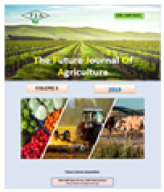
Available online free at www.futurejournals.org

The Future Journal of Agriculture

Print ISSN: 2687-8151 Online ISSN: 2687-8216

Future Science Association



Future J. Agric., 4 (2019) **25-39** **OPEN ACCES**

EFFECT OF WATER QUANTITY AND FOLIAR SPRAY WITH SOME SAFELY SUBSTANCES ON GROWTH, YIELD QUALITY AND STORABILITY OF GARLIC
2- STORABILITY AND VOLATILE OIL PERCENTAGE

Anwar, R. S.[1], Omaima O. Mohamed[2] and Dina M.G. Hendi[3]

[1]Vegetable Crops Department, Hort. Res. Inst., ARC, Giza, **Egypt.**
[2]Post Harvest and Handling of Vegetable Crops Dept., Hort. Res. Inst., ARC, Giza, **Egypt.**
[3]Medicinal and Aromatic Plants Res. Depart., Hort. Res. Inst., ARC, Giza, **Egypt.**

[*]Corresponding author: knour23@yahoo.com **Received:** 25 Sept. 2019 **; Accepted:** 25 Oct. 2019

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 at 1% ,Algae extract at 0.3%, Potassium humate at 0.2%, Calcium carbonate at 6% and control treatment) on volatile oil percentage and oil yield per plant of garlic plants (*Allium sativum* L.) cv. Chinese, grown under sandy soil conditions using drip irrigation system. This work aimed also to study the effect of the abovementioned treatments on garlic plants during storage at different periods; i.e., 40, 80, 120, 160 and 200 up to 320 days. Irrigation water quantity at 2600 or 1950 m^3/ fed. were the superior treatments which significantly increased volatile oil percentage and oil yield per plant. Aqueous solution of calcium carbonate at 6% and/ or potassium humate at 0.2% as foliar spray had a promotive effect, on volatile oil percentage and oil yield per plant. The interaction between calcium carbonate at 6% and/ or potassium humate at 0.2% and irrigation water quantity at 2600 or 1950 m^3/ fed. enhanced volatile oil percentage and oil yield per plant**.** Regarding storage experiment, the obtained results showed that there were a considerable and a continuous increase in weight loss and sprouting % as the storage period was extended, while TSS% was increased by increasing storage period. Increasing irrigation water up to 2600 m^3/fed. significantly increased weight loss and sprouting %, while TSS% was decreased. Foliar application with calcium carbonate at 6% and/ or potassium humate at 0.2% were the superior treatments for increasing TSS% and decreasing weight loss and sprouting percentage. As for the triple interaction treatments, the beast values of weight loss, sprouting and TSS% at the end of storage period were noticed by irrigation with1300 m^3/fed. and foliar spray with $CaCo_3$ and/or potassium humate followed by irrigation with 1950 m^3/fed. with the same foliar application solutions.

Key words: garlic, water quantity, calcium carbonate, potassium humate, algae extract, storage period, weight loss, sprouting and TSS%.

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the oldest and very important vegetable crops in Egypt, due to its wide local consumption as a spice or condiment, exportation and food as well as medicinal industries. 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 most important factors that affecting garlic storability, where deficit or excess irrigation water inferior bulb storability. However, increasing available soil moisture and/ or irrigation water quantity significantly increased weight loss percentage in bulbs during storage. **(El-Mansi *et al.*, 1999 and El-Mansi *et al.*, 2004** on garlic).

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 components of humus. **Ahmed *et al*., (2010)** reported that, plants applied with humic acid had better storability than untreated plants. i.e., reduced total weight loss, decay and sprouting percentages of garlic bulbs during storage periods compared to untreated plants, in both seasons. Spraying inoculated plants with biofertilizer (Halex-2) for three times via humic acid gave best results for garlic longevity throughout increasing bulbs weight and decreasing bulbs weight loose after four months of storage **(Abdel-Razzak and EL Sharkawy, 2013)**.

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. Calcium has many roles in the plant. A high proportion of Ca in plant cells is found in the cell wall/middle lamella region **(Marschner, 1995).** Here it is bound to carboxyl groups of polygalacturonic acids (pectin), where it links adjacent galacturonic acid chains through ionic bonds **(Carpita and Gilbeaut, 1993)**. In addition, the lowest values in percent of loss in weight and decay were recorded with spraying garlic plants with calcium at 500 ppm when compared with other treatments after 3 and 6 months from storage **(Gmaa, 2016)**.

Algae extract (seaweeds) 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. Many investigators studied the effect of seaweed extract as foliar application on storability of garlic. Weight loss of garlic bulbs was the least with the application of seaweed extract (Alga 600) at 1g/l, **(Shalaby and El-Ramady, 2014)**. **Mansour, *et al*., (2019)** found that, the lowest values of total weight loss percentage after 180 days from storage period were shown when garlic plants sprayed with Algae at 2% in both seasons.

As for weight loss, **Hasan *et al*., (2017)** indicated that weight loss percentage of green garlic bulbs increased considerably and consistently with the prolongation of storage period. Continues increase in weight loss % with the prolongation of storage period **(El-Mansi *et al*., 2004 and Bardisi, 2004)** on garlic.

Total soluble solids (TSS) was decreased gradually and continuously with the prolongation of cold storage period, **Algadi *et al.* (2014)** on garlic.

Thus, this work aimed to investigate the effect of different rates of irrigation water and foliar spray with some safely substances on volatile oil percentage and storability of garlic plants grown under sandy soil conditions.

MATERIALS AND METHODS

Field experiment: 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 volatile oil percentage of garlic bulbs (Allium sativum L.) cv. Chinese, grown under sandy soil conditions using drip irrigation system. It aimed also to study the effect of the abovementioned treatments on garlic bulbs during storage at different periods; i.e., 40, 80, 120, 160 and 200 up to 320 days. 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 spray 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 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 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 (m^3/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.

Schedule 2. The average room temperature (ºC) and relative humidity (%) during storage months 2016 and 2017 seasons

Month	Season 2016				Season 2017			
	Temperature (ºc)		Relative humidity %		Temperature (ºc)		Relative humidity %	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
May	32.1	16.2	82.8	53.2	31.5	18.9	84.5	54.6
June	34.8	19.3	81.2	55.3	32.2	19.9	85.9	56.3
Joule	37.2	20.7	81.9	53.7	35.7	21.1	86.6	58.7
August	34.5	20.8	86.2	61.2	32.1	20.8	88.6	60.2
September	32.5	19.1	89.0	64.3	31.4	19.0	88.4	61.4
October	30.2	16.8	87.7	62.6	28.8	16.3	86.3	58.7
November	25.4	13.1	81.2	58.4	26.5	13.9	84.2	57.3
December	21.1	9.1	81.0	56.0	25.6	12.3	82.5	54.5

Data recorded

Essential oil extraction

After harvesting essential oil was isolated in bulbs by hydro distillation using a Clevenger type apparatus according to **Guenther (1961)** and essential oil percentage was calculated based on dry weight and the essential oil yield was thus calculated by multiplication of bulb weight (g) x oil (%). The essential oil was dried with anhydrous sodium sulphate and subjected to gas chromatography analysis.

Gas chromatography analysis

The essential oil was analyzed using a gas chromatography Hewlett Packard (HP) 6890 series equipped with flame ionization detector and capillary column HP-5 (30 m x 0.25 mm, o.25 µm film thickness). The oven temperature increased from 70 to 220ºC at a rate of 8ºC/min. The injector and detector temperatures were 220ºC and 250ºC, respectively and Hydrogen was used as the carrier gas. The identification of the compounds was done by matching their retention times with those of authentic samples injected under the same conditions. The essential oil composition was determined in samples of the 1st season.

Storage experiment

At harvesting time, the yield of every plot was translocated to a shady place on the same day for curing. Plants were placed for three weeks in shady place at 25+5 ^{O}C and 60-75% R.H., samples of cured and uniform plants (2 kg) were packed in plastic mesh and the three bags as one replicate, fifteen replications for each treatment were stored at normal room temperature. Three bags from each treatment were taken at random of three replications and arranged in a complete randomized design. In both seasons the storage zero time was 1st June and the end was 20th December. The following data were randomly taken every 40 days in both seasons of study:

Weight loss (%): It was measured as the percentage of loss from the initial weight (cumulative losses).

$$\text{Weight loss (\%)} = \frac{\text{Initial plants wei.} - \text{plants wei. at sampling dates}}{\text{Initial weight}} \times 100$$

Total soluble solids (TSS): It was determined by using a hand Refractometer according to the methods mentioned in **A.O.A.C. (1990)**.

Sprouting (%): it was estimated and expressed as percentage of number of sprout bulbs at 200, 240, 280 and 320 days from storage then the cumulative sprouting percentage was calculated.

Statistical analysis

Data of field experiment were statistically analyzed as randomized split plot design, and storage experiment data were statistically analyzed as complete randomized 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

Field experiment

Volatile oil

With respect to the main effect of water quantity, it is obvious from the data in Table 2 that water quantity significantly affected volatile oil percentage, oil yield per plant and total oil yield per feddan. Increasing water quantity levels, in general, significantly increased the volatile oil percentage, oil yield per plant and total oil yield per feddan. 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 volatile oil percentage oil yield per plant and total oil yield per feddan followed by 1950 m^3/ fed. It is seen also, from the same data that volatile oil percentage, oil yield per plant and total oil yield per feddan were at the lowest values under water stress; i.e., 1300 m^3/ fed. in both seasons.

It could be suggested that increasing water quantity applied to garlic plant led to keep higher moisture content in the soil and this in turn might favoured the plant metabolism that leads to increase plant growth characters and to produce higher dry matter, water stress on the other hand led to cause a reduction in the uptake of nutritional elements that might causes a disturbance in the physiological process need for plant growth **(Salter and Goode, 1967)**.

Regarding foliar spray, it is obvious from the data in Table 2 that spraying garlic plants with different used substances; i.e., potassium chloride, algae extract, potassium humate and calcium carbonate had a promoting effect on volatile oil percentage, oil yield per plant and total oil yield per feddan. Application of calcium carbonate at 6% and/or potassium humate at 2% showed, in general, favourable effect in this respect when compared with control treatment.

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)** and this in turn might favoured the oil percentage.

As for the effect of 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 volatile oil percentage, oil yield per plant and total oil yield per feddan. The effect of foliar application treatments was more pronounced under the highest level of applied water (2600 m^3/fed.). It is also clear that the interaction between water quantity at 2600 m^3/fed. and calcium carbonate at 6% was the superior treatment in this respect followed by potassium humate at 0.2%. On the other side, the lowest values of volatile oil percentage and oil yield per plant were recorded by the interaction between control treatment and the lowest level of irrigation (1300 m^3/fed.) these results are true in both seasons of study.

Essential oil composition

Effect of drip irrigation rates and foliar spray with some safely substance on essential oil composition are shown in Table (4) and figures (1,2 and 3) ,the GC., profile of the essential oil for the control, and treatments showed 10 compounds , it could be noticed that Diallyl sulfide ,Allyl methyl disulfide, Dimethyl trisulfide , Diallyl disulfide,Allyl (z)-1-propenyl disulfide, Allyl methyl trisulfide ,2-vinyl-4H-1,3-dithiine , Diallyl trisulfide , Allyl propyl trisulfide , Dial tetra sulfide.

The main components were Diallyl disulfide (32.54%to 34.60%), allyl(z)-1-propenyl disulfide (13.32% to 14.27%), Diallyl trisulfide (19.83% to 21.14%), Dial tetrasulfide (7.17% to 7.48%), 2-vinyl-4H-1,3-dithiine (5.354% to 5.358%), Allyl propyl trisulfide (3.57% to3.77%), Dimethyl trisulfide (2.58% to2.90%) , Allyl methyl disulfide (0.914 %to1.06%) and Diallyl sulfide (0.56% to 0.58%).

Table 2. Effect of drip irrigation rates and foliar spray with some safely substances on volatile oil of garlic plants grown under sandy soil condition

Treatments	**Volatile oil**					
	Season 2015/2016			**Season 2016/2017**		
Water quantity (m^3/fed)	**Volatile oil %**	**Volatile oil yield (g/plant)**	**Volatile oil yield (kg/fed.)**	**Volatile oil %**	**Volatile oil yield (g/plant)**	**Volatile oil yield (kg/fed.)**
1300	0.216	0.104	11.921	0.212	0.103	11.816
1950	0.367	0.253	28.885	0.347	0.244	27.932
2600	0.447	0.325	37.122	0.403	0.307	35.083
LSD at 0.05 level	0.024	0.005	2.106	0.030	0.006	2.189
Foliar spray						
Control	0.229	0.136	15.600	0.222	0.129	14.715
Potassium chloride	0.258	0.166	18.937	0.244	0.153	17.515
Algae extract	0.382	0.252	28.860	0.347	0.240	27.430
Potassium humate	0.407	0.277	31.699	0.376	0.266	30.440
Calcium carbonates	0.444	0.304	34.782	0.414	0.303	34.618
LSD at 0.05 level	0.027	0.004	2.428	0.023	0.005	2.665

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at0.2% and calcium carbonate at 6%

Table 3. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on volatile oil of garlic plants grown under sandy soil condition

Treatments		Volatile oil					
		Season 2015/2016			Season 2016/2017		
Water quantity (m^3/fed)	Foliar spray	Volatile oil %	Volatile oil yield (g/plant)	Volatile oil yield (kg/fed.)	Volatile oil %	Volatile oil yield (g/plant)	Volatile oil yield (kg/fed.)
1300	Control	0.133	0.052	6.038	0.146	0.053	6.088
	Potassium chloride	0.160	0.071	8.122	0.173	0.071	8.165
	Algae extract	0.280	0.137	15.694	0.226	0.115	13.189
	Potassium humate	0.246	0.126	14.398	0.240	0.128	14.659
	Calcium carbonates	0.260	0.134	15.353	0.273	0.149	16.980
1950	Control	0.246	0.135	15.456	0.246	0.131	14.932
	Potassium chloride	0.260	0.171	19.515	0.253	0.159	18.178
	Algae extract	0.406	0.286	32.703	0.386	0.281	32.115
	Potassium humate	0.433	0.310	35.475	0.393	0.294	33.641
	Calcium carbonates	0.500	0.361	41.275	0.456	0.357	40.793
2600	Control	0.306	0.221	25.306	0.273	0.202	23.125
	Potassium chloride	0.353	0.255	29.175	0.306	0.229	26.202
	Algae extract	0.460	0.334	38.184	0.426	0.324	36.985
	Potassium humate	0.540	0.396	45.225	0.493	0.376	43.019
	Calcium carbonates	0.573	0.418	47.719	0.513	0.403	46.082
LSD at 0.05 level		0.037	0.007	4.206	0.40	0.008	4.618

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at0.2% and calcium carbonate at 6%

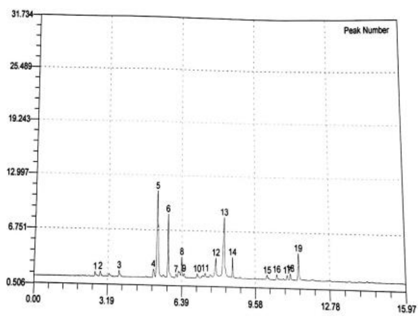


Fig. (1). Control + 1300 m^3 water / fed.

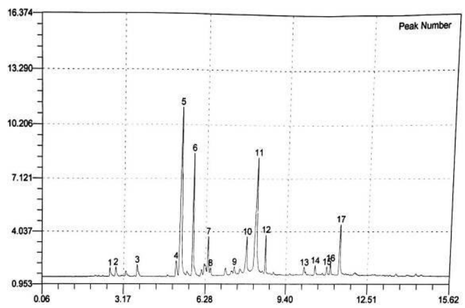


Fig. (2). Potassium humate + 2600 m^3 water / fed.

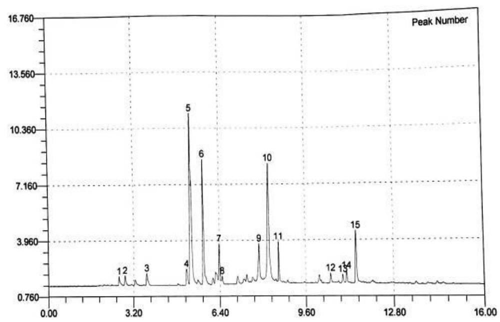


Fig. (3). Calcium carbonate + 2600 m^3 water / fed.

Table 4. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on essential oil composition of garlic bulbs during 2015/2016 season

Treatments / Components (%)	Control + 1300 m^3/ fed.	Potassium humate + 2600 m^3/ fed.	Calcium carbonate + 2600 m^3/ fed.
Diallyl sulfide	0.579	0.562	0.578
Allyl methyl disulfide	0.914	1.063	1.027
Dimethyl trisulfide	2.576	2.900	2.692
Diallyl disulfide	32.542	33.886	34.604
Allyl (z)-1-propenyl disulfide	13.324	13.940	14.273
Allyl methyl trisulfide	4.236	4.379	4.501
2-vinyl-4H-1,3-dithiine	5.354	5.350	5.358
Diallyl trisulfide	19.829	20.745	21.144
Allyl propyl trisulfide	3.575	3.679	3.778
Dial tetrasulfide	7.168	7.432	7.482
Others	9.903	6.064	4.563

Storage experiment

Weigh loss percentage

It is clear from the data in Table 5 and 6 that there was a considerable and continuous increase in weight loss percentage as the storage period was extended, whereas the maximum values of weight loss were occurred at the end of storage period (200 days) and it reached to 8.91 and 8.15 % in the 1st and 2nd seasons, respectively. Normally, the weight loss occurs during the bulbs storage may be attributed to respiration and other senescence related metabolic processes during storage **(Watada and Qi, 1999)**. Similar results were obtained by **Bardisi (2004), El-Mansi *et al.* (2004)** and **Hasan *et al.* (2017)** on garlic.

With regard to irrigation water quantity, it is obvious from the data in Table 5 and 6 that irrigation water quantity had significant effect on weight loss percentage of garlic bulbs during storage period in both seasons. Weight loss % significantly increased with increasing irrigation water up to 2600 m^3/fed. but irrigation water quantity at 1300 m^3/fed. gave the lowest values in this respect during storage period.

These results might be attributed to that increasing irrigation water quantity led to increased free water and decreased bound water (as previously explained in part one of this research) and this in turn may by increase water loss through evaporation.

Moreover, it may be attributed to the loss of dry matter through respiration, thereby affect weight loss of garlic bulbs during storage. These results agree with those reported by **El-Mansi *et al.* (1999) and El-Mansi *et al.* (2004)** on garlic, they found that weight loss increased with increasing soil moisture content or increasing water quantity.

Concerning to foliar application, the results in Table 5 and 6 demonstrate that there were significant differences among the used substances in weight loss percentage, where $CaCo_3$ at 6% gave the lowest values of weight loss (4.10and 3.60%) followed by algae extract at 0.3% and potassium humate at 0.2%, on the other hand control treatment recorded the highest values of weight loss (5.87 and 5.43%) in the 1st and 2nd seasons, respectively. The decreases in weight loss percentage due to application of potassium humate may be due to that increasing K concentration in the nutrient medium decreased post harvest moisture loss by increasing weight and by maintaining tissue integrity **(Shibairo *et al.*, 1998)**.

As for the interaction between water quantity and foliar application, the results show that the interaction treatment between the lowest level of irrigation (1300 m^3/fed.) and foliar application with $CaCo_3$ at 6% recorded the lowest values of weight loss % followed by the interaction between irrigation with 1950 m^3/fed. and foliar application with $CaCo_3$ at 6% without significant differences between them.

On the contrary, the highest values of weight loss % were obtained by the interaction between control treatment and irrigation with the highest level of water quantity (2600 m^3/fed.).

The interaction between irrigation water quantity and storage period show significant effect in both seasons, the lowest values of weight loss percentage (8.43 and 7.53%) at the end of storage period (200 days) were noticed by the lowest water quantity (1300m^3/fed.), while the highest values (9.57 and 9.07%) were recorded by the highest level of water irrigation at the end of storage period (200 days) in the first and second seasons, respectively. With respect to the interaction between storage period and foliar application the same results in Table 5 and 6 show that spraying garlic plants with $CaCo_3$ at 6% and algae extract at 0.3% recorded the lowest values of weight loss % at the end of storage period (7.69 and 6.73%) for $CaCo_3$ and (8.14 and 7.50%) for algae extract in the 1st and 2nd seasons, respectively, on the contrary the highest values at the end of storage period were recorded by control treatment which gave 10.69 and 9.72% in the 1st and 2nd seasons, respectively.

Regarding the effect of triple interaction among water quantity, foliar application and storage period, it is clear from the same data that the lowest values of weight loss % at the end of storage period (200 days) were noticed by irrigation with1950 m^3/fed. and foliar spray with $CaCo_3$ at 6% in the first season, while occurred in the second season by irrigation with1300 m^3/fed. and foliar spray with $CaCo_3$ at 6%. On the contrary the highest values in this respect at the end of storage period were recorded by control treatment when irrigated with 2600 m^3/fed.

Total soluble solids (TSS%)

The results listed in Table 7 and 8 indicated that garlic bulbs TSS% was decreased as the duration of storage is increased. The results demonstrated that total soluble solids of bulbs were significantly increased at the beginning of storage and then decreased with the prolongation of storage period in the two seasons. The increase in TSS% at the beginning of storage might owe much to the higher rate of moisture loss through transpiration. However, the reduction in TSS% during the end of storage period (200 days) may be due to the higher rate of sugar loss through respiration than water loss through transpiration **(Wills *et al.,* 1998)**. Similar results were obtained by **Algadi *et al.* (2014)** on garlic.

Concerning to irrigation water quantity, it is obvious from the data in Table 7 and 8 that irrigation water quantity had significant effect on TSS% of garlic bulbs during storage period in both seasons. Total soluble solids percentage significantly decreased with increasing irrigation water up to 2600 m^3/fed. but irrigation water quantity at1300 m^3/fed. recorded the highest values in this respect (40.3 and 39.6%) in the 1st and 2nd seasons, respectively. These results may be attributed to the increasing water quantity increased free water and decreased bound water (as previously explained in part one of this research) and this in turn may by decreased TSS% through evaporation. Moreover, it may be attributed to the loss of dry matter through respiration, thereby affect TSS% of garlic bulbs during storage.

With regard to foliar application, the results in Table 7 and 8 indicate that there were significant differences among the used substances in TSS%, where $CaCo_3$ at 6% gave the highest values of TSS% (40.5 and 39.8%) followed by potassium humate at 0.2% and algae extract at 0.3%, on the contrary control treatment recorded the lowest values (38.6 and 37.6%) in the 1st and 2nd seasons, respectively.

In respect to the interaction between water quantity and foliar application, the same results show that the interaction treatment between the lowest level of irrigation (1300 m^3/fed.) and foliar application with $CaCo_3$ at 6%, potassium humate at 0.2% and algae extract at 0.3% recorded the highest values of TSS% followed by the interaction between irrigation with 1950 m^3/fed. and foliar application with $CaCo_3$ at 6%. On the other side the lowest values of TSS% were obtained by the interaction between control treatment and irrigation with the highest level of water quantity (2600 m^3/fed.) these results are true in both seasons of study.

Concerning the interaction between irrigation water quantity and storage period it is obvious from the same data in table 7 and 8 that the interaction treatments between water quantity and storage period had significant effect on TSS% in both seasons.

The lowest values of TSS% (38.1 and 37.1%) at the end of storage period (200 days) were noted by the highest level of irrigation (2600 m^3/fed.), while the highest values (42.3 and 41.7%) were recorded from the lowest water quantity after 40 days from storage, in the first and second seasons, respectively.

With regard to the interaction between storage period and foliar application with some safely substances the same results show that spraying garlic plants with $CaCo_3$ at 6% recorded the maximum values of TSS% at the end of storage period (39.5 and 38.5%) followed by foliar application with algae extract at 0.3% which gave (39.0 and 38.2%) in the 1st and 2nd seasons respectively. On the contrary the minimum values of TSS% at the end of storage period were recorded by control treatment which gave 37.2 and 36.3% in the first and second seasons, respectively.

Table 5. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on weight loss % of garlic plants during storage periods during 2015/2016 season

Water quantity (m^3/fed)	Foliar spray	Season 2015/2016						
		Storage period (days)						
		0	40	80	120	160	200	Mean
		Weight loss %						
1300	Control	-	1.50	3.20	4.53	6.00	9.90	5.03
	Potassium chloride	-	1.30	3.14	4.16	5.63	8.12	4.47
	Algae extract	-	1.25	2.88	4.05	4.78	7.82	4.16
	Potassium humate	-	1.27	3.10	4.13	5.55	8.75	4.56
	Calcium carbonate	-	1.25	2.95	3.86	4.47	7.56	4.02
	Mean	-	1.31	3.05	4.15	5.29	8.43	4.45
1950	Control	-	1.69	4.05	5.37	7.24	10.34	5.74
	Potassium chloride	-	1.54	3.66	5.35	6.92	9.97	5.49
	Algae extract	-	1.28	2.65	4.10	4.97	7.33	4.07
	Potassium humate	-	1.49	2.76	4.22	6.90	9.07	4.89
	Calcium carbonate	-	1.54	2.66	3.97	4.88	7.00	4.01
	Mean	-	1.51	3.16	4.60	6.18	8.74	4.84
2600	Control	-	2.03	4.24	7.26	8.82	11.82	6.83
	Potassium chloride	-	1.98	3.57	5.09	6.94	9.23	5.36
	Algae extract	-	1.85	2.69	4.95	6.64	9.26	5.08
	Potassium humate	-	1.91	3.16	4.95	6.71	9.04	5.15
	Calcium carbonate	-	1.84	2.23	3.46	5.39	8.52	4.29
	Mean	-	1.92	3.18	5.14	6.90	9.57	5.34
Mean		-	1.58	3.13	4.63	6.12	8.91	-
Control		-	1.74	3.83	5.72	7.35	10.69	5.87
Potassium chloride		-	1.61	3.46	4.87	6.50	9.11	5.11
Algae extract		-	1.46	2.74	4.37	5.46	8.14	4.43
Potassium humate		-	1.16	3.01	4.43	6.39	8.95	4.87
Calcium carbonate		-	1.54	2.61	3.76	4.91	7.69	4.10

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at0.2% and calcium carbonate at 6%

L.S.D at 5%

Water quantity (W)	0.04	W × F	0.10
Foliar spray (F)	0.06	W × Sp	0.10
Storage period (Sp)	0.06	F × Sp	0.13
W × F × Sp	0.23		

Table 6. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on weight loss % of garlic plants during storage periods during 2016/2017 season

Water quantity (m^3/fed)	Foliar spray	Season 2016/2017						
		Storage period (days)						
		0	40	80	120	160	200	Mean
		Weight loss %						
1300	Control	-	1.20	2.90	4.23	5.70	8.60	4.53
	Potassium chloride	-	1.00	2.84	3.86	5.33	7.82	4.17
	Algae extract	-	0.95	2.58	3.75	4.48	7.52	3.86
	Potassium humate	-	0.97	2.80	3.83	5.25	7.45	4.06
	Calcium carbonate	-	0.95	2.65	3.56	4.17	6.26	3.52
	Mean	-	1.01	2.75	3.85	4.99	7.53	4.03
1950	Control	-	1.39	3.75	5.07	6.94	9.04	5.24
	Potassium chloride	-	1.24	3.36	5.05	6.62	8.67	4.99
	Algae extract	-	0.93	2.35	3.80	4.67	6.03	3.56
	Potassium humate	-	1.19	2.46	3.92	6.60	8.77	4.59
	Calcium carbonate	-	0.94	2.36	3.67	4.58	6.70	3.65
	Mean	-	1.14	2.86	4.30	5.88	7.84	4.40
2600	Control	-	1.73	3.94	6.96	8.52	11.52	6.53
	Potassium chloride	-	1.68	3.27	4.79	6.64	8.93	5.06
	Algae extract	-	0.95	2.39	4.65	6.34	8.96	4.66
	Potassium humate	-	1.61	2.86	4.65	6.41	8.74	4.85
	Calcium carbonate	-	0.74	1.93	3.16	5.09	7.22	3.63
	Mean	-	1.34	2.88	4.84	6.60	9.07	4.95
Mean		-	1.16	2.83	4.33	5.82	8.15	-
Control		-	1.44	3.53	5.42	7.05	9.72	5.43
Potassium chloride		-	1.31	3.16	4.57	6.20	8.47	4.74
Algae extract		-	0.94	2.44	4.07	5.16	7.50	4.02
Potassium humate		-	1.26	2.71	4.13	6.09	8.32	4.50
Calcium carbonate		-	0.88	2.31	3.46	4.61	6.73	3.60

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at0.2% and calcium carbonate at 6%

L.S.D at 5%

Water quantity	(W)	0.04	W × F	0.09
Foliar spray	(F)	0.05	W × Sp	0.09
Storage period	(Sp)	0.05	F × Sp	0.11
W × F × Sp		0.20		

Table 7. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on TSS% of garlic bulbs during storage periods during 2015/2016 season

Water quantity (m^3/fed)	Foliar spray	Season 2015/2016						
		Storage period (days)						
		0	40	80	120	160	200	Mean
		TSS %						
1300	Control	38.5	41.0	40.5	39.0	38.0	37.5	39.1
	Potassium chloride	39.0	42.0	41.0	40.5	39.5	38.5	40.1
	Algae extract	38.5	42.5	41.5	41.0	40.5	39.5	40.6
	Potassium humate	39.5	43.0	42.0	41.0	40.5	39.5	40.9
	Calcium carbonate	39.5	43.0	42.0	41.0	40.5	40.0	41.0
	Mean	39.0	42.3	41.4	40.5	39.8	39.0	40.3
1950	Control	36.5	40.5	40.0	39.5	38.0	37.0	38.6
	Potassium chloride	37.5	41.0	40.0	39.5	38.5	38.0	39.1
	Algae extract	37.5	41.5	41.0	40.0	39.5	39.0	39.7
	Potassium humate	37.0	42.0	41.0	40.5	40.0	39.0	39.9
	Calcium carbonate	37.5	42.5	42.0	41.0	40.5	39.5	40.5
	Mean	37.2	41.5	40.8	40.1	39.3	38.5	39.6
2600	Control	36.0	40.5	39.5	38.5	37.5	37.0	38.2
	Potassium chloride	36.5	41.0	40.5	39.5	38.5	37.5	38.9
	Algae extract	36.5	41.0	40.5	40.0	39.5	38.5	39.3
	Potassium humate	37.5	41.5	40.5	39.5	39.0	38.5	39.4
	Calcium carbonate	37.5	42.0	41.0	40.5	39.5	39.0	39.9
	Mean	36.8	41.2	40.4	39.6	38.8	38.1	39.2
Mean		37.7	41.7	40.9	40.1	39.3	38.5	-
Control		37.0	40.7	40.0	39.0	37.8	37.2	38.6
Potassium chloride		37.7	41.3	40.5	39.8	38.8	38.0	39.4
Algae extract		37.5	41.7	41.0	40.3	39.8	39.0	39.9
Potassium humate		38.0	42.2	41.2	40.3	39.8	39.0	40.1
Calcium carbonate		38.2	42.5	41.7	40.8	40.2	39.5	40.5

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at0.2% and calcium carbonate at 6%

L.S.D at 5%

Water quantity (W)	0.14	W × F	0.31
Foliar spray (F)	0.18	W × Sp	0.34
Storage period (Sp)	0.20	F × Sp	0.44
W × F × Sp	0.76		

Table 8. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on TSS% of garlic bulbs during storage periods during 2016/2017 season

Water quantity (m^3/fed)	Foliar spray	Season 2016/2017						
		Storage period (days)						
		0	40	80	120	160	200	Mean
		TSS %						
1300	Control	36.5	40.0	39.5	38.0	37.0	36.5	37.9
	Potassium chloride	38.0	41.5	40.5	40.0	39.0	38.5	39.6
	Algae extract	38.5	42.0	41.0	40.5	39.5	38.5	40.0
	Potassium humate	38.5	42.5	41.5	41.0	39.5	38.5	40.2
	Calcium carbonate	39.0	42.5	41.5	41.0	40.0	39.0	40.5
	Mean	38.1	41.7	40.8	40.1	39.0	38.2	39.6
1950	Control	35.5	39.5	39.0	38.0	37.0	36.5	37.6
	Potassium chloride	37.0	41.0	40.5	40.0	39.0	38.0	39.2
	Algae extract	37.5	41.0	40.5	40.0	39.0	38.5	39.4
	Potassium humate	37.0	41.0	39.5	39.0	38.5	38.0	38.8
	Calcium carbonate	37.5	41.5	41.0	40.0	39.5	38.5	39.7
	Mean	36.9	40.8	40.1	39.4	38.6	37.9	38.9
2600	Control	35.0	39.5	39.0	38.0	37.0	36.0	37.4
	Potassium chloride	36.0	40.5	40.0	39.5	38.5	37.0	38.6
	Algae extract	36.5	40.5	40.0	39.0	38.0	37.5	38.6
	Potassium humate	36.0	41.0	40.0	39.5	38.5	37.0	38.7
	Calcium carbonate	37.0	41.0	40.0	40.0	39.0	38.0	39.2
	Mean	36.1	40.5	39.8	39.2	38.2	37.1	38.5
Mean		37.0	41.0	40.2	39.6	38.6	37.7	-
Control		35.7	39.7	39.2	38.0	37.0	36.3	37.6
Potassium chloride		37.0	41.0	40.3	39.8	38.8	37.8	39.1
Algae extract		37.5	41.2	40.5	39.8	38.8	38.2	39.3
Potassium humate		37.2	41.5	40.3	39.8	38.8	37.8	39.2
Calcium carbonate		37.8	41.7	40.8	40.3	39.5	38.5	39.8

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at0.2% and calcium carbonate at 6%

L.S.D at 5%

Water quantity (W)	0.16	W × F	0.36
Foliar spray (F)	0.21	W × Sp	0.39
Storage period (Sp)	0.23	F × Sp	0.51
W × F × Sp	0.88		

Regarding the effect of triple interaction among water quantity, foliar application and storage period, it is clear from the same data that the maximum values of total soluble solids percentage at the end of storage period (200 days) were noted by irrigation with 1300 m^3/fed. and foliar application with calcium carbonate at 6% (40.0 and 39.0%) in the 1st and 2nd seasons respectively, on the other hand the minimum values in this respect at the end of storage period were recorded by control treatment when irrigated with 2600 m^3/fed. that gave (37.0 and 36.0 %) in the first and second seasons, respectively.

Sprouting percentage

It is clear from the data in Table 9 that there was a considerable and continuous increase in sprouting % when the storage period was extended, the maximum values of sprouting % were occurred at the end of storage (320 days) and it reached to 9.44 and 8.69 % in the 1st and 2nd seasons respectively such an increase in sprouting % negatively affected the market quality. Similar results were found by **Abou El-Khair (2004) and El-Sayed and El-Morsy (2012)** on garlic, they reported that a considerable increase in sprouting % with the prolongation of storage period.

Regarding irrigation water quantity, it is clear from the data in Table 9 that irrigation water quantity had significant effect on sprouting % of garlic bulbs during storage period in both seasons of study. Sprouting % significantly increased with increasing irrigation water quantity up to 2600 m^3/fed. but irrigation water at 1300 m^3/fed. gave the minimum values of sprouting % during storage period (4.83 and 3.90%) in the 1st and 2nd seasons, respectively. The high moisture levels in bulbs that received high water quantity decreased bound water and increased free water (as previously explained in part one of this research) which in turn led to increase sprouting percentage. These results agree with those reported by **Abou El-Khair (2004)** on garlic who found that increasing water quantity led to increasing percentage of sprouting.

With concern to foliar application the same results in Table 9 demonstrate that there were significant differences among the used safely substances in sprouting %, where $CaCo_3$ at 6% recorded the minimum values of sprouting (4.92 and 4.11%) followed by potassium humate at 0.2% which gave 5.11 and 4.30 % in the 1st and 2nd seasons, respectively without significant differences between them. On the contrary, control treatment recorded the maximum values of sprouting percentage (6.25 and 5.36 %) in the 1st and 2nd seasons, respectively.

As for the interaction between water quantity and foliar application the same results show that the interaction between the lowest level of irrigation (1300 m^3/fed.) and foliar application with calcium carbonate at 6% and/or potassium humate at 0.2% recorded the minimum values of sprouting % without significant differences between them. On the other side, the maximum values of sprouting % were obtained by the interaction between control treatment and the highest level of irrigation (2600 m^3/fed.) which gave 7.08 and 6.17 % in the first and second seasons respectively.

The interaction between irrigation water quantity and storage period show significant effect in both seasons of study, the minimum values of sprouting % at the end of storage period (320days) were noted by the lowest water quantity (1300 m^3/fed.) which gave 8.93 and 7.67 % in the first and second seasons respectively. While the maximum values in this respect (10.20 and 9.73%) were recorded by the highest level of irrigation at the end of storage period in the 1st and 2nd seasons, respectively.

With regard to the interaction between storage period and foliar application, the same results in Table 9 show that spraying garlic plants with $CaCo_3$ at 6% and/or potassium humate at 0.2% gave the minimum values of sprouting % at the end of storage period without significant differences between them which gave 8.78 and 8.11% for calcium carbonate and 9.00 and 8.22 % for potassium humate in the 1st and 2nd seasons, respectively. On the other hand, the maximum values in this respect at the end of storage period were recorded by control treatment which gave 10.22 and 9.44% in the first and second seasons respectively.

Concerning the effect of triple interaction among water quantity, foliar application and storage period, it is obvious from the same data that, the minimum values of sprouting percentage at the end of storage period were recorded by irrigation with1300 m^3/fed. and foliar application with calcium carbonate and/or potassium humate followed by the interaction between irrigation with1950 m^3/fed. and spraying with $CaCo_3$ at 6% and/or potassium humate at 0.2% without significant differences among the four treatments. On the contrary, the maximum values in this respect were obtained from control treatment when irrigated with the highest level of irrigation water (2600 m^3/fed.) these results are true in both seasons of study.

Table 9. Effect of the interaction between drip irrigation rates and foliar spray with some safely substances on sprouting % of garlic bulbs during storage periods

Water quantity (m^3/fed)	Foliar spray	Season 2015/2016					Season 2016/2017				
		Storage period (days)									
		200	240	280	320	Mean	200	240	280	320	Mean
		Sprouting %									
1300	Control	2.00	4.67	5.67	9.33	5.42	1.67	3.00	5.33	8.33	4.58
	Potassium chloride	1.67	3.67	5.33	9.33	5.00	1.67	2.67	4.67	8.00	4.25
	Algae extract	1.33	3.67	5.33	9.00	4.83	1.33	2.67	4.33	7.67	4.00
	Potassium humate	1.33	3.33	5.00	8.67	4.58	1.00	1.67	3.67	7.33	3.42
	Calcium carbonate	1.33	3.00	4.67	8.33	4.33	1.00	1.67	3.33	7.00	3.25
	Mean	1.53	3.67	5.20	8.93	4.83	1.33	2.33	4.26	7.67	3.90
1950	Control	2.67	5.00	7.33	10.00	6.25	2.33	3.67	5.67	9.67	5.33
	Potassium chloride	2.33	4.67	6.67	9.67	5.83	2.00	3.33	5.33	9.00	4.92
	Algae extract	2.00	4.33	6.00	9.00	5.33	1.67	3.33	5.33	8.67	4.75
	Potassium humate	1.67	4.00	5.67	8.67	5.00	1.67	3.00	4.67	8.00	4.33
	Calcium carbonate	1.67	3.67	5.33	8.67	4.83	1.33	3.00	4.33	8.00	4.16
	Mean	2.07	4.33	6.20	9.20	5.45	1.80	3.26	5.07	8.67	4.70
2600	Control	3.33	5.33	8.33	11.33	7.08	3.00	4.67	6.67	10.33	6.17
	Potassium chloride	3.00	5.33	8.00	10.67	6.75	2.67	4.00	6.33	10.00	5.75
	Algae extract	2.67	5.00	7.67	10.00	6.33	2.67	3.67	5.33	9.67	5.33
	Potassium humate	2.67	4.33	6.33	9.67	5.75	2.33	3.67	5.33	9.33	5.17
	Calcium carbonate	2.33	4.33	6.33	9.33	5.58	2.00	3.33	5.00	9.33	4.92
	Mean	2.80	4.86	7.33	10.20	6.30	2.53	3.87	5.73	9.73	5.46
Mean		2.13	4.29	6.24	9.44	-	1.89	3.15	5.02	8.69	-
Control		2.67	5.00	7.11	10.22	6.25	2.33	3.78	5.89	9.44	5.36
Potassium chloride		2.33	4.55	6.67	9.89	5.86	2.11	3.33	5.44	9.00	4.97
Algae extract		2.00	4.33	6.33	9.33	5.50	1.89	3.22	5.00	8.67	4.69
Potassium humate		1.89	3.89	5.67	9.00	5.11	1.67	2.78	4.55	8.22	4.30
Calcium carbonate		1.78	3.67	5.44	8.78	4.92	1.44	2.67	4.22	8.11	4.11

Potassium chloride at 1%, algae extract at 0.3%, potassium humate at0.2% and calcium carbonate at 6%

L.S.D at 5%	1st season	2nd season		1st season	2nd season
Water quantity (W)	0.16	0.24	W × F	0.37	0.54
Foliar spray (F)	0.21	0.31	W × Sp	0.33	0.49
Storage period (Sp)	0.19	0.28	F × Sp	0.43	0.63
W × F × Sp	1.80	1.10			

CONCLUSION

The results obtained in this investigation suggest that irrigation garlic plants grown under sandy soil conditions with 1950 m^3/ fed. in combination with foliar application of calcium carbonate at 6% or potassium humate at 0.2% were the best treatments for, volatile oil percentage and oil yield per plant and effectively improved weight loss percentage, total soluble solids and sprouting percentage.

REFERENCES

A.O.A.C. (1990). Quality of Official Analytical Chemists 15th ed. Washington DC. USA.

Abdel-Razzak, H. S. and EL- Sharkawy, G.A. (2013). Effect of biofertilizer and humic acid applications on growth, yield, quality and storability of two garlic (*Allium sativum* L.) cultivars. Asian J. of crop Sci., 5(1): 48-64.

Abou El-Khair, E.E. (2004). Effect of irrigation and fertilization treatments on garlic crop and its storageability under sandy soil conditions. Ph. D. Thesis, Fac. Agric., Zagazig Univ., Egypt. 159pp.

Ahmed, M. E. M.; El-Aidy, A.A.; Radwan, A.A. and Tahany, Sh. Abd El-Bary (2010). Response of garlic plants to humic acid and different application methods of potassium fertilizer. Minufiya J. Agric. Res., 35 (6): 1-17.

Algadi, M. Z.A.; Elgasim, E.A. and Ibrahim, F.S. (2014). Physicochemical properties of garlic (*Allium sativum*) paste treated with ascorbic and citric acids. Inter. J. Sci., Environ. and Technol., 3 (6): 1932 - 1942.

Bardisi, A. (2004). Influence of vitamin C and salicylic acid foliar application on garlic plants under sandy soil conditions. 2- Yield and storability. Zagazig J. Agric. Res., 31(4a): 1349-1360.

Carpita, N. C. and Gilbeaut, D. M. (1993). Structural models of primary cell walls in flowering plants: Consistency of molecular structure with the physical properties of the walls during growth. Plant J.3: 1-30.

El-Ghamriny, E. A.; Bardisi, A.; Fayad, A. N. and Anwar, R. S. (2005). Growth, plant water relations and chemical constituents of potato plants as affected by water quantity and some antitranspirants under sandy soil conditions. Zagazig J. Agric. Res., 32(3): 739-766.

El-Mansi, A.A.; El-Ghamriny, E. A.; Arisha, H. M. E. and Abou El-Khair, E.E. (1999). Effect of cultivar, irrigation intervals and water quantity on garlic under drip irrigation system in sandy soil. 3- Storageability. Zagazig J. Agric. Res., 26(6): 1695-1705.

El-Mansi, A.A.; Bardisi, A.; Fayad, A. N. and Abou El-Khair, E.E. (2004). Effect of water quantity and farmyard manure on garlic under sandy soil conditions. 3- Storability. Zagazig J. Agric. Res., 31(4a): 1361-1383.

El-Sharkawy, G.A. and Abdel-Razzak, H.S. (2010). Response of cabbage plants (*Brassica oleraceae* var. *capitata* L.) to fertilization with chicken manure, mineral nitrogen fertilizer and humic acid. Alex Sci. Exch. J. 31: 416–432.

El-Sayed, A. El-S. H. and El-Morsy, A. H. A. (2012). Response of productivity and storability of garlic (*Allium sativum* L.) to some potassium levels and foliar spray with mepiquat chloride (PIX). International Res. J. Agric. and Soil Sci., 2(7): 298-305.

Gmaa, S.S. (2016). Improving yield, quality and storageability of garlic (*Allium sativum* L.) by pre-harvest foliar application. J. Plant Production Mansoura Univ., 7 (1): 7- 12

Guenther, E. (1961). The Essential oils. Vol (1), van Nostrand Co., New York.

Hasan, Sh. Kh. H.; Mohamed, O.O. and Atress, A. S. H. (2017). Effect of plant spacing and harvesting date on yield, quality and storability of green garlic. Bull. Fac. Agric., Cairo Univ., 68(4): 385-536.

Mansour, F. Y.O.; Ramadan, M.M.A. and El-Metwaly, H.M.B. (2019). Effect of nitrogen fertilization and some stimulants on dry weight, yield, bulb quality and storability of garlic. Zagazig J. Agric. Res., 46 (3): 621-634.

Marschner, H. (1995). Mineral nutrition of higher plants 2nd Ed. Academic Press London, UK. 889. pp.

Salter, P.J. and Goode, T. E. (1967). Crop response to water at different stages of growth. Franham Reyal, Common Welth Agric., Bureaux.

Shalaby, T.A. and El-Ramady, H. (2014). Effect of foliar application of bio-stimulants on growth, yield, yield components, and storability of garlic (*Allium sativum* L.). AJCS, 8 (2): 271-275.

Shibairo, S. I.; Upadhyaya, M. K. and Toivonen, P. M. A. (1998). Potassium nutrition and post harvest moisture loss in carrots (*Daucus carota* L.). J. Hort. Sci. & Biotec., 73(6): 862-866.

Snedecor, C. W. and Cochran, W. G. (1980). Statistical Methods. 7th Ed. The lowa state Univ. Press.Ames. lowa, USA. 325-330.

Watada. A. E. and Qi, L. (1999). Quality of fresh cut produce. Postharvest Biol. and Technol., 15: 201-205.

Wills, R.; Mcglasson, B.; Graham, D. and Joyce, D. (1998). Post-harvest: An introduction to the physiology and handling of fruit, vegetables and ornamentals. Ed.: CAB International, Wallingford, UK.