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RESPONSE OF VEGETATIVE GROWTH, LEAF PIGMENTS, YIELD AND FRUIT QUALITY OF SOME SUMMER SQUASH CULTIVARS GROWN IN SANDY SOIL TO FOLIAR SPRAY WITH SOME ANTIOXIDANTS

Ahmed M.M. Abd-Alrahman*, A.A. Gad, A. Bardisi and H.G. Zyada

Hort. Dept., Fac. Agric., Zagazig Univ., Egypt

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ABSTRACT: The present work was carried out at Private Farm (The Experimental Farm of Sand Valley Company) at Ismailia Governorate, Egypt during the two summer seasons of 2016 and 2017 to study the response of vegetative growth, leaf pigments, yield and fruit quality of some summer squash cultivars (Haitek, Kortoba, Otto, Rivera and Shamis) grown in sandy soil to foliar spray with some antioxidants [Salicylic acid (SA), Vitamin B_1 and Vitamin C] at 100 ppm of each. The interaction between Revira cultivar and spraying with SA or with Vitamin C at 100 ppm of each increased number of leaves/ plant, leaves dry matter and leaf relative water content (%), crude protein and Vitamin C content in fruits, whereas the interaction between Revira or Shamis cultivars and spraying with SA at 100 ppm increased plant height, concentration of chlorophyll a in leaf tissues, total yield/ fad., total carbohydrates and TSS in fruits. The interaction between Shamis cultivar and spraying with Vitamin B_1 or Vitamin C at 100 ppm of each increased concentration of chlorophyll b in leaf tissues, but decreased the concentration of carotenoides in leaf tissues. On the other hand, spraying Otto cultivar with tap water gave the lowest value for each of chlorophyll a, b but recorded the highest concentration of carotenoides in leaf tissues, followed by Haitek and Kortoba, while spraying Kortoba cultivar with tap water gave the lowest value of total yield.

Key words: Summer squash, cultivars, antioxidants, leaf pigments, yield and fruit quality.

INTRODUCTION

Summer squash (*Cucurbita pepo* L.) is one of the most popular cucurbits vegetable crops grown in Egypt. The immature fruits are eaten as boiled, fried or stuffed. It has various health and medicinal benefits of human (**Bannayan *et al.,* 2011**). Squash is cultivated all over the year in Egypt, in open field during spring and summer, where in tunnels or-greenhouses in fall and winter. Global climate changes, *i.e.,* amount of CO_2 solar radiation and changes in temperature, the intensity of extreme weather have a different effects of plants at molecular function, morphological characteristics, physiology and developmental processes **(Gray and Brady, 2016)**.

There were significant differences among cultivars regarding vegetative growth **(Marie and Mohammed, 2010; Kumar and Sharma, 2018)** on squash, leaf pigments (**Sarhan *et al.*, 2011**), yield (**Esho and Saeed, 2017; Salama *et al.*, 2019**). and quality **(Kołota and Balbierz, 2015; Richardson, 2016)**.

Recently, great attention has been focused on natural and safety antioxidant substances, which have the ability quench to free radicals and thereby form a protective screen around plant cells and hence increasing plant resistance to stress, moreover, antioxidants provide adequate protection against the deleterious effect of activated oxygen species **(Alscher *et al.*, 1997)** on sweet pea. The appropriate application of SA could provide protection against several types of environmental stresses. It has important role in the regulation of plant growth and development **(Szepesi *et al.*, 2008)**. **Hara *et al.* (2011)** found that salicylic acid (SA) is important phytohormone

***Corresponding author: Tel. :** +201065519832
E-mail address: ahmedabdalrahman771@gmail.com

that plays a role in response to biotic stresses and pathogenesis. Apart from this role, recent studies have demonstrated that SA also participates in the signaling of abiotic stress responses. **Oertli (1987)** reported that Vitamin C (ascorbic acid) is an organic compound in higher plants which is required in trace amount to maintain normal growth. Ascorbic acid eliminates reactive oxygen species (ROS) through multiple mechanisms.. Also, **Eskling *et al.* (1997)** found that Ascorbic acid has a key role in photo protection . In addition, ascorbic acid levels increase in plant grown under high light and is a cofactor utilized in the xanthophyll cycle. Thiamine or Vitamin B_1 is a plant growth regulators required for growth and differentiation of some plant species (**Kaya *et al.*, 2015**).

Many authors showed that spraying plants with SA, Vitamin C and Vitamin B_1 significantly increased vegetative growth, leaf pigments, yield and fruit quality **(Elwan and El-Shatoury, 2014; Mady, 2014; Doklega, 2018; Wanas *et al.*, 2018; Abd-Elaziz *et al.*, 2019)** on squash for SA, **(El-Tohamy *et al.*, 2008)** on eggplants and **(El-Hifny and El-Sayed, 2011)** on Sweet Pepper and **(Youssef *et al.*, 2017)** on squash for Vitaminamin C, and **(Farouk *et al.*, 2012**) on tomato.

Therefore, the present work was carried out to evaluate the response of vegetative growth, leaf pigments yield and fruit quality of some summer squash cultivars grown in sandy soil to foliar spray with some antioxidants.

MATERIALS AND METHODS

The present work was carried out at Private Farm (The Experimental Farm of Sand Valley Company) at Ismailia, Ismailia Gov, Egypt during the two summer seasons of 2016 and 2017 to evaluate the response of vegetative growth, leaf pigments yield and fruit quality of some summer squash cultivars (Haitek, Kortoba, Otto, Rivera and Shamis) grown in sandy soil to foliar spray with some antioxidants (salicylic acid and Vitamins (B_1 and C) at 100 ppm of each, beside unsprayed plants.

Soil chemical analysis was applied using the method described by **Black (1982)**. The experimental soil was sandy in texture with drip irrigation system. The soil chemical properties values were: organic matter 0.07 and 0.09%; available N 14.62 and 14.98 ppm; available P 18.0 and 19.46 ppm; available K 59.6 and 63.1 ppm; pH 7.90 and 7.88 and E.C. 2.10 and 2.50 mmhos/cm in the first and second seasons, respectively.

This experiment included 20 treatments which were the combinations between five cultivars (Haitek, Kortoba, Otto, Rivera and Shamis) and three antioxidant treatments as foliar spray (salicylic acid, Vitamin B_1 and Vitamin C at 100 ppm of each, beside tab water).

These treatments were arranged in a split plot in a complete randomized block design with three replicates. Cultivars were randomly arranged in the main plots and antioxidant treatments were randomly distributed in the sub plots.

Seeds of summer squash cultivars were sown on 20^{th} and 27^{th} Feb. in seedling trays in the 1^{st} and 2^{nd} seasons, respectively. Transplants were transplanted on 15^{th} and 21^{st} March in the 1^{st} and 2^{nd} seasons, respectively on rows with 1.8 m width and 5 m length with 0.4 m apart between each plant and plot include 2 rows, plot area was 18 m^2.

The source of summer squash seed cultivars (Haitek, Kortoba, Otto, Rivera and Shamis) was (Sand valley, Syngenta, and Samtrade) Comp, Cairo, Egypt. The source of antioxidants (Salicylic acid, Vitamin B_1 and Vitamin C) was Technogen Company, El-Dokky, Giza, Egypt.

Salicylic acid ($C_7H_6O_3$), thiamin or Vitamin B_1 ($C_{12}H_{17}N_4OS$) and Vitamin C ($C_6H_8O_6$) were sprayed three times, after 20 days from planting and the two other doses were done weekly later. Each plot received 2 L aqueous solutions of salicylic acid, Vitamin B_1 and Vitamin C using spreading agent (reflecting materials). The control plants (check) were sprayed with tap water and spreading agent only.

Ammonium sulphate (20.5%N), calcium superphosphate (15.5-16.0% P_2O_5) and potassium sulphate (48-50.0% K_2O) were used as the sources of N, P and K mineral fertilizers at the rate of 200 kg, 150 kg and 100 kg per faddan, respectively. All the amount of phosphorus fertilizer was applied once during soil preparation. The amounts of nitrogen and potassium fertilizers were added in two equal doses through fertigation at 20 days after planting and at flowering stage.

All plants were received normal agricultural practices whenever they were needed.

Five plants were randomly chosen from every plot at 35 days after planting in both seasons and the following data were recorded:

Vegetative Growth

Plant height (cm), number of leaves per plant, leaves dry matter (%): One hundred grams of the leaves were dried at 105°C till constant weight and DM (%) was recorded.

Leaf Relative Water Content (LRWC)

To evaluate the water status during the stress period, relative water content (RWC) was used, it was determined according to **Barrs and Weatherley (1962)**. Cut leaves were weighted (fresh weight, FW), then left saturated in water for three hours and their turgid weights (TW) were calculated. The samples were then dried in an oven at 80°C for 24 hours and weighted (DW). The RWC is determined as follows:

$$RWC = (FW - DW) / (TW - DW) \times 100$$

Leaf pigments

A random sample from the upper fourth leaf subtending the terminal bud of stem was taken to determine both chlorophyll a and b, as well as carotenoids at 35 days after sowing according to the method described by **Wettestein (1957).**

Yield and its components after planting

Fruits at marketable stage at 35 days after planting were harvested from each plot every 2 or 3 days, upon reaching 12-15 cm length and the following data were recorded:

1. Total yield was recorded during the harvesting period (ton/fad.).
2. Relative yield (%) were calculated=

$$\frac{\text{Yield of treatment}}{\text{Yield of control}} \times 100$$

Fruit quality

It was determined at the mid of harvesting season by using ten fruits from each plot, as follows:

1. Total carbohydrates (%) was determined in squash fruits according to the method described by **Dubois *et al.* (1956)**.
2. Crude protein percentage in squash fruits were calculated by multiplying the total N by 6.25 (**AOAC 2000**).
3. Vitamin C (mg/100g) in squash fruits were determined according to the method reported by **(AOAC 2000**).
4. Total soluble solids percentage (TSS brix ^{o}) in summer squash fruits were determined by using Hand Refractometer.

Statistical Analysis

All the obtained data were statistically analysis using the COSTAT program and means separation were done by least significant value (LSD) at 0.05 level of probability according to **Snedecor and Cochran (1967)**.

RESULTS AND DISCUSSION

Vegetative Growth

Effect of cultivar

There were significant differences among the five cultivars with respect to plant height, number of leaves/plant and leaves dry matter at 35 days after planting in both seasons (Table 1).

Revira cultivar gave the tallest plants, followed by Shamis cultivar, whereas Otto cultivar gave the shortest plants, followed by Kortoba cultivar in both seasons. Also Revira cultivar recorded the maximum value for each of number of leaves/plant and leaves dry matter (%), followed by Shamis cultivar.

As for relative water content (%), Revira and Shamis cultivars recorded maximum values, followed by Haitek cultivar in both seasons.

The increases in leaves dry matter were about 0.50 and 0.91% for Revira cultivar and 0.07 and 0.23% for Shamis cultivar over Kortoba cultivar in the 1st and 2nd seasons, respectively.

Form the foregoing results, it could be concluded that Revira and Shamis cultivars were the best cultivars in plant height, number of leaves/plant, leaves dry matter (%) and leaf relative content (%).

Table 1. Effect of cultivars and some antioxidants on vegetative growth and leaf water content of summer squash at 35 days after planting during 2016 and 2017 seasons

Treatment	Plant height (cm)		Number of leaves/plant		Leaves dry matter (%)		Leaf water content (%)	
	2016	2017	2016	2017	2016	2017	2016	2017
	Cultivars							
Haitek	63.08	60.83	34.00	33.58	11.70	11.77	74.33	73.72
Kortoba	54.25	55.33	25.42	27.00	11.86	11.90	70.88	72.17
Otto	50.17	53.33	25.33	26.42	11.52	11.51	72.95	71.97
Revira	70.33	72.33	37.00	38.67	12.36	12.81	76.94	77.22
Shamis	70.00	70.33	35.67	34.83	11.93	12.13	76.38	75.54
LSD at 5%	**3.86**	**2.45**	**2.84**	**1.98**	**0.07**	**0.13**	**0.68**	**0.36**
	Antioxidants (each at 100 ppm)							
Control (tap water)	58.47	56.73	30.07	31.93	11.20	11.34	72.02	71.92
Salicylic acid	62.93	66.20	32.40	33.47	12.17	12.32	74.79	74.58
Vitamin B_1	62.00	64.13	30.73	31.27	11.98	12.10	74.74	74.19
Vitamin C	62.87	62.67	32.73	31.73	12.14	12.33	75.64	75.81
LSD at 5%	**NS**	**1.93**	**2.13**	**1.57**	**0.09**	**0.08**	**0.45**	**0.44**

The differences among summer squash cultivars could be attributed to the genetic differences between cultivars. Differences among squash cultivars were also observed by **Marie and Mohammed (2010)** and **Kumar and Sharma (2018)** on squash. They found that there were significant differences among squash cultivars regarding plant height, number of laves and leaves dry matter.

Effect of some antioxidants

Spraying summer squash plants with some antioxidants had significant effect on plant height, number of leaves/plant and leaves dry matter at 35 days after planting in both seasons, except plant height in the 1st season (Table 1). Foliar spray with salicylic acid (SA) at 100 ppm recorded the tallest plants, followed by spraying with Vitamin B_1 at 100 ppm in the 2nd season. As for leaves dry matter, spraying with SA at 100 ppm increased leaves dry matter (%) with no significant differences with Vitamin C in both seasons. Respecting number of leaves/ plant, spraying with SA at 100 ppm increased number of leaves/plant with no significant differences with Vitamin C in the 1st season and with control (spraying with tap water) in the 2nd season. On the other sides, spraying with Vitamin C at 100 ppm increased leaf relative water content (%) in both seasons.

The increases in leaves dry matter were about 0.97 and 0.98 % for spraying with SA at 100 ppm and 0.94 and 0.99 % for spraying with Vitamin C over the control (spraying with tap water) in the 1st and 2nd seasons, respectively.

Form the foregoing results, it could be concluded that, in general spraying with SA or with Vitamin C at 100 ppm of each increased number of leaves/plant and leaves dry matter (%) as well as leaf relative water content (%).

The positive effect of ascorbic acid on plant height and number of leaves/plants may be due to its role in enhancing the efficiency of photosynthesis, cell expansion and cell division (**Naz *et al*., 2016**). Also, application of Vitamins to plants may enhance plant growth by acting as growth regulators under normal conditions (**Oertli, 1987**) and/or produce hormones and Vitamins such as IAA, thiamine, riboflavin and biotin, in addition fixing nitrogen which might stimulates plant growth due to enhancing root development, so it increased plant growth.

Similar results were reported by **El-Tohamy *et al.* (2008)** on eggplant and **El-Hifny and El-Sayed (2011)** on sweet pepper plants for Vitamin C, **Elwan and El-Shatoury (2014)** and **Mady (2014)** on squash for SA and **Farouk *et al.* (2012)** on tomato for Vitamin B_1.

Effect of the interaction

Obtained results in Table 2 show that spraying plants with SA, Vitamin B_1 and Vitamin C at 100 ppm of each had significant effect on plant height, number of laves and leaves dry matter for all cultivars.

Spraying Revira and Shamis cultivars with SA at 100 ppm gave the tallest plants, whereas spraying Revira cultivar with SA at 100 ppm increased number of leaves/plant, leaves dry matter (%) and leaf relative water content (%), followed by spraying the same cultivar with Vitamin C at 100 ppm in both seasons, with no significant differences with spraying Shamis cultivar with SA or Vitamin C at 100 ppm of each with respect number of leaves/plant in the 1st season.

Form the foregoing results, it could be concluded that, the interaction between Revira cultivar and spraying with SA or with Vitamin C at 100 ppm of each increased number of leaves/ plant, leaves dry matter (%) and leaf relative water content (%), whereas the interaction between Revira or Shamis cultivars and spraying with SA at 100 ppm increased plant height.

Photosynthetic Pigments

Effect of cultivar

Results in Table 3 show that Revira cultivar recorded the highest values of the concentration of chlorophyll a and b in leaf tissues in the 2nd season, whereas, Shamis cultivar recorded the highest values of the concentration of chlorophyll a and b in leaf tissues in the 1st season. In general, Revira and Shamis cultivars recorded the highest value for each of the concentration of chlorophyll a and b in leaf tissues. On the other hand, Otto cultivar gave the lowest value for each of chlorophyll a and b, but recorded maximum value of the concentration of carotenoides in leaf tissues, followed by Haitek and Kortoba.

The variability among the tested cultivars might be due to the heredity differences. These results are in harmony with those reported by **Sarhan *et al.* (2011)** who showed that Mullah Ahmed cultivar recorded higher value of total chlorophyll than Sucheimie cultivar.

Effect of some antioxidants

Spraying summer squash plants with SA, Vitamin B_1 and Vitamin C at 100 ppm of each increased chlorophyll a and b in leaf tissues compared to control (spraying with tap water) as shown in Table 3.

Spraying plants with SA or Vitamin C at 100 ppm of each increased chlorophyll a and b with no significant differences with respect of chlorophyll a in both seasons.

In general, spraying plants with SA or Vitamin C at 100 ppm of each increased the concentration of chlorophyll a and b in leaf tissues. However, spraying with Vitamin C at 100 ppm gave the lowest values of the concentration of carotenoides in leaf tissues, followed by Vitamin B_1 and SA at 100 ppm of each in both seasons.

Salicylic acid (SA) functions as a potential non-enzymatic antioxidant and as a plant regulator, which plays an important role in controlling a variety of plant physiological processes including photosynthesis (**Arfan *et al.*, 2007**). Also, Vitamin B_1 enhanced the formation of chlorophylls and delayed the degradation and senescence of chlorophyll at leaves. This favorable effect of B- Vitamins on the formation of chlorophyll might be due to their important roles in the synthesis of succinyl-Co A and glycin amino acid and for the reaction between them to form α – aminolevulinic acid (**Strove, 1989**) the main intermediate compound for formation of protoporphyrin the precursor of chlorophyll (**Hess, 1981**).

These results are agree with those reported by **Elwan and El-Shatoury (2014), Mady (2014), Maswada *et al.* (2014), Abd El-Mageed *et al.* (2016), Doklega (2018) Wanas *et al.* (2018)**

Table 2. Effect of the interaction treatments between cultivars and some antioxidants on vegetative growth and leaf water content of summer squash at 35 days after planting during 2016 and 2017 seasons

Treatment		Plant height (cm)		Number of leaves/plant		Leaves dry matter (%)		Leaf water content (%)	
		2016	2017	2016	2016	2016	2017	2016	2017
Cultivar	**Antioxidant**								
Haitek	**Control**	61.67	54.00	32.67	32.00	11.13	11.10	72.37	71.81
	Salicylic acid	60.00	59.33	36.33	37.33	11.64	11.77	74.99	73.92
	Vitamin B_1	64.67	70.33	36.33	35.33	12.09	12.51	74.35	74.14
	Vitamin C	66.00	59.67	30.67	29.67	11.95	11.70	75.61	75.00
Kortoba	**Control**	50.67	52.33	26.33	28.33	11.03	11.14	68.43	69.71
	Salicylic acid	55.00	57.67	24.00	25.67	12.33	12.42	71.05	72.61
	Vitamin B_1	59.67	62.33	23.00	25.33	11.92	11.77	71.59	72.23
	Vitamin C	51.67	49.00	28.33	28.67	12.15	12.29	72.46	74.15
Otto	**Control**	49.33	46.67	25.33	29.00	11.08	11.08	70.65	69.74
	Salicylic acid	48.33	51.33	23.00	24.67	11.67	11.50	73.93	72.92
	Vitamin B_1	47.67	54.67	26.67	27.67	11.64	11.75	73.07	71.56
	Vitamin C	55.33	60.67	26.33	24.33	11.68	11.72	74.15	73.66
Revira	**Control**	62.67	68.00	33.00	36.00	11.56	11.75	74.85	75.41
	Salicylic acid	77.00	83.67	41.00	43.67	13.03	13.64	77.91	78.41
	Vitamin B_1	66.33	60.67	34.00	36.00	12.25	12.56	76.19	75.23
	Vitamin C	75.33	77.00	40.00	39.00	12.59	13.30	78.82	79.85
Shamis	**Control**	68.00	62.67	33.00	34.33	11.19	11.64	73.81	72.95
	Salicylic acid	74.33	79.00	37.67	36.00	12.18	12.29	76.09	75.03
	Vitamin B_1	71.67	72.67	33.67	32.00	12.02	11.91	78.48	77.79
	Vitamin C	66.00	67.00	38.33	37.00	12.33	12.67	77.15	76.38
LSD at 5%		**10.21**	**4.45**	**4.99**	**3.63**	**0.20**	**0.21**	**1.10**	**0.93**

Table 3. Effect of cultivars and some antioxidants on leaf pigments (mg/100 g as fresh weight) of summer squash at 35 days after planting during 2016 and 2017 seasons

Treatment	Chlorophyll a content (mg/100g f.w.)		Chlorophyll b content (mg/100g f.w.)		Carotenoids content (mg/100g f.w.)	
	2016	2017	2016	2017	2016	2017
			Cultivars			
Haitek	0.821	0.818	0.447	0.434	0.231	0.217
Kortoba	0.797	0.800	0.442	0.436	0.213	0.214
Otto	0.798	0.799	0.432	0.431	0.230	0.226
Revira	0.838	0.860	0.456	0.457	0.199	0.204
Shamis	0.857	0.838	0.467	0.451	0.201	0.198
LSD at 5%	**0.007**	**0.007**	**0.007**	**0.005**	**0.005**	**0.004**
			Antioxidant (each at 100 ppm)			
Control (tap water)	0.753	0.765	0.428	0.421	0.230	0.227
Salicylic acid	0.858	0.853	0.453	0.446	0.212	0.208
Vitamin B_1	0.825	0.824	0.453	0.444	0.211	0.209
Vitamin C	0.852	0.850	0.461	0.457	0.206	0.204
LSD at 5%	**0.006**	**0.005**	**0.004**	**0.004**	**0.003**	**0.003**

and Abd-Elaziz *et al.* (2019) on squas for SA. **Youssef *et al.* (2017)** on squash **and Abdel-Wahab (2018)** on cucumber for ascorbic acid. **Farouk *et al.* (2012)** on tomato for thiamine (Vitamin B_1). They showed that spraying plants with different antioxidants increased the concentrations of chlorophyll in leaf tissues.

Effect of the interaction

For all cultivars, spraying plants with SA, Vitamin B_1 and Vitamin C at 100 ppm of each increased the concentration of chlorophyll a and b in leaf tissues in both seasons (Table 4).

As for chlorophyll a, spraying Revira and Shamis cultivars with SA at 100 ppm increased chlorophyll a in leaf tissues. Respecting chlorophyll b, spraying Shamis cultivar with Vitamin C at 100 ppm increased chlorophyll b in leaf tissues. Spraying Otto cultivar with tap water (control) gave the lowest value for each of chlorophyll a, b but recorded the highest concentration of carotenoides in leaf tissues in both seasons.

In general, the interaction between Revira and Shamis cultivars and spraying with SA at 100 ppm increased chlorophyll a, whereas the interaction between Shamis cultivar and spraying with Vitamin B_1 or Vitamin C at 100 ppm of each increased chlorophyll b but lowest carotenoides in leaf tissues.

Results are in harmony with those reported with **Hussein and Mustaf (2019)** who indicated that the interaction between Alexandria cultivar and spraying with ascorbic acid at 100 mg/ l gave the highest total chlorophyll in leaves of squash plant.

Effect of cultivars

There were significant differences among the five cultivars with respect to total yield/fad., in both seasons (Table 5).

Revira cultivar gave the highest value of total yield/fad., with no significant differences with Shamis cultivar in the 2^{nd} season. Kortoba cultivar gave the lowest value of total fruit yield/ fad., followed by Otto cultivar in both seasons

Table 4. Effect of the interaction treatments between cultivars and some antioxidants on leaf pigments (mg/100 g as fresh weight) of summer squash at 35 days after planting during 2016 and 2017 seasons

Treatment		Chlorophyll a content (mg/100g f.w.)		Chlorophyll b content (mg/100g f.w.)		Carotenoids content (mg/100g f.w.)	
		2016	2017	2016	2017	2016	2017
Cultivar	**Antioxidant**						
Haitek	Control	0.724	0.851	0.423	0.420	0.248	0.232
	Salicylic acid	0.847	0.840	0.458	0.432	0.231	0.225
	Vitamin B_1	0.847	0.829	0.447	0.428	0.219	0.202
	Vitamin C	0.868	0.853	0.459	0.454	0.226	0.208
Kortoba	Control	0.733	0.753	0.420	0.411	0.232	0.237
	Salicylic acid	0.826	0.817	0.456	0.445	0.212	0.198
	Vitamin B_1	0.798	0.805	0.438	0.440	0.205	0.209
	Vitamin C	0.832	0.825	0.453	0.449	0.202	0.211
Otto	Control	0.742	0.745	0.419	0.405	0.245	0.249
	Salicylic acid	0.825	0.816	0.437	0.439	0.233	0.226
	Vitamin B_1	0.812	0.818	0.433	0.441	0.216	0.222
	Vitamin C	0.812	0.819	0.440	0.437	0.225	0.206
Revira	Control	0.772	0.807	0.443	0.441	0.219	0.218
	Salicylic acid	0.883	0.901	0.454	0.464	0.190	0.202
	Vitamin B_1	0.832	0.847	0.455	0.449	0.198	0.200
	Vitamin C	0.866	0.886	0.473	0.476	0.190	0.196
Shamis	Control	0.794	0.770	0.434	0.428	0.204	0.198
	Salicylic acid	0.909	0.892	0.462	0.448	0.194	0.186
	Vitamin B_1	0.838	0.822	0.490	0.461	0.218	0.209
	Vitamin C	0.885	0.866	0.480	0.468	0.189	0.198
LSD at 5%		**0.013**	**0.012**	**0.011**	**0.009**	**0.007**	**0.007**

Table 5. Effect of cultivars and some antioxidants and their interactions on total yield/faddan (ton) and relative total yield of summer squash during 2016 and 2017 seasons

Treatment	Total yield (ton/fad.)					Relative total yield (%)					
Antioxidant	Control	SA	Vit. B_1	Vit. C	Average (A)	Control	SA	Vit. B_1	Vit. C	RYcv	RY Anti
Cultivar					2016 season						
Haitek	6.440	8.260	7.560	8.036	7.574	107.98	138.50	126.76	134.74	110.75	100.00
Kortoba	5.964	7.336	6.440	7.616	6.839	100.00	123.00	107.98	127.70	100.00	132.16
Otto	6.272	7.896	7.028	7.392	7.147	105.16	132.39	117.84	123.94	104.50	115.70
Revira	7.504	10.024	8.568	9.464	8.890	125.82	168.08	143.66	158.69	129.99	127.56
Shamis	6.636	9.856	8.372	9.352	8.554	111.27	165.26	140.38	156.81	125.08	
Average (B)	6.563	8.674	7.594	8.372	---					---	
LSD at 5%	**A=0.138**		**B= 0.096**		**AB= 0.231**			**----**			
					2017 season						
Haitek	6.860	8.316	7.504	7.896	7.644	110.86	134.39	121.27	127.60	110.41	100.00
Kortoba	6.188	7.560	6.748	7.196	6.923	100.00	122.17	109.05	116.29	100.00	133.57
Otto	6.524	8.176	6.636	7.980	7.329	105.43	132.13	107.24	128.96	105.86	109.93
Revira	6.860	10.332	7.924	8.988	8.526	110.86	166.97	128.05	145.25	123.15	124.99
Shamis	6.832	10.052	7.756	9.520	8.540	110.41	162.44	125.34	153.85	123.36	----
Average (B)	6.653	8.887	7.314	8.316	----					----	
LSD at 5%	**A= 0.109**		**B= 0.122**		**AB= 0.261**			**----**			

Relative total yield (%) = Yield of treatment / yield of control x100
Control of cultivars : Kortoba, Control of antioxidants = spraying with tap water
Control of the interaction = Kortoba x spraying with tap water
RYcv= Relative yield of cultivar RY Anti. = Relative yield of antioxidants

The increases in total yield/fad., were about 29.98 and 23.15% for Revira cultivar, 25.08 and 23.36% for Shamis cultivar, 10.75 and 10.41% for Haitek cultivar and 4.50 and 5.86% for Otto cultivar over the Kortoba cultivar in the 1^{st} and 2^{nd} seasons, respectively.

The increase in total yield was directly due to the increase in vegetative growth (Table 1) and high photosynthesis capacity expressed in leaf pigments (Table 3).

The differences in yield between tested varieties may be attributed to the variation in genetic structure, which capable to adapte with the environmental growing conditions, as well as the potential to transport and accumulate photosynthetic assimulate materials.

The varietals differences among the studied cultivars may be due to the heredity differences and also, may be due to the differences among them in their yield attributes. Similar findings were reported by **Kołota and Balbierz (2015)**, **Richardson (2016)**, **Esho and Saeed (2017)**, **Kumar and Sharma (2018)** and **Salama *et al.* (2019)** all on squash. They showed that there were significant differences between cultivars regarding yield and its components.

Effect of some antioxidants

Spraying plants with SA, Vitamin B_1 and Vitamin C at 100 ppm of each increased total yield/fad., compared to control (spraying with tap water) as show in Table 5. Spraying with SA at 100 ppm increased total yield/fad., followed by spraying with Vitamin C at 100 ppm in both seasons.

The increases in total yield/fad., were about 32.16 and 33.57% for spraying with SA at 100 ppm, 27.56 and 24.99% for spraying with Vitamin C at 100 ppm and 15.70 and 9.93% for Vitamin B_1 over the control (spraying with tap water) in the 1^{st} and 2^{nd} seasons, respectively.

The increase in total yield was directly due to the increase in plant growth (Table 1) and high photosynthesis capacity expressed in leaf pigments (Table 3).

The beneficial effect of salicylic acid on fruit yield may be due to its impact on physiological and biochemical processes, including photosynthesis, ion absorption, membrane permeability, enzyme activity, flora, energy production and plant growth and development (**Arberg, 1981**).

These results are in harmony with the findings of **Elwan and El-Shatoury (2014)**, **Mady (2014), Maswada *et al.* (2014)**, **Al-Rubaye and Atia (2016)** on squash for SA effect. **Abdel-Wahab (2018)** on cucumber, **Youssef *et al.* (2017)** on squash for Vitamin C, F**arouk *et al.* (2012) on tomato** for Vitamin B_1.

In this connection**, Doklega (2018)** reported that foliar spray of summer squash (*Cucurbita pepo* L.) cv. Mabroka with ascorbic acid at 1g/l or salicylic acid at 1 g/l showed significant increases in the early and total yield ton/fad., compared to control (spraying with tap water). Also, **Abd-Elaziz *et al.* (2019**) showed that spraying summer squash with salicylic acid (SA) at different rates (1, 2 or 3 mM) recorded the higher values of early yield/plant and total fruit yield/fad., than unsprayed plants.

Effect of the interaction

Spraying Revira and Shamis cultivar with SA or Vitamin C at 100 ppm of each increased total yield/fad., in both seasons (Table 5). Spraying all cultivars with tap water gave the lowest value of total yield/fad., compared the other interaction treatments.

The increases in total yield/fad., were about 68.07 and 66.96% for spraying Revira cultivar with SA at 100 ppm, 58.68 and 45.24% for spraying Revira cultivar with Vitamin C and 65.25 and 62.44% for spraying Shamis with SA at 100 ppm and 56.80 and 53.84 for spraying Shamis cultivar with Vitamin C at 100 ppm over spraying Kortoba cultivar with tap water (control) in the 1st and 2nd seasons, respectively.

The stimulative effect of spraying Revira and Shamis cultivars with SA or Vitamin C at 100 ppm of each on total yield/fad., may be due to increased vegetative growth (Table 1) and high photosynthesis capacity expressed in leaf pigments (Table 4).

Fruit Quality

Effect of cultivars

There were significant differences among the five cultivars with respect to total carbohydrates, crude protein (%) total soluble solids and ascorbic acid content in fruits in both seasons (Table 6). Revira and Shamis cultivars gave the highest value for each of total carbohydrates (%), crude protein (%) and TSS in fruits in both seasons, whereas Revira cultivar recorded maximum Vitamin C content in fruits, followed by Shamis cultivar in both seasons compared to the other three cultivars.

Results are in harmony with **Richardson (2016)**, **Kumar and Sharma (2018)** and **Salama *et al.* (2019**) they showed that there were significant differences between cultivars regarding fruit quality.

Effect of some antioxidants

Spraying summer squash plants with SA, Vitamin B_1 and Vitamin C at 100 ppm of each increased total carbohydrates (%), crude protein (%) TSS and ascorbic acid content in fruits compared to control (spraying with tap water) as shown in Table 6. Also, spraying plants with SA or with Vitamin C at 100 ppm of each increased total carbohydrates (%), crude protein (%) and Vitamin C content in fruits followed by spraying with Vitamin B_1.Whereas spraying with SA at 100 ppm increased TSS in fruits, followed by spraying with Vitamin C at 100 ppm in fruits in both seasons.

Results are in harmony with **Mady (2014)** and **Al-Rubaye and Atia (2016), Youssef *et al.* (2017)**, **Doklega (2018)** and **Abd-Elaziz *et al.* (2019)** on squash. They showed that spraying summer squash with SA or Vitamin C increased fruit quality such as TSS, total sugars, and crude protein as well as Vitamin C contents in fruits as compared with unsprayed plants.

Effect of the interaction

Results in Table 7 show that spraying Revira and Shamis cultivars with SA or Vitamin C at 100 ppm of each increased total carbohydrates

Table 6. Effect of cultivars and some antioxidants on quality of summer squash fruits during 2016 and 2017 seasons

Treatment	Total carbohydrates (%)		Crude protein (%)		Total soluble solids (Brix°)		Ascorbic acid content (mg/100 g f. w.)	
	2016	2017	2016	2017	2016	2017	2016	2017
				Cultivars				
Haitek	14.34	14.10	12.30	11.73	5.00	5.01	19.15	19.14
Kortoba	14.66	14.18	10.42	11.02	4.55	4.60	18.25	18.23
Otto	14.20	13.89	10.98	11.29	4.71	4.81	19.29	19.59
Revira	15.47	15.69	13.45	13.65	5.26	5.28	21.58	22.02
Shamis	15.69	15.59	13.20	13.24	5.36	5.12	20.70	20.64
LSD at 5%	**0.079**	**0.095**	**0.165**	**0.088**	**0.02**	**0.04**	**0.18**	**0.25**
				Antioxidant (each at 100 ppm)				
Control (tap water)	14.27	14.18	10.96	11.05	4.69	4.65	18.19	18.67
Salicylic acid	15.18	14.87	12.60	12.99	5.31	5.23	20.92	21.42
Vitamin B_1	14.87	14.66	11.89	11.92	4.84	4.85	19.25	19.43
Vitamin C	15.18	15.05	12.83	12.78	5.06	5.12	20.81	20.40
LSD at 5%	**0.073**	**0.084**	**0.147**	**0.096**	**0.03**	**0.03**	**0.17**	**0.018**

Table7. Effect of the interaction treatments between cultivars and some antioxidants on quality of summer squash fruits during 2016 and 2017 seasons

Treatment		Total carbohydrates (%)		Crude protein (%)		Total soluble solids (Brix°)		Ascorbic acid content (mg/100 g f. w.)	
		2016	2017	2016	2017	2016	2017	2016	2017
Cultivar	Antioxidant								
Haitek	Control	13.49	13.24	11.39	10.88	4.84	4.65	17.58	18.03
	Salicylic acid	14.77	14.32	12.75	12.18	5.12	5.22	20.26	21.05
	Vitamin B_1	14.63	14.59	12.30	11.69	4.98	4.95	19.12	18.38
	Vitamin C	14.59	14.28	12.76	12.17	5.07	5.22	19.64	20.19
Kortoba	Control	14.27	13.79	9.17	9.33	4.29	4.16	16.23	17.21
	Salicylic acid	14.67	14.19	11.43	12.15	4.93	5.01	20.09	19.62
	Vitamin B_1	14.75	13.95	10.08	11.04	4.29	4.36	16.84	17.11
	Vitamin C	14.94	14.79	10.99	11.54	4.67	4.87	19.82	18.97
Otto	Control	13.35	13.38	9.71	10.11	4.31	4.48	18.15	18.73
	Salicylic acid	14.40	13.89	10.34	12.01	4.95	5.01	19.96	20.45
	Vitamin B_1	14.41	14.10	11.87	10.93	4.68	4.77	19.18	19.53
	Vitamin C	14.65	14.19	11.99	12.11	4.88	4.97	19.89	19.64
Revira	Control	15.03	15.23	12.26	12.51	4.97	5.02	20.12	19.77
	Salicylic acid	15.93	16.07	14.26	14.65	5.67	5.59	22.14	24.63
	Vitamin B_1	14.88	15.33	12.85	13.25	5.15	5.20	20.85	21.23
	Vitamin C	16.04	16.12	14.42	14.20	5.25	5.32	23.20	22.46
Shamis	Control	15.24	13.28	12.27	12.14	5.03	4.96	18.89	19.61
	Salicylic acid	16.12	15.91	14.20	13.99	5.87	5.32	22.15	21.34
	Vitamin B_1	15.71	15.32	12.37	12.71	5.12	4.98	20.27	20.88
	Vitamin C	15.70	15.86	13.98	13.87	5.42	5.22	21.50	20.72
LSD at 5%		**0.163**	**0.188**	**0.328**	**0.206**	**0.06**	**0.07**	**0.36**	**0.42**

(%) and crude protein (%) in fruits, also spraying Revira cultivar with SA at 100 ppm increased crude protein (%), followed by spraying Revira cultivar with Vitamin C and spraying Shamis cultivar with SA or with Vitamin C at 100 ppm of each in both seasons.

In general, spraying Revira and Shamis cultivars with SA or Vitamin C at 100 ppm of each increased total carbohydrates (%), whereas spraying Revira cultivar with SA or Vitamin C at 100 ppm of each increased Vitamin C content in fruits. Spraying Revira and Shamis cultivars with SA at 100 ppm increased TSS.

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استجابة النمو الخضري، صبغات الورقة، المحصول وجودة ثمار بعض أصناف الكوسة الصيفية المزروعة في الأرض الرملية للرش ببعض مضادات الأكسدة

أحمد محمد محمد عبدالرحمن- عبد المنعم عامر جاد - عبد الله برديسي أحمد - هاني جمال زيادة

قسم البساتين - كلية الزراعة - جامعة الزقازيـق – مصر

أجرى هذا العمل بمزرعة خاصة (المزرعة البحثية لشركة ساند فالى)، الإسماعيلية، محافظة الإسماعيلية، مصر، خلال موسمى صيف ٢٠١٦ ، ٢٠١٧ وذلك لدراسة استجابة النمو الخضري، صبغات الورقة، المحصول وجوده الثمار لبعض أصناف الكوسة (هايتك، قرطبه، أوتو ، ريفيرا ، شاميس) المزروعة فى الأرض الرملية للرش ببعض مضادات الأكسدة (حمض السالسيلك ، فيتامين ب١ وحمض الاسكوربيك بتركيز ١٠٠ جز ء فى المليون لكل منهم)، سجلت معامله التفاعل بين رش الصنف ريفيرا بحمض السالسيلك أو حمض الاسكوربيك بتركيز ١٠٠ جز ء فى المليون لكل منهما إلى زيادة عدد الأوراق/نبات، نسبه المادده الجافة فى الأوراق، النسبة المئوية لمحتوى الماء فى الورقة، النسبة المئوية لمحتوى الثمار من البروتين الخام وحمض الاسكوربيك، بينما سجلت معامله التفاعل بين رش الصنف ريفيرا أو الصنف شاميس بحمض السالسيلك بتركيز ١٠٠ جز ء فى المليون إلى زيادة ارتفاع النبات، و تركيز كلورفيل أ فى انسجه الورقة، والمحصول الكلى للفدان، ومحتوى الثمار من كل من الكربوهيدرات الكلية وتركيز المواد الصلبة الكلية الذائبة، سجل التفاعل بين رش الصنف شاميس بفيتامين ب١ أو حمض الاسكوربيك إلى زيادة تركيز كلورفيل ب فى أنسجة الورقة ولكن سجل أقل تركيز للكاروتينويدات على الجانب الأخر فقد سجل رش نباتات الصنف أوتو بالماء فقط أقل القيم لمحتوى أنسجه الورقه من كلورفيل ا وكلورفيل ب وأعلى تركيز للكاروتينويدات يليه الصنف هايتك ثم قرطبة، بينما سجل الصنف قرطبة مع الرش بالماء أقل القيم للمحصول الكلى .

المحكمـــــون:

١- د. خـالـد عطيـة نــــور رئيس بحوث بمعهد بحوث البساتين – مركز البحوث الزراعية.

٢- أ.د. داليا أحمد سامي نوار أستاذ الخضر – كلية الزراعة – جامعة الزقازيق.