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(Original Article)

Effect of Foliar Application of Salicylic Acid and Potassium Silicate on Productivity and Physical Quality Characteristics of Hot Pepper (*Capsicum annuum* L.) Fruits

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Abstract

This study was carried out at the Experimental Farm, Faculty of Agriculture, Assiut University,Assiut, Egypt, during two summer seasons (2018/2019 and 2019/2020) under development irrigation system to assess the growth and productivity of hot pepper. The experiment consisted of two released hot pepper cultivars (Ealaganle and Bigmama 3), two foliar concentrations of salicylic acid (SA) and two foliar concentrations potassium silicate (PS). Treatments were laid out under Split plot design with three replications where, cultivars were assigned as main plot factor, foliar concentrations were arranged as sub plot factors. Data were collected for physical fruit quality and fruit Productivity of hot pepper.

Analysis of variances (ANOVA) revealed that varieties differed significantly ($P \leq 0.05$) in fruit physical quality of hot pepper fruit and fruit productivity. Ealaganle cultivar, surpassed Bigmama3 cultivar, in physical quality of hot pepper fruit and fruit productivity. Results proved that spraying Ealaganle cultivar, with 8 ml/L of potassium silicate 9 times significantly increased pepper fruit yield and yield attribute. Application of potassium silicate at 4 and 8 ml/L gave the maximum hot pepper yield (21.14 and 20.03 %) and (32.17 and 30.97%) compared to the control in the first and second seasons, respectively. Additionally, a positive and highly significant relationship between yield and harvest frequency was recorded.

Keywords: *Hot pepper, Cultivars, Potassium silicate, Growth, Yield.*

Introduction

In Egypt, Ministry of Agriculture and Land Reclamation reported that Pepper production reached 654,271.000 Ton in (2016) (CEIC, 2021). This records an increase from the previous number of 614,302.000 Ton for (2015). Pepper crop (*Capsicum annuum*, L) is considered one of the most important vegetable crops, especially under greenhouse conditions. Several studies were investigating the impacts of different concentration of salicylic acid and

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potassium silicate on horticulture yields and quality. Increasing horticulture yields and quality did not only occur from foliar application of salicylic acid alone, but in combined with other compounds. Ibrahim *et al*. (2019) study the effect of humic and salicylic acids on the growth, yield, and fruit quality of three red sweet pepper (*Capsicum annuum*) cultivars (Barbero, Ferrari, and Imperio) under greenhouse conditions. Humic or salicylic acids were sprayed at 0, 0.5, 1.0, and 1.5 g/L at 20, 40, and 60 days after transplanting. Foliar application of humic or salicylic acids significantly increased vegetative growth, fruit yield, and quality of the three red sweet pepper cultivars as compared with the control plants. Spraying red sweet pepper cultivars with salicylic acid at a rate of 1.5 g/L increased vegetative growth; fruit yield components and fruit quality. These responses were differing between sweet pepper cultivars. Total yield increased by 27.7% 15.9% and 17.9% in Barbero, Ferrari, and Imperio cultivars, respectively. Also, Hassan *et al*., (2021) aimed to study the influence of foliar application of calcium nitrate $(CaNO_3)_2$ at (0, 250, or 500 gl^{-1}) and salicylic acid (SA) at (0, 0.25 or 0.5 gl^{-1}) as well as their interactions on growth, yield and postharvest storability of Omega F_1 hot pepper plants grown in clay loam soil. Results revealed that foliar application of 250 gl^{-1} $(CaNO_3)_2$ with 0.25 gl^{-1}or 0.5 gl^{-1} SA improved the vegetative growth characteristics (plant height, number of branches, leaves total chlorophyll contents and dry matter). They concluded their results that plants treated with 500 gl^{-1} $(CaNO_3)_2$ with 0.25 gl^{-1} SA gave the highest significant total yield 17.09 and 16.86 $ton.fed^{-1}$ in 2016 and 2017, respectively.

Abou El-Yazied (2011) studied the effect of foliar application with 50 and 100 ppm of salicylic acid (SA) and 50 and 100 ppm chelated zinc (Zn) and their combination on some growth aspects, of sweet pepper cv. California Wonder during autumn 2009 and 2010 seasons. He indicated that different applied treatments concentrations significantly increased growth parameters and pepper quality. Furthermore, the highest early, marketable and total yields as well as physical characters of sweet pepper fruits were obtained with 100 ppm salicylic acid plus chelated 50 ppm zinc followed by 50 ppm SA plus 100 ppm Zn.

Additionally, Kanai *et al*., (2007) reported that potassium silicate is a source of highly soluble potassium and silicon. It is used in agricultural Production systems primarily as a silica amendment and has the added benefit of supplying small amounts of potassium.

Foliar spraying with potassium silicate alone as one of various silicon sources was studied. Abdel-Aziz and Geeth (2018) carried out study during the two late summer seasons of 2016 and 2017 at Sids Horticulture Research Station, Beni Sueif Governorate, Agriculture Research Center, Egypt to study the effect of foliar spraying with five silicon sources at two rates as well as the control treatment (spraying with tap water) under the two late summer seasons condition on the vegetative growth parameters, yield and its components, fruit quality and some chemical contents in sweet pepper leaves. The results showed that, the most estimated parameters were significantly affected with silicon sources. The

superiority effect of the treatments was recorded by using kaolin (Aluminum silicate) followed by potassium silicate and paclobutrazol at a rate of 50 mg/ L as well as sunless respectively. Moreover, Kamal. (2013) defined that foliar spraying with kaolin and potassium silicate induced an increasing in total sugars and total soluble solids (%) of sweet pepper fruits.

Therefore, this research work aimed to assess the response of two hot pepper cultivars to two foliar concentrations of salicylic acid and two foliar concentrations potassium silicate.

Materials and Methods

The present experiment was carried out at the Experimental Farm of Vegetable Crops Department, Faculty of Agriculture, Assiut University, Assiut, Egypt for two summer seasons (2018/2019 and 2019/2020). Two cultivars (Cvs.) (Bigmamma3 and Elaganle) of Caynne hot peppers (*Capsicum annuum* L.) were obtained from Kanza Group Company and two foliar applications with salicylic acid (SA) and potassium silicate (PS) were applied in two concentrations were used in this investigation.

Table 1. Some physical properties of the soil in both seasons

Sand %	Silt %	Clay %	Texture	pH 1:1	ECe dS/m	Total $CaCO_3$ %
19.3	31.0	49.7	Clay	7.80	1.42	3.13
21	29.4	49	Clay	8.1	1.1	3.25

Table 2. Some chemical properties of the soil in both seasons

Year	Total N %	Available nutrients ppm				
		P	K	Fe	Mn	Zn
2018/2019	1.80	16.4	354	9.7	10.3	1.2
2019/2020	1.88	11.2	325	8.6	12.0	1.5

The experiment was conducted to assess the influence of two foliar concentrations of SA and two foliar concentrations PS on yield and quality of two hot pepper cultivars grown under Assiut conditions. The soil texture of the experimental site was clay soil in the plots had a pH of 7.8 and 8.1 and was sufficient in total N, available phosphorus and potassium. Some physical and chemical properties of the soil were presented in Tables 1 and 2.

Seeds were sown in seedling trays. The seedling trays were maintained in the nursery greenhouse and followed by regular practices for 40 days where the transplants became 10 to 12 cm tall. Hot pepper seedlings were planted in the open field at the last week of August (28/8 in each season) in the first (2018/2019) and second (2019/2020) seasons. The well-developed 40 days old transplants (with 3 or 4 true leaves) were transplanted into the open field on the northern side of 3 m long and 70 cm wide rows at 30 cm apart for pepper. Plot area was 10.5 m^2 (3 m length and 3.5 m width.

A split plot design with three replicates was used in this experiment. Two cultivars of hot pepper (Bigmama3 and Elaganle) were laid out in the main plot and foliar application with SA and PS were arranged in the sub plot.

The treatments of this experiment were arranged as follows: Main plots: Cultivars (Elaganle and Bigmamma3). The Sub plots: foliar application rates: 1- Control (plants treated with distilled water). 2- Spraying with SA with (8 mg/L). 3- Spraying with SA with (16 mg/L). 4- Spraying with PS at a concentration of (4 ml/L). 5- Spraying with PS at a concentration of (8 ml/L). Spraying was done once a week from the beginning of sowing the seeds in the trays and after transplanting until the beginning of the harvest. Tween 20 at a rate of 0.05 ml/L was used as wetting agent. The doses of K_2SiO_3 followed technical recommendation (Solo Fértil SP Comercial Agrícola Ltda, São José do Rio Preto, São Paulo). 9 foliar applications for each application were performed during the experimental period starting 15 days after transplant (DAT) and finishing 120 DAT.

All agricultural managements such as irrigation, fertilization and pest control were achieved for all treatments as recommended by the Egyptian Ministry of Agriculture for hot pepper production. Fruits harvesting was started 62 after planting (30/10). Pepper fruits were harvested 5 times and the weight was recorded in each collection.

Measurements

Physical quality of hot pepper fruit

Fruit length). The way to take the length of the fruit is to take three diameters, then collect them, divide by three, and take the average

Fruit diameter (cm). The method of taking the diameter of the fruit is to take three diameters, then collect them, divide by three, and take the average

Fruit weight (gm). 10 fruits are weighed and then the average is taken.

Total yield (ton/fed.-1): It was calculated from (the sum of all fruit weight for each harvest)

Statistical analyses

Data were statistically analyzed using analysis of variance (ANOVA) procedure for each year separately and homogeneity of error variances was assured. Subsequently, combined ANOVA analysis was tested over the two years (Gomez and Gomez, 1984). Useful mean comparisons were determined through the status of significance of the different total variance partitions. Means were separated using the Least Significance Difference (LSD) test at 0.05 level of probability.

Result and Discussion

Effects on some yield characters

Physical quality of pepper fruit

Fruit length (cm)

Data of fruit length (cm) recorded as influenced by hot pepper cultivars, foliar application treatments, and their interaction are presented in Table (3) and

fig. (1). Data demonstrated in the table (3) stated that the main values of fruit length for hot pepper cultivars highly significantly affected by the type of cultivars (cvs.) (A) under the study in both seasons.

Table 3. Fruit length as affected by cultivars, foliar application and their interactions in 2018/ 2019 and 2019/ 2020

Cultivars	Treatments	1st season	2nd season
Bigmama3	T1	26.8	26.8
	T2	26.7	26.7
	T3	27.3	27.3
	T4	27.8	27.7
	T5	29.3	29.1
Mean		27.58	27.52
Elaganle	T1	26.8	26.8
	T2	28.1	27.9
	T3	28.3	28.2
	T4	29.6	29.5
	T5	30.0	30.0
Mean		28.6	28.5
Main effects	T1	26.8	26.8
	T2	27.4	27.3
	T3	27.8	27.8
	T4	28.7	28.6
	T5	29.6	29.5
A (Cultivars)		**	**
B (Treatments)		0.078	0.089
AB		0.110	0.125

** Significant at 0.01 level of probability.

Generally, the mean value of Elaganle cv. (28.60 cm) surpassed Bigmama3 cv. (27.58 cm) in increasing mean fruit length in the 1st season (Table, 3) with an increasing percent of 3.69%. In addition, values of mean fruit length in the 2nd season (Table, 3) followed the same trend for Elaganle cv. (28.50 cm) over Bigmama3 cv. (27.52 cm) with increasing percent 3.56%.

The main effects of treatments (B) recorded significant effects of foliar application of (T2, T3, T4 and T5) on mean fruit length compared to the control treatment (T1). The obtained results show that foliar application of both Salicylic Acid (SA) (T2 and T3) and Potassium Silicate (PS) (T4 and T5) significantly increased the mean fruit length compared to the control (T1). The increase in fruit length reached (2.24 and 3.73%) and (1.86 and 3.73%) due to foliar application with SA at 8 and 16 mg/L over the control treatment in the 1st and 2nd seasons, respectively. Meanwhile, foliar application with PS at 4 and 8 mg/L increased fruit length by (7.10 and 10.45%) and (6.72 and 10.07%) over the control (T1) in the 1st and 2nd seasons, respectively. It is worthwhile to mention here that; PS is considered more effective than SA. These results may be due to the supplements of potassium, which, potassium is considered a key nutrient for enhancing photosynthesis, enzyme activation, cell turgor maintenance, an important role in the water status of plants, promoting the synthesis of sugars and

polysaccharides. Potassium is involved in numerous biochemical and physiological processes in plants (Irfan, 2015).

Application of SA may influence a range of diverse processes in plants, including stomatal closure, ion uptake and transport (Gunes *et al*., 2005), membrane permeability (Barkosky and Einhellig, 1993), as well as photosynthetic and growth rates (Khan *et al*., 2003).

Interaction effects between cultivars and foliar application revealed that spraying Elaganle cv. with PS at a rate of 8 ppm (T5) gave the maximum fruit length compared with all other foliar treatments. These results may be explained on the basis that plants sprayed with PS at a rate of 8 mg/L-1 stimulate the process of photosynthesis which, in turn, positively affected the vegetative growth parameters of sweet pepper plants. Increasing the ability of sweet pepper plants to absorption of soil nutrients due to planting distance positively affects all fruit quality parameters. These results were in agreement with El-Gazzar, *et al*., (2020). The result of the present study for this character is in agreement with the findings of Islam *et al*. (2011) on sweet pepper; Edgar *et al*. (2017) on green pepper and Lihiang and Lumingkewas (2017) on maize.

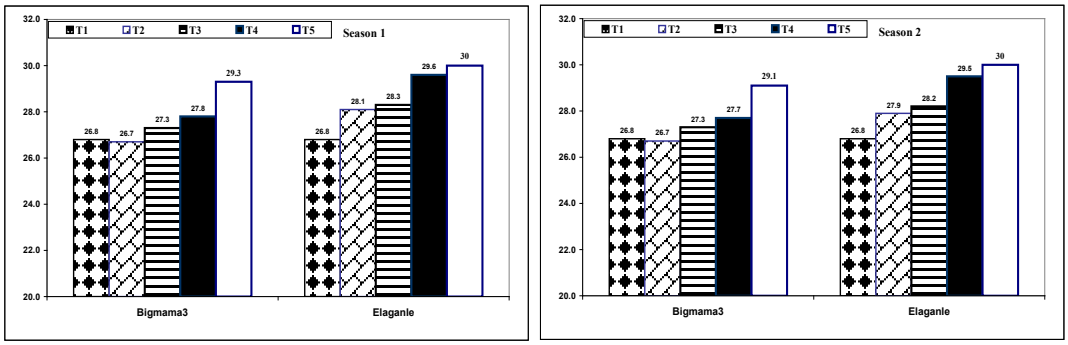

Fig. 1. Fruit length as affected by cultivars, foliar application and their interactions in 2018/ 2019 and 2019/ 2020

Data demonstrated in Table (4) recorded the effects of factories under the study on fruit length values at different harvest frequency in both seasons. Harvest frequency was significantly affected by the type of cultivar and the foliar treatments and their interaction. Moreover, foliar applications with PS gave longer fruit length than SA. This held true under each concentration. The results show the superiority of the Elaganle cultivar over the Bigmama3 on fruit length at all harvest frequency. The highest mean values of fruit length (32.32 and 32.39 cm) were obtained as a result of spraying Elaganle cultivar with PS at a rate of 8 ml/L-1 at the 5th harvest compared to all other interactions in the 1st and 2nd season, respectively.

Data tabulated show clearly that the highest values of mean fruit length were recorded for the Elaganle cultivar treated with foliar PS (T5) under each harvest time. In addition, Observation tended to show that the increase in fruit length increased with increasing harvest time and the highest fruit length was

obtained at the 5th harvest time compared to the 1st harvest time in both seasons, respectively.

Table 4. Mean performance of average fruit length of hot pepper as affected by cultivars, foliar application at every harvest in 2018/ 2019 and 2019/ 2020 seasons

Cvs.	Treatments.	1st season					2nd season				
Bigmama3	T1	25.10	26.27	27.39	27.35	27.86	25.13	26.12	27.44	27.30	27.81
	T2	25.09	26.19	27.53	27.53	27.39	25.12	26.09	27.63	27.42	27.40
	T3	25.39	27.33	28.22	27.21	28.31	25.95	27.14	28.15	27.14	28.22
	T4	25.83	27.08	28.55	28.07	29.34	25.97	26.96	28.46	27.93	29.23
	T5	27.00	27.72	29.89	29.46	32.31	26.84	27.64	29.58	29.24	32.08
Mean		25.68	26.92	28.32	27.92	29.04	25.80	26.79	28.25	27.81	28.95
Elaganle	T1	25.10	26.34	27.24	27.18	28.33	25.13	26.14	27.24	27.19	28.21
	T2	25.57	28.14	28.81	28.46	29.31	25.43	28.12	28.34	28.43	29.15
	T3	25.95	27.87	28.75	28.96	29.99	25.91	27.80	28.57	28.92	29.92
	T4	27.09	28.42	30.04	30.35	32.31	27.01	28.39	29.85	30.19	32.24
	T5	27.18	29.12	30.19	31.25	32.32	27.17	29.13	30.12	31.14	32.39
Mean		26.18	28.00	29.00	29.20	30.50	26.10	27.90	28.80	29.20	30.40
Main effects	T1	25.10	26.30	27.30	27.30	28.10	25.10	26.10	27.30	27.20	28.00
	T2	25.33	27.20	28.20	28.00	28.40	25.30	27.10	28.00	27.90	28.30
	T3	25.67	27.60	28.50	28.10	29.20	25.90	27.50	28.40	28.00	29.10
	T4	26.46	27.80	29.30	29.20	30.80	26.50	27.70	29.20	29.10	30.70
	T5	27.09	28.40	30.00	30.40	32.30	27.00	28.40	29.90	30.20	32.20
F-test A (Cvs.)		n.s	**	**	**	**	n.s	**	n.s	**	**
(L.S.D 0.05) B (Tre)		0.23	0.14	0.212	0.076	0.16	0.22	0.038	0.23	0.09	0.111
(L.S.D 0.05) AB		n.s	0.20	vxcxqes0.300	0.104	0.23	0.31	0.054	0.33	0.13	0.158

** Significant at 0.01 level of probability, ns: not significant

Obtained results in Table (4) reveal that fruit length was significantly improved with foliar application of PS which gave longer Elaganle hot pepper fruit in comparison to the Bigmama3 cultivar at the 5th harvest.

These results may be due to the genetic of Elaganle cultivar and the effectiveness of the foliar application of PS on fruit physical properties (El Kholy *et al*., 2018) who found that fruit physical properties (fruit length, diameter, thickness pulp % and firmness were by Loquat trees sprayed with K2SiO3 at 1 and 2 %. showed significant increases than control treatment. The obtained results in this respect go in line with those reported by Kaluwa *et al*. (2010) on 'Hass' avocado. Stamatakis *et al*. (2003) reported that the application of silicon with higher concentration resulted in more firmness of tomato fruits. Moreover, Weerahewa and David (2015) revealed that fruit firmness, weight and size of tomato fruits cv. Maheshi have significantly increased duo to 50 and 100 mg/L Si applied at the growth or flowering stage. Also, Badran *et al*. (2015) found foliar spray of seaweed extract at 4% with Silicon at 0.5 % was the promising treatment to increase height, diameter of fruit, fruit weight, pulp weight and total soluble solids as well as sugars content. Moreover, Hanumanthaiah *et al*., (2015) reported that foliar application of PS at 2 ml L-1 plant-1 at 15 days interval recorded highest pulp peel ratio of banana fruits.

Table 5. Fruit diameter as affected by cultivars, foliar application and their interactions in 2018/ 2019 and 2019/ 2020

Cultivars	Treatments	1st season	2nd season
Bigmama3	T1	1.967	1.957
	T2	2.082	2.095
	T3	2.076	2.083
	T4	2.131	2.143
	T5	2.123	2.132
Mean		2.076	2.082
Elaganle	T1	1.943	1.944
	T2	2.165	2.196
	T3	2.138	2.149
	T4	2.154	2.380
	T5	2.143	2.365
Mean		2.108	2.207
Main effects	T1	1.955	1.950
	T2	2.123	2.145
	T3	2.107	2.116
	T4	2.142	2.262
	T5	2.133	2.249
F-test A (Cultivars)		*	*
(L.S.D 0.05) B (Treatments)		0.034	0.024
(L.S.D 0.05) AB		0.041	0.036

* Significant at 0.05 level of probability.

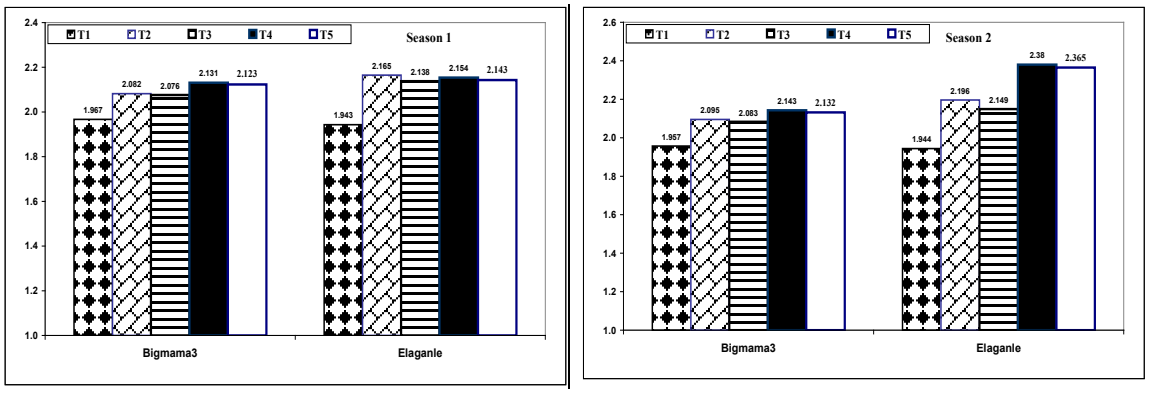

Fig. 2. Fruit diameter as affected by cultivars, foliar application and their interactions in 2018/ 2019 and 2019/ 2020

Fruit diameter (cm)

Data demonstrated in Table (5) and fig. (2) show that main value of fruit diameter (cm) as affected by pepper varieties, foliar application and their interactions at in both seasons, respectively. Fruit diameter (cm) significantly affected by pepper cultivars in the 1st and 2nd, respectively. Elaganle cultivar gave wider fruit diameter than Bigmama3 in the 1st and 2nd season, respectively.

The demonstrated data in Table (5) show that foliar application of both SA (T2 and T3) and PS (T4 and T5) significantly increased mean fruit diameter (cm) compared to the control in (T1) in both seasons. Foliar application with PS once a week from the beginning of sowing the seeds in the trays and after transplanting until the beginning of the harvest at a rate of 4 ml/L (T4) gave the highest values of (2.142 & 2.262 cm) in the 1st and 2nd seasons, respectively. On the other hand, control treatment gave the lowest values of fruit diameter (cm)

(1.955 & 1.948 in the 1st and 2nd seasons, respectively. The interaction effects between cultivars (A) and foliar treatments (B) show insignificant effect on mean values of fruit diameter (cm). These results are in agreement with those reported by Omar (2017) who indicated that foliar application with either SA at 200 ppm or Si at 100 ppm; resulted in significant increase in fruit length and diameter of cucumber compared to control plants.

Foliar application of PS which contains 10.25 % K_2O, potassium can enhance vegetative growth parameters especially plant height (cm) and Number of branches plant-1. These improvements of sweet pepper plants might be attributed to stomatal regulation by potassium and corresponding higher rates of photosynthesis as well as potassium is considered to be the key to promote the growth of meristematic tissue as well as increased level of nitrogen also promotes the vegetative growth. Furthermore, potassium is also essential for the translocation of photo assimilates in root growth and increase the root surface and subsequence increased root water as well as minerals uptake Abel-Aziz and Geeth (2018). Similar results were mentioned by several investigators; Kamal (2013) mentioned that spraying kaolin at a rate of 4 % and PS at a rate of 1.5 kg/ fed., obtained an increase in vegetative growth characteristics of sweet pepper plants. Ahmed (2017) concluded that kaolin processing technology plays a key role in reducing plant transpiration

Data presented in Table (6) indicated that fruit diameter (cm) insignificantly affected by type of varieties in both seasons except at the 5th harvest. As shown in Table (6) by means presentation, no differences in both seasons were detected among various harvest frequencies for each fruit diameter (cm). Meanwhile, fruit diameter (cm) increased with increasing harvest time in the 1st and 2nd seasons, respectively.

All values of fruit diameter significantly affected by foliar treatments under each harvest time either by SA (T2, T3) or by PS (T4 and T5) compared to the control treatment (T1) in both seasons. The maximum values of fruit diameter (2.333 and 2.849) were obtained at the 5th fruit harvest time in the 1st and 2nd seasons, respectively.

The significantly effect recorded in Table (6) between the interaction pepper cultivar and foliar treatments (A X B) tended to be various according to harvest frequency. These interactions held true in 2018/19 and 2019/20 seasons, respectively. The highest values of fruit diameter were recorded due to the interaction between cultivar and foliar application PS (T5) at the 5th harvest in both seasons. Spraying Elaganle cv. with 8 ml/L PS once a week from the beginning of sowing the seeds in the trays and after transplanting until the beginning of the harvest gave the maximum values of fruit diameters at the 5th harvest in both seasons

In summary, the analysis of variance for fruit diameter shows significant difference among treatment at 5% probability level. The maximum fruit diameter was obtained from treating Elaganle hot pepper cultivar with foliar application once a week from the beginning of sowing the seeds in the trays and after

transplanting until the beginning of the harvest at 8 ml/L PS at the 5th harvest time).

Table 6. Mean performance of average fruit diameter of hot pepper as affected by cultivars, foliar application at every harvest in 2018/ 2019 and 2019/ 2020 seasons

Cultivars	Treatments	1st season					2nd season				
Bigmama3	T1	1.753	1.870	2.007	2.110	2.093	1.693	1.870	2.040	2.083	2.097
	T2	1.860	1.990	2.090	2.220	2.250	1.880	1.990	2.140	2.210	2.254
	T3	1.900	1.950	2.090	2.190	2.250	1.870	1.960	2.130	2.200	2.257
	T4	1.942	2.035	2.105	2.248	2.323	1.938	2.013	2.162	2.258	2.345
	T5	1.950	1.983	2.137	2.230	2.317	1.930	1.977	2.180	2.247	2.327
Mean		1.881	1.966	2.086	2.200	2.247	1.862	1.962	2.130	2.200	2.256
Elaganle	T1	1.770	1.803	2.054	2.010	2.080	1.720	1.843	2.043	2.020	2.095
	T2	1.883	2.080	2.150	2.373	2.337	1.963	2.090	2.237	2.347	2.342
	T3	1.933	2.087	2.073	2.267	2.330	1.947	2.050	2.143	2.270	2.337
	T4	1.947	2.040	2.137	2.302	2.343	1.968	2.063	2.203	2.315	3.353
	T5	2.010	2.000	2.123	2.230	2.350	1.973	2.037	2.170	2.283	3.361
Mean		1.909	2.002	2.107	2.236	2.288	1.914	2.017	2.159	2.247	2.698
Main effects	T1	1.762	1.837	2.031	2.060	2.087	1.707	1.857	2.042	2.052	2.096
	T2	1.872	2.035	2.120	2.297	2.294	1.922	2.040	2.189	2.279	2.298
	T3	1.917	2.019	2.082	2.229	2.290	1.909	2.005	2.137	2.235	2.297
	T4	1.945	2.038	2.121	2.275	2.333	1.953	2.038	2.183	2.287	2.849
	T5	1.980	1.992	2.130	2.230	2.334	1.952	2.007	2.175	2.265	2.844
F-test A (Cultivars)		n.s	n.s	n.s	n.s	*	n.s	n.s	n.s	n.s	*
(L.S.D 0.05) B (Treatments)		0.14	0.063	0.044	0.038	0.047	0.063	0.035	0.028	0.032	0.019
(L.S.D 0.05) AB		n.s	0.088	0.063	0.054	0.052	n.s	0.051	0.041	0.044	0.028

* Significant at 0.05 level of probability, ns: not significant

Fruit weight (gm)

Main values of fruit weight (gm) as affected by hot pepper cultivars, foliar treatments and their interaction at various harvest times in 2018/2019 and 2019/2020 seasons are presented in Table (7) and fig. (3).

Results in Table (7) and fig. (3) recorded clearly that the fruit weight positively increased with Elaganle cultivar (37.61 and 36.74 gm) in comparison to Bigmama3 cultivar (37.36 and 36.60 gm) in the 1st and 2nd season, respectively.

Results recorded in Table (7) show clearly that there was a significant difference among foliar treatments compared to the control on fruit weight in both seasons. Both foliar application (T2, T3, T4 and T5) significantly increased fruit weight in comparison to control treatment (T1) in both seasons. Treating pepper plant with foliar PS gave the highest fruit weight values (38.49 and 37.89) as compared with all other treatments in 2018/2019 and 2019/2020 seasons, respectively.

Table 7. Fruit weight of hot pepper as affected by cultivars, foliar application and their interactions in 2018/ 2019 and 2019/ 2020

Cultivars	Treatment	1st season	2nd season
Bigmama3	T1	35.86	35.38
	T2	37.70	36.63
	T3	39.14	38.01
	T4	35.38	35.06
	T5	38.71	37.93
Mean		37.36	36.60
Elaganle	T1	38.12	36.51
	T2	37.62	36.47
	T3	37.12	36.42
	T4	36.93	36.45
	T5	38.28	37.86
Mean		37.61	36.74
Main effects	T1	36.99	35.95
	T2	37.66	36.55
	T3	38.13	37.21
	T4	36.15	35.76
	T5	38.49	37.89
F-test A (Cultivars)		*	*
(L.S.D 0.05) B (Treatments)		0.226	0.199
(L.S.D 0.05) AB		n.s	n.s

* Significant at 0.05 level of probability, ns: not significant

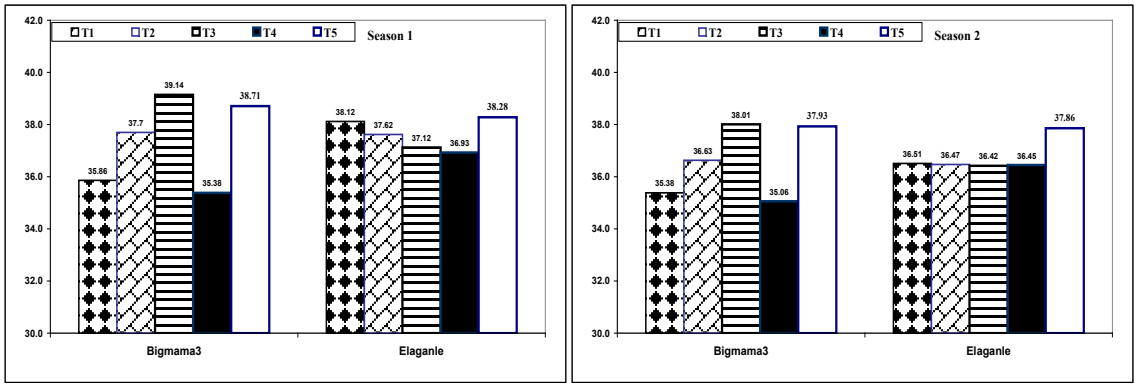

Fig 3. Fruit weight of hot pepper as affected by cultivars, foliar application and their interactions in 2018/ 2019 and 2019/ 2020

Similar results in agreements with El Kholy *et al* (2018) who found that fruit physical properties (fruit length, diameter, thickness pulp % and firmness were by Loquat trees sprayed with K2SiO3 at 1 and 2 %. showed significant increases than control treatment. The obtained results in this respect go in line with those reported by Kaluwa *et al*. (2010) on 'Hass' avocado. Stamatakis *et al*. (2003) reported that, application of silicon with higher concentration resulted in more firmness of tomato fruits. Moreover, Weerahewa. and David (2015) revealed that fruit firmness, weight and size of tomato fruits cv. Maheshi were significantly increased duo to 50 and 100 mg/L-1 Si applied at the growth or flowering stage. Also, Badran *et al*. (2015) found foliar spray of seaweed extract at 4% with Silicon at 0.5 % was the promising treatment to increase height, diameter of fruit, fruit weight, pulp weight and total soluble solids as well as

sugars content. Moreover, Hanumanthaiah *et al*., (2015) reported that foliar application of PS at 2 ml L-1/plant-1 at 15 days interval recorded highest pulp peel ratio of banana fruits.

Data in Table (8) show the effect of fruit weight (gm) as affected by hot pepper cultivars, foliar treatments and their interaction at different harvest times and in 2018/2019 and 2019/2020 seasons. Data revealed that most fruit weight (gm) values significantly affected by hot pepper cultivars at all harvest times under the study except at some harvest time in 2018/2019 and 2019/2020 seasons, respectively. Also, foliar application of SA and PS gave maximum values of mean fruit weight (gm) at the 5th harvest in both seasons. Application SA at a concentration at 8 (T2) and 16 (T3) mg/L-1 gave fruit weight values of (49.08 and 49.33) and (46.70 and 47.62) compared to control treatment values (48.49) and (45.80) in (T1) in the 1st and 2nd season, respectively. Under the 5th harvest frequency, the increase percentage of fruit weight 8 (T2) and 16 (T3) mg/L-1 reached (1, 21 and 1.73%) and 1.96 and 3.97%) due to foliar application with SA compared to control treatment (T1) in the 1st and 2nd season, respectively.

Table 8. Mean performance of average fruit weight of hot pepper as affected by cultivars, foliar application at every harvest in 2018/ 2019 and 2019/ 2020 seasons.

Cultivars	Treatments	1st season					2nd season				
Bigmama3	T1	24.70	28.50	37.90	40.97	47.22	25.00	28.60	36.10	41.93	45.27
	T2	25.99	29.53	39.87	44.07	49.06	26.04	29.68	37.41	43.68	46.35
	T3	27.67	31.10	40.77	45.95	50.22	27.27	31.18	38.58	45.53	47.47
	T4	24.95	28.55	35.12	40.22	48.05	24.78	28.73	34.27	39.57	47.97
	T5	26.90	31.39	40.53	44.58	50.15	26.93	31.69	38.09	44.35	48.59
Mean		26.04	29.81	38.84	43.16	48.94	26.00	29.98	36.89	43.01	47.13
Elaganle	T1	25.60	29.00	40.95	45.28	49.75	25.87	29.25	37.53	43.58	46.32
	T2	25.52	29.78	40.06	43.66	49.09	25.74	30.09	36.98	42.48	47.04
	T3	25.43	30.55	39.17	42.03	48.43	25.62	30.93	36.42	41.37	47.77
	T4	25.51	30.26	38.19	41.82	48.86	25.67	30.62	36.09	41.37	48.48
	T5	26.13	31.68	40.28	43.22	50.08	26.60	32.19	37.60	43.17	49.72
Mean		25.64	30.25	39.73	43.20	49.24	25.90	30.62	36.92	42.39	47.87
Main effects	T1	25.15	28.75	39.43	43.13	48.49	25.44	28.93	36.82	42.76	45.80
	T2	25.76	29.66	39.97	43.87	49.08	25.89	29.89	37.20	43.08	46.70
	T3	26.55	30.83	39.97	43.99	49.33	26.45	31.06	37.50	43.45	47.62
	T4	25.23	29.41	36.66	41.02	48.46	25.23	29.68	35.18	40.47	48.23
	T5	26.52	31.54	40.41	43.90	50.12	26.77	31.94	37.85	43.76	49.16
F-test A (Cultivars)		n.s	*	**	**	n.s	n.s	*	**	**	**
(L.S.D 0.05) B (Treatments)		0.23	0.20	0.69	0.47	0.40	0.28	0.40	0.49	0.45	0.40
(L.S.D 0.05) AB		0.32	0.28	0.98	0.66	0.56	n.s	0.58	n.s	n.s	0.57

* Significant at 0.05 level of probability, ** Significant at 0.01 level of probability, ns: not significant

Increasing hot pepper fruit yield was achieved due to foliar application with SA might be attributed to the increase of vegetative growth parameters as

reported earlier. The present results are in agreement with those obtained by (Elwan and EL-Shatoury, 2014; Abd El-Mageed *et al*., 2016; AL-Rubaye and Atia, 2016) who found that exogenously applied SA; increased the highest squash yield/ plant-1 and total yield/hectare-1 compare to the other tested concentrations. Omar (2017) illustrated that foliar application of SA at 200 ppm caused a significant increase readily cucumber early and total fruit yield compared to control plants.

Additionally, the increase percentage of fruit weight foliar application with PS at 8 ppm (T5) ml/L-1 reached (3.36 and 7.33%) compared to control treatment (T1) in the 1st and 2nd season, respectively.

These results could be concluded that foliar application with PS at 8 ml/L-1 gave the highest fruit weight under all harvest frequency especially under the 5th harvest time.

recorded in Table (8) indicate that the interaction effect between cultivars and foliar treatment application on fruit weight tended to be significant especially in the 1st season. Data show clearly that, at the fifth and last harvest, the two growing seasons share together in the significant interaction between cultivar and treatments. Generally, Elaganle cultivar treated with PS foliar application at 16 ppm once a week from the beginning of sowing the seeds in the trays and after transplanting until the beginning of the harvest, significantly affected fruit weight (gm) at all harvest times except the 1st, 3rd and 4th harvest time in the 2nd season.

Total yield (ton/fed)

The effect of cultivar and foliar application and their interaction on total yield (ton fed.-1) during the 2018/2019 and 2019/2020 seasons are presented in Tables (9 and 10) and figs. (4 and 5).

Data observation reveals that the total yield of hot pepper positively affected by cultivar type. The total yield of Elaganle cv., hot pepper significantly surpassed Bigmama3 cv., in the 1st and 2nd seasons, respectively. The increased percentage for Elaganle cv., recorded (10.08 and 9.77 %) comparing to Bigmama 3 cv., in the 1st and 2nd seasons, respectively.

Table 9. Total yield of hot pepper (ton/fed.$^{-1}$) as affected by cultivars, foliar application and their interactions in 2018/ 2019 and 2019/ 2020 seasons

Var. \ Tre.	2020					Mean
	T1	T2	T3	T4	T5	
Bigmama3	5.054	6.208	5.726	6.105	7.136	6.046
Elaganle	5.860	6.661	6.352	7.116	7.290	6.656
Mean	5.457	6.435	6.039	6.611	7.213	
F-test A(cultivars)			*			
L.S.D 0.05 B (treatments)			0.188			
AB			0.211			

* Significant at 0.05 level of probability

Table 10. Average of total yield ton /fed as affected by varieties, foliar application and their interactions in 2019/ 2020 season

Tre. / Var.	2020					Mean
	T1	T2	T3	T4	T5	
Bigmama3	5.030	6.028	5.806	6.097	7.059	6.004
Elaganle	5.889	6.513	6.308	7.010	7.243	6.593
Mean	5.460	6.271	6.057	6.554	7.151	
F-test A (cultivar)	*					
L.S.D 0.05 B (treatments)	0.073					
AB	0.103					

* Significant at 0.05 level of probability

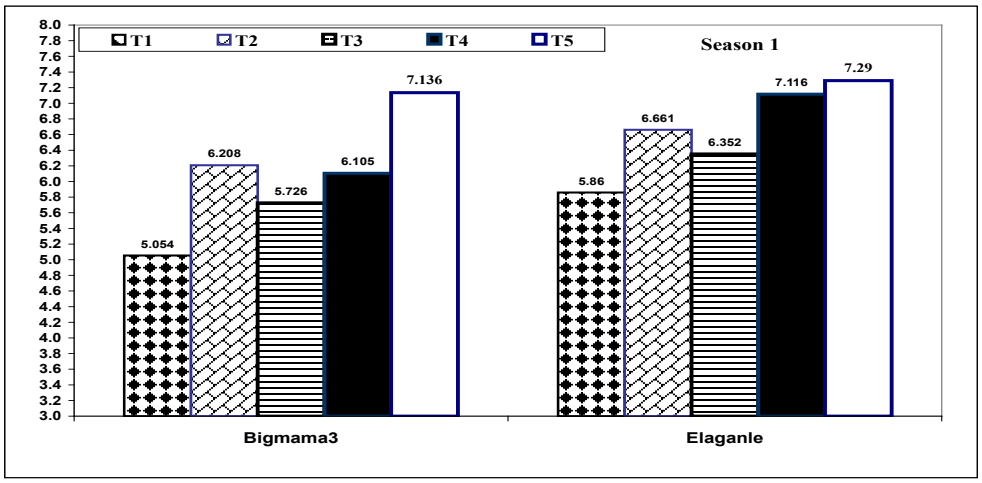

Fig. 4. Total yield of hot pepper (ton/fed.$^{-1}$) as affected by cultivars, foliar application and their interactions in 2018/2019 and 2019/2020 seasons

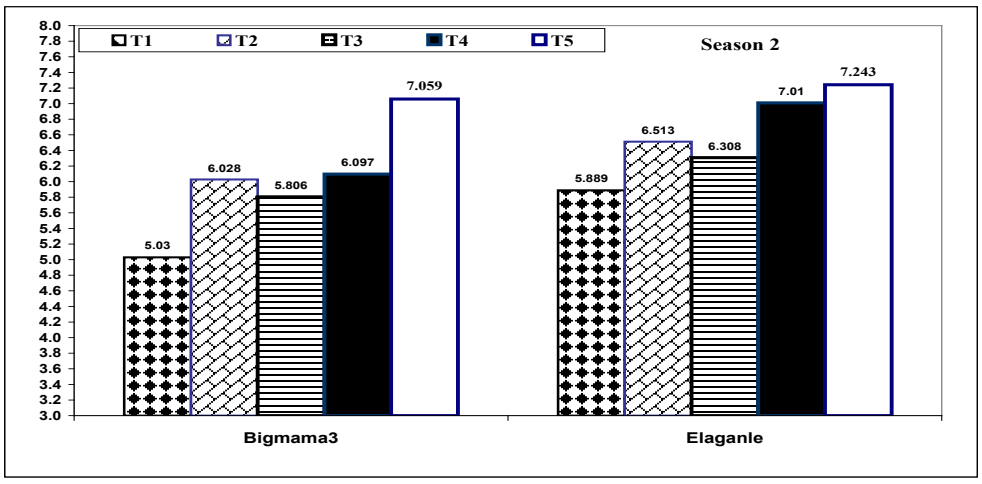

Fig. 5. Total yield ton /fed as affected by varieties, foliar application and their interactions in 2019/ 2020

The Observed differences in the total yield of cultivars are mainly due to the genotype of each cultivar. The same results nearly were obtained by Ado (1990) who reported that a great variation in morphological characters between pepper cultivars may be the reason for this response.

Results indicated that total yield was significantly affected by foliar application, this effect depended on the type and concentration of spraying compound. Spraying either SA or PS gave a higher yield compared to the control

treatment. Results presented in Table (9) show that the increased percentages of mean values of total yield due to foliar application of SA at 8 and 16 mg/L-1 recorded (17.92 and 14.85%) for T2 and (10.66 and 10.93%) for T3. Meanwhile, this increase due to foliar application of PS at 4 and 8 ml/L-1 reached (21.14 and 20.03%) for T4 and (32.17 and 30.97%) for T5 compared to the control (T1) in the 1st and 2nd seasons, respectively. These results indicated the importance and effectiveness of PS as foliar fertilization which contains 10.25 % K2O, potassium can enhance vegetative growth parameters This enhancement of hot pepper plants and yield might be attributed to the improvements of photosynthesis, promote vegetative growth, increased level of nitrogen and due to the vital role of potassium as an essential nutrient for the translocation of photo-assimilates in root growth and increase the root surface and subsequence increased root water as well as minerals uptake (Abdel-Aziz and Geeth, 2018). Similar results were mentioned by several investigators; Kamal (2013) and Ahmed (2017).

Similar results were obtained by Abou El-Yazied (2011) who recommended that foliar spraying with SA at 100 ppm and chelated zinc at 50 ppm can be used to increase the final yield and fruit quality of sweet pepper plants during the low temperatures of autumn plantations.

The highest values of total yield were obtained due to spraying pepper plant with 8 ml/L-1 PS (T5) once a week from the beginning of sowing the seeds in the trays and after transplanting until the beginning of the harvest in comparison to all treatments under the study, in the 1st and 2nd season, respectively.

Also, spraying pepper plant, at 8 ml/L-1 PS once a week from the beginning of sowing the seeds in the trays and after transplanting until the beginning of the harvest, increased total yield by (32.17 % and 30.97%) over the control treatment, in the 1st and 2nd seasons, respectively.

Results presented in Tables (9 and 10) show that the interactions between cultivars and foliar application proved that the highest total yield of hot pepper were obtained from spraying hot pepper plant with 8 ml/L-1 PS in the 1st and 2nd season, respectively.

Coefficients of correlation

Continuous harvesting and quantity of pepper yield important trait from agronomic and biological perspectives. Correlations provide information on whether the two traits (yield and harvest frequency) are related. This relationship can assist in various decisions especially breeding selection. Obtained results in Table (11) and Fig. (6) proved a positive and highly significant relationship between yield and harvest frequency. Hot pepper yield responses were recorded at the five harvest times. This held true in both seasons. This highly significant relationship between yield and harvest frequency might be due to hot pepper yield components, fruit length, fruit diameter and fruit weight. Similarly, positive and significant correlation was recorded by Sharma *et al* (2019). Similar results were reported by (Sunita *et al*., 2010, Naik *et al*., 2010 and Sasu *et al*., 2013).

Table 11. Coefficients of correlation (r) between hot pepper yield and harvesting frequency for each season

Harvest frequency	Season1	Season2
H1	0.986**	0.998**
H2	0.982**	0.994**
H3	0.970**	0.950**
H4	0.990**	0.990**
H5	0.985**	0.966**

**. Correlation is significant at the 0.01 level.

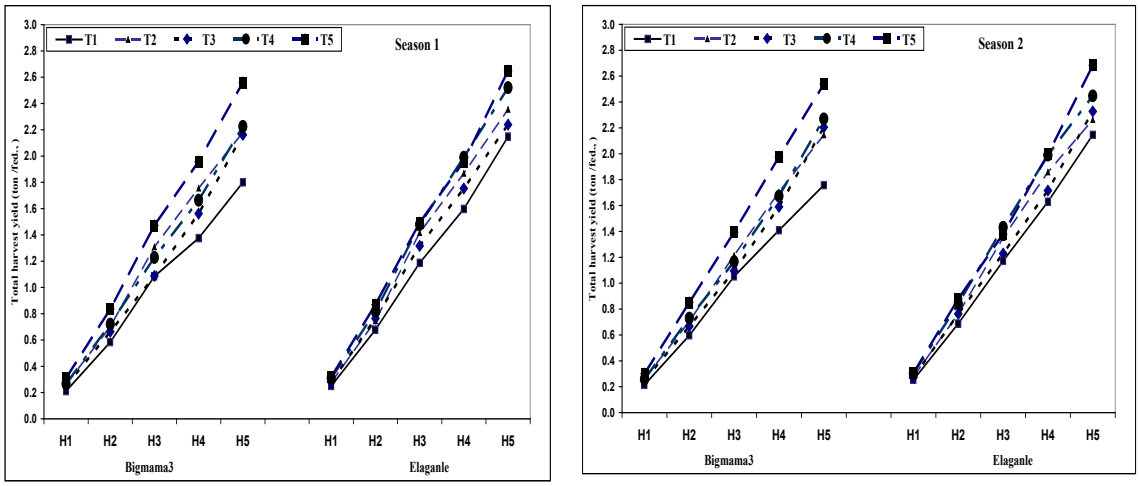

Fig. 6. Coefficients of correlation (r) between hot pepper yield and harvesting frequency for each season

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الأنتاجية وصفات الجودة الطبيعية فى الفلفل الحار وتأثرها بالصنف والرش الورقي بحامض الساليسيليك وسيليكات البوتاسيوم تحت ظروف مصر العليا

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الملخص

أجريت تجربة بمزرعة كلية الزراعة، جامعة أسيوط، محافظة أسيوط، مصر بهدف دراسة الخواص الطبيعية لثمار الفلفل الحار وتأثرها بالصنف والرش الورقي بحامض الساليسيليك وسليكات البوتاسيوم تحت ظروف مصر العليا.

أجريت التجربة خلال موسمين زراعة متتالين 2019/2018 و2020/2019 تحت نظام الري السطحي المطور. شملت الدراسة صنفين من الفلفل الحار هما (Ealaganle) و (Bigmama3)، والرش الورقي اسبوعياً بتركيزين بحامض الساليسيليك (8 و16 مجم / لتر) وتركيزين بسيليكات البوتاسيوم (4 و8 مل / لتر).

تم وضع المعاملات في نظام تصميم القطعة المنشقة بثلاثة مكررات حيث تم وضع الاصناف في القطع الرئيسية، وتم توزيع معاملات الرش الورقي في القطع الفرعية كالتالي (معاملة الكنترول (T1) الرش بالماء المقطر- معاملة (T2) الرش بحمض الساليسيليك بتركيز (8 مجم / لتر) – معاملة (T3) الرش بحمض الساليسيليك بتركيز (16 مجم / لتر) - معاملة (T4) بسيليكات البوتاسيوم بتركيز (4 مل / لتر) - معاملة (T5) الرش بسيليكات البوتاسيوم بتركيز (8 مل / لتر).

تم دراسة الخواص الطبيعية لثمار الفلفل الحار وإنتاجيتها وأظهر التحليل الاحصائي النتائج الأتية

- وجود اختلافات معنوية ($P\leq0.05$) بين الصنفين في الخواص الطبيعية لثمار الفلفل الحار وانتاجيتها حيث أظهر الصنف (Ealaganle) تفوقا معنويا عن الصنف (Bigmama3)
- أدى رش الصنف Ealaganle بتركيز 8 مل / لتر من سيليكات البوتاسيوم الى زيادة معنوية لمحصول ثمار الفلفل الحار.
- أعطت إضافة سيليكات البوتاسيوم فى المعاملة الرابعة عند تركيز 4 و8 مل / لتر أقصى إنتاجية من الفلفل الحار بزيادة قدرها (21.14 و20.03%) وكذلك أعطت إضافة سيليكات البوتاسيوم فى المعاملة الخامسة زيادة قدرها (32.17 و30.97%) مقارنة مع معاملة الكنترول في الموسمين الأول والثاني على التوالي.
- بالإضافة إلى ذلك، وجدت علاقة ارتباط موجبة وعالية المعنوية بين المحصول وتكرار الحصاد.