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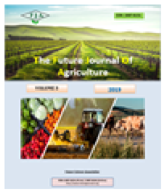

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EFFECT OF WATER QUANTITY AND FOLIAR SPRAY WITH SOME SAFELY SUBSTANCES ON GROWTH, YIELD QUALITY AND STORABILITY OF GARLIC
1- GROWTH, YIELD, WATER RELATIONS AND LEAF PIGMENTS

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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 m^3/ 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 m^3/ 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 m^3/ 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, 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 m^3/ 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 that 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 treatment 100 % cumulative pan evaporation (CPE) **(Gupta *et al.*, 2017)**.

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 ($CaCO_3$) decomposes to calcium oxide (CaO) and carbon dioxide (CO_2) in leaves stomata, and this carbon dioxide increases the intensity of photosynthesis. Spraying snap bean plants with $CaCO_3$ (Lithovit) at 3 g/l reflected the highest values in all studied growth and yield traits **(Abo-Sedera *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, **Shalaby 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).

Table 1. Physical and chemical properties of the tested soil during 2015/2016 and 2016/2017 seasons

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 capacity (%)	13.8	14.5			

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 m^3 water /fed. (Recommended rate),

2- 1950 m^3 water /fed.

3- 1300 m^3 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 2015and 2016, respectively. The experimental unit area was 12.6 m^2 it contained three dripper lines with 6 m in long and 70 cm in width and the distance between drippers was 25cm, 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 m^3 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 (m^3/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(m^3/fed)	Irrigation number during the season	Irrigation time in every irrigation (min.)	Water quantity(m3/fed) /in every irrigation	Water quantity(m^3/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% + K_2O 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 ^{0}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 **Wettestein (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:

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

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

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.

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 135days after planting

Treatments	Vegetative growth characters / plant									
	Season 2015/2016					Season 2016/2017				
Water quantity (m^3/fed)	Plant height (cm)	Leaves No.	Vine dry weight(g)	Bulb dry weigh (g)	Leaf area (cm^2)	Plant height (cm)	Leaves No.	Vine dry weight(g)	Bulb dry weigh (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 at0.2% and calcium carbonate at 6%

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.

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				
Water quantity (m^3/fed)	Foliar spray	Plant height (cm)	Leaves No.	Vine dry weight (g)	Bulb dry weigh (g)	Leaf area (cm^2)	Plant height (cm)	Leaves No.	Vine dry weight (g)	Bulb dry weigh (g)	Leaf area (cm^2)
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
1950	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
2600	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
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 at0.2% 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 (m^3/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	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 (m^3/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
	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
1300	**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%

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 to1300 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 Ca Co_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 achived 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 1950m^3/fed. without 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 convertion 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	Yield and its components							
	Season 2015/2016				Season 2016/2017			
Water quantity (m^3/fed)	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 (%)
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		Yield and its components							
		Season 2015/2016				Season 2016/2017			
Water quantity (m^3/fed)	Foliar spray	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 (%)
1300	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
1950	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
2600	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		4.25	N.S	1.050	-	5.72	N.S	0.485	-

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									
	Season 2015/2016					Season 2016/2017				
Water quantity (m^3/fed)	Total water %	Bound water %	Free water %	W.U (m^3/kg)	W.E (Kg/m)	Total water %	Bound water %	Free water %	W.U (m^3/kg)	W.E (Kg/m^3)
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										
Control	80.84	26.75	54.08	0.303	3.298	80.72	28.12	52.60	0.313	3.193
Potassium chloride	81.35	25.96	55.39	0.277	3.644	81.74	27.25	54.48	0.283	3.536
Algae extract	82.66	24.33	58.33	0.262	3.877	82.63	25.84	56.79	0.252	4.032
Potassium humate	84.34	22.76	61.58	0.256	3.974	83.68	24.65	59.03	0.246	4.148
Calcium carbonate	86.03	22.77	63.27	0.256	3.992	85.56	23.07	62.49	0.239	4.276
LSD at 0.05 level	4.73	3.38	3.14	0.023	0.310	4.73	3.84	3.72	0.010	0.177

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

It is obvious from the same data that total and free water% as well as water economy kg/m^3 were at the highest level after spraying with $CaCo_3$ at 6%, potassium humate at 0.2% and algae extract at 0.3% without significant differences among them in most cases. However, $CaCo_3$ seemed to be the superior one as compared to all other treatments. It is also clear that, $CaCo_3$ 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/m^3, whereas the effects of foliar spray on both water utilization m^3/kg and bound water % in both seasons were opposite to that of their effects on both free water% and water economy kg/m^3. 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 ($CaCo_3$) 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 $CaCo_3$ at 6 %, potassium humate at 0.2% and algae extract at 0.3% were the superior under all irrigation water quantites 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 $CaCo_3$ at 6 %, potassium humate at 0.2% and algae extract at 0.3% under higher levels of irrigation water applied (2600 or 1950 m^3/fed.). However, the lowest values were obtained from untreated plants (control) under the lowest irrigation water quantity (1300 m^3/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 m^3/fed. when compared with other interaction treatments. Meantime, spraying under 1300 m^3/fed. irrigation water quantity was the superior one in this respect.

It is of great interest to notice that, spraying garlic plants with $CaCo_3$ at 6% or potassium humate at 0.2% recorded the lowest values of water utilization especially under 1300 m^3/fed. while the same treatments gave the lowest values of bound water under 2600 m^3/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 m^3/fed, in both seasons. That means more intensive leaves were observed under water stress (1300 m^3/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 1300m^3 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 m^3/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 $CaCo_3$ 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 $CaCO_3$ 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 $CaCo_3$ 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 (Table11).

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 chlorophyll A were achived after spraying with $CaCo_3$ at 6%, potassium humate at 0.2% and algae extract at 0.3% under the lowest level of water quantity (1300 m^3/fed.) followed by the same treatments under irrigation water quantity 1950 m^3/fed. with regard to proline content it is clear from the same data in Table 11 that spraying garlic plants with $CaCo_3$ 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 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.

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

Treatments		Water relations									
Water quantity (m^3/fed)	Foliar spray	Season 2015/2016					Season 2016/2017				
		Total water %	Bound water %	Free water %	W.U (m^3/kg	W.E (Kg/m^3)	Total water %	Bound water %	Free water %	W.U (m^3/kg	W.E (m^3/kg)
1300	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
	Algae	79.25	27.55	51.70	0.232	4.311	78.24	32.08	46.16	0.222	4.489
	Potassium humate	80.50	25.36	55.14	0.222	4.502	80.04	30.95	49.09	0.213	4.698
	Calcium carbonate	83.56	26.23	57.33	0.220	4.542	82.75	27.25	55.50	0.209	4.785
1950	Control	79.94	28.36	51.58	0.310	3.222	81.93	26.80	55.13	0.321	3.113
	Potassium chloride	80.16	27.15	53.01	0.260	3.849	82.97	25.41	57.56	0.271	3.684
	Algae	82.54	25.21	57.33	0.242	4.130	84.32	23.96	60.36	0.234	4.267
	Potassium humate	84.89	22.46	62.43	0.238	4.201	84.94	22.66	62.28	0.228	4.390
	Calcium carbonate	86.60	21.38	65.22	0.236	4.233	86.97	21.32	65.65	0.218	4.587
2600	Control	84.76	22.18	62.58	0.314	3.181	83.95	22.73	61.22	0.307	3.258
	Potassium chloride	85.60	21.89	63.71	0.315	3.179	84.34	22.86	61.48	0.304	3.293
	Algae	86.19	20.23	65.96	0.313	3.192	85.34	21.48	63.86	0.299	3.339
	Potassium humate	87.64	20.46	67.18	0.310	3.221	86.08	20.36	65.72	0.298	3.356
	Calcium carbonate	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%

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	Leaf pigments and Proline							
	Season 2015/2016				Season 2016/2017			
Water quantity (m^3/fed)	Chl. A (mg/g F.W.)	Chl. B (mg/g F.W.)	Total Chl. (A+B)	Proline (mg/100g D.W.)	Chl. A (mg/g F.W.)	Chl. B (mg/g F.W.)	Total Chl. (A+B)	Proline (mg/100g D.W)
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	2.90	1.71	4.61	108.77	2.82	1.27	4.08	111.36
Potassium chloride	2.90	1.70	4.60	107.87	2.83	1.29	4.11	109.87
Algae	2.91	1.72	4.64	104.55	2.85	1.32	4.17	107.76
Potassium humate	2.91	1.75	4.66	101.51	2.88	1.37	4.24	105.70
Calcium carbonate	2.92	1.77	4.69	98.63	2.91	1.41	4.32	102.73
LSD at 0.05 level	N.S	N.S	N.S	3.81	N.S	N.S	N.S	4.37

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		Leaf pigments and Proline							
		Season 2015/2016				Season 2016/2017			
Water quantity (m^3/fed)	Foliar spray	Chl. A (mg/g F.W.)	Chl. B (mg/g F.W.)	Total Chl. (A+B)	Proline (mg/100g D.W.)	Chl. A (mg/g F.W.)	Chl. B (mg/g F.W.)	Total Chl. (A+B)	Proline (mg/100g D.W)
1300	**Control**	3.09	1.78	4.87	141.82	3.03	1.41	4.44	155.75
	Potassium chloride	3.07	1.77	4.84	140.60	3.00	1.41	4.41	152.70
	Algae	3.10	1.78	4.88	135.31	3.01	1.43	4.44	150.20
	Potassium humate	3.11	1.79	4.90	130.20	3.03	1.4	4.48	147.44
	Calcium carbonate	3.13	1.80	4.93	127.11	3.05	1.48	4.53	141.33
1950	**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
	Algae	2.95	1.73	4.68	99.22	2.87	1.29	4.16	102.53
	Potassium humate	2.97	1.74	4.71	95.11	2.90	1.35	4.25	100.42
	Calcium carbonate	3.03	1.76	4.79	90.44	2.94	1.38	4.32	97.12
2600	**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
	Algae	2.69	1.66	4.35	79.11	2.68	1.25	3.93	70.55
	Potassium humate	2.66	1.71	4.37	79.22	2.70	1.30	4.00	69.25
	Calcium carbonate	2.61	1.75	4.36	78.35	2.75	1.36	4.11	69.75
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 m^3/ 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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