EFFECT OF WATER QUANTITY AND FOLIAR SPRAY WITH SOME SAFELY SUBSTANCES ON GROWTH, YIELD QUALITY AND STORABILITY OF GARLIC
1- GROWTH, YIELD, WATER RELATIONS AND LEAF PIGMENTS

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ABSTRACT: Two field experiments were carried out during two successive winter seasons of 2015-2016 and 2016-2017 at the Experimental Farm, El Kassasein Horticultural Research Station, Ismailia Governorate, to clarify the effects of different rates of irrigation water; i.e., 1300, 1950 and 2600 m³/ fed. and foliar spray with some safely substances; i.e., potassium chloride, algae extract, potassium humate and calcium carbonate in addition to control treatment on growth, bulb quality, yield, water relations as well as leaf pigments and proline amino acid content of garlic plants (Allium sativum L.) cv. Chinese, grown under sandy soil conditions using drip irrigation system. Irrigation water quantity at 2600 or 1950 m³/ fed. were the superior treatments which significantly increased vegetative growth characters, bulb physical characters, total water, free water, water utilization and total yield without significant differences between them in most cases. Meanwhile, chlorophylls, bound water, water economy and proline amino acid content were at their maximum values under water stress (1300 m³/ fed.). Aqueous solution of calcium carbonate at 6% and/ or potassium humate at 0.2% as foliar spray had significant effect, in most cases, on plant growth, bulb physical characters, total water, free water, water economy and total yield without significant differences between them. The interaction between calcium carbonate at 6% and/ or potassium humate at 0.2% and irrigation water quantity at 1950 m³/ fed. enhanced plant growth, bulb physical characters, total water, free water, water economy and total yield.

Key words: garlic, water quantity, calcium carbonate, potassium humate, algae extract, growth, water relations yield, storage period.

INTRODUCTION

Garlic (Allium sativum L.) is one of the most important vegetable crops in the world. It is widely used in flavouring of food and has health benefits including its antioxidant, anticancer, antimicrobial, and lowering sugar and lipids in blood (Baghalian, 2005). Furthermore, the economic importance of the garlic crop has increased considerably in recent years for local consumption and exportation. So, essential aims for growers are increasing yield and improving bulb quality.

Irrigation is one of the important factors affecting garlic productions for both economic and rotational perspective view. Maximizing the production of garlic requires suitable cultural practices, such as the favorable quantity and quality of irrigation water requires as well as the favorable type of fertilizers. In that regard, Islam and Zaman (2017) reported that irrigation frequency of 10 days interval significantly influenced yield of garlic and morphological characteristics (plant height, individual bulb weight/plant, number of clove/bulb, clove weight and bulb yield). The highest significant values in the garlic plant fresh weight and leaf area as well as bulb weight, diameter, total yield and marketable exerted from using the irrigation level of 80 % from crop evapotranspiration (Moustafa et al., 2017). Irrigation levels significantly affected plant height, marketable bulb yield and gross bulb yield of garlic. However, the neck thickness was not affected by irrigation levels, the highest plant height, marketable bulb yield and gross bulb yield were recorded in
Potassium humate is a commercial product contains many elements necessary to the development of plant life (El-Sharkawy and Abdel-Razzak, 2010).

Also, potassium humate can be used as a non-expensive source for potassium and it could be used as soil dressing, drenching or foliar applications. In addition, Humic acid (HA) is one of the major component of humus. Application of (HA) has several benefits and agriculturists all over the world are accepting HA as an integral part of their fertilizer program. (Abou El-Khair et al. 2010, Zeinali and Moradi, 2015) they found that, foliar application with humic acid led to positive effects on plant growth and improvement garlic plant production.

Treating garlic plants with potassium humate at 5g/l increased plant height, number of leaves/plant, both neck and bulb diameter, total dry weight/plant, N, P and K contents in bulbs and leaves, total yield/fed. and bulb dry matter as well as total soluble solid in bulbs (Mohsen et al., 2017). Application of potassium humate at the rate of 6 kg/fed. significantly increased vegetative growth characters, yield and its components, as well as minerals content of garlic, when compared with control treatment (Mahmoud and Youssif, 2015).

Calcium carbonate (CaCO₃) decomposes to calcium oxide (CaO) and carbon dioxide (CO₂) in leaves stomata, and this carbon dioxide increases the intensity of photosynthesis. Spraying snap bean plants with CaCO₃ (Lithovit) at 3 g/l reflected the highest values in all studied growth and yield traits (Abo-Sderëa et al., 2016).

Potassium chloride (KCl) as a foliar spray resulted in the highest values in vegetative growth characters (plant length, leaves number, neck diameter, fresh and dry weight of leaves and bulb) and also gave the highest total yield and quality of onion bulb (bulb weight, diameter, length and TSS). Moreover, it significantly reduced the flaking rate during storage and increased the exportable bulbs percentage (Ghoname et al., 2007).

Algae extract (seaweed) are the macroscopic marine algae found attached to the bottom in relatively shallow costal water. They grow in the intertidal, shallow and deep sea areas up to 180 meter depth and also in estuaries and backwater on the solid substrate such as rocks, dead corals and pebbles. Seaweed zone is one of the conspicuous and wide-spread biotope in the shallow marine environment. The seaweeds are totally different from higher plants as they neither have true leaves, stems and roots or vascular system none specialized sex organs (Thirumaran et al., 2009). More than 15 million metric tons of seaweed products are used annually as nutrient supplements and biostmulants in agriculture and horticultural crop production (FAO, 2006).

Many investigators studied the effect of seaweed extract as foliar application on plant growth, Shelaby and El-Ramady (2014) on garlic showed that, application of Alga 600 (1 g l⁻¹) showed the heaviest bulb weight.

Thus, this work aimed to investigate the effect of different rates of irrigation water and foliar spray with some safely substances on growth, bulb quality, yield and water relations as well as leaf pigments of garlic plants grown under sandy soil conditions using drip irrigation system.

**MATERIALS AND METHODS**

The present investigation was conducted at the Experimental Farm, El Kassasein Horticultural Research Station, Ismailia Governorate, during two successive winter seasons of 2015-2016 and 2016-2017 to clarify the effects of different rates of irrigation water and foliar spray with some safely substances on growth, bulb quality and yield of garlic plants (*Allium sativum* L.) cv. Chinese, grown under sandy soil conditions using drip irrigation system. Physical and chemical properties of the experimental soil are presented in Table (1).

| Physical properties | Chemical properties | 1st season | 2nd season | 1st season | 2nd season |
|---------------------|---------------------|----------------|----------------|----------------|----------------|
| Sand (%)            | 94.9                | 94.5            | Organic matter | 0.21            | 0.28            |
| Silt (%)            | 2.6                 | 2.7             | Available K (mg/kg) | 76             | 78             |
| Clay (%)            | 2.5                 | 2.8             | Available P (mg/kg) | 22             | 26             |
| F C (%)             | 6.5                 | 6.8             | Available N (mg/kg) | 91             | 93             |
| W P (%)             | 2.4                 | 2.5             | Calcium carbonate% | 0.18            | 0.26            |
| Available water     | 4.5                 | 4.5             | pH              | 7.8             | 7.8             |
| Water holding       | 13.8                | 14.5            |                 |                 |                 |

**Table 1. Physical and chemical properties of the tested soil during 2015/2016 and 2016/2017 seasons**
This experiment included 15 treatments, which were the combinations between three drip irrigation rates, and foliar application with five substances. The treatments were arranged in a split plot design with three replicates, drip irrigation rates were randomly assigned in the main plots, while foliar application treatments were randomly distributed in the sub-plots as follows:

**A - Irrigation rates:**
1. 2600 m³ water /fed. (Recommended rate),
2. 1950 m³ water /fed.
3. 1300 m³ water /fed.

**B - Foliar spry treatments:**
1. Control (spraying plants with tap water),
2. Potassium chloride at 1%
3. Algae extract at 0.3%
4. Potassium humate at 0.2%
5. Calcium carbonate at 6%

Cloves of garlic, Chinese cultivar were selected for uniformity in shape and size then it were sown on both sides of the dripper line at distance of 10 cm apart. Sowing was done on September 21st and 26th in 2015 and 2016, respectively. The experimental unit area was 12.6 m² it contained three dripper lines with 6 m in long and 70 cm in width and the distance between drippers was 25 cm, thus each replicate contains 72 drippers. In addition, one row was left between each two experimental units as a guard row to avoid the overlapping infiltration of irrigation or spraying solution.

All experimental units received equal amounts of water during germination stage up to 25 days from sowing (100 m³ water/fed.). The irrigation treatments were started at 25 days from planting, the irrigation treatments were stopped at 15 days before harvesting time. The water was added by using water counter and pressure counter. The time and amount of water in every irrigation are shown in Schedule 1.

**Schedule 1. The time (minute) and amounts of applied irrigation water (m³/fed. as well as /plot) in every irrigation during the growth period of garlic via dripper lines with discharge of 2 l/h for each dripper at 0.5 bar**

| Water quantity (m³/fed) | Irrigation number during the season | Irrigation time in every irrigation (min.) | Water quantity (m³/fed)/in every irrigation | Water quantity (m³/plot)/in every irrigation |
|------------------------|------------------------------------|--------------------------------------------|--------------------------------------------|--------------------------------------------|
| 1300                   | 80                                 | 20.3                                       | 16.25                                      | 0.04875                                    |
| 1950                   | 80                                 | 30.9                                       | 24.37                                      | 0.07312                                    |
| 2600                   | 80                                 | 40.6                                       | 32.50                                      | 0.09750                                    |

Treatments of foliar application were sprayed three times i.e., 60, 90 and 120 days from sowing. Each plot received 2 l/solution for each treatment and using spreading agent (Super Film 1ml / l), the untreated plants were sprayed with tap water. Other cultural practices control were carried out according to the recommendations of Ministry of Agriculture.

The fresh cyanobacterial strain belonging to Spirulina platensis (algae extract) was obtained from Algal Biotechnology Unit, National Research Centre, Egypt, while the sources of potassium chloride and calcium carbonate was El-Gomhouria Co. for trading medicines, chemicals and medical appliances, Sharkia Governorate, Zagazig, Egypt. Potassium humate granule contains of (potassium humate 85% + K₂O 8% + fulvic acid 3%) and the source of potassium humate was EfcO Egyptian Company for Fertilizers and Chemicals, Egypt.

Data recorded

**Growth parameters:** A random sample of nine plants was taken from each sub-plot at 135 days after sowing, in both seasons of study, for measuring the growth characters of garlic plants expressed as: Plant height, leaves number / plant, leaf area, neck and bulb diameter, bulb length as well as bulbing ratio according to the equation of Mann (1952).

\[
\text{Bulbing ratio} = \frac{\text{Neck diameter}}{\text{Bulb diameter}}
\]

**Dry weight:** The different parts of garlic plant, i.e., leaves and bulb were oven dried at 70 °C till constant weight and then the following data were recorded: Bulb dry weight / plant, and vine dry weight / plant.

**Photosynthetic pigments:** Disk samples from the fourth outer leaf were taken at 135 days after sowing to determine chlorophyll a, b and total chlorophyll according to Wettstein (1957).
Proline amino acid content: It was determined in dry leaves at 135 days after planting in both seasons of study according to the method described by Bates (1973). Plant water relations: Total, free and bound water in the fourth outer leaf of garlic plants were determined for every experimental unit at 135 days after planting, in both seasons, according to the method described by Gosev (1960).

Water Use Efficiency (WUE): It was calculated according to equation of Begg and Turner (1976) as follows:

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\text{Water use efficiency (water economy)} = \frac{\text{Yield (kg/fed)}}{\text{Water quantity (m}^3/\text{fed)}} \quad \text{kg/m}^3
\]

\[
\text{Water utilization} = \frac{\text{Water quantity (m}^3/\text{fed)}}{\text{Yield (kg/fed)}} \quad \text{m}^3/\text{kg}
\]

Yield and its components: At proper maturity stage of bulbs (200 days after sowing), bulbs in every plot were harvested and the following data were recorded: Average bulb weight (g), number of cloves / bulb and total yield (ton/fed.).

Statistical analysis

Obtained data were statistically analyzed as randomized split plot design, by using MSTAT statistical software and the treatments means were compared by using LSD at 0.05 level probability according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Vegetative growth characters

Regarding irrigation water quantity data presented in Table 2 show that, water quantity significantly affected the vegetative growth characters and dry weight of different parts per plant. Increasing irrigation water quantity levels, in general, significantly increased vegetative growth characters and dry weight of different parts per plant. The highest water quantity; i.e., 2600 m\(^3\)/fed. came in the first rank in this respect, this treatment was the most superior one for enhancing plant growth and dry weight of garlic plant. It is seen also, from the same data, that all plant growth characters and dry weight of different parts were at the lowest values under water stress; i.e.,1300 m\(^3\)/fed. in both seasons of study.

The increment in growth characters by increasing the quantity of applied water could be suggested that increasing water quantity applied to the soil increases the soil moisture content that makes the nutrient elements more available to the plant, and this in turn might favoured the plant growth characters and most of the physiological process (El-Ghamriny et al., 2005). Similar findings were reported by Gupta et al., (2017), Islam and Zaman (2017), and Moustafa et al., (2017) on garlic.

Concerning foliar application, it is obvious from data in Table 2 that spraying garlic plants with different substances; i.e., potassium chloride, algae extract, potassium humate and calcium carbonate had significant effects on growth characters and dry weight of garlic plants parts except number of leaves per plant in both seasons. Application of calcium carbonate (CaCo\(_3\)) at 6% and potassium humate at 0.2% showed, in general, favourable effect on plant height, vine and bulb dry weight, as well as leaf area when compared with control treatment. It is evident from the same data in Table 2 that the used substances were different in their effects on vegetative growth characters, whilst CaCo\(_3\) at 6% and potassium humate at 0.2% were the superior treatments regarding plant height and leaf area without significant differences between them, spraying plants with either potassium humate at 0.2% or algae extract at 0.3% gave the highest dry weight values of vine and bulb without significant differences between them. Such results were true in both seasons.

Calcium carbonate is considered as antitranspirants, so it could be suggest that spraying garlic plants with calcium carbonate led to form a layer on the foliage surface, that in turn decreased transpiration rate, and hence led to keep more water in plant tissues that would reflect favourable effect on plant metabolism, photosynthetic rate and that directly affect plant growth (El-Ghamriny et al., 2005).

The enhancing effect of potassium humate on growth parameters may be due to that potassium humate contains many elements necessary to the development of plant life (El-Sharkawy and Abdel-Razzak, 2010) and the mechanism of possible growth promoting effect, usually attributed to hormone-like impact, activation of photosynthesis, accelerate cell division, increase the permeability of plant cell membranes and improved nutrient uptake and finally the activation of biomass production (Verlinden et al., 2009). Moreover, humic acid contains a stable fraction of carbon, thus regulating the carbon cycle and release the nutrients which improved plant growth.
Similar findings were obtained by Abo-Sedera et al., (2016) on snap bean concerning calcium carbonate. In addition, the obtained results with potassium humate are in harmony with those reported by Mahmoud and Youssif (2015) and Mohsen et al., (2017) on garlic.

As for effect of the interaction, illustrated data in Table 3 indicate that, the interaction treatments between irrigation water quantity and foliar application with some safely substances had significant effect on vegetative growth characters of garlic plants at 135 days from planting, except number of leaves in first season only.

The effect of foliar spray, in general, was more pronounced under the highest level of applied water. It is also clear that the interaction treatments between CaCO$_3$ at 6% and irrigation water quantity at 2600 or 1950 m$^3$/fed. were the superior treatments regarding vegetative growth characters followed by the interaction between potassium humate at 0.2 % and irrigation with 2600 or 1950 m$^3$/fed. without significant differences among the four treatments.

Table 2. Effect of drip irrigation rates and foliar spray with some safely substances on vegetative growth characters of garlic plants grown under sandy soil conditions at 135 days after planting.

| Treatments | Season 2015/2016 | Season 2016/2017 |
|------------|-----------------|-----------------|
| Water quantity (m$^3$/fed) | Plant height (cm) | Leaves (No.) | Vine dry weight (g) | Bulb dry weight (g) | Leaf area (cm$^2$) | Plant height (cm) | Leaves (No.) | Vine dry weight (g) | Bulb dry weight (g) | Leaf area (cm$^2$) |
| 1300 | 60.1 | 8.6 | 12.6 | 26.7 | 148.7 | 61.7 | 8.6 | 11.9 | 26.1 | 155.2 |
| 1950 | 74.8 | 10.1 | 15.4 | 34.5 | 161.9 | 73.1 | 10.0 | 14.7 | 33.7 | 164.2 |
| 2600 | 77.4 | 10.1 | 16.9 | 36.5 | 168.9 | 74.7 | 10.1 | 15.7 | 35.4 | 171.6 |
| LSD at 0.05 level | 3.6 | 0.3 | 1.1 | 2.4 | 5.86 | 1.1 | 0.6 | 1.8 | 1.8 | 2.56 |

Foliar spray

Control | 66.8 | 9.2 | 12.6 | 28.5 | 146.3 | 64.5 | 9.2 | 11.8 | 27.6 | 151.4 |
Potassium chloride | 69.4 | 9.3 | 14.4 | 30.9 | 155.4 | 68.7 | 9.4 | 13.3 | 30.4 | 162.4 |
Algae extract | 71.3 | 9.5 | 15.7 | 34.4 | 158.8 | 70.7 | 9.5 | 15.0 | 33.4 | 161.6 |
Potassium humate | 72.2 | 9.8 | 16.5 | 34.8 | 166.4 | 71.7 | 9.7 | 15.6 | 34.1 | 169.9 |
Calcium carbonate | 73.8 | 10.0 | 15.6 | 34.2 | 172.3 | 73.4 | 9.8 | 14.8 | 33.3 | 173.1 |
LSD at 0.05 level | 4.2 | N.S | 2.5 | 3.3 | 6.8 | 2.8 | N.S | 2.8 | 2.7 | 7.0 |

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6%

Physical characters of bulbs

With regard to irrigation water quantity, data presented in Table 4 show that water quantity significantly affected physical characters of bulbs except bulbing ratio in both seasons and bulb diameter in second season only. Increasing water quantity levels significantly increased bulbs physical characters, the highest water quantity; i.e., 2600 m$^3$/fed. came in the first rank in this respect followed by 1950 m$^3$/fed. without significant differences between them. On the other side the lowest values in all measured physical characters traits were recorded in case of using the lowest water quantity (1300 m$^3$/fed.).

The promotion effect of irrigation water quantity on bulbs physical characters of garlic might owe too much to the increases in plant growth (Table2).

Concerning foliar application, data in Table 4 show that, spraying garlic plants with different used substances; i.e., potassium chloride, algae extract, potassium humate and calcium carbonate had a significant effect on physical characters of bulbs except bulbing ratio in both seasons. Spraying plants with CaCO$_3$ at 6% and potassium humate at 0.2% showed, generally, favourable effect on bulb diameter, neck diameter and bulb length when compared with control treatment. The enhancing
effect of foliar application with CaCO$_3$ and potassium humate on physical characters of bulbs may be due to the increasing in vegetative growth (Table 2). Regarding the effect of interaction, the interaction between irrigation water quantity and foliar application with some safely substances had favourable significant effect on bulb diameter, neck diameter and bulb length, but had no significant effect on bulbing ratio (Table 5). Spraying garlic plants with CaCO$_3$ at 6% and/or potassium humate at 0.2% were the most favourable treatments under all irrigation water quantity levels in this respect as compared to all other interaction treatments, meanwhile, the uppermost values of bulb diameter, neck diameter and bulb length were achieved by spraying with calcium carbonate at 6% under irrigation water quantity at 2600 or 1950 m$^3$/fed. followed by the interaction treatments between potassium humate at 0.2% and water quantity at 2600 and/or 1950 m$^3$/fed. without significant differences among the four treatments.

Table 3. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on vegetative growth characters of garlic plants grown under sandy soil conditions at 135days after planting

| Treatments | Vegetative growth characters / plant | Season 2015/2016 | Season 2016/2017 |
|------------|------------------------------------|------------------|------------------|
|            | Plant height (cm) | Leaves No. | Vine dry weight (g) | Bulb dry weight (g) | Leaf area (cm$^2$) | Plant height (cm) | Leaves No. | Vine dry weight (g) | Bulb dry weight (g) | Leaf area (cm$^2$) |
| Water quantity (m$^3$/fed) | Foliar spray | | | | | | | | | |
| 1300 | Control | 55.0 | 8.0 | 9.3 | 21.3 | 127.8 | 57.3 | 8.0 | 8.6 | 20.6 | 136.4 |
| | Potassium chloride | 58.3 | 8.6 | 12.5 | 25.0 | 141.8 | 60.3 | 8.3 | 10.5 | 24.7 | 153.2 |
| | Algae extract | 61.3 | 8.6 | 13.3 | 29.2 | 151.8 | 62.3 | 8.6 | 13.3 | 28.4 | 160.1 |
| | Potassium humate | 62.3 | 9.0 | 14.7 | 29.4 | 158.9 | 63.0 | 9.0 | 14.1 | 28.7 | 162.4 |
| | Calcium carbonate | 63.3 | 9.3 | 13.3 | 28.9 | 163.3 | 65.6 | 9.0 | 13.1 | 27.9 | 164.1 |
| | Control | 70.3 | 9.6 | 12.5 | 29.2 | 151.7 | 65.3 | 9.6 | 12.0 | 28.9 | 154.4 |
| | Potassium chloride | 73.3 | 10.0 | 14.8 | 31.9 | 158.9 | 72.6 | 10.0 | 14.3 | 32.0 | 162.6 |
| | Algae extract | 75.0 | 10.0 | 16.5 | 36.9 | 157.3 | 74.6 | 10.0 | 15.9 | 35.2 | 155.5 |
| | Potassium humate | 76.3 | 10.3 | 16.9 | 37.5 | 168.5 | 76.0 | 10.0 | 16.2 | 36.7 | 173.1 |
| | Calcium carbonate | 79.0 | 10.3 | 16.4 | 36.9 | 173.3 | 77.0 | 10.3 | 15.1 | 35.8 | 175.3 |
| | Control | 75.3 | 10.0 | 16.0 | 35.1 | 159.5 | 71.0 | 10.0 | 14.9 | 33.3 | 163.5 |
| | Potassium chloride | 76.6 | 10.0 | 16.0 | 35.7 | 165.6 | 73.3 | 10.0 | 15.2 | 34.6 | 171.3 |
| | Algae extract | 77.6 | 10.0 | 17.3 | 37.2 | 167.4 | 75.3 | 10.0 | 15.7 | 36.5 | 169.2 |
| | Potassium humate | 78.0 | 10.3 | 17.9 | 37.6 | 171.7 | 76.3 | 10.3 | 16.5 | 36.7 | 174.3 |
| | Calcium carbonate | 79.3 | 10.3 | 17.3 | 36.9 | 180.4 | 77.6 | 10.3 | 16.2 | 36.1 | 179.8 |
| 1950 | LSD at 0.05 level | 7.3 | N.S | 4.4 | 5.8 | 11.8 | 5.0 | 2.1 | 4.8 | 4.7 | 12.2 |

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6%
Table 4. Effect of drip irrigation rates and foliar spray with some safely substances on physical characters of garlic plants grown under sandy soil conditions at 135days after planting

| Treatments | Physical characters | Season 2015/2016 | Season 2016/2017 |
|------------|-------------------|------------------|------------------|
| Water quantity (m³/fed) | Bulb diam. (cm) | Neck diam. (cm) | Bulb length (cm) | Bulbing ratio | Bulb diam. (cm) | Neck diam. (cm) | Bulb length (cm) | Bulbing ratio |
| 1300       | 5.34             | 1.12             | 4.62             | 0.20           | 5.48           | 1.15             | 4.53             | 0.21 |
| 1950       | 6.20             | 1.24             | 5.18             | 0.20           | 5.71           | 1.30             | 5.00             | 0.23 |
| 2600       | 6.10             | 1.24             | 5.30             | 0.20           | 5.68           | 1.20             | 4.98             | 0.22 |
| LSD at 0.05 level | 0.20 | 0.10 | 0.19 | N.S | 0.11 | 0.08 | N.S |

Foliar spray

Control | 5.53 | 1.06 | 4.56 | 0.19 | 4.96 | 1.14 | 4.43 | 0.23 |
Potassium chloride | 5.80 | 1.16 | 4.86 | 0.20 | 5.63 | 1.18 | 4.76 | 0.21 |
Algae extract | 5.93 | 1.23 | 5.00 | 0.20 | 5.82 | 1.20 | 4.88 | 0.21 |
Potassium humate | 6.10 | 1.26 | 5.56 | 0.21 | 5.90 | 1.32 | 5.06 | 0.23 |
Calcium carbonate | 6.03 | 1.27 | 5.16 | 0.21 | 5.80 | 1.24 | 5.03 | 0.22 |
LSD at 0.05 level | 0.27 | 0.11 | 0.20 | N.S | 0.54 | 0.15 | 0.21 | N.S |

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6%

Table 5. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on physical characters of garlic plants grown under sandy soil conditions at 135days after planting

| Treatments | Physical characters | Season 2015/2016 | Season 2016/2017 |
|------------|-------------------|------------------|------------------|
| Water quantity (m³/fed) | Foliar spray | Bulb diam. (cm) | Neck diam. (cm) | Bulb length (cm) | Bulbing ratio | Bulb diam. (cm) | Neck diam. (cm) | Bulb length (cm) | Bulbing ratio |
| 1300       | Control | 4.9 | 1.1 | 4.3 | 0.22 | 4.9 | 1.1 | 4.3 | 0.22 |
|           | Potassium chloride | 5.3 | 1.0 | 4.5 | 0.19 | 5.5 | 1.1 | 4.5 | 0.20 |
|           | Algae extract | 5.4 | 1.1 | 4.7 | 0.20 | 5.7 | 1.1 | 4.6 | 0.20 |
|           | Potassium humate | 5.6 | 1.2 | 4.9 | 0.21 | 5.7 | 1.3 | 4.6 | 0.23 |
|           | Calcium carbonate | 5.5 | 1.2 | 4.7 | 0.22 | 5.7 | 1.2 | 4.7 | 0.22 |
|           | Control | 5.8 | 1.0 | 4.5 | 0.17 | 4.9 | 1.2 | 4.4 | 0.25 |
|           | Potassium chloride | 6.1 | 1.3 | 5.0 | 0.21 | 5.8 | 1.3 | 4.9 | 0.23 |
| 1950       | Algae extract | 6.3 | 1.3 | 5.1 | 0.20 | 5.9 | 1.3 | 5.1 | 0.22 |
|           | Potassium humate | 6.5 | 1.3 | 5.9 | 0.20 | 6.0 | 1.4 | 5.4 | 0.23 |
|           | Calcium carbonate | 6.3 | 1.3 | 5.4 | 0.21 | 6.0 | 1.3 | 5.2 | 0.22 |
|           | Control | 5.9 | 1.1 | 4.9 | 0.19 | 5.1 | 1.1 | 4.6 | 0.24 |
|           | Potassium chloride | 6.0 | 1.2 | 5.1 | 0.20 | 5.6 | 1.1 | 4.9 | 0.21 |
| 2600       | Algae extract | 6.1 | 1.3 | 5.2 | 0.21 | 5.9 | 1.2 | 5.0 | 0.21 |
|           | Potassium humate | 6.2 | 1.3 | 5.9 | 0.21 | 6.0 | 1.2 | 5.2 | 0.21 |
|           | Calcium carbonate | 6.3 | 1.3 | 5.4 | 0.21 | 5.8 | 1.2 | 5.2 | 0.21 |
| LSD at 0.05 level | 0.4 | 0.2 | 0.3 | N.S | 0.9 | 0.2 | 0.4 | N.S |

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6%

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Yield and its components

Regarding the main effect of water quantity, it is obvious from data in Table 6 that irrigation water quantity had significant effect on average bulb weight and total yield per feddan in the two seasons, except number of cloves per bulb in the second season only. It is clear that average weight of bulb and total yield per feddan were significantly increased with increasing irrigation water quantity up to the highest level; i.e., 2600 m$^3$/feddan. In other words, the lowest water quantity; i.e., 1300 m$^3$/fed. recorded maximum values of number of cloves per bulb in the first season only.

Decreasing irrigation water quantity applied to garlic plants up to 1300 m$^3$/fed. decreased total yield to 64.95 and 62.30% in the first and second seasons, respectively less the control (2600 m$^3$/fed.) the noticed reduction in yield and its components under low level of irrigation water may be due to the reduction in plant growth (Table 2).

On the other hand, the increases of total yield/fed. by increasing the quantity of applied water might be due to the increasing in average bulb weight. Also, this might be due to the favourable effect of higher amounts of irrigation water on vegetative growth (Table 2). It could be suggested that increasing the quantity of water applied to the soil increases the soil moisture content, that makes the nutrient elements more available to the plant, and this in turn might favoured the plant growth characters and most of the physiological processes, that directly affect the yield and its components. In addition, higher water quantity applied to plants led to keep higher water content in the plant tissues, and this turn produced bulbs heavier than those under water stress (El-Ghamriny et al., 2005). Similar findings were reported by Gupta et al., (2017), Islam and Zaman (2017) and Moustafa et al., (2017) on garlic.

With regard to foliar spray, it is obvious from data in Table 6 that number of cloves per bulb was not significantly affected by foliar application with different substances in both seasons, while, spraying garlic plants with different substances; i.e., potassium chloride, algae extract, potassium humate and calcium carbonate reflected significant effect on average bulb weight and total yield per fed. Generally treating garlic plants with potassium humate at 0.2% and/or CaCO$_3$ at 6% each led to attain the highest values of average weight bulb and total yield per feddan as compared to all other treatments.

Calcium carbonate at 6% was the superior one and came in the first rank followed by potassium humate at 0.2% without significant differences between them. On the contrary control treatment and potassium chloride recorded the highest values of number of cloves per bulb but the increment did not reaching to the statistical level. The total yield/fed. increased by about 17.78 and 29.07%, 17.44 and 25.03% after spraying with CaCO$_3$ at 6% and potassium humate at 0.2% in the 1st and 2nd seasons, respectively. The superiority of using calcium carbonate (CaCO$_3$) on total produced yield and its components may be attributed to the role of it as a source of calcium and carbonate which reduced inside plant cell to form carbon dioxide which accumulate in cells and increased the rate of photosynthetic assimilation and consequently increased vegetative growth and produced yield (Abo-Sedera et al., 2016).

In this connection, Marschner (1995), under sufficient water conditions, reported that there were decrease in ABA and increase in CYT, GA and IAA reflecting good growth, good synthesis of carbohydrates and protein and finally attained higher yield.

The enhancing effect of potassium humate on yield of garlic may be attributed the enhancement effect of the humic acid improving plant growth parameters and yield components which ultimately resulted in higher bulb yield and also due to the supply of humate, micronutrients and indirectly the physical condition of the soil viz., aggregation, aeration, permeability, water holding capacity and biological condition of soil, which resulted in significantly higher bulb yield of garlic (El-Sharkawy and Abdel-Razzak, 2010).

Obtained results are in good line with those reported by El-Ghamriny et al., (2005) on potato and Abo-Sedera et al., (2016) on snap bean for calcium chloride, Mahmoud and Youssif (2015) and Mohsen et al., (2017) on garlic for potassium humate.

With respect to the effect of interaction, the interaction between irrigation water quantity and foliar application with safely substances had significant effect on average bulb weight and total yield per feddan, but had no significant effect on number of cloves per bulb (Table7).

Spraying garlic plants with CaCO$_3$ at 6%, potassium humate at 0.2% and algae extract at 0.3% were the most favourable treatments under all irrigation water treatments. Meantime, the uppermost values of total yield and its components were achieved after spraying with CaCO$_3$ at 6%, potassium humate at 0.2% and algae extract at 0.3% under the highest level of water quantity (2600 m$^3$/fed.) followed by the same treatments under irrigation water quantity 1950 m$^3$/fed. without

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significant differences among the six treatments. On the contrary the interaction between the lowest irrigation water quantity level and unsprayed plants gave the lowermost values of average bulb weight and total yield.

Moreover, it is of great interest to notice that the effect of foliar application on total yield and its components greatly increased by increasing water quantity level. These results agree with those reported by (El-Ghamriny et al., 2005) on potato regarding calcium carbonate.

**Water relations and water use efficiency**

As for the main effect of water quantity on water relations (total, bound and free water %) and water use efficiency (water utilization and water economy), it is obvious from data in Table 8 that increasing water quantity applied to garlic plants up to highest level (2600 m$^3$/fed.) significantly enhanced both free and total water % in garlic leaf tissues as well as water utilization (WU) m$^3$/kg, on the contrary the lowest water quantity (1300 m$^3$/fed.) recorded minimum values of total water, free water and WU in both seasons.

In this connection, 2600 m$^3$/fed. was the superior treatment and came in first rank, followed by 1950 m$^3$/fed. which came in the second rank. Concerning bound water (%) and water economy kg/m$^3$ the maximum values were obtained under water stress or irrigation with 1300 m$^3$/fed. and this trend was opposite to that of free or total water percentage as well as water utilization.

The increasing in bound water and the decreasing in total water and free water under water stress was mainly due to the increases in cell sap concentration and its osmotic pressure resulted from the conversion of starch into soluble carbohydrates (Lancher, 1993). The obtained results are in harmony with those reported by Abou El-Khair (2004) on garlic, Anwar, 2005, and El-Ghamriny et al., 2005 regarding water economy on potato.

With respect to foliar spray, it is obvious from data in Table 8 that spraying garlic plants with different used substances; i.e., potassium chloride, algae extract, potassium humate and calcium carbonate had a promoting effect on water relations and water use efficiency except total water in both seasons and bound water in the second season only.

### Table 6. Effect of drip irrigation rates and foliar spray with some safely substances on yield and its components of garlic plants grown under sandy soil conditions

| Treatments       | Season 2015/2016 | Season 2016/2017 |
|------------------|------------------|------------------|
|                  | Average bulb weight (g) | No. of cloves/bulb | Total yield (ton/ fed.) | Relative increases in total yield (%) | Average bulb weight (g) | No. of cloves/bulb | Total yield (ton/ fed.) | Relative increases in total yield (%) |
| Water quantity (m$^3$/fed) |                   |                   |                           |                                       |                   |                   |                           |                                       |
| 1300             | 47.21            | 18.40             | 5.396                     | 64.95                                | 47.35            | 17.40             | 5.411                     | 62.30                                |
| 1950             | 67.01            | 16.66             | 7.658                     | 92.17                                | 68.39            | 16.55             | 7.816                     | 89.99                                |
| 2600             | 72.69            | 16.20             | 8.308                     | 100.00                               | 75.99            | 16.66             | 8.685                     | 100.00                               |
| LSD at 0.05 level | 1.56             | 0.47              | 0.295                     | -                                    | 1.64             | N.S               | 0.461                     | -                                    |
| Foliar spray     |                   |                   |                           |                                       |                   |                   |                           |                                       |
| Control          | 55.69            | 17.33             | 6.364                     | 100.00                               | 54.57            | 18.66             | 6.237                     | 100.00                               |
| Potassium chloride | 60.80        | 17.44             | 6.949                     | 109.19                               | 59.70            | 18.22             | 6.823                     | 109.39                               |
| Algae extract    | 64.05            | 17.00             | 7.320                     | 115.02                               | 66.61            | 16.77             | 7.613                     | 122.06                               |
| Potassium humate | 65.39            | 16.88             | 7.474                     | 117.44                               | 68.23            | 15.33             | 7.798                     | 125.03                               |
| Calcium carbonate | 65.59         | 16.77             | 7.496                     | 117.78                               | 70.44            | 15.33             | 8.050                     | 129.07                               |
| LSD at 0.05 level | 2.45             | N.S               | 0.606                     | -                                    | 3.31             | N.S               | 0.281                     | -                                    |

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6%
Table 7. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on yield and its components of garlic plants grown under sandy soil conditions

| Treatments          | Season 2015/2016 | Season 2016/2017 |
|---------------------|------------------|------------------|
|                     | Av. bulb weight (g) | No. of cloves per bulb | Total yield (ton/fed.) | Relative increases in total yield (%) | Av. bulb weight (g) | No. of cloves per bulb | Total yield (ton/fed.) | Relative increases in total yield (%) |
|                     |                  |                  |                   |                                    |                  |                  |                   |                                    |
| Control             | 39.72            | 18.0             | 4.540             | 54.90                             | 36.48            | 18.3             | 4.170             | 49.22                             |
| Potassium chloride  | 44.41            | 18.3             | 5.076             | 61.38                             | 41.30            | 18.3             | 4.720             | 55.72                             |
| Algae extract       | 49.04            | 18.6             | 5.605             | 67.77                             | 51.06            | 17.6             | 5.836             | 68.89                             |
| Potassium humate    | 51.21            | 18.6             | 5.853             | 70.77                             | 53.44            | 16.0             | 6.108             | 72.10                             |
| Calcium carbonate   | 51.66            | 18.3             | 5.905             | 71.40                             | 54.42            | 16.6             | 6.220             | 73.42                             |
| Control             | 54.97            | 17.3             | 6.283             | 75.97                             | 53.11            | 19.3             | 6.070             | 71.65                             |
| Potassium chloride  | 65.67            | 17.6             | 7.506             | 90.76                             | 62.86            | 17.6             | 7.185             | 84.82                             |
| Algae extract       | 70.48            | 16.3             | 8.055             | 97.40                             | 72.80            | 16.6             | 8.320             | 98.22                             |
| Potassium humate    | 71.69            | 16.0             | 8.193             | 99.07                             | 74.90            | 14.6             | 8.560             | 101.05                            |
| Calcium carbonate   | 72.23            | 16.0             | 8.255             | 99.82                             | 78.27            | 14.3             | 8.946             | 105.61                            |
| Control             | 72.36            | 16.6             | 8.270             | 100.00                            | 74.12            | 18.3             | 8.471             | 100.00                            |
| Potassium chloride  | 72.31            | 16.3             | 8.265             | 99.94                             | 74.92            | 18.6             | 8.563             | 101.09                            |
| Algae extract       | 72.63            | 16.0             | 8.301             | 100.37                            | 75.96            | 16.0             | 8.682             | 102.49                            |
| Potassium humate    | 73.28            | 16.0             | 8.375             | 101.27                            | 76.35            | 15.3             | 8.726             | 103.01                            |
| Calcium carbonate   | 72.87            | 16.0             | 8.328             | 100.70                            | 78.60            | 15.0             | 8.983             | 106.04                            |

LSD at 0.05 level

| Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6% |

Table 8. Effect of drip irrigation rates and foliar spray with some safely substances on water relations of garlic plants grown under sandy soil conditions

| Treatments          | Water relations | Water relations |
|---------------------|-----------------|-----------------|
|                     | Season 2015/2016 | Season 2016/2017 |
|                     | Total water %    | Bound water %   | Free water %| W.U (m³/kg) | W.E (Kg/m) | Total water % | Bound water % | Free water %| W.U (m³/kg) | W.E (Kg/m) |
| 1300                | 79.89            | 27.54           | 52.34      | 0.244       | 4.151      | 79.05         | 31.72        | 47.32       | 0.247       | 4.162      |
| 1950                | 82.82            | 24.91           | 57.91      | 0.257       | 4.017      | 84.22         | 24.03        | 60.19       | 0.254       | 4.008      |
| 2600                | 86.92            | 21.09           | 65.83      | 0.315       | 3.218      | 85.33         | 21.61        | 63.72       | 0.299       | 3.340      |
| LSD at 0.05 level   | 1.91             | 1.46            | 2.31       | 0.011       | 0.161      | 2.60          | 2.27         | 1.44        | 0.018       | 0.299      |

Foliar spray

| Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6% | Future J. Agric., 4 (2019) 10-24 | 19 |
It is obvious from the same data that total and free water% as well as water economy kg/m³ were at the highest level after spraying with CaCO₃ at 6%, potassium humate at 0.2% and algae extract at 0.3% without significant differences among them in most cases. However, CaCO₃ seemed to be the superior one as compared to all other treatments. It is also clear that, CaCO₃ at 6%, potassium humate at 0.2% and algae extract at 0.3% were more similar in their effects on both free water % and water economy kg/m³, whereas the effects of foliar spray on both water utilization m³/kg and bound water % in both seasons were opposite to that of their effects on both free water% and water economy kg/m³. Thus, it could be concluded from such data in Table 8 that foliar application treatments which showed the maximum content of total and free water as well as water economy showed in the meantime the least values of bound water and water utilization.

The plants that received no foliar application substances (control) attained minimum values of free water and water economy, on the other hand it recorded the maximum values of bound water and water utilization. In this connection spraying potato plants with white wash (CaCO₃) at 6% increased free water and WE while decreased bound water and WU (Anwar, 2005).

Concerning the effect of interaction between irrigation water quantity and foliar application with safely substances, it is evident from data in Table 9 that all plant water relations, i.e., total water, free water and bound water as well as water use efficiency, i.e., water economy and water utilization were significantly affected by the interaction treatments.

It is quite clear that treating garlic plants with CaCO₃ at 6 %, potassium humate at 0.2% and algae extract at 0.3% were the superior under all irrigation water quantities when compared with other interaction treatments regarding total water, free water % in leaf tissues and water economy. Meantime, the highest values of total water, free water and water economy were obtained after spraying plants with CaCO₃ at 6 %, potassium humate at 0.2% and algae extract at 0.3% under higher levels of irrigation water applied (2600 or 1950 m³/fed.). However, the lowest values were obtained from untreated plants (control) under the lowest irrigation water quantity (1300 m³/fed.).

As for bound water and WU it is quite clear that both the two traits were frequently at the highest level when garlic plants received no foliar application substances (sprayed with tap water) under low irrigation water quantity 1300 m³/fed. when compared with other interaction treatments. Meantime, spraying under 1300 m³/fed. irrigation water quantity was the superior one in this respect.

It is of great interest to notice that, spraying garlic plants with CaCO₃ at 6% or potassium humate at 0.2% recorded the lowest values of water utilization especially under 1300 m³/fed. while the same treatments gave the lowest values of bound water under 2600 m³/fed. irrigation water quantity. These results agree with those reported by (Anwar, 2005) on potato regarding calcium carbonate.

Leaf pigments and proline content

With respect to the main effect of water quantity, it is obvious from data in Table 10 that irrigation water quantity had a significant effect on chlorophyll a, b and total (a+b) as well as proline content in leaf tissues of garlic plant at 135 days after sowing except chlorophyll B in the first season only. It is clear that the concentration of chlorophyll a, b, total (a+b) as well as proline content significantly decreased with increasing irrigation water quantity up to 2600 m³/fed, in both seasons. That means more intensive leaves were observed under water stress (1300 m³/fed).

In other words, addition of low quantity of water to garlic plants resulted in lowering the water content in leaf tissues and increases the thickness of blade of leaves and this in turn increased the intensity of the chlorophyll of garlic leaves.

This means that 1300m³ water fed. recorded maximum concentration of chlorophyll a, b and total (a+b) in leaf tissues of garlic. Meanwhile, proline amino acid content in leaf tissues was at the highest level under lower values of applied water (1300 m³/fed). Thus, proline content in leaf tissues can be considered as an indicator for water stress. These results agree with those reported by Abou El-Khair (2004) on garlic and Anwar (2005) on potato.

Regarding foliar spray, it is obvious from the data in Table 10 that spraying garlic plants with different used substances; i.e., potassium chloride, algae extract, potassium humate and calcium carbonate had a promoting effect on chlorophyll a, b and total (a+b) as well as proline content in leaf tissues of garlic plant at 135 days after sowing but the increment did not reaching to the statistical level. Generally, spraying garlic plants with CaCO₃ at 6% and potassium humate at 0.2% showed the highest values in this respect. Meanwhile, proline amino acid content in leaf tissues was at the lowest level after spraying with either CaCO₃ at 6% or potassium humate at 0.2%. However, calcium carbonate seemed to be the best one compared to all other treatments, the plants that received no foliar spray attained maximum values of proline content. The decrement in the amount of proline in leaf tissues after spraying with safely substances may be attributed to that CaCO₃ led to decrease water loss from plants through evaporation and transpiration, and this in turn increase the amount of water content in the tissues, resulting decrease in proline content.
Similar findings were reported by Abou El-Khair (2004) on garlic and Anwar (2005) on potato.

With respect to the effect of interaction, the interaction treatments between irrigation water quantity and foliar application with safely substances had significant effect on chlorophyll A and proline content, but had no significant effect on chlorophyll B and total a+b (Table 11).

Spraying garlic plants with CaCo3 at 6%, potassium humate at 0.2% and algae extract at 0.3% were the most favourable treatments under all irrigation water treatments. Meantime, the uppermost values of chlorophyll A were achieved after spraying with CaCo3 at 6%, potassium humate at 0.2% and algae extract at 0.3% under the lowest level of water quantity (1300 m3/fed.) followed by the same treatments under irrigation water quantity 1950 m3/fed. with regard to proline content it is clear from the same data in Table 11 that spraying garlic plants with CaCo3 at 6% and/or potassium humate at 0.2% were the best treatments under all irrigation water quantity levels in this respect as compared to all other interaction treatments, meanwhile, the lowermost values of proline were achieved by spraying with calcium carbonate at 6% under irrigation water quantity at 2600 or 1950 m3/fed. followed by the interaction treatments between potassium humate at 0.2% and water quantity at 2600 and/or 1950 m3/fed. without significant differences among the four treatments.

On the contrary the interaction between the lowest irrigation water quantity level and unsprayed plants gave the uppermost values of proline content. Moreover, it is of great interest to notice that the effect of foliar application on proline content greatly decreased by increasing water quantity level. These results agree with those reported by (Anwar, 2005) on potato regarding calcium carbonate.

### Table 9. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on water relations of garlic plants grown under sandy soil conditions

| Water quantity (m³/fed) | Foliar spray          | Season 2015/2016 | Season 2016/2017 |
|-------------------------|-----------------------|------------------|------------------|
|                         |                       | Total water %    | Bound water %    | Free water % | W.U (m³/kg) | W.E (Kg/m³) | Total water % | Bound water % | Free water % | W.U (m³/kg) | W.E (m³/kg) |
| Control                 | 77.83                 | 29.73            | 48.10            | 0.286         | 3.492       | 76.30        | 34.84         | 41.46         | 0.312       | 3.208        |
| Potassium chloride      | 78.31                 | 28.86            | 49.45            | 0.256         | 3.905       | 77.92        | 33.50         | 44.42         | 0.275       | 3.631        |
| 1300                    | 79.25                 | 27.55            | 51.70            | 0.232         | 4.311       | 78.24        | 32.08         | 46.16         | 0.222       | 4.489        |
| Algae                   | 80.50                 | 25.36            | 55.14            | 0.222         | 4.502       | 80.04        | 30.95         | 49.09         | 0.213       | 4.698        |
| Potassium humate        | 83.56                 | 26.23            | 57.33            | 0.220         | 4.542       | 82.75        | 27.25         | 55.50         | 0.209       | 4.785        |
| Calcium carbonate       | 79.94                 | 28.36            | 51.58            | 0.310         | 3.222       | 81.93        | 26.80         | 55.13         | 0.321       | 3.113        |
| Control                 | 80.16                 | 27.15            | 53.01            | 0.260         | 3.849       | 82.97        | 25.41         | 57.56         | 0.271       | 3.684        |
| Potassium chloride      | 82.54                 | 25.21            | 57.33            | 0.242         | 4.130       | 84.32        | 23.96         | 60.36         | 0.234       | 4.267        |
| 1950                    | 84.89                 | 22.46            | 62.43            | 0.238         | 4.201       | 84.94        | 22.66         | 62.28         | 0.228       | 4.390        |
| Algae                   | 86.60                 | 21.38            | 65.22            | 0.236         | 4.233       | 86.97        | 21.32         | 65.65         | 0.218       | 4.587        |
| Potassium humate        | 84.76                 | 22.18            | 62.58            | 0.314         | 3.181       | 83.95        | 22.73         | 61.22         | 0.307       | 3.258        |
| Calcium carbonate       | 85.60                 | 21.89            | 63.71            | 0.315         | 3.179       | 84.34        | 22.86         | 61.48         | 0.304       | 3.293        |
| Control                 | 86.19                 | 20.23            | 65.96            | 0.313         | 3.192       | 85.34        | 21.48         | 63.86         | 0.299       | 3.339        |
| Potassium chloride      | 87.64                 | 20.46            | 67.18            | 0.310         | 3.221       | 86.08        | 20.36         | 65.72         | 0.298       | 3.356        |
| 2600                    | 87.95                 | 20.69            | 67.26            | 0.312         | 3.203       | 86.97        | 20.65         | 66.32         | 0.289       | 3.455        |

| LSD at 0.05 level       | 8.19                  | 5.84             | 5.43             | 0.039         | 0.537       | 8.20         | 6.65          | 6.44          | 0.018       | 0.307        |

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6%.

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Table 10: Effect of drip irrigation rates and foliar spray with some safely substances on leaf pigments and proline content of garlic plants grown under sandy soil conditions

| Treatments | Season 2015/2016 | Season 2016/2017 |
|------------|------------------|------------------|
|             | Chl. A (mg/g F.W.) | Chl. B (mg/g F.W.) | Total Chl. (A+B) (mg/g F.W.) | Proline (mg/100g D.W.) | Chl. A (mg/g F.W.) | Chl. B (mg/g F.W.) | Total Chl. (A+B) (mg/g F.W.) | Proline (mg/100g D.W.) |
| Water quantity (m³/fed) |                  |                  |                          |                          |                  |                  |                          |                          |
| 1300        | 3.10             | 1.87             | 4.88                     | 135.01                  | 3.02             | 1.44             | 4.46                     | 149.48                  |
| 1950        | 2.95             | 1.74             | 4.67                     | 98.50                   | 2.87             | 1.30             | 4.17                     | 103.04                  |
| 2600        | 2.68             | 1.67             | 4.35                     | 79.29                   | 2.68             | 1.25             | 3.93                     | 69.93                   |
| LSD at 0.05 level | 0.12             | N.S              | 0.32                     | 3.96                    | 0.18             | 0.18             | 0.34                     | 2.59                    |

Foliar spray

- Control
- Potassium chloride
- Algae
- Potassium humate
- Calcium carbonate

LSD at 0.05 level

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6%

Table 11. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on leaf pigments and proline content of garlic plants grown under sandy soil conditions

| Treatments | Season 2015/2016 | Season 2016/2017 |
|------------|------------------|------------------|
|             | Chl. A (mg/g F.W.) | Chl. B (mg/g F.W.) | Total Chl. (A+B) (mg/g F.W.) | Proline (mg/100g D.W.) | Chl. A (mg/g F.W.) | Chl. B (mg/g F.W.) | Total Chl. (A+B) (mg/g F.W.) | Proline (mg/100g D.W.) |
| Water quantity (m³/fed) |                  |                  |                          |                          |                  |                  |                          |                          |
| 1300        | 3.09             | 1.78             | 4.87                     | 141.82                  | 3.03             | 1.41             | 4.44                     | 155.75                  |
|             | 3.07             | 1.77             | 4.84                     | 108.77                  | 3.00             | 1.27             | 4.08                     | 111.36                  |
| Potassium chloride |                  |                  |                          |                          |                  |                  |                          |                          |
| 1950        | 3.11             | 1.79             | 4.90                     | 130.20                  | 3.03             | 1.4             | 4.48                     | 147.44                  |
| 2600        | 3.13             | 1.80             | 4.93                     | 127.11                  | 3.05             | 1.48             | 4.53                     | 141.33                  |
| Algae       | 3.11             | 1.79             | 4.90                     | 130.20                  | 3.03             | 1.4             | 4.48                     | 147.44                  |
| Potassium humate |                  |                  |                          |                          |                  |                  |                          |                          |
| Control     | 2.89             | 1.74             | 4.63                     | 104.98                  | 2.80             | 1.24             | 4.04                     | 108.89                  |
| Potassium chloride | 2.92             | 1.71             | 4.63                     | 102.77                  | 2.85             | 1.26             | 4.11                     | 106.25                  |
| 1300        |                 |                  |                          |                          |                  |                  |                          |                          |
| 1950        | 2.95             | 1.73             | 4.68                     | 99.22                   | 2.87             | 1.29             | 4.16                     | 102.53                  |
| 2600        | 2.97             | 1.74             | 4.71                     | 95.11                   | 2.90             | 1.35             | 4.25                     | 100.42                  |
| Algae       | 3.03             | 1.76             | 4.79                     | 90.44                   | 2.94             | 1.38             | 4.32                     | 97.12                   |
| Potassium humate |                  |                  |                          |                          |                  |                  |                          |                          |
| Control     | 2.73             | 1.61             | 4.34                     | 79.52                   | 2.62             | 1.16             | 3.78                     | 69.45                   |
| Potassium chloride | 2.71             | 1.63             | 4.34                     | 80.25                   | 2.63             | 1.19             | 3.82                     | 70.66                   |
| 1950        |                 |                  |                          |                          |                  |                  |                          |                          |
| 2600        | 2.69             | 1.66             | 4.35                     | 79.11                   | 2.68             | 1.25             | 3.93                     | 70.55                   |
| Algae       | 2.66             | 1.71             | 4.37                     | 79.22                   | 2.70             | 1.30             | 4.00                     | 69.25                   |
| Potassium humate |                  |                  |                          |                          |                  |                  |                          |                          |
| Control     | 2.61             | 1.75             | 4.36                     | 78.35                   | 2.75             | 1.36             | 4.11                     | 69.75                   |
| Calcium carbonate |                  |                  |                          |                          |                  |                  |                          |                          |
| LSD at 0.05 level | 0.52             | N.S              | N.S                      | 6.60                    | 0.54             | N.S              | N.S                      | 7.56                    |

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at 0.2% and calcium carbonate at 6%
CONCLUSION

From the previous results of this investigation, it could be concluded that irrigation of garlic plants grown under sandy soil conditions at the rate 1950 m³/ fed. in combination with foliar application of calcium carbonate at 6% or potassium humate at 0.2% were the superior treatments for enhancing growth, water relations, water use efficiency, leaf pigments and yield and its components as compared to other treatments.

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