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EFFECT OF FOLIAR APPLICATION OF POTASSIUM SILICATE AND SOME POSTHARVEST TREATMENTS ON GROWTH, PRODUCTIVITY AND STORABILITY OF GARLIC

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ABSTRACT

Two experiments were carried out in the experimental farm of Al-Kanater Research Station at El-Qalyubia Governorate, during the two consecutive years of 2016/2017 and 2017/2018 to investigate the effect of potassium silicate foliar application on growth, productivity and some postharvest treatments on storability of garlic ((*Allium sativum* L.)" clone sids 40".

In the field experiment, the treatments comprised of control(water spray),foliar application of potassium silicate at 4000, 6000 and 8000ppm and plants were sprayed at 30, 60 and 90 days after planting.

In the storage experiment, cured bulbs were stored at room temperature conditions and subjected to sixteen postharvest treatments included the previous four treatments (the three potassium silicate levels and control). In addition, three spraying treatments of sodium silicate at 6000 ppm, chitosan at 200 ppm and calcium chloride at 3000 ppm both separately and their combinations with potassium silicate (three treatments in field) were done.

The results revealed that, the highest plant length, number of leaves, fresh, dry weight\plant, neck diameter, bulb diameter and chlorophyll content of garlic were achieved from foliar application of potassium silicate at the 4000ppm after 120 days from planting compared to the control. Foliar spray of potassium silicate at 4000 ppm recorded the highest total yield and bulb quality such as bulb diameter, bulb weight/plant, number of cloves, cloves weight, total soluble solids and dry matter of bulbs. Leaf K percentage significantly increased by spraying of potassium silicate at 6000ppm.Further, all potassium silicate treatments recorded higher silicon percentage over the control.

Postharvest results showed that weight loss and shrinking percentages of the bulbs after 7 months of the storage were the least with the foliar application of potassium silicate at 8000ppm plus chitosan at 200ppm in storage followed by chitosan individually, potassium silicate at 8000 ppm and potassium silicate at 6000 ppm combined with calcium chloride as a postharvest treatment. However, the highest total soluble solids after 7 months of the storage was obtained from foliar spraying of potassium silicate at 4000 ppm combined with either sodium silicate or chitosan. Also, bulbs treated with foliar application of potassium silicate at 6000 or 8000 ppm combined with chitosan at 200 ppm, had the highest values of dry matter after 7 months from storage.

In general, foliar application of potassium silicate at 4000ppm was the superior treatment for enhancing plant growth, yield and quality. Also, foliar application of potassium silicate at 8000ppm and sprayed with chitosan at 200 ppm was the most effective for garlic storability seven months at the room temperature conditions.

Key words: Garlic, Potassium silicate, Growth, Yield, Chitosan, calcium chloride and storability

INTRODUCTION

In Egypt, garlic (*Allium sativum* L.) is consider one of the most important vegetables for both local consumption and exportation. Garlic is a second vital cultivated *Allium* species after onion worldwide. Garlic is used as a spices, seasonings, condiments, medicinal value. As well as, flavoring for foodstuff involving both green tops and bulbs **Dufoo-Hurtado et al 2015).**

Silicon concentration ranges from 1% to 10% or higher in plant dry matter **(Epstein, 1999).** Since plants require silica to resist against biotic and abiotic stress **(Ma, 2004),** Si has an important potential in the plant growth and development (**Datnoff *et al*., 2001 and Henk 2018).**

Potassium application on garlic significantly increased plant growth, yield and its components and concentration of TSS, N, P, K as well as chemical constituents and storability of bulbs **(El-Morsy et al 2004)**. Potassium element is very important in overall metabolism of plant enzymes activity, it was found to serve a vital role in photosynthesis by direct increasing in growth **Mansour, (2006**). Supplemental dose of potassium as a foliar spray had a significant effect on the onion yield **(Ghoname et al 2007)**.Potassium silicate can improve the physiological response of plant leaves as increased the photosynthetic pigments, compatible solutes, and enzyme activity then improve the ability to resist against white rot disease then increase the yield production of the onion plants **(Mamdouh et al 2017)**.Silicic acid sprays increase growth and yield and decrease biotic and abiotic stress and attributed, these effects to that monosilicic acid is absorbed by the leaf and fulfills a role as a signaling molecule for the activation of growth-promoting and anti-stress hormones **(Henk, 2018).**

Calcium chloride treatment reduced decay percentage due to the vital roles of calcium in plant tissues, such increase membrane stability, and cell wall strength **(Poovaiah et al 1988).** As pointed out by **Taain (2011)** postharvest treatment of jujube fruits with calcium chloride and calcium nitrate decreased the decay of fruits particularly caused by fungi, decreased weight loss. In addition, preharvest applications of CaCl2 showed improved fruit Ca concentration, texture, and flavor; and decreased weight loss of papaya **(Babak et al 2015)**. Moreover, Ca application delays postharvest softening and decreases weight loss tomato fruits (**Dhia et al 2017).**

Chitosan is a natural antimicrobial biopolymer with a good film forming ability, hence, it is used as an edible coating on whole and fresh cut fruits and vegetables where, Chitosan improves storability of postharvest fruits and vegetables because it forms a semi permeable film that regulates the gas exchange and reduce transpiration and respiration **(Shehata et al 2012).** Hence weight loss is reduced and fruit ripening is slowed down. This effect has been reported for numerous horticultural commodities such as tomatoes, strawberries **(Kittur et al 2001 and Bautista et al 2006)** and garlic **(Khreba et al 2014 and El-Sagan and El Dsouky, 2015).**

Therefore, this study was carried out to investigate the influence of foliar application of some potassium silicate concentrations on garlic growth .As well as, the effect of spraying chitosan, sodium silicate and calcium chloride on storability improvement.

MATERIALS AND METHODS

Two field experiments were carried out on garlic (*Allium sativum* L.) "clone sids 40" during 2016\2017 and 2017\2018 at the experimental farm of Al-Kanater Research Station El-Qalyubia Governorate, Egypt, to investigate the effect of foliar application of potassium silicate levels on growth, yield, its components and storability; as well as the effect of some postharvest treatments on garlic storability, two experiments were conducted :

The first experiment:

Three concentrations of potassium silicate were foliar sprayed at 4000ppm, 6000ppm ,8000ppm and control (tap water) treatments started after 30, 60 and 90 days from planting. All other agricultural practices were applied according to the recommendation of Hort. Res. Inst., A.R.C. Ministry of Agric. Egypt, under drip irrigation condition. The experimental design was a complete randomized block design with three replicates. Planting dates were at the 4^{th} and 6^{th} of October in the two seasons respectively. Plants were arranged in four row-bed system with 100cm width and 30cm height. Garlic clove seeds were planted in hills at 10 cm apart within each row. Planting was done on both sides of each hill and experimental plot area was 20 m^2 (four rows with five meters length and 1m width).

Data recorded

Vegetative growth parameters

After 120 days from planting, ten plants from each experimental plot were randomly selected for measuring the following characters i.e., plant length (cm), number of leaves/plant, fresh and dry weight of plant (g), neck diameter(cm), bulb diameter(cm), and Leaf total chlorophyll readings (SPAD) were measured on attached leaves using a portable chlorophyll meter (SPAD–502, Konica Minolta Sensing, Inc., Japan).

Yield and its quality

At harvest time in 20th May and after curing for 7 days, yield per plot was calculated and yield per fed./ton was estimated according to the yield \ plot**.** Ten bulbs were taken randomly from each experimental plot to measure the bulb quality of the following characters i.e., bulb fresh weight (g), bulb diameter (cm), number and weight of cloves /bulb and bulb ratio were measured.

Chemical composition

Dry matter (%)

It was calculated twice, after curing bulbs and after seven months of storage.

Mineral contents

Silicon and potassium were determined in the digested dry matter of leaves as follows: -Silicon percentage was determined with an inductively coupled plasma (ICP) spectrometer according to **Stefansson and Grioud (2007).** Potassium percentage was determined by using Flame photometer according to **Brown and Lilliland (1946).**

Total soluble solid content (TSS)

Total soluble solid of cloves were taken twice, after curing bulb and after seven months of storage, using a JK-SR-113ATC digital Refractometer (Shanghi Co. Ld., China).

The second experiment

Included 16 storage treatments to investigate the effect of them on storability of bulbs as follows :

1- Four treatments from field experiment

Control (tab water), Potassium silicate at three concentrations (4000, 6000 and 8000 ppm).

2-Three postharvest treatments:-

Sodium silicate at 6000 ppm, chitosan at 200 ppm, Calcium chloride at 3000 ppm.

3- Nine treatments combinations

The previous postharvest treatments were combined with Potassium silicate levels chosen from field treatments at 4000, 6000 and 8000ppm.

1Kg of uniform bulbs was sprayed after curing by the three postharvest treatments and placed in nets, then distributed in a complete randomized design. Three replicates were prepared for each treatment. All treatments were stored at room temperature at 24 C ± 5°C with common storage conditions with aeration conditions and stored for seven months at Al-Kanater Horticulture Research Station. The experimental design was a complete randomized design with three replicates in the storage conditions.

Data recorded

Data were recorded, during the storage period, from seventh and ninth of May until1st and 5th of Decembers in the two growing seasons respectively as follows:-

1- Weight loss

It was calculated monthly according to the following formula: Weight loss (%) = initial weight – weight of bulbs for sampling dates × 100\ initial weight of bulb.

2-Shrinking %

The percentage of shrinking cloves was calculated monthly according to the following formula: shrinking cloves (%) = Number of Shrinked cloves /Total number of cloves x100.

3-Total weight loss percentage

It was taken after seven months of storage.

Statistical analysis

Analysis of data was done by IBM computer and means were compared using Duncan's multiple range tested as described according to **Snedecor and Cochran (1982).**

RESULTS AND DISCUSSION

1- Field experiment

Vegetative growth

Results in **Table (1)** indicate that the highest plant length was produced from foliar spray with potassium silicate at 6000 or 8000 ppm followed by 4000 ppm in the first season. Moreover, all the concentrations of potassium silicate showed the taller plant length compared with untreated plants in the second season. Also, potassium silicate at 4000 ppm recorded the highest number of leaves

/plant in the two growing seasons**.** In this connection, spraying tomato transplants by silicic acid were taller than control **(Olle and Schnug, 2016**).Also, foliar application of potassium silicate enhanced plant growth as reported by **(Diwate, 2018)** on sweet orange.

Data in **Table (1)** indicate that the highest fresh weight per plant was achieved from 4000ppm followed by 8000ppm in the two tested seasons. Also, the highest dry weight percentage per plant was recorded from the application of potassium silicate at 4000ppm compared with the untreated plants in the two growing seasons. While, in the first season there were no significant differences among the three potassium concentrations. This result was agree with findings of **Ali (2017)** who found that the foliar spraying with salicylic acid on garlic plants increased plant growth traits, i.e., plant height, both fresh and dry weight/plant.

Table 1. Effect of foliar spray with potassium silicate concentrations on vegetative growth characters of garlic plants at 120 days from planting during 2016/ 2017 and 2017/2018 seasons.

Character / Treatments	Plant length (cm)	No. leaves /plant	fresh weight/ plant (g)	dry weight/ plant (%)	Neck diameter (cm)	Bulb diameter (cm)
2016/2017						
control	72.40 c	7.14 c	76.06c	28.48 b	1.01 c	2.06 c
potassium silicate4000ppm	78.71 b	9.85 a	100.76a	37.20 a	1.53 a	3.03 a
potassium silicate6000ppm	81.28 a	8.56 ab	84.72bc	35.72 a	1.48 ab	2.56 b
potassium silicate8000ppm	81.91 a	9.06 ab	89.00b	36.39 a	1.28 b	2.10 c
2017/2018						
control	68.36 b	8.61 c	75.67b	30.01 c	1.13 b	2.16 c
potassium silicate4000ppm	80.97 a	10.20 a	115.50a	40.82 a	1.58 a	3.05 a
potassium silicate6000ppm	82.65 a	9.46 b	79.67b	36.34 b	1.51ab	2.62 b
potassium silicate8000ppm	82.25 a	9.22 bc	89.00ab	35.67 b	1.26 b	2.21 c

Values within the column followed by the same capital /s do not significantly differ from each other according to Duncan 's multiple range test at 5 % level.

In respect to the neck diameter, results in **Table (1)** indicate that the highest neck diameters were obtained from both of the application of potassium silicate at 4000 and 6000 ppm in the two tested seasons. In addition, the largest bulb diameter was obtained with the application of potassium silicate at 4000ppm during the vegetative growth stage in both seasons. In this connection, foliar potassium on garlic plants increased growth characters **(Gmaa, 2016) and (Olle and Schnug, 2016**) on tomato. Such results are in agreement with findings of **Ali (2017)** who showed that the foliar spraying with yeast extract and salicylic acid on garlic increased plant growth traits**.**

Table (2) clearly show that the highest chlorophyll content was observed from foliar spray with potassium silicate at 4000ppm followed by 6000 and 8000ppm without significant differences between each of them. While, the lowest content of chlorophyll was recorded by the control plants in the two seasons. Application of potassium silicate have accelerated the synthesis of chlorophyll associated with photosynthesis and accumulated carbohydrates that resulted an increase in the size of bulb as indicated by diameter and average bulb weight, as well as ultimately the overall yield. Similar findings were also noticed by **Mansour (2006) and Talware et al (2010)** on garlic plants and **(Mamdouh et al 2017)** on onion.

Yield and its components

Results in **Table (2)** show that, the foliar application of potassium silicate at 4000ppm significantly increased yield of bulbs, followed by the treatment of 8000ppm during the two growing seasons. On the other hand, the lowest value of yield was shown by untreated plants (control) in both tested seasons. Supplemental dose of potassium as foliar spray had a significant effect on the onion yield **Ghoname et al (2007) and Diwate (2018)** on sweet orange. Potassium silicate can improve the physiological response of plant leaves as increased the photosynthetic pigments, compatible solutes, and enzyme activity then increase the yield production of the onion plants **(Mamdouh et al 2017)**.

Furthermore, **Table (2)** showed that the foliar application of potassium silicate at 4000 ppm produced the highest bulb fresh weight /plant followed by 8000ppm .On the contrary, the untreated plants produced the lowest values in both seasons. **(Shalaby and El-Ramady, 2014 and Ali, 2017)** indicated that foliar application of biostimulants on garlic effectively increased yield and quality. In addition, significant increment in bulb diameter with potassium silicate foliar application and the highest bulb diameter was achieved by using 4000ppm followed by 6000ppm compared with control. Potassium silicate could be affect the final bulb weight and size which improve the total yield. Silicon sprays significantly improved some growth parameters and ground cover **(Janmo hammadi, et al 2016)** on safflower crop**.**

Table 2. Effect of foliar spray with potassium silicate concentrations on total chlorophyll, yield and bulb quality in 2016/2017 and 2017/2018 seasons.

Character / Treatments	Total Chlorophyll (SPAD)	Yield (ton/fed.)	fresh bulb weight/ plant (g)	bulb diameter (cm)	No .of cloves	Clove weight (g)	bulbing ratio
2016/2017							
Control	69.59 c	5.92 c	61.38 c	4.17 d	23.00 c	2.35 c	0.59 b
potassium silicate4000ppm	83.44 a	10.38 a	77.33a	6.11 a	26.20 a	4.08a	0.69 ab
potassium silicate6000ppm	77.42 b	7.88 b	69.90 b	5.36 b	22.93 c	3.52 ab	0.68 ab
potassium silicate 8000 ppm	78.46 b	7.793 b	71.40b	4.60 c	25.00 b	3.24 b	0.74 a
2017/2018							
Control	73.59 c	7.51 d	50.5 d	4.56 d	23.05a	1.94 b	0.61 c
potassium silicate4000ppm	85.71 a	12.18 a	74.1 a	6.69 a	22.33a	3.75 a	0.75 b
potassium silicate 6000 ppm	80.92 b	8.81 c	56.13 c	5.71 b	24.00a	3.33 a	0.62 c
potassium silicate 8000 ppm	81.09 b	9.89 b	68.25 b	4.80 c	22.50a	3.08 a	0.86 a

Values within the column followed by the same capital /s do not significantly differ from each other according to Duncan 's multiple range test at 5 % level

Table (2) clearly showed that foliar application with potassium silicate at 4000 ppm gave the highest number of cloves followed by 8000ppm in the first season. However, there were no significant differences between all treatments in the second season. Results are in harmony with **Gmaa (2016)** who demonstrated that stimulants not significantly affect number of cloves. Also, foliar spray with 4000ppm and 6000 ppm recorded the highest weight of cloves following by 8000 ppm compared to the control which recorded the lowest weight of cloves in the two seasons. In addition, the bulbing ratio was significantly increased by the different treatments compared to the control. Where, the application of potassium silicate at 8000 recorded the highest values of bulb ratio in the two tested seasons. In this connection, foliar application of potassium on garlic plants increased growth characters **(Gmaa, 2016)** on garlic **and (Olle and Schnug, 2016**) on tomato. This is in agreement with findings of **Ali, (2017)** who showed that the foliar spraying with yeast extract and salicylic acid on garlic increased plant growth traits and bulbing ratio.

Data in **Table (3)** show that the highest potassium leaves concentrations was observed from foliar spraying with potassium silicate at 6000ppm and there were no significant differences among 4000, 8000ppm and control in the two tested seasons. Additionally, the highest values of silicon content of leaves was recorded by spraying 4000ppm and there were no significant differences between 6000 or 8000 ppm compared with control in the first and second seasons. Similar findings were obtained by **Praksh et al (2011)** they showed that application of silicon increased the shoot silicon concentration of rice and **Ali (2017)** demonstrated that the interaction between foliar spray with yeast extract and salicylic acid increased K content in garlic leaves. Moreover**, Satisha et al (2017)** found that application of Potassium silicate on chili increased nutrient uptake

In respect to bulb total soluble solids content at harvest, data showed that spraying with potassium silicate at 4000ppm produced the highest values followed by 8000 ppm in the first season. In addition, the foliar application of potassium silicate at 4000 and 8000 ppm had significant increment of total soluble solids content in the second season.

Table 3. Effect of foliar spray with potassium silicate concentrations on Potassium, silicon, total soluble solids and dry matter contents of garlic in 2016/2017 and 2017/2018 seasons.

Character / Treatments	Potassium% of leaves	Silicon% of leaves	TSS Of bulbs	Dry matter % of bulbs
2016/2017				
control	1.22b	1.65b	37.30c	28.16 d
Potassium silicate4000ppm	1.24b	3.16a	40.80a	35.24 a
potassium silicate6000ppm	1.56a	2.49ab	39.40b	30.50 c
potassium silicate8000ppm	1.24b	2.43ab	40.10b	33.10 b
2017/2018				
control	1.27b	1.79b	38.90c	40.44 c
potassium silicate4000ppm	1.39b	2.98a	42.10a	51.95 a
potassium silicate6000ppm	1.96a	2.79a	40.40b	47.16 b
potassium silicate8000ppm	1.21b	2.98a	41.00ab	48.27 b

Values within the column followed by the same capital /s do not significantly differ from each other according to Duncan 's multiple range test at 5 % level

On the other hand, the control recorded the lowest values of total soluble solids content in the two seasons **(Table 3).** The increment in the percentage of total soluble solids may be due to the reduction of moisture content of bulbs and the lower moisture content of the fruit increases the concentration of the cell juice of the bulbs and thus increases the percentage of soluble solids as mentioned by **(Burton 1982)**.Similarly, potassium silicate at 4000ppm recorded the highest values of dry matter percentage of bulbs at harvest followed by 6000 or 8000ppm. On the contrary, the untreated plants produced the lowest dry matter of bulbs in two tested seasons. These findings are similar with **Gmaa (2016**) who demonstrated that dry matter of bulb was increased by spraying with potassium oxide on garlic plants.

2- The second experiment (storage experiment)

Weight loss percentage

It is clear from data presented in **Table (4)** that there were significant differences among the different treatments of postharvest in weight loss percentage after two, four and seven months of the storage. The foliar application of potassium silicate at 8000 ppm individually or plus chitosan at 200 ppm and the treatment of chitosan at 200ppm recorded the lowest weight loss values followed by the foliar application of potassium silicate at 6000 ppm plus calcium chloride at 3000 ppm compared with the other tested treatments.

Presented results are agreement with those obtained by **Babak et al (2015)** who showed that Preharvest applications of $CaCl_2$ decreased weight loss of papaya**.**

In this aspect, potassium silicate at 8000 ppm without postharvest treatments had less weight loss percentage **(Table 4).** These results may be due to the stimulatory effect of silicon on growth parameters, which may be reflected on quality and storability of garlic bulbs during storage. On the other side, the highest weight loss percentage was obtained with control treatment or spraying of potassium silicate 4000 ppm field treatment plus calcium chloride 3000 ppm in both seasons. The effect of spraying chitosan on garlic bulbs storability due to the positive effect of chitosan that extend the storage through the reduction of respiration rate and water loss. Coating fruits with semi permeable film has generally been shown to retard ripening by modifying the endogenous CO_2, O_2, and ethylene levels of fruits (**El Ghaouth et al 1991**).

Chitosan coating is likely to modify the internal atmosphere without causing anaerobic respiration, since chitosan films are more selectively permeable to O_2 than to CO_2 **Shehata et al (2012**). These results may be due to the stimulatory effect of silicon on growth parameters, which may be reflected on quality and storability of garlic bulbs during storage. Chitosan is a natural biopolymer with a good film forming ability, hence, it is used as an edible coating on vegetables and fruits **(Khreba et al 2014 and El-Sagan and El Dsouky, 2015).** Ca application as postharvest treatment decrease weight loss of tomato fruits (**Dhia et al 2017).**

Table 4. Effect of foliar spray of potassium silicate levels and postharvest treatments on weight loss % after two, four and seven months of the storage periods during 2016/2017 and 2017/2018 seasons.

Treatments	weight loss %					
	After 2 month		After 4 month		After 7 month	
	Season1	Season2	Season1	Season2	Season1	Season2
Control	21.63 a	21.81 ab	25.80 a	28.16 ab	33.47 abc	29.48 abcd
Potassium silicate 4000ppm	13.56 bcd	19.63 abc	16.60 bcdefg	23.71 bcd	35.12 ab	34.82 ab
Potassium silicate 6000ppm	11.00 def	14.05 ef	18.78 bcde	17.62 efg	31.41 bcde	25.97 de
Potassium silicate 8000ppm	8.50 fg	11.02 fg	18.58 bcdef	15.60 fg	26.08 f	23.47 de
Sodium silicate 6000ppm	10.30 defg	16.40 cde	15.37 defg	22.37 cde	33.50 abc	26.83 bcde
Chitosan 200ppm	9.80 efg	13.37 ef	14.30 fg	20.91 de	27.99 def	26.10 cde
calcium chloride 3000ppm	12.23 cde	14.49 def	17.35 bcdef	21.57 cde	27.21 ef	25.37 de
Potassium silicate 4000ppm + Sodium silicate 6cm/L	15.03 bc	22.79 ab	20.77 b	26.38 abc	31.12 bcde	34.13 abc
Potassium silicate 4000ppm + Chitosan200ppm	13.02 cde	19.27 bc	17.25bcdef	22.05 cde	29.63cdef	35.53 a
Potassium silicate 4000ppm + calcium chloride 3000ppm	16.87 b	23.20 a	19.45 bcd	29.27 a	35.51 ab	37.23 a
Potassium silicate 6000ppm + Sodium silicate 6cm/L	13.73 bcd	16.30 cde	18.10bcdef	22.52cde	35.59 ab	26.30 cde
Potassium silicate 6000ppm + Chitosan200ppm	11.70 cdef	14.69 def	16.20 cdefg	20.30 def	36.22 a	30.20 abcd
Potassium silicate 6000ppm + calcium chloride 3000ppm	11.00 def	13.27 ef	16.90bcdefg	18.39 efg	29.60 cdef	24.93 de
Potassium silicate 8000ppm + Sodium silicate 6cm/L	10.60 defg	16.08 cde	14.47 efg	20.20 def	32.41 bcde	26.47 cde
Potassium silicate 8000ppm + Chitosan200ppm	7.53 g	9.36 g	12.57 g	14.82 g	27.59 ef	18.83 e
Potassium silicate 8000ppm + calcium chloride 3000ppm	14.83 bc	17.97 bc	19.93 bc	21.50 cde	28.59 def	26.77 bcde

Values within the column followed by the same capital /s do not significantly differ from each other according to Duncan 's multiple range test at 5 % level.

Shrinking percentage

Results in **Table (5)** showed that the lowest value of shrinking percentage was recorded for foliar application with potassium silicate at 8000 ppm plus chitosan at 200 ppm as a postharvest treatment without significant difference with coating chitosan at 200 ppm followed by those sprayed with potassium silicate at 6000ppm in the field and treated with calcium chloride at 3000 ppm. On the other hand, the highest values were recorded for control and spraying of potassium silicate at 4000 ppm plus calcium chloride at 3000 ppm in the two seasons. In this connection, calcium treatment may be improved storability of postharvest vegetables, hence, calcium involved in plant cell wall integrity and has been reported in its role in improving storage life of several fruits and increased fruit firmness **(Ghani et al 2010).** Also, chitosan improves storability of postharvest fruits and vegetables because it forms a semi permeable film that regulates the gas exchange and reduce transpiration and respiration **(Shehata et al 2012).**

Table 5. Effect of foliar spray of potassium silicate levels and postharvest treatments on shrinking, total weight loss, total soluble solids and dry matter Percentages after seven months of the storage during 2016/2017 and 2017/2018 seasons.

Character / Treatments	Shrinking %		Total weight loss %		TSS %		Dry matter %	
	Season1	Season2	Season1	Season2	Season1	Season2	Season1	Season2
Control	33.58 ab	45.15 a	46.07 ab	49.53 a	38.67ab	39.67 cd	38.73 h	40.00g
Potassium silicate 4000ppm	30.31 bcd	30.98 efg	47.87 a	48.53 ab	38.00abc	38.33 de	40.36fgh	44.67de
Potassium silicate 6 000ppm	29.21 bcd	39.58 bc	41.80 abcd	30.90def	34.33gh	37.87 ef	43.06def	45.00 d
Potassium silicate 8000ppm	27.32 def	33.93 de	45.00 abc	30.37def	36.37cdef	37.60 ef	48.67bc	51.00 b
Sodium silicate 6000ppm	26.28defg	28.91 fgh	39.00 bcde	44.23abc	36.27def	39.00cde	40.37fgh	42.33 f
Chitosan 200ppm	21.79 gh	25.16 hi	37.13 cde	31.10def	36.00efg	36.67 fg	43.87de	51.00 b
calcium chloride 3000ppm	32.11 bc	33.54 def	39.43abcde	39.40bcd	37.79abcd	39.67 cd	39.50 gh	43.00 ef
Potassium silicate 4000ppm + Sodium silicate 6cm/L	27.63cdef	33.54 def	44.57 abc	36.37cde	39.00 a	41.20 ab	48.69bc	45.67d
Potassium silicate 4000ppm + Chitosan200ppm	22.26gh	36.23 cd	38.00 bcde	49.40 a	39.10 a	41.67 a	45.72cd	48.00c
Potassium silicate4000ppm + calcium chloride 3000ppm	38.00a	41.39 ab	41.00 abcd	42.93abc	38.00 abc	40.17 bc	42.00efg	43.00ef
Potassium silicate 6000ppm + Sodium silicate 6cm/L	28.08cde	32.61 def	43.77 abc	45.97abc	37.17bcde	38.53 de	43.06def	45.00d
Potassium silicate 6000ppm + Chitosan200ppm	28.46cde	33.41 def	41.28 abcd	49.40 ab	36.13 def	38.00 ef	54.26 a	56.33a
Potassium silicate 6000ppm + calcium chloride 3000ppm	24.41efg	29.48efgh	31.17 de	28.10 ef	37.17bcde	39.00cde	40.33fgh	43.00ef
Potassium silicate 8000ppm + Sodium silicate 6cm/L	28.74cde	42.12ab	41.10 abcd	29.07 ef	34.67 fgh	36.00 gh	48.96b	51.83b
Potassium silicate 8000ppm + Chitosan200ppm	19.36h	20.67 i	34.37 de	24.83 f	34.00 h	35.00 h	56.17a	55.33a
Potassium silicate 8000ppm + calcium chloride 3000ppm	23.25fgh	26.19gh	45.67 abc	36.20cde	37.83abcd	38.57 de	42.16efg	44.00def

Values within the column followed by the same capital /s do not significantly differ from each other according to Duncan 's multiple range test at 5 % level

Furthermore, results are harmony with those reported by **Shalaby and El-Ramady (2014)** on garlic; they noticed that plants sprayed with some biostimulants had better storability of bulbs than the control.

Total weight loss

Data in **Table (5)** show that bulbs received foliar application of potassium silicate at 8000 ppm plus chitosan at 200 ppm after 7 months in storage resulted in the lowest values of total weight loss percentages and without significant difference with the treatment sprayed with potassium silicate at 6000ppm in the field combined with calcium chloride at 3000 ppm and the treatment of chitosan at 200 ppm compared with the other treatments .It is noted that the fruits soaked with calcium chloride solution decreased the percentage of loss in weight because of calcium increases cell wall strength and reduces the decomposition of pectin and wax layer surrounding the fruit epidermis, which leads to reduce the evaporation of water content of fruits **Taain (2011)** on jujube fruits

Total soluble solids content

It is obvious from results in **Table (5)** that the highest total soluble solids after 7 months of storage were obtained from foliar spraying of potassium silicate at 4000 ppm combined with sodium silicate at 6000 ppm or with chitosan at 200 ppm in both seasons. While, the lowest total soluble solids resulted from spraying of potassium silicate at

8000 ppm combined with chitosan at 200 ppm or sodium silicate at 6000 ppm in the two tested seasons. Increasing in TSS during storage may result from an increase in concentration of organic solutes as a consequence of water loss. **Smith et al (1979)** reported that increased in TSS may occur due to numerous anabolic and catabolic processes taking place in apple, preparing it for senescence**.** The metabolic process related to the advance of ripening, probably due to disassociation of some molecules and structural enzymes in soluble compounds directly influence the levels of total soluble solids, where fruits in advanced stage of ripening present the highest levels of soluble solids **(Lyon et al 1992)** on persimmons**.** These results agree with those of **Gmaa (2016**) on garlic who mentioned the total soluble solids of cloves increased as prolonged storage period owing to the greater degradation or biosynthesis of the polysaccharides and accumulation of sugars

Dry matter

Data listed in **Table (5)** show that significant differences were found among the different treatments on dry matter after seven months from storage, the highest values were obtained from foliar application of potassium silicate at 6000 ppm plus chitosan at 200 ppm and foliar application of potassium silicate at 8000 ppm plus chitosan 200. On the other hand, untreated bulbs and calcium chloride at 3000ppm produced the lowest values of dry matter. These results are in agreement with those of **Nurzynsk and Wierdak(1998)** they found that dry matter content has increased as the storage duration increased of peeled garlic. The increase in dry matter content during storage months could be due to moisture losses from the outer skin over the storage period. This result is supported by work **Henriksen and Hansen (2001)** they showed slight increase in dry matter and accounted it to loss of moisture from the bulbs as well as to hydrolysis of fructans upon termination of the dormancy where the bulbs began to sprout. Similar results were also observed by **Currah and Rabinowitch (2002)** on onion and by **Sebsebe et al (2010)** on shallot.

Conclusion

The study recommends applying potassium silicate at 4000 ppm to increase growth, yield and quality of garlic bulbs. In addition, foliar application of potassium silicate at 8000ppm in field and treated bulbs with chitosan at 200 ppm enhanced storability of garlic followed by foliar application of potassium silicate at 6000ppm and treated with calcium chloride at 3000 ppm or treated with chitosan at 200 ppm.

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تأثير الرش بسيليكات البوتاسيوم وبعض معاملات ما بعد الحصاد علي النمو والإنتاجية والقدرة التخزينية في الثوم

[70]

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الموجـــــــز

اجريت هذه التجربة في محطة بحوث البساتين بالقناطر الخيريه– محافظة القليوبية خلال موسمي 2017/2016 و2017/ 2018 لدراسة تاثير الرش بسيليكات البوتاسيوم وبعض معاملات ما بعد الحصاد علي النمو واالانتاجية والقدرة التخزينية للثوم للصنف سدس 40 في تجربتين علي النحو التالي:

1–تجربة حقلية: الرش بسيليكات البوتاسيوم بثلاث تركيزات وهي 4000 – 6000 – 8000 جزء في المليون ومعاملة المقارنة (الرش بالماء). وتم إجراء الرش بعد 30 و60 و90 يوم من الزراعة وكان تصميم التجربة في قطاعات كاملة العشوائية بثلاث مكررات

2–تجربة التخزين: تم تخزين معاملات أبصال التجربة الحقلية أربعة معاملات سابقة الذكر بالإضافة إلي ثلاث معاملات ما بعد الحصاد وهي: سيليكات الصوديوم بتركيز 6000 جزء في المليون والشيتوسان 200 جزء في المليون وكلوريد الكالسيوم 3000 جزء في المليون وكذالك التوافقات التسعة بين معاملات الحقل ومعاملات ما بعد الحصاد بإجمالي ستة عشر معامله. وكان تصميم تجربة التخزين تصميم تام العشوائية بثلاث مكررات.

أوضحت نتائج التجربة الحقلية أن صفات كل من طول النبات وعدد الأوراق والمادة الطازجة والجافة للنبات وقطر كلا من العنق والبصلة ونسبة الكلوروفيل للأوراق قد أزداد معنويا عند الرش بسيليكات البوتاسيوم بتركيز 4000 جزء في المليون مقارنة بمعاملة المقارنة. كما نتج عن الرش أيضا بتركيز 4000 جزء في المليون أعلي زيادة معنوية للمحصول الكلي وجودة الأبصال (قطر ووزن البصلة وعدد ووزن الفصوص والمواد الصلبة الذائبة للأبصال والمادة الجافة للأبصال) مقارنة بالمعاملات الاخري. وأظهرت المعاملة بسيليكات البوتاسيوم بتركيز 8000 جزء في المليون أعلي زيادة في معدل التبصيل، بينما كان اعلي محتوي من البوتاسيوم في الأوراق عند الرش بسيليكات البوتاسيوم بتركيز 6000 جزء في المليون وقد زاد محتوي الأوراق من السيليكون معنويا بكل التركيزات مقارنة بمعاملة المقارنة.

أظهرت نتائج تجربة التخزين أن معاملة الأبصال الناتجة من رش النباتات في الحقل بسيليكات البوتاسيوم بتركيز 8000 جزء في المليون ثم معاملتها بالشيتوسان 200 جزء في المليون في المخزن كانت أفضل النتائج حيث أعطت اقل فقد في الوزن وأقل نسبة تفريغ للأبصال ويليها كلا من المعاملة بالشيتوسان بتركيز 200 جزء في المليون منفردا ثم معامله رش النباتات بسيليكات البوتاسيوم بتركيز 6000 جزء في المليون يليها معامله الرش بكلوريد الكالسيوم بتركيز 3000

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جزء في المليون علي التوالي لفترة 7 شهور من التخزين في درجة حرارة الغرفة.

كما أدي رش النباتات بسيليكات البوتاسيوم 4000 جزء في المليون ومعامله الأبصال سواء بسيليكات الصوديوم بتركيز 6000 جزء في المليون أو بالشيتوسان بتركيز 200 جزء في المليون عند التخزين إلي الحصول علي أعلي القيم المعنوية للمواد الصلبة الذائبة بالأبصال خلال فترة التخزين (7 شهور). كما أظهرت معامله الرش بكل من سيليكات البوتاسيوم 6000 أو 8000 جزء في المليون مع معامله الأبصال بالشيتوسان بتركيز 200 جزء في المليون أعلي القيم المعنوية للمادة الجافة بالأبصال .

وتوصى الدراسة برش نباتات الثوم بسيليكات البوتاسيوم بتركيز 4000 جزء في المليون للحصول علي أعلي زيادة في نمو وإنتاجية أبصال الثوم وبغرض زيادة القدرة التخزينية للثوم خلال 7شهور رش النباتات بسيليكات البوتاسيوم بتركيز 8000 جزء في المليون مع معامله الأبصال الناتجة بالشيتوسان بتركيز 200 جزء في المليون تحت ظروف الغرفة العادية.