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

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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 B₁ 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 B₁ 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 CO₂ 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 (Kolota 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

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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 B1, 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 B1, 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 Vitamin 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 Vitamin B1 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 B1 and Vitamin C at 100 ppm of each, beside tap 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 20th and 27th Feb. in seedling trays in the 1st and 2nd seasons, respectively. Transplants were transplanted on 15th and 21st March in the 1st and 2nd 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 m².

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 B1 and Vitamin C) was Technogen Company, El-Dokky, Giza, Egypt.

Salicylic acid (C7H6O3), thiamin or Vitamin B1 (C12H17N4OS) and Vitamin C (C6H8O6) 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 B1 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% P2O5) and potassium sulphate (48-50.0% K2O) 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:

\[
RWC = \frac{(FW - DW)}{(TW - DW)} \times 100
\]

### 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 °) 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<sub>1</sub>         | 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 leaves 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 1<sup>st</sup> season (Table 1). Foliar spray with salicylic acid (SA) at 100 ppm recorded the tallest plants, followed by spraying with Vitamin B<sub>1</sub> at 100 ppm in the 2<sup>nd</sup> 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 1<sup>st</sup> season and with control (spraying with tap water) in the 2<sup>nd</sup> 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 1<sup>st</sup> and 2<sup>nd</sup> 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 B1.

Effect of the interaction

Obtained results in Table 2 show that spraying plants with SA, Vitamin B1 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 carotenoids 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 B1 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 carotenoids in leaf tissues, followed by Vitamin B1 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 B1 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 glycine 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

| Cultivar | Antioxidant | Plant height (cm) | Number of leaves/plant | Leaves dry matter (%) | Leaf water content (%) |
|----------|-------------|-------------------|------------------------|-----------------------|------------------------|
|          |             | 2016  | 2017  | 2016  | 2016  | 2016  | 2017  | 2016  | 2017  |
| 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 B₁  | 66.00 | 59.67 | 30.67 | 29.67 | 11.95 | 11.70 | 75.61 | 75.00 |
|          | Control     | 50.67 | 52.33 | 26.33 | 28.33 | 11.03 | 11.14 | 68.43 | 69.71 |
|          | Salicylic acid | 60.00 | 59.33 | 36.33 | 37.33 | 11.64 | 11.77 | 74.99 | 73.92 |
|          | Vitamin B₁  | 66.00 | 59.67 | 30.67 | 29.67 | 11.95 | 11.70 | 75.61 | 75.00 |
|          | Control     | 50.67 | 52.33 | 26.33 | 28.33 | 11.03 | 11.14 | 68.43 | 69.71 |
| Kortoba  | Control     | 50.67 | 52.33 | 26.33 | 28.33 | 11.03 | 11.14 | 68.43 | 69.71 |
|          | Salicylic acid | 60.00 | 59.33 | 36.33 | 37.33 | 11.64 | 11.77 | 74.99 | 73.92 |
|          | Vitamin B₁  | 66.00 | 59.67 | 30.67 | 29.67 | 11.95 | 11.70 | 75.61 | 75.00 |
|          | Control     | 50.67 | 52.33 | 26.33 | 28.33 | 11.03 | 11.14 | 68.43 | 69.71 |
| Otto     | 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 B₁  | 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 |
|          | Control     | 68.00 | 62.67 | 33.00 | 34.33 | 11.19 | 11.64 | 73.81 | 72.95 |
| Revira   | Control     | 74.33 | 79.00 | 37.67 | 36.00 | 12.18 | 12.29 | 76.09 | 75.03 |
|          | Salicylic acid | 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 |
| 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 B₁  | 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<sub>1</sub> | 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 |

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<sub>1</sub> 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 2nd 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  |      |      |      |      |      |      |
|           |      |      |      |      |      |      |
| 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<sub>1</sub> | 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|
| 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|
| Kortoba   |      |      |      |      |      |      |
| Vitamin B<sub>1</sub> | 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|
| 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|
| Otto      |      |      |      |      |      |      |
| Salicylic acid | 0.883| 0.901| 0.454| 0.464| 0.190| 0.202|
| Vitamin B<sub>1</sub> | 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|
| Control   | 0.772| 0.807| 0.443| 0.441| 0.219| 0.218|
| Salicylic acid | 0.832| 0.847| 0.455| 0.449| 0.198| 0.200|
| Revira    |      |      |      |      |      |      |
| Vitamin B<sub>1</sub> | 0.866| 0.886| 0.473| 0.476| 0.190| 0.196|
| Vitamin C | 0.866| 0.886| 0.473| 0.476| 0.190| 0.196|
| 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|
| Shamis    |      |      |      |      |      |      |
| Salicylic acid | 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 (%) |
|-----------|------------------------|--------------------------|
|           | Control | SA | Vit. B<sub>1</sub> | Vit. C | Average (A) | Control | SA | Vit. B<sub>1</sub> | Vit. C | RYcv | RY Anti |
| Cultivar  |         |    |               |       |             |         |    |               |       |      |         |
| Side      |         |    |               |       |             |         |    |               |       |      |         |
|           | 2016    |    |               |       |             | 2017    |    |               |       |      |         |
| 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 | 110.75 | 115.70|
| Revira    | 7.504   | 10.024 | 8.568 | 9.464 | 8.890 | 125.82 | 158.69 | 143.66 | 158.99 | 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 | 8.550 | 111.27 | 165.26 | 140.38 | 156.81 | 125.08 |         |
| LSD at 5% A=0.138 | B=0.096 | AB=0.231 |          |        |        |        |        |        |        |        |         |
| 2017      |         |    |               |       |             |         |    |               |       |      |         |
| 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 | 8.520 | 110.41 | 162.44 | 125.34 | 153.85 | 123.36 |         |
| 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 Haiitek cultivar and 4.50 and 5.86% for Otto cultivar over the Kortoba cultivar in the 1<sup>st</sup> and 2<sup>nd</sup> 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 Kolota 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<sub>1</sub> 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<sub>1</sub> over the control (spraying with tap water) in the 1<sup>st</sup> and 2<sup>nd</sup> 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, Yousef et al. (2017) on squash for Vitamin C, Farouk et al. (2012) on tomato for Vitamin B1.

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 B1 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 B1. 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), Yousef 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 on 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)

| 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 |
| 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 B₁ | 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|

Table 7. 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 B₁ | 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|
|          | Control | 14.27| 13.79| 9.17 | 9.33 | 4.29 | 4.16 | 16.23| 17.21|
| Kortoba  | Salicylic acid | 14.67| 14.19| 11.43| 12.15| 4.93 | 5.01 | 20.09| 19.62|
|          | Vitamin B₁ | 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|
|          | Control | 13.35| 13.38| 9.71 | 10.11| 4.31 | 4.48 | 18.15| 18.73|
| Otto     | Salicylic acid | 14.40| 13.89| 10.34| 12.01| 4.95 | 5.01 | 19.96| 20.45|
|          | Vitamin B₁ | 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|
|          | Control | 15.03| 15.23| 12.26| 12.51| 4.97 | 5.02 | 20.12| 19.77|
| Revira   | Salicylic acid | 15.93| 16.07| 14.26| 14.65| 5.67 | 5.59 | 22.14| 24.63|
|          | Vitamin B₁ | 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|
|          | Control | 15.24| 15.39| 12.27| 12.14| 5.03 | 4.96 | 18.89| 19.61|
| Shamis   | Salicylic acid | 16.12| 15.91| 14.20| 13.99| 5.87 | 5.32 | 22.15| 21.34|
|          | Vitamin B₁ | 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 الكوسا الصيفية المزروعة في الأرض الرملية للرقص بعض مضادات الأكسدة

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أجرى هذا العمل بمزرعة خاصة (المزرعة البحثية لشركة ساد فالي)، الإسماعيلية، محافظة الإسماعيلية، مصر، خلال موسم 2016-2017، وذلك لدراسة استجابة النمو الخضري، صبغات الورقة، المحصول وجودة ثمار بعض أصناف الكوسا (هايتك، قرطبة، اتو، ريفيرا، شاميس) المزروعة في الأرض الرملية للرخص بعض مضادات الأكسدة (حمض السالسليك، فيتامين ب1 وحمض الأسكوربيك بتريكيز 100 جزء في المليون لكل منهم)، سجلت معامله التفاعل بين رص الصنف ريفيرا بحمض السالسليك أو حمض الأسكوربيك بتريكيز 100 جزء في المليون لكل منهما إلى زيادة عدد الأوراق/نبات، نسبة المادة الجافة في الورقة، نسبة الملونة لمحتوى الماء في الورقة، نسبة الملونة لمحتوى أصناف الورقة، نسبة الملونة لمحتوى أصناف شاميس بحمض السالسليك بتريكيز 100 جزء في المليون إلى زيادة ارتفاع النباتات، وتركيز كلورفين في النسيج الورقة، والمحصول الكلبي للفرد، ومحتوى الثمار من كل من الكريستالات الكلية وتركيز المواد الصلبة الكلية الذائبة، سجل التفاعل بين رص الصنف شاميس بتريكيز 100 أو حمض الأسكوربيك إلى زيادة تركيز كلورفين في النسيج الورقة ولكن سجل أقل تركيز للكاروتينويدات على الجانب الآخر فقد سجل رش نباتات الصنف اتو بالماء فقط أقل القيمة لمحتوى أنسج الورقة من كلورفين وأكسيكلورفين وواصل تركيز الكاروتينويدات يليه الصنف هايتك ثم جربية، بينما سجل الصنف جربية مع الرحل بالماء أقل القيمة للمحصول الكلبي.