.0 c
		Check	12.4 b	67.3 c	80.1 d	11.6 g	12.4 g	67.6 b	85.7 d	13.0 d

Table 3: Effect of irrigation water levels, cultivars and spraying with Se and Si on N, P, K and proline content of garlic leaves during the two tested seasons of 2016/2017 and 2017/2018.

Season		2016/2017				2017/2018			
Treatments		N (%)	P (%)	K (%)	Proline (mg/g F.W)	N (%)	P (%)	K (%)	Proline (mg/g F.W)
Irrigation	60% of IR	2.46 A	0.48 A	1.33 C	45.2 A	2.35 A	0.46 A	1.26 C	43.7 A
	80% of IR	2.26 B	0.47 A	1.50 B	43.7 B	2.24 A	0.45 A	1.38 B	42.3 B
	100% of IR	1.77 C	0.35 B	1.61 A	42.6 C	1.56 B	0.34 B	1.59 A	41.8 C
Cultivar	Sids 40	2.06 B	0.39 B	1.28 B	43.5 A	1.96 B	0.38 B	1.31 B	42.2 B
	Balady	2.27 A	0.47 A	1.68 A	44.2 A	2.14 A	0.46 A	1.50 A	42.9 A
Fertilizer	Se	2.29 A	0.46 A	1.49 B	48.9 A	2.27 A	0.44 B	1.37 B	47.2 A
	Si	2.16 B	0.46 A	1.65 A	46.6 B	2.06 B	0.45 A	1.63 A	45.7 B
	Check	2.03 C	0.37 B	1.30 C	36.0 C	1.82 C	0.36 C	1.23 C	34.7 C
60%	Sids 40	2.63 a	0.58 a	1.08 d	48.4 a	2.48 a	0.56 a	1.17 d	46.9 a
	Balady	2.28 b	0.37 d	1.57 b	46.7 b	2.13 c	0.48 b	1.35 c	44.8 b
80%	Sids 40	2.25 b	0.45 c	1.33 c	42.0 d	2.22 c	0.36 c	1.31 d	43.5 c
	Balady	2.26 b	0.50 b	1.67 b	43.8 c	2.35 b	0.43 b	1.44 b	40.4 d
100%	Sids 40	1.63 d	0.35 de	1.42 c	40.7 e	1.31 e	0.33 c	1.47 b	39.8 e
	Balady	1.91 c	0.34 e	1.80 a	41.3 de	1.81 d	0.34 c	1.71 a	40.0 de
60%	Se	2.41 b	0.38 c	1.43 e	45.0 d	2.19 b	0.36 c	1.22 def	42.7 d
	Si	2.42 b	0.42 b	1.26 g	49.5 c	2.39 a	0.40 b	1.18 ef	49.1 c
	Check	2.54 a	0.63 a	1.21 h	57.0 a	2.46 a	0.60 a	1.17 f	56.4 a
80%	Se	2.38 b	0.66 a	1.62 c	55.4 b	2.43 a	0.63 a	1.64 b	52.6 b
	Si	2.26 c	0.41 b	1.44 e	41.8 ef	2.25 b	0.40 b	1.29 d	41.6 de
	Check	2.12 d	0.35 d	1.33 f	41.0 f	2.00 c	0.33 d	1.27 df	40.0 de
100%	Se	2.05 d	0.42 b	1.79 a	41.9 e	1.88 d	0.41 b	1.81 a	39.2 e
	Si	1.69 e	0.33 d	1.71 b	34.0 g	1.54 e	0.31 de	1.67 b	32.6 f
	Check	1.56 f	0.30 e	1.51 d	28.8 h	1.27 f	0.29 e	1.42 c	28.9 g

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Table 3: Continued.

Season			2016/2017				2017/2018			
Treatments			N (%)	P (%)	K (%)	Proline (mg/g F.W)	N (%)	P (%)	K (%)	Proline (mg/g F.W)
Sids 40		Se	2.22 b	0.44 c	1.46 b	46.8 bc	1.99 c	0.43 b	1.36 cd	44.7 c
		Si	2.02 d	0.38 d	1.45 b	45.2 c	1.85 d	0.37 cd	1.31 d	43.6 c
		Check	1.92 e	0.35 e	1.14 c	34.2 e	1.76 e	0.34 d	1.10 e	33.2 e
Balady		Se	2.35 a	0.53 a	1.84 a	51.0 a	2.42 a	0.51 a	1.72 a	49.8 a
		Si	2.30 a	0.49 b	1.75 a	48.0 b	2.13 b	0.48 a	1.54 b	47.8 b
		Check	2.14 c	0.40 d	1.23 c	37.7 d	2.12 b	0.38 c	1.43 c	36.2 d
60%	Sids 40	Se	2.48 c	0.50 c	1.07 k	54.0 c	2.46 c	0.45 c	1.19 jk	51.3 d
		Si	2.63 b	0.80 b	1.14 j	57.5 b	2.61 b	0.42 d	1.15 k	58.4 b
		Check	2.79 a	0.83 a	1.03 l	63.8 a	2.69 a	0.81 a	1.05 m	64.9 a
	Balady	Se	2.37 de	0.44 de	1.39 h	47.4 e	2.20 g	0.44 cd	1.34 h	45.0 f
		Si	2.36 e	0.43 e	1.59 g	50.2 d	2.26 ef	0.49 b	1.29 i	47.8 e
		Check	2.41 d	0.46 d	1.14 j	56.8 b	2.31 d	0.77 a	1.10 l	54.0 c
80%	Sids 40	Se	2.19 h	0.37 fg	1.25 i	41.8 h	2.09 h	0.32 g	1.33 h	40.3 hi
		Si	2.15 h	0.36 gh	1.53 g	42.2 gh	1.89 i	0.30 h	1.31 hi	39.6 ij
		Check	2.09 i	0.34 hi	1.26 i	41.5 h	1.45 l	0.29 hi	1.22 j	25.3 m
	Balady	Se	2.28 f	0.43 e	1.59 g	45.3 f	2.30 de	0.37 e	1.68 c	45.8 f
		Si	2.26 g	0.39 f	1.38 h	42.6 g	2.33 fg	0.35 ef	1.52 f	41.0 h
		Check	2.25 g	0.38 f	1.30 h	41.6 h	1.73 j	0.28 ij	1.40 g	37.3 k
100%	Sids 40	Se	1.64 k	0.33 i	1.84 c	32.2 k	2.12 h	0.37 e	1.70 c	39.9 ij
		Si	1.52 l	0.31 ij	1.78 d	25.5 l	1.50 k	0.34 f	1.61 d	32.6 l
		Check	1.48 l	0.30 j	1.64 f	23.0 m	1.09 h	0.27 j	1.56 e	25.2 m
	Balady	Se	2.21 h	0.51 c	1.94 a	45.0 f	2.31 de	0.48 b	1.90 a	43.0 g
		Si	1.90 j	0.30 j	1.87 b	40.2 i	2.23 fg	0.44 cd	1.82 b	40.3 hi
		Check	1.86 j	0.27 k	1.74 e	38.3 j	1.34 m	0.34 f	1.71 c	37.4 k

has the ability to regulate the water status of plants under conditions of drought, by increasing the water uptake capacity of the root system (Kuznetsov *et al*., 2003).

Yield Quality Parameters

Data in Table 4 reveal that all parameters under investigation, *i.e.* total yield, bulb and bulb neck diameters, average clove weight and number of cloves per bulb, increased with increasing irrigation water level up to full irrigation. Balady cultivar gave higher values than Sids-40, and this may be due to the genetic variations. Selenium showed better effect in increasing the studied parameters, followed by Si, compared to the check treatment. These results might be a reflection to the obtained results on plant growth (Table 2) and the chemical composition (Table 3).

Regarding the interaction between irrigation water levels with the studied cultivars, results showed that Balady cultivar irrigated with full requirements gave the highest values of the studied parameters, followed by the same cultivar that irrigated with 80% of IR. Regarding the interaction between irrigation water levels with foliar sprays of Se and Si, results showed that spraying Se on garlic leaves caused significant increase in all the studied parameters especially under full irrigation, followed by the effect of Si, and Se with irrigation by 80% of IR came in the third order. These results were true in the two studied seasons. Regarding the interaction between the studied cultivars and foliar spraying of Se and Si, results showed that Se increased yield parameters of Balady cultivar more than Sids-40, followed by the effect of Si on the same cultivar as compared to the other cultivar. Regarding the interaction among the studied treatments, results showed that foliar spraying of Se on Balady cultivar irrigated with full requirements gave the highest yield of the studied parameters, followed by the effect of Si, and in general, the effect of Se followed by Si, compared to the check treatment enhanced the studied parameters under irrigation with 80% of IR, that came in the third order. Obtained results showed that minimizing irrigation level to 80% of IR decreased garlic total yield of Balady cultivar in check treatment by 17.6%, and to 60% of IR by 31.5%, in the first season. Balady cultivar sprayed with Se decreased total yield by 11.5% under irrigation with 80% of IR, and by 16.4% under irrigation with 60% of IR, in the first season. While, Si decreased total yield in Balady cultivar by 13.6 and 19.1% under irrigation with 80 and 60% of IR, respectively, during the first season. Regarding Sids-40 cultivar, the check treatment decreased total yield in the first season by 18.7 and 33.5% under irrigation with 80 and 60% of IR, respectively. Selenium decreased yield by 13.9 and 17.3% under irrigation with 80 and 60% of IR, respectively. Silicon decreased total yield by 14.0 and 26.7% under irrigation with 80 and 60% of IR, respectively. Similar trend was found in the second season. These findings are in a good agreement with those obtained by Mustafa *et al*. (2017); Abd-Elrazzak and El-Sharkawy (2013).

In other words, Se followed by Si increased the total yield under water stress conditions compared to the check treatment. This may be due to increasing the tested vegetative growth parameters (Table 2) and improving the N, P and K percent as well as raising the proline concentration in garlic leaves compared to check treatment (Table 3).

Chemical Components of Garlic Bulb

Ascorbic acid increased with increasing the availability of good environment around the plant, such as irrigation water level up to full requirements, spraying Se and Si that encourage the growth, and selecting a suitable cultivar like cv. Balady (Table 5). Regarding the interaction between irrigation water levels and the studied cultivars, Balady cultivar that irrigated with full requirements gave the highest value, followed by Sids-40 cultivar that irrigated with the same level. Regarding the interaction between the irrigation water levels and foliar sprays, the treatments of Se and irrigation with full requirements gave the highest value, followed by Si with the same irrigation level. Regarding the interaction between the studied cultivars and foliar sprays, the treatment of spraying Se on Balady cultivar gave the highest value, followed by the treatment of Si sprayed on the same cultivar. Regarding the interaction among all treatments, the treatment of Se sprayed on Balady cultivar that irrigated with full requirements gave the highest value, followed by Si under the same conditions. Ascorbic acid, generally known as vitamin C is present in all fresh vegetables and fruits,

Table 4: Effect of irrigation water levels, cultivars and spraying with Se and Si on yield quality of garlic during the two tested seasons of 2016/2017 and 2017/2018.

Season		**2016/2017**					**2017/2018**				
Treatments		**Total yield (ton/fed)**	**Bulb diameter (cm)**	**Neck diameter (cm)**	**Average clove weight (g)**	**Number of cloves per bulb**	**Total yield (ton/fed)**	**Bulb diameter (cm)**	**Neck diameter (cm)**	**Average clove weight (g)**	**Number of cloves per bulb**
Irrigation	**60% of IR**	6.08 B	3.01 C	1.75 B	2.09 C	14.6 C	5.95 C	3.55 B	1.73 B	2.13 C	13.2 B
	80% of IR	6.92 A	3.70 B	1.86 A	2.49 B	17.0 B	7.07 B	3.97 A	1.83 A	2.72 B	18.2 A
	100% of IR	7.44 A	4.88 A	1.89 A	3.01 A	19.3 A	7.53 A	4.03 A	1.91 A	3.16 A	19.9 A
Cultivar	**Sids 40**	4.37 B	3.39 B	1.78 B	2.08 B	14.8 B	4.53 B	2.78 B	1.81 A	2.30 B	13.9 B
	Balady	9.25 A	4.34 A	1.89 A	2.98 A	19.1 A	9.17 A	4.92 A	1.85 A	3.05 A	20.4 A
Fertilizer	**Se**	7.33 A	4.09 A	1.85 A	2.77 A	17.8 A	7.55 A	4.18 A	1.86 A	2.93 A	18.0 A
	Si	6.92 A	3.85 B	1.87 A	2.61 A	16.3 B	6.99 B	3.64 B	1.85 A	2.58 B	18.0 A
	Check	6.19 B	3.65 C	1.78 B	2.20 B	16.8 B	6.01 C	3.73 B	1.76 A	2.51 B	15.5 B
60%	**Sids 40**	4.05 e	2.72 e	1.71 d	1.63 d	13.1 e	4.03 e	2.68 c	1.67 d	1.40 e	11.6 d
	Balady	8.11 c	3.31 c	1.81 c	2.55 b	16.1 c	7.86 b	4.41 b	1.78 c	2.57 cd	14.9 c
80%	**Sids 40**	4.37 de	3.11 d	1.81 c	2.04 c	14.7 d	4.50 d	2.73 c	1.83 b	2.54 d	10.4 d
	Balady	9.46 b	4.29 b	1.92 b	2.93 b	19.3 b	9.65 a	5.20 a	1.84 b	2.91 b	26.2 a
100%	**Sids 40**	4.69 d	4.34 b	1.83 c	2.56 b	16.6 c	5.07 c	2.44 d	1.93 a	2.65 c	16.4 c
	Balady	10.2 a	5.42 a	1.95 a	3.46 a	22.0 a	9.99 a	5.15 a	1.93 a	3.67 a	20.0 b
60%	**Se**	6.81 cd	3.10 f	1.81 e	2.33 d	14.8 de	6.35 e	4.09 bc	1.77 e	2.54 e	13.3 f
	Si	6.46 e	2.99 f	1.76 f	2.13 e	14.7 ef	6.57 d	3.42 f	1.75 e	2.02 f	13.2 f
	Check	4.97 f	2.95 f	1.69 g	1.81 f	14.4 f	4.93 f	3.12 g	1.65 f	1.83 g	13.0 g
80%	**Se**	7.31 b	3.94 d	1.88 c	2.66 b	18.1 c	7.73 b	4.17 b	1.86 c	2.91 c	20.9 b
	Si	6.53 e	3.67 e	1.86 d	2.48 c	17.8 c	6.75 c	4.04 c	1.87 c	2.72 d	19.9 c
	Check	6.68 d	3.50 e	1.84 d	2.32 d	15.1 d	6.35 e	3.59 e	1.78 e	2.54 e	15.3 e
100%	**Se**	7.86 a	5.21 a	1.91 b	3.32 a	20.7 a	8.58 a	4.28 a	1.96 a	3.33 a	23.6 a
	Si	7.77 a	4.90 b	1.96 a	3.24 a	19.3 b	7.65 b	4.03 c	1.92 b	3.16 ab	17.8 d
	Check	6.91 c	4.52 c	1.81 e	2.47 c	18.1 c	6.74 c	3.91 d	1.86 c	3.00 bc	17.1 d

Table 4: Continued.

Season			2016/2017					2017/2018				
Treatments			Total yield (ton/fed)	Bulb diameter (cm)	Neck diameter (cm)	Average clove weight (g)	Number of cloves per bulb	Total yield (ton/fed)	Bulb diameter (cm)	Neck diameter (cm)	Average clove weight (g)	Number of cloves per bulb
Sids 40		Se	4.91 c	3.50 c	1.81 c	2.09 d	16.3 c	5.07 c	3.17 c	1.86 a	2.36 d	15.7 d
		Si	3.85 d	3.59 c	1.84 b	2.13 d	14.8 d	4.26 d	2.64 d	1.83 b	2.34 d	13.8 e
		Check	4.35 cd	3.08 d	1.69 d	2.01 d	13.4 e	4.27 d	2.54 d	1.71 d	2.19 e	12.1 f
Balady		Se	9.74 a	4.67 a	1.91 a	3.46 a	19.4 a	10.0 a	5.20 a	1.86 a	3.51 a	22.1 a
		Si	9.99 a	4.23 b	1.89 a	3.10 b	19.3 ab	9.72 a	4.82 b	1.87 a	2.97 b	20.3 b
		Check	8.03 b	4.12 b	1.88 a	2.39 c	18.7 b	7.74 b	4.74 b	1.82 c	2.67 c	18.8 c
60%	Sids 40	Se	4.22 k	2.91 j	1.78 ij	1.76 k	13.6 j	4.24 gh	3.11 j	1.74 i	1.87 k	13.0 j
		Si	3.51 l	2.74 k	1.71 k	1.57 l	13.2 k	3.95 i	2.76 l	1.68 k	1.63 l	11.5 l
		Check	2.78 n	2.49 l	1.61 l	1.55 l	12.5 l	3.20 j	2.04 n	1.58 l	1.59 l	10.4 m
	Balady	Se	9.45 d	3.46 g	1.84 g	3.11 b	16.3 f	9.19 de	4.90 f	1.81 h	3.20 c	16.3 gh
		Si	8.58 f	3.18 hi	1.81 h	2.69 def	16.1 fg	8.45 f	4.21 g	1.82 g	2.41 h	14.8 i
		Check	6.30 g	3.08 i	1.77 ij	1.86 jk	15.8 g	5.95 h	4.02 h	1.72 j	2.07 j	13.5 j
80%	Sids 40	Se	4.39 j	3.40 g	1.87 f	2.13 h	15.7 h	4.95 e	3.13 j	1.89 d	2.73 fg	17.5 f
		Si	4.12 k	3.24 h	1.78 i	2.05 i	15.2 i	4.37 g	2.91 k	1.88 e	2.43 h	12.1 k
		Check	3.40 m	2.92 j	1.76 j	1.95 j	13.2 k	4.19 h	2.17 m	1.73 j	2.21 i	11.4 l
	Balady	Se	10.0 c	4.65 c	1.96 b	3.20 b	21.0 c	10.5 c	5.14 cd	1.96 a	3.26 c	24.4 b
		Si	9.16 e	4.16 e	1.91 de	2.90 c	19.8 d	9.31 d	5.17 bc	1.86 f	2.87 e	21.0 d
		Check	7.58 f	4.07 e	1.89 e	2.69 de	16.9 e	8.15 g	5.00 e	1.82 g	2.76 f	16.2 h
100%	Sids 40	Se	5.10 h	4.68 c	1.93 c	2.77 d	20.0 d	6.02 h	3.26 i	1.91 c	3.09 d	18.0 f
		Si	4.79 i	4.51 d	1.84 g	2.59 f	16.2 f	4.65 f	2.96 k	1.82 g	2.68 g	16.8 g
		Check	4.18 k	3.82 f	1.71 k	2.31 g	13.8 j	4.54 f	2.68 l	1.82 g	2.27 i	14.6 i
	Balady	Se	11.3 a	5.91 a	1.98 a	4.06 a	24.7 a	11.1 a	5.44 a	1.97 a	4.23 a	30.1 a
		Si	10.6 b	5.22 b	1.97 a	3.70 b	21.4 b	10.7 b	5.21 b	1.93 b	3.73 b	23.0 c
		Check	9.20 e	5.11 b	1.91 d	2.62 ef	20.0 d	9.12 e	5.09 d	1.91 c	3.06 d	19.2 e

Table 5: Effect of irrigation water levels, cultivars and spraying with Se and Si on garlic bulb content of some components that affect the quality during the two tested seasons of 2016/2017 and 2017/2018.

Season		2016/2017					2017/2018				
Treatments		Vitamin C (mg/100 g fresh bulb)	TSS (Brix)	Pungency (µM PA/g fresh bulb)	Protein (%)	Total carbohydrate (%)	Vitamin C (mg/100 g fresh bulb)	TSS (Brix)	Pungency (µM PA/g fresh bulb)	Protein (%)	Total carbohydrate (%)
Irrigation	60% of IR	10.6 C	30.0 A	28.6 C	14.9 A	22.3 B	9.83 B	28.8 A	28.9 B	13.9 A	19.8 B
	80% of IR	11.7 B	28.2 B	31.4 B	13.0 B	22.4 B	10.4 B	27.8 B	34.0 A	12.6 B	21.6 B
	100% of IR	13.4 A	27.2 C	33.1 A	10.4 C	24.4 A	12.8 A	26.4 C	34.4 A	11.7 C	23.6 A
Cultivar	Sids 40	10.7 B	28.8 A	29.6 B	11.9 B	20.3 B	10.4 B	28.0 A	31.7 B	11.6 B	19.8 B
	Balady	13.0 A	28.2 A	32.5 A	13.7 A	25.8 A	11.6 A	27.3 B	33.1 A	13.8 A	23.5 A
Fertilizer	Se	12.9 A	27.2 C	32.2 A	14.2 A	25.3 A	12.6 A	26.6 B	34.8 A	14.3 A	24.9 A
	Si	11.6 B	28.9 B	30.6 B	12.2 B	23.2 B	11.2 B	28.1 A	31.7 B	12.2 B	21.7 B
	Check	11.1 B	29.3 A	30.2 B	11.9 B	20.7 C	9.18 C	28.2 A	30.8 C	11.6 B	18.3 C
60%	Sids 40	10.3 e	30.2 a	26.6 e	15.8 a	19.3 d	9.72 e	29.1 a	27.3 d	14.9 a	18.6 d
	Balady	10.4 de	29.7 b	30.7 d	14.0 b	20.1 d	10.0 e	28.6 b	30.5 c	13.9 b	21.0 c
80%	Sids 40	10.7 d	29.0 c	30.6 d	12.5 d	21.4 c	10.2 d	28.7 b	34.0 a	11.4 d	19.1 d
	Balady	11.5 c	27.5 d	31.6 c	13.4 c	25.2 b	10.5 c	26.8 c	34.4 a	12.8 c	21.6 c
100%	Sids 40	13.1 b	27.7 d	32.1 b	9.11 f	24.8 b	11.1 b	26.5 c	33.5 b	10.7 d	24.0 b
	Balady	15.2 a	26.7 e	34.5 a	11.8 e	27.4 a	14.4 a	25.9 d	34.5 a	12.7 c	25.6 a
60%	Se	12.0 d	28.5 d	31.7 cd	15.1 b	22.7 d	8.73 e	28.2 c	33.4 d	13.5 c	19.5 e
	Si	8.48 f	29.6 b	28.4 f	15.2 b	19.9 f	7.38 f	28.9 b	32.8 f	14.2 b	18.9 e
	Check	7.11 g	33.3 a	27.1 g	16.7 a	19.5 f	6.83 g	31.7 a	26.0 h	15.9 a	16.6 f
80%	Se	14.2 b	26.7 f	31.8 c	12.9 c	24.8 c	14.2 b	25.9 f	33.9 c	12.8 d	24.9 b
	Si	12.4 d	27.1 e	31.6 d	11.9 d	22.5 d	11.4 d	26.5 e	33.3 de	12.0 e	20.8 d
	Check	9.08 e	29.5 b	30.6 e	11.0 e	22.1 e	8.34 e	28.6 bc	27.8 g	11.7 f	19.4 e
100%	Se	16.0 a	26.1 g	34.7 a	11.7 d	25.9 a	15.3 a	25.2 g	36.2 a	12.2 e	26.5 a
	Si	14.0 b	26.7 f	32.7 b	10.6 e	25.4 b	14.1 b	26.6 e	35.3 b	11.6 f	25.0 b
	Check	13.5 c	28.9 c	30.4 e	9.76 f	24.6 c	12.7 c	27.4 d	33.1 e	10.7 g	23.3 c

Table 5: Continued.

Season			2016/2017					2017/2018				
Treatment			Vitamin C (mg/100 g fresh bulb)	TSS (Brix)	Pungency (µM PA/g fresh bulb)	Protein (%)	Total carbohydrate (%)	Vitamin C (mg/100 g fresh bulb)	TSS (Brix)	Pungency (µM PA/g fresh bulb)	Protein (%)	Total carbohydrate (%)
	Sids 40	Se	12.7 b	26.5 e	31.1 c	13.2 b	22.6 c	11.3 b	25.7 e	32.6 c	13.0 b	22.5 b
	Sids 40	Si	11.4 d	29.2 b	29.4 d	12.6 c	20.1 d	10.7 d	28.4 b	31.4 d	12.8 b	20.5 c
	Sids 40	Check	8.09 d	30.7 a	28.8 d	11.2 d	18.8 e	7.64 e	30.5 a	30.3 e	10.5 d	16.8 d
	Balady	Se	14.2 a	27.0 d	34.0 a	15.2 a	28.6 a	12.9 a	26.0 e	35.4 a	15.4 a	27.3 a
	Balady	Si	13.1 b	29.4 b	32.3 b	13.3 b	26.3 b	12.3 b	27.4 d	34.1 b	13.2 b	23.4 b
	Balady	Check	11.8 c	28.0 c	30.5 c	11.3 d	21.9 c	11.1 c	27.9 c	30.8 e	11.1 c	19.9 c
60%	Sids 40	Se	7.87 l	31.6 c	29.1 j	14.9 d	19.5 m	7.50 kl	29.9 d	29.3 i	13.2 e	17.8 k
60%	Sids 40	Si	7.26 m	32.4 b	28.5 k	16.9 b	18.7 n	7.27 lm	31.7 ab	26.3 k	15.3 b	16.9 l
60%	Sids 40	Check	6.97 m	34.1 a	25.1 m	17.6 a	17.6 o	6.65 n	31.8 a	23.7 l	16.9 a	15.4 m
60%	Balady	Se	9.28 j	28.6 f	31.6 g	13.0 f	21.2 jk	8.08 j	29.5 e	32.4 g	13.1 e	21.0 g
60%	Balady	Si	7.90 l	30.4 e	29.3 j	13.5 e	21.0 k	7.58 k	31.3 c	31.8 h	14.1 d	20.8 h
60%	Balady	Check	7.69 l	31.1 d	26.1 l	15.8 c	19.3 m	7.00 m	31.7 b	28.3 j	15.0 c	17.6 k
80%	Sids 40	Se	13.3 g	28.7 f	32.3 e	12.4 g	22.1 h	9.38 h	27.1 j	33.6 e	13.1 e	22.4 f
80%	Sids 40	Si	9.69 i	30.9 d	30.8 h	11.4 i	21.5 ij	8.95 i	27.3 ij	33.5 ef	11.7 g	21.2 g
80%	Sids 40	Check	8.47 k	31.3 cd	30.2 i	12.2 h	20.0 l	7.74 k	29.3 f	32.6 g	12.0 f	18.1 j
80%	Balady	Se	15.5 d	25.7 i	33.0 c	15.6 c	26.1 d	14.9 c	25.4 k	35.9 b	14.8 c	23.7 d
80%	Balady	Si	13.7 f	28.0 g	32.1 ef	12.9 f	24.7 f	13.0 f	27.3 ij	34.1 d	13.1 e	22.9 e
80%	Balady	Check	12.9 h	28.9 f	30.9 h	12.4 g	21.6 i	12.7 g	28.5 g	33.3 f	12.1 f	19.3 i
100%	Sids 40	Se	16.0 c	22.5 k	32.8 cd	10.7 j	28.1 c	15.3 b	21.6 n	34.7 c	11.4 h	26.8 c
100%	Sids 40	Si	16.1 c	26.2 h	32.6 d	8.96 l	28.2 c	13.7 e	24.5 l	34.4 d	10.3 k	23.9 d
100%	Sids 40	Check	13.5 fg	28.1 g	31.0 h	8.82 l	22.6 g	12.8 fg	28.2 h	33.5 ef	9.24 l	21.2 g
100%	Balady	Se	16.8 a	24.1 j	36.7 a	12.3 gh	29.2 a	15.7 a	23.1 m	36.6 a	11.4 h	29.3 a
100%	Balady	Si	16.4 b	24.5 j	34.4 b	11.3 i	28.6 b	15.3 b	24.7 l	35.9 b	11.2 i	28.8 b
100%	Balady	Check	14.8 e	25.7 i	31.9 f	9.55 k	25.1 e	14.5 d	24.8 l	33.8 e	10.9 j	22.7 e

increasing content of this component is a good indicator on plant healthy and its riches in nutritional value (Mustafa *et al*., 2017).

Total soluble solids (TSS) content as an important indicator of quality and how the plant expose to the stress, were estimated as presented in Table 5. It took an opposite trend as compared to vitamin C content, as it was decreased with increasing irrigation water level, increased in Sids-40 cultivar and the check treatment gave the highest value as compared to spraying Si and Se, respectively. The decreased content with increasing irrigation water level may be due to dilution effect. It increased in Sids-40 as indication on increasing plant sensitivity and affected by the stress. The check treatment gave the highest value as indication on the effect of Se and Si to increase plant tolerance to face the stress, so, giving lower values compared to check. Regarding the interaction between the studied cultivars that irrigated with the studied calculated levels of IR, the treatment of Sids-40 that irrigated with 60% of IR gave the highest value of TSS. Regarding the interaction between the irrigation water level and foliar sprays, the check treatment that irrigated with 60% of IR gave the highest value. Regarding the interaction between the studied cultivars and their foliar additions, Sids-40 without any sprays (check) gave the highest value. Regarding the interaction among all the studied treatments, Sids-40 without any spray and irrigated with 60% of IR gave the highest value.

As for pungency, it took similar trend of that obtained in vitamin C content. Balady cultivar sprayed with Se and that irrigated with full requirements gave the highest value of pyruvic acid content. Pungency develops when allianase enzyme interacts with precursors collectively known as S-allyl cysteine sulfoxide, and expressed as pyruvic acid (Magray, 2015). It is an indicator of well quality of the bulb and its taste.

As for protein, it took similar trend to that obtained in bulb TSS content. Sids-40 without any spray and irrigated with 60% of IR gave the highest content of protein. Protein content related positively with proline and N contents in garlic leaves, as shown in Tables 3 and 5. It may be due to the way to increase osmotic potential inside the plant cell under drought stress.

Total carbohydrates content in bulb took similar trend to that obtained in vitamin C and pungency, as shown in Table 5. Increasing carbohydrates content in bulb indication of high rate of photosynthesis, normal rate of respiration, abundant supply of carbohydrates available of growth and excess of dry matter accumulation which reflects the best yield and quality (Mustafa *et al*., 2017). Balady cultivar sprayed with Se and supplied with full irrigation requirements gave the highest value of total carbohydrate content in bulb. These findings are in agreement in both tested seasons. The obtained results agree with those obtained by Magray (2015); Ahmed *et al*. (2009).

Water Use Efficiency (WUE)

Data in Table 6 show the calculated values of WUE of garlic plants under different irrigation water levels, cultivars and fertilizers during the two studied seasons of 2016 and 2017. Obtained results showed that Se foliar application gave the highest values 3.81 and 4.14 in the first and second seasons respectively. Regarding the cultivars, Balady cultivar gave the highest values 4.75 and 5.05 for first and second seasons respectively. Regarding the irrigation treatments, the treatment of 60% from IR gave the highest values 4.64 and 4.89 in the first and second seasons respectively, without significant effect with the irrigation treatment 80% of IR. Data revealed that the treatment of 60% irrigation level combined with cultivar Balady and Si foliar application gave the highest values (7.21 and 7.55) in the first and second seasons, respectively, compared to the other treatments. On the other hand, the highest WUE values for Sids-40 cultivar when was sprayed with Se under 60% irrigation water level from IR, compared to the other tested treatments. These results agree with those obtained by Mustafa *et al*. (2017); Abadi *et al*. (2010) on garlic and water saving.

Table 6: Water use efficiency of garlic plants under different irrigation water levels, cultivar and fertilizer types in the two seasons of 2016 and 2017.

Irrigation level	Fertilizer / Cultivar	Se	Si	Check	Mean
			Season 2016/2017		
60%	**Sids 40**	3.85 f	2.65 h	2.78 h	**3.09 d**
	Balady	6.54 b	7.21 a	4.80 c	**6.19 a**
Mean		**5.20 a**	**4.93 a**	**3.79 b**	**4.64 A**
80%	**Sids 40**	2.10 ij	1.78 k	2.12 i	**2.00 e**
	Balady	4.59 c	4.19 de	4.21 d	**4.33 b**
Mean		**3.35 c**	**2.99 de**	**3.16 d**	**3.17 A**
100%	**Sids 40**	1.87 jk	1.53 l	1.75 kl	**1.72 e**
	Balady	3.89 f	4.16 e	3.14 g	**3.73 c**
Mean		**2.88 e**	**2.84 e**	**2.45 f**	**2.72 B**
	Sids 40	**2.61 c**	**1.99 d**	**2.22 d**	**2.27 B**
	Balady	**5.01 a**	**5.19 a**	**4.05 b**	**4.75 A**
		3.81 A	**3.59 A**	**3.13 B**	
			Season 2017/2018		
60%	**Sids 40**	3.49 g	3.25 h	3.20 h	**3.31 d**
	Balady	6.94 b	7.55 a	4.89 d	**6.46 a**
Mean		**5.22 a**	**5.40 a**	**4.05 b**	**4.89 A**
80%	**Sids 40**	2.44 i	2.07 k	2.16 jk	**2.22 e**
	Balady	5.19 c	4.59 e	4.50 e	**4.76 b**
Mean		**3.81 c**	**3.33 d**	**3.33 d**	**3.49 A**
100%	**Sids 40**	2.38 ij	1.83 l	1.79 l	**2.00 e**
	Balady	4.40 ef	4.21 f	3.22 h	**3.94 c**
Mean		**3.39 d**	**3.02 e**	**2.50 f**	**2.97 B**
	Sids 40	**2.77 c**	**2.38 d**	**2.38 d**	**2.51 B**
	Balady	**5.51 a**	**5.45 a**	**4.20 b**	**5.05 A**
		4.14 A	**3.92 A**	**3.29 B**	

Conclusion

It could be concluded that garlic as an important vegetable crop for its richness in many essential nutrients and benefit components, and for exportation; also due to water scarcity, here in this study we tried to suggest a tool to enhance yield with Se and Si foliar additions under drought conditions. Of course full irrigation gave better growth and yield of garlic, but the treatment of 80% irrigation level with foliar application of Se followed by Si was not the worse. Balady cultivar showed vigor growth and better yield, may be due to its suitability to grow under Egyptian conditions more than Sids-40 cultivar. So, it's recommended to apply foliar application of Se to garlic cultivars under drought stress conditions to give better yield and quality.

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