Enhancement of Canino Apricots Yield and Quality by Foliar Application of Potassium Silicate, Salicylic Acid and Citric Acid

Mohamed S. M. Ali[1] and Heba F. S. Ibrahim[2]
[1]Hort. Dept., Fac. of Agric., Suez Canal Univ., Ismailia, Egypt
[2]Hort. Dept., Fac. of Agric., Minia Univ., Minia, Egypt

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Abstract: A field experiment was conducted in two successive seasons (2019 and 2020) to study the effect of potassium silicate (K_2SiO_3), salicylic acid (SA) and citric acid (CA) on productivity and fruit physicochemical properties of Canino apricots. The experiment was done at a private farm located at Cairo-Assiut Western desert road of Minia Governorate. A randomized complete block design was used. The obtained results confirmed that spraying trees with K_2SiO_3 (at 0.05%, 0.1% and 0.2%), SA and CA each at 250 and 500 ppm significantly enhanced Canino apricots (yield; kg/tree), fruit number/tree, fruit physicochemical properties, as well as proline content (mg/100g FW). The maximum values in above mentioned parameters were observed when the trees received the three examined compounds at higher concentrations compared to the control trees or other treatments. However, no significant differences were observed between the two higher concentrations of K_2SiO_3 (0.1% and 0.2%). Generally, the results of the present work demonstrated that application of K_2SiO_3, SA and CA play a remarkable role in improving fruit set, yield and fruit physical and chemical properties of Canino apricots cultivated at El-Minia Governorate conditions under salinity stress.

Keywords: *Prunus armeniaca* L., salinity, potassium silicate, salicylic acid, citric acid

INTRODUCTION

Apricot (*Prunus armeniaca* L.) is one of the most important deciduous fruit trees grown in Arab countries, especially in Egypt. Apricot cultivated area is gradually increasing and reached 15045 Feddans producing 98295 tons in 2019 (FAO-Stat, 2019). In addition, 'Canino' apricot is one of the most important cultivars that newly introduced in Egypt and present higher adaptation under Egyptian environmental condition. Potassium silicate (K_2SiO_3) plays major and important roles in fruit trees production such as: Activates the plant's internal resistance against diseases and stress. The silicon supports the plant cells and increases their hardness, thus resisting penetration of the fungus and reducing the fungal infection, increases plant cells ability of transportation and storage. It protects plants from environmental stresses such as high and low temperature, drought and salinity. K_2SiO_3 can significantly reduce the loss of water from apricot fruits. Furthermore, this compound is environmentally safe. Salicylic acid (SA, also called Ortho-Hydroxy Benzoic Acid) from Latin salix willow trees is widely used in organic synthesis and function as a plant hormone. It is derived from the metabolism of salicin (Swinehat, 1992; Klessing and Malamy, 1994; Vazirimeh and Rigi, 2014; Zou *et al.,* 2014). It is a phenolic compound found in plants with role in plant growth development, photosynthesis, transpiration as well as uptake and transport of nutrients (Conrath *et al.,* 1995; Hayat and Ahmed, 2007; Harvath *et al.,* 2007). In addition, SA induces specific changes in leaf anatomy and chloroplast structure (Hayat and Ahmed, 2007 and Grabinski, 2014). However, citric acid (CA) is a natural antioxidant compound which has an auxinic action; it provides disease control, cell division and promotion of lipase, synergistic effect on rooting and improving growth, flowering, yield and fruit quality of fruit trees (Elade, 1992; Khiamy, 1999; Ahmed *et al.,* 2003; Abo El-Komsan *et al.,* 2003).

The target of present study was to investigate the effect of spraying potassium silicate (K_2SiO_3), salicylic acid (SA) and citric acid (CA) individually or in combination at different concentrations on flowering, yield and fruit quality of Canino apricots grown under salinity stress conditions in sandy soil at Minia Governorate.

MATERIALS AND METHODS

Plant materials and treatments:

The present study was conducted during two successive seasons 2019 and 2020 on 108 uniforms in vigor Canino apricot trees, grown in private orchard, located at Cairo-Assiut Western desert road, Minia Governorate (250 km southern Cairo city) where the soil texture is sandy. The water table depth is not less than two meters. The chosen apricot trees were 8-year-old bearing and planted at 4 × 5 meters apart. Winter pruning was followed at the last week of December. Drip irrigation system was adopted, irrigation carried by using water supply from underground well.

The soil texture of this experimental field was sandy soil (table 1). A soil and well water composite sample was collected and subjected to physicochemical analysis according to the procedures of Walsh and Beaton (1986). The data of soil and water sample analyses are shown in Table (1).

Experimental work:

In order to study the effect of spraying potassium silicate, salicylic acid and citric acid each individually or in combinations, four concentrations

*Corresponding author e-mail: mdm26114@yahoo.com

of K_2SiO_3 (0.0, 0.05%, 0.1% and 0.2%), three concentrations from SA and CA (at 0.0, 250 ppm and 500 ppm) were tested on Canino apricot cultivar of the present experiment. All the tested compounds were sprayed three times during the growth season: at last week of March, last week of April and one month later. Each treatment was replicated three times, one tree per each. Triton B (at 0.25 ml/liter) as a wetting agent was added to all spraying solutions.

Table (1): Physicochemical analysis of orchard soil and the well water used in irrigation

Soil analysis		Water analysis	
Constituents	**Values**	**Constituents**	**Values**
Sand %	85.0	**E.C (µS/cm)**	953
Silt %	10.2	**Hardness**	19.7
Clay %	4.8	**pH**	7.35
Texture	Sandy Loam	**Ca (mg/L)**	38.4
EC (1: 2.5 extract) mmhos/cm/25 C	3.2	**Mg (mg/L)**	24.3
Organic matter %	0.55	**K (mg/L)**	5.07
pH (1: 2.5 extract)	7.89	**Na (mg/L)**	95.8
Active lime %	3% ($CaCO_3$)	**Sum of Cations (mg/L)**	8.16
N (mg/kg)	185	**Alkalinity (mg/L)**	182
Phosphorus (ppm)	9.80	**Chlorides (mg/L)**	121
Available Ca (meq/100g)	17.9	**Nitrate (mg/L)**	11.0
Available Mg (meq/100g)	2.33	**Sulphates (mg/L)**	53.1
Available K (meq/100g)	0.56	**Sum of anions (mg/L)**	7.69
Available Na (meq/100g)	1.21	**Boron (ppm)**	0.08
C/N Ratio	17.2	**SAR**	2.97

Experimental design:

Treatments were arranged in a complete randomized block design in split plot. The main plot was occupied by K_2SiO_3 while SA and CA as well as their combination were occupied the sub plot. Each treatment was replicated three times using one tree per each replicate.

Measurements and determinations:

Fruit set and fruit drop

During the flowering period, four shoots per tree were assigned and the total number of flowers per shoot were counted and recorded. After fruit setting, the total number of fruits per selected shoot were counted and recorded. The total number of flowers and total number of fruit setting per tree were calculated. Then, percentage of fruit setting was calculated for each replicate, using the following equation:

$$\textbf{Fruit setting \%} = \frac{Total\ number\ of\ fruit\ set/tree}{Total\ number\ of\ flower/tree} x\ 100$$

At harvesting time, total number of fruits per tree was counted and the percentage of fruit drop was calculated according to the following equation:

$$\textbf{Fruit drop \%} = \frac{(Number\ of setting\ fruits - number\ of\ fruits\ at\ harvest)}{Number\ of\ setting\ fruits/tree} x\ 100$$

Fruit yield:

The fruits were harvested when it became fully colored and the TSS/Acid ratio in the juice reached 5 to 6 in the two experimental seasons according to Ibrahim (2010). Yield per tree was calculated and expressed as (kg) in terms of number of fruits per tree average fruit weight.

The following physico-chemical characteristics of fruit were studied:

Average fruit weight (g) estimated by using a balance with 0.01g accuracy. Average fruit length and fruit diameter (cm) measured by using Vernier caliper with 0.01cm accuracy. Fruit firmness was done utilizing a hand-held pressure tester as described by Magness and Taylor (1925). Push a 3-mm diameter flat plunger's force for penetration the pulp of peeled apricot fruit was gauged. The fruit penetration force was estimated on two opposite sides and the average readings was determined for each fruit and expressed by kg cm^{-1}.

Pulp and seed weight (g) were determined. Fruit pulp (100 g) of each replicate was randomly taken and homogenized, pressed by Electric Extractor using dilution 1:1 for extracting the juice. Percentage of total soluble solids (TSS %) were determined in fruit juice utilizing a LCII-Digital refractometer at 25°C (Medline scientific, United Kingdom, SR-95) according to Rangana (1977). Percentage of total acidity (TA), expressed as g citric acid per 100 g of juice, by titration against 0.1 N NaOH, using 1 ml diluted juice in 10 ml distilled H_2O, according to A.O.A.C (2000). Percentage of total sugars was determined using Lane and Eynon volumetric method (Rangana, 1977). Free proline in fruit was determined in 0.5g dried fruit tissue (Bates *et al.,* 1973). Samples were assimilated using 10 ml of 3% (v/v) sulphosalicylic acid, then the homogenate was centrifuged at 10000 x g for 10 min. In a test tube, 2 ml of the filtrate was added to 2 ml of freshly acid ninhydrin (1.25 g ninhydrin was warmed in 30 ml of glacial acetic acid, and 20 ml of 6 M phosphoric acid, with agitation till dissolved). Tube's sample was incubated in water bath at 90°C for 30 min, then the reaction was conducted in an ice-bath. The reaction mixture after that was extracted adding 5 ml toluene and vortex-mixed for 20sec. At room temperature, the tube was set for at least 20 min in dark to separate the toluene and aqueous phases. The absorbance of toluene phase was evaluated at 520 nm against toluene blank. The concentration of proline was calculated using standard curve of L. proline and expressed as mg/g fruit flesh DW.

Statistical analysis of data:

All the obtained data were tabulated and subjected to variance analysis (ANOVA) using the statistical package MSTATC Program. Comparisons between means were made by the F-test and least significant differences (New LSD) at $p \leq 0.05$.

RESULTS AND DISCUSSION

Effect of potassium silicate, salicylic acid and citric acid on fruit setting % and fruit dropping %:

Data in Table (2) shows the effect of spraying K_2SiO_3, SA and CA on average fruit setting % and fruit dropping % during 2019 and 2020 seasons. The obtained data during the two experimental seasons displayed that, regardless the concentration used, all treatments with potassium silicate and salicylic and citric acids induced an increase of fruit setting % and decreased fruit drop % rather than untreated trees. It is clear from the obtained data that treating Canino apricot with K_2SiO_3 at 0.05% to 0.2%, SA at 250 & 500 ppm and CA at 250 & 500 ppm significantly stimulated fruit setting %. This stimulation was related to the increase in concentrations from 0.0% to 0.1% of K_2SiO_3, however increasing potassium silicate from 0.1% to 0.2% caused a slight decrease in fruit setting during the two experimental seasons.

Table (2): Effect of potassium silicate, salicylic acid and citric acid on fruit set (%) and fruit drop (%) of Canino apricot during 2019 and 2020 seasons

Treatments	Fruit Set (%)					Fruit Drop (%)				
	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B
(First season – 2019)										
SA 0.0 ppm + CA 0.0 ppm (b1)	16.4	18.1	19.5	19.1	18.3	79	72	60	62	68.3
SA 250 ppm (b2)	19.2	22.2	23.9	22.7	22.0	66	61	57	54	59.5
SA 500 ppm (b3)	19.8	24.2	26.8	25.8	24.2	61	57	53	51	55.5
CA 250 ppm (b4)	18.4	24.7	25.5	25.0	23.4	69	60	60	55	61.0
CA 500 ppm (b5)	19.1	24.1	25.6	24.3	23.3	67	59	55	54	58.8
SA 250 + CA 250 (b6)	21.1	25.9	28.2	27.9	25.8	55	49	42	41	46.8
SA 250 + CA 500 (b7)	22.3	26.4	29.9	28.2	26.7	51	48	41	39	44.8
SA 500 + CA 250 (b8)	25.2	28.7	30.2	29.6	28.4	49	42	37	37	41.3
SA 500 ppm + CA 500 ppm (b9)	24.3	27.1	28.7	29.1	27.3	46	40	35	36	39.3
Mean A	**20.6**	**24.6**	**26.5**	**25.7**		**60.3**	**54.2**	**48.9**	**47.7**	
New LSD 5%	**A= 4.19 ; B= 4.72 ; AB = 6.89**					**A= 5.24 ; B= 6.82 ; AB = 9.32**				
(Second season – 2020)										
SA 0.0 ppm + CA 0.0 ppm (b1)	17.2	18.8	20.3	20.2	19.1	81	69	59	59	67.0
SA 250 ppm (b2)	21.1	23.1	23.9	22.9	22.8	67	62	60	56	61.3
SA 500 ppm (b3)	22.8	24.9	28.6	26.7	25.8	59	55	54	51	54.8
CA 250 ppm (b4)	20.2	25.3	27.3	24.9	24.4	66	59	55	57	59.3
CA 500 ppm (b5)	23.3	25.8	27.9	26.3	25.8	61	55	51	50	54.3
SA 250 + CA 250 (b6)	24.5	26.4	30.2	29.9	27.8	54	53	49	47	50.8
SA 250 + CA 500 (b7)	24.6	27.2	31.1	31.2	28.5	53	44	40	38	43.8
SA 500 + CA 250 (b8)	27.9	29.9	32.9	31.8	30.6	43	37	37	35	38.0
SA 500 ppm + CA 500 ppm (b9)	26.1	29.1	30.8	29.9	28.9	44	38	31	31	36.0
Mean A	**23.1**	**25.6**	**28.1**	**27.1**		**58.7**	**52.4**	**48.4**	**47.1**	
New LSD 5%	**A= 1.12 ; B= 1.03 ; AB =1.51**					**A= 5.81 ; B=5.90 ; AB = 8.55**				

On the opposite side, increasing K_2SiO_3 from 0.05% to 0.2%, SA and CA each acid from 250 to 500 ppm significantly enhanced fruit set % and decreased the percentage of fruit drops during the two experimental seasons. It's clear from the same Table that, all trees received the combined treatments of potassium silicate, salicylic acid and citric acid present higher and significant fruit set % and lower fruit drop % rather than the single application of each one alone, during the two seasons.

In regards to the interaction of spraying potassium silicate and the two antioxidants on fruit set and fruit drop %, it was significantly in the two experimental seasons as illustrated in Table (2). It is clear that spraying Canino apricot with K_2SiO_3 accompanied with SA and CA each at 500 ppm recorded the highest fruit set % and lowest fruit drop %. However, non-significant differences were observed between the two high concentrations of potassium silicate. These results were true in both seasons.

Effect of potassium silicate, salicylic acid and citric acid on fruit yield and its components:

Data obtained during the two seasons are illustrated in Table (3 and 4) shows the number of fruits per tree, average fruit weight and yield (kg/tree), regardless of the compound or the concentration used. Non-significant differences were observed in the number fruits/shoot in the first season. However, remarkable and significant increase in yield/tree was found in the first season especial with the higher concentrations of the three examined compounds, this may be due to the significant promotion in fruit weight. While, in the second season, all treatments concerning the three examined compounds caused significant increase in fruit numbers/tree than those recorded for the control treatment. Regarding the average fruit weight and yield (kg/tree), all the three examined compounds exert a significant effect on these two parameters. Neither the number of fruits per trees nor the average weight of fruit significantly improved with increasing K_2SiO_3 from 0.1 to 0.2%.

Table (3): Effect of potassium silicate, salicylic acid and citric acid on average fruit numbers/tree and average fruit weight (g) of Canino apricot during 2019 and 2020 seasons

Treatments	Number of fruits/tree					Average Fruit weight (g)				
	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B
(First season – 2019)										
SA 0.0 ppm + CA 0.0 ppm (b1)	817	814	816	819	816	29.8	30.1	33.1	32.9	31.5
SA 250 ppm (b2)	819	814	820	817	817	31.2	32.1	34.8	34.9	33.3
SA 500 ppm (b3)	811	816	821	820	817	31.8	32.4	35.1	35.8	33.8
CA 250 ppm (b4)	799	814	818	822	813	31.7	32.7	36.6	37.1	34.5
CA 500 ppm (b5)	824	818	817	824	820	31.9	32.5	36.9	36.8	34.6
SA 250 + CA 250 (b6)	818	817	820	819	818	33.3	34.4	35.9	36.1	34.9
SA 250 + CA 500 (b7)	812	815	822	822	817	33.8	34.9	36.8	36.8	35.6
SA 500 + CA 250 (b8)	819	818	819	825	820	35.4	37.2	38.2	37.9	37.2
SA 500 ppm + CA 500 ppm (b9)	820	818	820	819	819	35.4	36.9	38.8	38.0	37.3
Mean A	**815**	**816**	**819**	**820**		**32.7**	**33.7**	**36.2**	**36.3**	
New LSD 5%	**A= NS ; B= NS ; AB = NS**					**A = 0.91 ; B= 1.03 ; AB = 1.51**				
(Second season – 2020)										
SA 0.0 ppm + CA 0.0 ppm (b1)	814	826	887	898	856	29.9	31.3	34.2	34.0	32.4
SA 250 ppm (b2)	822	836	895	899	863	32.8	32.9	35.2	35.1	34.0
SA 500 ppm (b3)	829	845	901	896	867	34.4	33.8	36.6	35.9	35.2
CA 250 ppm (b4)	835	841	909	895	870	33.9	32.8	36.0	35.8	34.6
CA 500 ppm (b5)	841	852	908	906	876	35.8	34.4	36.9	36.0	35.8
SA 250 + CA 250 (b6)	855	863	916	922	889	36.4	34.1	38.4	37.8	36.7
SA 250 + CA 500 (b7)	862	879	921	920	895	36.9	37.2	39.9	38.6	38.2
SA 500 + CA 250 (b8)	879	884	931	940	908	37.2	38.3	40.1	39.6	38.8
SA 500 ppm + CA 500 ppm (b9)	879	889	933	938	909	36.5	37.4	38.8	38.9	37.9
Mean A	**846**	**857**	**911**	**913**		**34.8**	**34.7**	**37.3**	**36.9**	
New LSD 5%	**A= 15 ; B= 11 ; AB = 16**					**A = 1.12 ; B= 1.15 ; AB= 1.68**				

The same Table also shows that treated Canino apricot trees with the three examined compounds in combination gave the higher and significant number of fruits/tree and fruit weight (g) than the rest of the treatments. Furthermore, CA shows a noticeable superiority over salicylic acid in these characters when used separately.

The interactions between K_2SiO_3, SA and CA treatments were significant for fruits number/tree, fruit weight (g) and yield expressed as kg/tree of Canino apricot trees, in the two seasons, except the number of fruits/tree at the first season as shown in Tables (3 and 4).

The role of the three examined compounds (K_2SiO_3, SA and CA) in improving yield and its components which obtained in the present study was in accordance with the results of some studies on apricot trees or other fruit trees species, such as: Ali (2000) on Flame Seedless grapevines; Ahmed *et al.* (2010) on Crimson Seedless grapevines; Ahmed *et al.* (2011) on Thompson Seedless grapevines; Abd E-Hammed *et al.* (2012) on Early Superior grapevines; Mekawy (2012) on Thompson Seedless grapevines; Gobara (2004) on Washington navel orange; Guneri *et al.* (2012) on lemon and Valencia orange; Samra *et al.* (2012) on Balady mandarin.

Table (4): Effect of potassium silicate, salicylic acid and citric acid on yield (kg/tree) and fruit firmness (kg/cm^2) of Canino apricot during 2019 and 2020 seasons

Treatments	Yield (kg/tree)					Fruit firmness (kg/cm^2)				
	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B
(First season – 2019)										
SA 0.0 ppm + CA 0.0 ppm (b1)	23.94	24.50	27.01	26.95	25.60	2.1	1.8	1.6	1.5	1.75
SA 250 ppm (b2)	25.55	26.13	28.82	28.51	27.25	2.0	1.9	1.7	1.7	1.83
SA 500 ppm (b3)	25.79	26.44	28.82	29.36	27.60	2.0	1.8	1.6	1.6	1.75
CA 250 ppm (b4)	25.33	26.62	30.35	30.50	28.20	1.8	1.6	1.5	1.5	1.60
CA 500 ppm (b5)	26.29	26.59	30.15	30.32	28.34	1.7	1.5	1.4	1.4	1.50
SA 250 + CA 250 (b6)	27.24	28.10	29.44	29.57	28.59	1.9	1.8	1.7	1.7	1.77
SA 250 + CA 500 (b7)	27.45	28.44	30.25	30.25	29.10	1.7	1.7	1.5	1.5	1.60
SA 500 + CA 250 (b8)	28.99	30.43	31.29	31.27	30.50	1.7	1.8	1.6	1.5	1.65
SA 500 ppm + CA 500 ppm (b9)	29.03	30.18	31.82	31.12	30.54	1.6	1.5	1.4	1.4	1.48
Mean A	**26.62**	**27.49**	**29.77**	**29.76**		**1.83**	**1.71**	**1.56**	**1.53**	
New LSD 5%	**A =2.89 ; B= 2.78 ; AB = 4.06**					**A = 0.16 ; B= 0.19 ; AB = 0.28**				
(Second season – 2020)										
SA 0.0 ppm + CA 0.0 ppm (b1)	24.35	25.85	30.34	30.53	27.77	2.2	1.7	1.5	1.5	1.73
SA 250 ppm (b2)	26.96	27.50	31.50	31.55	29.38	2.3	2.1	1.8	1.7	1.98
SA 500 ppm (b3)	28.52	28.56	32.98	32.17	30.58	2.2	2.0	1.9	1.8	1.96
CA 250 ppm (b4)	28.31	27.58	32.72	32.04	30.16	1.7	1.6	1.5	1.5	1.58
CA 500 ppm (b5)	30.11	29.31	33.51	32.62	31.39	1.6	1.4	1.4	1.3	1.43
SA 250 + CA 250 (b6)	31.12	29.43	35.17	34.85	32.64	1.7	1.7	1.5	1.3	1.55
SA 250 + CA 500 (b7)	31.81	32.70	36.75	35.51	34.19	1.6	1.3	1.3	1.2	1.35
SA 500 + CA 250 (b8)	32.70	33.86	37.33	37.22	35.28	1.8	1.6	1.5	1.4	1.58
SA 500 ppm + CA 500 ppm (b9)	32.08	33.25	36.20	36.49	34.51	1.7	1.4	1.2	1.2	1.38
Mean A	**26.33**	**29.78**	**33.85**	**33.66**		**1.62**	**1.64**	**1.51**	**1.43**	
New LSD 5%	**A= 3.21 ; B= 3.06 ; AB = 4.48**					**A = 0.21 ; B= 0.21 ; AB= 0.31**				

It is well known that, K has many functions in plant nutrition and growth that logically has a positive influence on yield per tree. These included regulations of metabolic processes such as photosynthesis; activation of enzymes that metabolized carbohydrate for synthesis of amino acids and proteins; function of cell division and growth by helping to move starches and sugars between plant parts. The aforementioned roles of potassium could be explanted its effect on improve fruit weight and increasing the yield/tree (Munson, 1985; Marschner, 1997; Havlin *et al.,* 2005; Mengel, 2007; Kow and Nabwami, 2015). However, the use of antioxidants (SA and CA) for enhancing the productivity of deciduous fruit trees, especially apricot trees, is well established in the previous studies. Bio-stimulants can lead to improve fruit numbers and weight and also referred as metabolic enhancement (Georgidou *et al.,* 2016; Abdelmoniem *et al.,* 2019). Furthermore, antioxidants application lead to improve mineral uptake and natural growth regulators produced by plants (El-Kady, 2011; Georgidou *et al.,* 2016).

Effect of potassium silicate, salicylic acid and citric acid on fruit physical properties:

Fruit dimensions:

Data concerning the effect of K_2SiO_3, SA and CA on Canino apricot fruit length and width (cm) during 2019 and 2020 seasons are illustrated in Table (5). Data of the two experimental seasons revealed that, spraying Canino apricot trees with K_2SiO_3, SA and CA each one alone or in companied significantly increased fruit length and fruit diameter (cm) than the control treatment.

Increasing the concentration of K_2SiO_3 from 0.0% to 0.2% remarkably enhanced fruit length and width (cm). However, during the first season, the trees received K_2SiO_3 at 0.1% present the highest fruit length (4.31 cm) and fruit width (4.08 cm) than those untreated or treated with 0.05% or 0.2%. While, in the second season the trees received higher concentration of K_2SiO_3 (0.2%) present the highest fruit length (4.57 cm) and higher fruit width (4.08 cm). Non-significant differences were found between the two highest K_2SiO_3concentrations, during the two experimental seasons. In relation to SA or/and CA application resulted a significant increase in fruit length and diameter, during the two seasons over untreated trees as clearly shown in Table (5). It could be seen also that; the trees received the SA accompanied with CA each at 500 ppm gave higher fruit length and diameter than those received the low concentrations.

The interactions between the three examined compounds had significant promotion effect on the fruit length and width. However, the trees sprayed with higher concentrations of the three compounds (K_2SiO_3 at 0.2%, SA and CA at 500 ppm) produced the highest fruit length (4.6 and 4.7 cm) and fruit width (4.3 and 4.4 cm) during the two seasons; respectively. However, untreated trees produced the lowest fruit height (3.7 and 3.6 cm) and lowest fruit width (3.2 and 3.2 cm), during the two seasons, respectively.

Table (5): Effect of potassium silicate, salicylic acid and citric acid on fruit length (cm) and fruit width (cm) of Canino apricot during 2019 and 2020 seasons

Treatments	Fruit length (cm)					Fruit width (cm)				
	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B
(First season – 2019)										
SA 0.0 ppm + CA 0.0 ppm (b1)	3.7	3.8	4.0	4.0	3.88	3.2	3.4	3.7	3.6	3.48
SA 250 ppm (b2)	3.7	3.9	4.2	4.1	3.98	3.4	3.6	3.9	3.8	3.68
SA 500 ppm (b3)	3.9	4.0	4.4	4.2	4.13	3.6	3.7	4.1	4.0	3.85
CA 250 ppm (b4)	3.8	4.1	4.2	4.1	4.05	3.4	3.6	4.0	3.7	3.68
CA 500 ppm (b5)	3.8	4.1	4.3	4.2	4.10	3.5	3.6	4.1	3.9	3.78
SA 250 + CA 250 (b6)	3.9	4.1	4.3	4.2	4.13	3.5	3.7	4.2	3.9	3.83
SA 250 + CA 500 (b7)	4.1	4.2	4.4	4,.3	4.25	3.6	3.8	4.2	4.0	3.90
SA 500 + CA 250 (b8)	4.2	4.3	4.5	4.5	4.38	3.6	3.9	4.2	4.1	3.98
SA 500 ppm + CA 500 ppm (b9)	4.2	4.3	4.5	4.6	4.40	3.6	3.9	4.2	4.3	3.98
Mean A	**3.92**	**4.09**	**4.31**	**4.24**		**3.48**	**3.69**	**4.08**	**3.93**	
New LSD 5%	**A =0.32 ; B=0.21 ; AB = 0.31**					**A =0.20 ; B= 0.24 ; AB = 0.39**				
(Second season – 2020)										
SA 0.0 ppm + CA 0.0 ppm (b1)	3.6	3.8	4.1	4.1	3.90	3.2	3.5	3.7	3.7	3.53
SA 250 ppm (b2)	3.8	3.9	4.0	4.2	3.98	3.5	3.6	3.8	3.8	3.68
SA 500 ppm (b3)	3.8	3.9	4.1	4.2	4.00	3.6	3.7	3.7	3.8	3.67
CA 250 ppm (b4)	3.9	4.1	4.2	4.3	4.13	3.4	3.6	3.9	4.1	3.75
CA 500 ppm (b5)	3.9	4.1	4.3	4.3	4.15	3.6	3.8	4.1	4.2	3.93
SA 250 + CA 250 (b6)	4.1	4.2	4.3	4.4	4.25	3.5	3.7	4.2	4.2	3.90
SA 250 + CA 500 (b7)	4.1	4.3	4.4	4.5	4.33	3.6	3.8	4.1	4.2	3.93
SA 500 + CA 250 (b8)	4.3	4.4	4.5	4.6	4.45	3.7	4.0	4.2	4.3	4.05
SA 500 ppm + CA 500 ppm (b9)	4.4	4.5	4.7	4.7	4.58	3.7	4.0	4.3	4.4	4.10
Mean A	**3.99**	**4.13**	**4.29**	**4.37**		**3.53**	**3.74**	**4.00**	**4.08**	
New LSD 5%	**A= 1.12 ; B= 1.03 ; AB =1.51**					**A = 0.21 ; B= 0.21 ; AB= 0.31**				

Fruit pulp and seed weight:

Data concerning the effect of K_2SiO_3, SA and CA on Canino apricot pulp weight (g) and seed weight (g) during 2019 and 2020 seasons are showed in Table (6).

Table (6): Effect of potassium silicate, salicylic acid and citric acid on fruit pulp weight (g) and seed weight (g) of Canino apricot during 2019 and 2020 seasons

Treatments	Pulp weight (g)					Seed weight (g)				
	(First season – 2019)									
	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B
SA 0.0 ppm + CA 0.0 ppm (b1)	26.2	26.9	29.5	29.3	27.98	3.6	3.5	3.7	3.6	3.60
SA 250 ppm (b2)	27.5	28.5	31.2	31.1	29.58	3.7	3.6	3.6	3.8	3.68
SA 500 ppm (b3)	28.3	28.7	31.4	32.0	30.10	3.5	3.7	3.6	3.6	3.65
CA 250 ppm (b4)	28.1	29.0	33.1	33.5	30.93	3.6	3.7	3.5	3.6	3.60
CA 500 ppm (b5)	28.2	28.9	33.3	33.2	30.90	3.7	3.6	3.6	3.6	3.63
SA 250 + CA 250 (b6)	29.8	30.8	32.3	32.4	31.33	3.5	3.6	3.6	3.7	3.60
SA 250 + CA 500 (b7)	30.2	31.3	33.3	33.1	31.98	3.6	3.6	3.5	3.7	3.60
SA 500 + CA 250 (b8)	32.8	32.7	34.6	34.1	33.55	3.6	3.5	3.6	3.8	3.65
SA 500 ppm + CA 500 ppm (b9)	32.9	33.3	35.0	35.2	34.1	3.5	3.6	3.8	3.8	3.68
Mean A	**29.33**	**30.01**	**32.63**	**32.66**		**3.59**	**3.61**	**3.60**	**3.69**	
New LSD 5%	**A = 2.01 ; B= 2.12 ; AB = 3.07**					**A = NS ; B= NS ; AB = NS**				
	(Second season – 2020)									
SA 0.0 ppm + CA 0.0 ppm (b1)	26.2	27.6	30.5	34.3	29.65	3.7	3.7	3.7	3.7	3.7
SA 250 ppm (b2)	29.2	29.2	32.6	31.4	30.60	3.6	3.7	3.6	3.7	3.65
SA 500 ppm (b3)	30.6	30.0	33.0	32.2	31.45	3.8	3.8	3.6	3.7	3.75
CA 250 ppm (b4)	30.2	29.1	32.3	32.3	30.98	3.7	3.7	3.7	3.6	3.68
CA 500 ppm (b5)	32.1	31.7	33.2	32.3	32.08	3.7	3.7	3.7	3.7	3.70
SA 250 + CA 250 (b6)	32.8	31.5	34.8	34.0	33.28	3.6	3.6	3.6	3.8	3.65
SA 250 + CA 500 (b7)	33.3	33.5	36.2	34.9	34.48	3.6	3.7	3.7	3.7	3.68
SA 500 + CA 250 (b8)	33.5	34.5	36.4	35.7	33.05	3.7	3.8	3.7	3.8	3.75
SA 500 ppm + CA 500 ppm (b9)	33.8	34.5	35. 8	35.8	34.95	3.7	3.6	3.7	3.9	3.73
Mean A	**31.3**	**31.29**	**33.87**	**33.69**		**3.67**	**3.70**	**3.67**	**3.73**	
New LSD 5%	**A= 2.19 ; B= 2.09 ; AB = 3.05**					**A = NS ; B= 0.07 ; AB= 0.18**				

It is evident from the obtained data that, during the two experimental seasons, fruit pulp of Canino apricot varied significantly as a response to spraying the three examined compounds.

Subjecting Canino apricot to gradual concentration of K_2SiO_3 0.0%, 0.05%, 0.1% and 0.2% significantly was responsible for enhancing fruit pulp weight (g) relative to the control treatment. In opposite side, all the three examined compounds were failed to significantly affect seed weight during the first seasons. However, there was a gradual and significant promotion in pulp and seed weight during the second season with increasing the concentrations of these three compounds. However, increasing concentrations of K_2SiO_3 from 0.1% to 0.2% had no significant promotion on fruit length. The results were true in the two experimental seasons.

Fruit pulp of Canino apricot was significantly increased during the two seasons as a result of spraying SA at 250 and 500 ppm alone or in competition with CA each at 250 or 500 ppm, rather than untreated trees. However, the combined application of SA and CA each at 500 ppm had a remarkable promotion than spraying each one alone.

The interaction between K_2SiO_3 concentrations and SA or/and CA had significant effect on the fruit pulp and seed weights in both seasons, and seed weight only during the second seasons. The trees received the highest concentrations of the three examined compounds in combination produced the highest fruit pulp during 2019 and 2020 seasons. On the other hand, the untreated trees produced the lowest weight of fruit pulp (26.2 and 26.2 g) in both seasons, respectively.

Effect of potassium silicate, salicylic acid and citric acid on fruit chemical properties:

Effect on TSS %, total sugars % and proline contents:

Data concerning the single and combined effects of K_2SiO_3, SA or/and CA at different concentrations on Canino apricot total soluble solids % and total sugars % during 2019 and 2020 seasons are reported in Table (7). K_2SiO_3, SA and CA were capable to causing significant improvements in TSS % and total sugars % of Canino apricot over control trees, during the two seasons.

Gradual promotion of TSS % and total sugars % were associated with increasing $K_2SiO_3$from 0.0 to 0.2%. Spraying any concentration of K_2SiO_3 was capable to significantly increase the TSS and total sugars percentages over that of the rest of the treatments. However, the higher concentration of K_2SiO3 remarkably and significantly enhanced TSS % and total sugars % than the lower concentrations. The date takes the similar trend during the two experimental seasons. The trees received the highest K_2SiO_3 and CA concentrations produced higher and significant TSS % and total sugars % during 2019 and 2020 seasons.

Subjecting Canino apricot trees to K_2SiO_3 at 0.5% to 1.5% or/and SA at 250 or 500 ppm was significantly responsible for enhancing the proline contents (mg/100g F.W.), rather than the rest of the treatments (Table 8). Furthermore, the combined application of K_2SiO_3, SA and CA were more effective on proline contents, rather than spraying each compound alone. It is worth to mention that data presented in the same table shows that the trees received the three examined compounds in combination produced more pronounced effect on proline contents than control trees or other treatments, in both seasons. However, the interactions between the three examined compounds on proline contents were significant. Increasing K_2SiO_3 concentration companied with SA or/and CA enhanced proline contents significantly, during the two seasons. Furthermore, the highest proline contents (81.9 & 84.2 mg/100g F.W) were produced from the trees received K_2SiO_3 at 0.2% accompanied with SA and CA each at 500 ppm, the data were true during the two seasons. While, unfavorable effects on proline contents (30.9 & 31.4 mg/100 g F.W.), during the two experimental seasons respectively, were produced by untreated trees.

Table (7): Effect of potassium silicate, salicylic acid and citric acid on TSS% and total sugars % of Canino apricot, during 2019 and 2020 seasons

Treatments	TSS (%)					Total sugars (%)				
	(First season – 2019)									
	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B
SA 0.0 ppm + CA 0.0 ppm (b1)	9.8	10.2	11.0	11.7	10.68	8.0	9.0	9.4	9.6	9.00
SA 250 ppm (b2)	9.0	9.6	10.8	11.0	10.10	7.2	7.7	8.8	9.2	8.23
SA 500 ppm (b3)	9.1	9.4	10.9	11.1	10.13	7.3	7.9	8.3	9.1	8.15
CA 250 ppm (b4)	10.2	10.6	11.3	11.8	10.98	8.7	8.6	9.4	9.6	9.08
CA 500 ppm (b5)	10.7	11.4	11.9	12.1	11.53	8.9	9.2	9.5	9.8	9.35
SA 250 + CA 250 (b6)	10.8	11.3	11.8	11.9	11.45	9.2	9.4	9.6	9.7	9.48
SA 250 + CA 500 (b7)	10.9	11.6	12.0	12.2	11.68	9.3	9.8	9.9	10.4	9.85
SA 500 + CA 250 (b8)	11.0	11.9	12.1	12.5	11.88	9.5	9.9	10.5	10.8	10.18
SA 500 ppm + CA 500 ppm (b9)	11.1	11.8	12.2	12.5	11.90	9.5	9.9	10.6	10.9	10.23
Mean A	**10.29**	**10.87**	**11.56**	**11.87**		**8.62**	**9.04**	**9.52**	**9.90**	
New LSD 5%	**A = 0.51 ; B= 0.61 ; AB = 0.88**					**A = 0.41 ; B= 0.39 ; AB = 0.59**				
	(Second season – 2020)									
SA 0.0 ppm + CA 0.0 ppm (b1)	9.7	10.5	11.6	11.8	10.90	7.9	8.3	9.2	9.4	8.70
SA 250 ppm (b2)	9.1	10.6	11.0	11.5	10.55	7.1	8.5	8.9	9.1	8.50
SA 500 ppm (b3)	9.1	10.8	11.6	11.8	10.83	7.4	8.1	8.6	9.3	8.35
CA 250 ppm (b4)	10.4	11.7	11.9	11.9	11.48	8.5	8.9	9.5	9.6	9.13
CA 500 ppm (b5)	10.8	11.9	12.6	12.7	12.02	8.9	9.6	9.9	9.9	9.58
SA 250 + CA 250 (b6)	11.0	11.9	12.0	12.2	11.78	8.4	9.2	9.6	9.5	9.18
SA 250 + CA 500 (b7)	11.4	12.0	12.2	12.5	12.03	9.0	9.4	10.0	10.4	9.70
SA 500 + CA 250 (b8)	11.6	12.1	12.5	12.6		9.1	9.2	9.8	10.0	9.53
SA 500 ppm + CA 500 ppm (b9)	11.8	12.1	12.3	12.7	12.23	9.6	10.2	10.4	10.5	10.18
Mean A	**9.53**	**11.51**	**11.97**	**12.19**		**7.50**	**9.05**	**9.57**	**9.74**	
New LSD 5%	**A= 1.12 ; B= 1.03 ; AB =1.51**					**A = 0.98 ; B= 0.87 ; AB= 1.27**				

Table (8): Effect of potassium silicate, salicylic acid and citric acid on total acidity % proline (mg/100g F.W.) of Canino apricot, during 2019 and 2020 seasons

Treatments	Total acidity (%)					Proline (mg/100 g F.W.)				
	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B	K-Silicate 0.0% (a1)	K-Silicate 0.05% (a2)	K-Silicate 0.1% (a3)	K-Silicate 0.2% (a4)	Mean B
	(First season – 2019)									
SA 0.0 ppm + CA 0.0 ppm (b1)	1.7	1.5	1.3	1.3	1.45	3٠.5	40.8	42.1	44.5	39.48
SA 250 ppm (b2)	1.7	1.5	1.3	1.2	1.42	45.4	49.4	55.1	57.1	51.75
SA 500 ppm (b3)	1.8	1.5	1.2	1.2	1.45	59.7	61.1	67.8	69.3	64.48
CA 250 ppm (b4)	1.6	1.4	1.2	1.1	1.33	41.5	55.5	57.3	57.4	52.93
CA 500 ppm (b5)	1.5	1.3	1.1	1.1	1.25	47.3	48.3	59.9	61.3	54.20
SA 250 + CA 250 (b6)	1.5	1.3	1.3	1.2	1.33	59.9	62.9	66.5	69.3	64.65
SA 250 + CA 500 (b7)	1.5	1.2	1.2	1.1	1.25	62.5	64.8	68.8	70.1	66.55
SA 500 + CA 250 (b8)	1.4	1.3	1.1	1.0	1.20	68.8	72.2	75.5	74.9	72.85
SA 500 ppm + CA 500 ppm (b9)	1.3	1.1	1.0	1.0	1.10	74.5	74.3	79.7	81.9	77.60
Mean A	**1.56**	**1.36**	**1.19**	**1.13**		**54.46**	**58.81**	**63.63**	**65.09**	
New LSD 5%	**A = 0.24 ; B= 0.12 ; AB = 0.19**					**A = 6.10 ; B= 7.17 ; AB = 10.41**				
	(Second season – 2020)									
SA 0.0 ppm + CA 0.0 ppm (b1)	1.8	1.7	1.5	1.5	1.63	31.4	41.8	44.5	45.6	40.83
SA 250 ppm (b2)	1.8	1.6	1.6	1.6	1.65	48.9	51.9	55.7	61.2	54.43
SA 500 ppm (b3)	1.8	1.7	1.6	1.5	1.65	62.2	66.1	68.9	71.3	61.13
CA 250 ppm (b4)	1.5	1.4	1.4	1.4	1.43	53.1	50.9	52.8	59.3	54.03
CA 500 ppm (b5)	1.4	1.3	1.3	1.3	1.33	58.3	60.2	62.7	63.3	61.13
SA 250 + CA 250 (b6)	1.5	1.5	1.4	1.3	1.43	62.2	68.3	69.2	72.7	68.10
SA 250 + CA 500 (b7)	1.5	1.5	1.2	1.2	1.35	64.8	70.1	71.9	74.6	70.35
SA 500 + CA 250 (b8)	1.4	1.2	1.1	1.0	1.18	72.1	74.5	77.3	80.9	76.2
SA 500 ppm + CA 500 ppm (b9)	1.4	1.1	1.0	0.9	1.10	78.2	77.1	81.7	84.2	80.30
Mean A	**1.57**	**1.44**	**1.34**	**1.30**		**59.02**	**64.97**	**67.99**	**68.12**	
New LSD 5%	**A= 0.11 ; B= 0.13 ; AB = 0.19**					**A = 5.21 ; B= 8.31 ; AB= 12.05**				

The promotion effect of K_2SiO_3 on Canino apricot fruits showed in the present investigation was also decided by some authors on apricot or other fruit trees (El-Mehrat *et al*., 2018) on ARRA 15 and ARRA 18 grapevines cultivars, Lopes *et al*. (2014) and Shetty *et al.* (2011) on strawberry plants. It's well known that, potassium is an essential element for plant nutrition. The important roles of potassium concerning increasing total soluble solids and sugars contents in Canino apricot fruit can be explained by its effect on enzyme activation, cellular membrane transport processes and translocation of assimilates, anion neutralization, which is essential in maintenance of membrane potential and osmotic potential regulation, which is one of the important mechanisms in the control of plant water relations.

This positive effect of salicylic acid application on Canino apricot fruit quality might be explained as follows: The spray of salicylic acid regulates the carbohydrate metabolism in both source and sinks tissue of the plants; the hydrolysis of sucrose by invertase regulates the levels of some hormones like indole-3 acetic acid, SA and Jasmonic acid (Le Clere *et al.,* 2003). This formation confirms the relationship between SA and invertase activity. Thus, the accumulation of reducing sugar might be due to increased translocation of more photosynthetic assimilates to the fruits and breakdown of starch during ripening. The positive effect of SA and CA on physical and chemical properties of apricot and other fruit trees were previously reported by: Abdel Aal and Oraby (2013) on mango trees under salinity stress; Abd El-Rady (2015) on Flame seedless grapevine; Abdel Aal and Aly (2013) on Ruby Seedless grapevines; Mohamed *et al.* (2015) on Superior grapevines; Abo El-Fadle (2017) on Superior grapevines. Furthermore, similar findings were obtained by other authors on evergreen orchard trees such as: Maksoud *et al.* (2009) on Chemlali olive fruits; El-Badawy (2013); El-Badawy *et al.* (2017); Abdelmoniem *et al.* (2019) on Washington navel orange trees.

The important role of these two antioxidants (SA and CA) on enhancing mineral elements uptick and stimulating some important biological functions in plant cells as synthesis and accumulation of carbohydrates was able to explain its favorable effect on berry chemical properties, which found in this study. Furthermore, SA and CA are natural and organic antioxidants compounds have as auxinic action, it can provide disease control, cell division and promotion of lipase, synergistic effect on and improving fruit physical and chemical properties of Canino apricot and other fruit trees (Elade, 1992; Ahmed *et al.,* 2003; Abo El-Komsan *et al.,* 2003; Khiamy, 1999).

CONCLUSION

The results of this investigation confirmed that it is strongly recommended to spray Canino apricot grown under sandy soil at El-Minia Governorate and resembling conditions with K_2SiO_3 at 0.1% in combination with SA and CA each at 500 ppm in order to improve fruit set %, productivity as well as fruit physical and chemical properties of Canino apricot trees.

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تعزيز إنتاجية وجودة ثمار المشمش صنف كانينو عن طريق الرش بسليكات البوتاسيوم وحامض الساليسيلك وحامض الستريك

محمد صالح محمد علي[١]، هبة فوزى سيد إبراهيم [٢]
[١]قسم البساتين، كلية الزراعة، جامعة قناة السويس، الإسماعيلية، مصر
[٢]قسم البساتين، كلية الزراعة، جامعة المنيا، المنيا، مصر

أجريت التجربة البستانية خلال موسمي ٢٠١٩ و٢٠٢٠ تحت ظروف الأراضي الرملية المتأثرة بالملوحة، بمحافظة المنيا. وقد هدفت الدراسة إلى معرفة تأثير رش سليكات البوتاسيوم وحامض السلسيلك وحامض السيتريك على الإنتاجية وجودة الثمار في أشجار المشمش صنف الكانينو. وقد استخدم لتنفيذ التجربة تصميم القطاعات كاملة العشوائية في صورة القطع المنشقة مرة واحدة.وقد أوضحت النتائج المتحصل عليها خلال هذه الدراسة بأن معاملة الأشجار رشاً بسليكات البوتاسيوم بتركيز (٠,٠٥٪ و ٠,١٪ و ٠,٢٪) وحامض السلسيلك وحامض السيتريك كلاً منهما بتركيزين ٢٥٠ و ٥٠٠ جزء في المليون أدت إلى حدوث زيادة معنوية في نسبة عقد الثمار، عدد الثمار على الشجرة ومتوسط وزن الثمرة وكمية المحصول بالـ كجم/ الشجرة وكذلك تحسين المواصفات الطبيعية والكيميائية للثمرة وفى ذات الصدد تزايدت نسبة البرولين في الثمار.وقد تحققت أفضل النتائج في الصفات المذكورة عندما تم رش الأشجار بالتركيزات المرتفعة من الثلاثة مركبات معاً، وذلك بالمقارنة بمعاملة الكنترول والتركيزات الأخرى. ولم تُسجل أي فروق معنوية بين التركيزين الأعلى من سليكات البوتاسيوم (٠.١٪ و ٠,٢٪). وبصفة عامة فإن نتائج هذه الدراسة توضح الدور الهام والجوهري لسليكات البوتاسيوم وحامض السلسيلك وحامض الستريك في تحسين نسبة العقد وكمية المحصول وكذلك المواصفات الطبيعية والكيماوية لثمار أشجار المشمش صنف الكانينو، وذلك تحت ظروف الأراضي الرملية بمحافظة المنيا.