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Pre-Harvest Treatments On Canino Apricot Trees to Improve Yield, Fruit Quality at Harvest and During Storage

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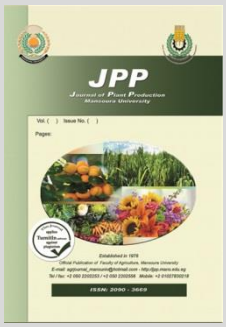

ABSTRACT

The present study was conducted on eighteen years old Canino apricot trees grown in a private orchard at Motobus, Kafr El-Sheikh governorate, Egypt in 2019 and 2020 seasons to evaluate the effects of preharvest foliar treatments of potassium sulphate at 1.5% and calcium chloride at 2% individually or in combination in addition to Control (tap water) on yield, fruit quality at picking date and during cold storage at 0±1°C with 90 – 95 % RH. Canino apricot trees were sprayed three times starting after full bloom, fruit setting and finally ten days before harvest with one of the abomination treatments. The results showed that all treatments increased yield and improved fruit weight, size, height and width compared to control. Application of 1.5% K2SO4 produced the highest vitamin C content and SSC% after 7, 14 and 21 days of cold storage in both seasons. While, Application of 2% CaCl2 showed the lowest fruit decay % and SSC %, and maintained fruit firmness until 28 days of cold storage in both seasons. The combination between 1.5 % K2SO4 and 2% CaCl2 treatment produced the highest vitamin C content and acidity% and maintained fruit weight loss% and SSC/acid ratio in lowest values until 21 and 28 days of cold storage in both seasons. Finally, it could be recommend to spray K2SO4 at 1.5% and CaCl2 at 2% on Canino apricot trees three times to increase yield and improve physical and chemical fruit quality and maintains characteristics of fruit under cold storage.

Keywords: Apricot, potassium, calcium, firmness, ascorbic acid

INTRODUCTION

Apricot (*Prunus armeniaca* L.) occupies a prime position among the stone fruit species in Egypt. Due to its consumed freshly, dried or manufacture and fruits have a high commercial and nutritive value in terms of rich in several minerals as like potassium, calcium, iron, magnesium as well as fibers, antioxidants, vitamins (Fatima *et al.,* 2018). Although apricot fruits have a high attributes and commercial importance, it cannot be enjoyed for long period due to short duration of the fruits display in the markets and poor shelf life. Moreover, apricot fruits are climacteric fruits that produce great amount of ethylene which accelerate the ripening processes quickly after harvest (Stanley, 2015). Thus, fruits beginning to loss the chemical and physical quality attribute, moreover it's exposed to several physiological disorders such as losses of weight and dry matter as well as increase fruit decay as a result of microbial attack which limit fruit shelf life and marketability (Ezzat *et al.,* 2012). So, pre-harvest applications could be play an important role in increasing yield, enhancing fruit quality. Foliar treatments of minerals are efficient for improving yield and fruit quality of apricot, also foliar sprays can supply essential elements directly to the foliage and fruits (Fernandez *et al.,* 2013). Therefore, foliar treatments are an alternative path for increasing yield and rise the marketable fruit percent with a good quality, also it can be consider as a technique which could reduce the environmental hazard, especially ground water pollution resulting from excessive soil fertilization (Amiri *et al.,* 2008). Spraying calcium and potassium can plays a vital role in increasing yield and keeping the quality and storability of apricot fruits. In this respect, Taha and Sherif (2015) revealed that, spraying four times with different sources of calcium such as Inca, Calbor and $CaCl_2$ at two concentrations (1 and 2 %) on Canino apricot trees led to increase yield and improve physical and chemical fruit quality. Also, Nagy (2018) concluded that spraying $CaCl_2$ at 2% alone or combined with Aminoethoxyvinylglycine at 150 ppm and 1-Methylcyclopropene at 25 ppm was more efficient in reducing fruit abscission, increasing fruit weight and yield at harvest plus maintaining firmness, other physical and chemical qualities and prolonging the storability of "Canino" apricots stored at 0°C for 30 days. Moreover, Martin-Diana *et al.* (2007) reported that, Calcium chloride application was effective to delay fruit ripening, keeping firmness, reduce weight loss and fruit respiration rate. In addition, Jan *et al.,* (2015) summarized that $CaCl_2$ foliar treatment increased fruit firmness and ascorbic acid content of Apple fruits however; it reduced the weight loss % of fruits, decay % and total sugars. In this line, Abd-rabboh, (2012) concluded that, Calcium application was effective in maintaining membrane functionality, reduces the losses of phospholipids, proteins and ion leakage which led to lower weight loss in Apricot fruit.

Similarly, Mosa *et al.,* (2016) reported that, foliar application of potassium sulphate 2% or boron acid 0.01% singly produces the highest fruit yield and enhanced physical fruit quality such as fruit weight, height, width and firmness as well as chemical properties as lick SSC %, acidity % and SSC/ acid ratio of "Florida Prince" peach

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trees. Also, Mosa *et al.,* (2015) showed that foliar application of potassium sulphate, boron acid and humic acid individually or in combinations led to improve fruit width, height, weight, firmness and SSC/acid ratio of Anna apple fruits. Also, Prasad *et al*. (2015) clearly showed that different pre-harvest treatments of calcium chloride and potassium nitrate at 1.5% enhanced the quality characters of Pear fruits. Moreover, El-Dengawy *et al.* (2019) concluded that, pre-harvest treatment of 1.5% K_2SO_4 and 2 % $CaCl_2$ on peach trees recorded the greatest values of fruit firmness, Vitamin C contents, SSC %, acidity %, total sugars %, and recorded the lowest percentages of both fruit decay and weight loss under cold storage up to 24 days. Thus potassium nutrient showed a positive effects on fruit firmness through several paths as increasing fruit tissues pressure potentiality (Lester *et al.,* 2006) and improve Apple fruit firmness and size (Zhang *et al.,* 2017).

This study was conduct for evaluating the effect of pre-harvest foliar treatments of potassium sulphate and calcium chloride individually or in combination on yield, fruit quality at harvest and during cold storage of Canino apricot fruits.

MATERIALS AND METHODS

The present work was carried out during 2019 and 2020 seasons on eighteen years old Apricot (*Prunus armeniaca* L) "Canino" cv. trees in a private orchard at Motobus, Kafr El-Sheikh governorate, Egypt. The trees were grafted on Balady apricot rootstock and planted at 5×5 m spacing in clay soil under flood irrigation system. The soil texture was clay (57.67% clay, 34.10% silt and 8.23% sand at 0 to 90cm soil depth), 1.41% organic mater, 1.75 dSm^{-1} an electrical conductivity, pH of 8.21 and water table at 1.5 m. Thirty six trees were selected as uniform as possible in vigor, fruiting and free from any visual disease. The trees were subjected to the recommended orchard management system in this area. Trees were arranged as a randomized complete blocks design, every treatment replicated three times with three trees per replicate. The study includes four treatments as: Control (tap water), K_2SO_4 at 1.5%, $CaCl_2$ at 2% and K_2SO_4 at 1.5% + $CaCl_2$ at 2%.

Treatments were applied as foliar spraying at three times, the first one was done at 13 ,16 March (after full bloom), the second one was done at 11 ,9 April (after fruiting) and the last one was done at 29 ,27 May (ten days before harvest) in both seasons, respectively. Each tree was sprayed using a hand sprayer with solution 10 L/tree at early morning in both seasons. The components (K_2SO_4 and $CaCl_2$) of combination treatment were sprayed individually with 2h intervals.

The following data was recorded:

Yield

Yield was harvested at June7^{th} and 5^{th} in 2019 and 2020; respectively when fruits reached a yellowish-green color with SSC 12% according to Crisosto and Kader (1999). Yield of each replicate was determined as kg/tree and total yield as ton/feddan were calculated.

Some physical fruit quality parameters at harvest

At harvest time fruit samples were selected for uniform in size, color and free from injuries and insect damages. The harvested fruits were transported to the laboratory of Sakha Horticulture Research Station, Kafr El-Sheikh governorate at less than two hours, cleaned, washed by distilled water, left until fruit surface dry, and then, twenty fruits per treatment were taken to measurement of some physical fruit quality parameters such as: fruit weight (g), fruit size (cm^3), fruit height (cm) and fruit width (cm) using proper digital balance, water displacement method and caliper, respectively. Fruit firmness was measured as ($Ib/inch^2$) on the two opposite sides of apricot fruit using Effigi pressure tester at the tropic of the fruit (mod. Ft 327) and the values of readings were converted to Newton unit ($Ib/inch^2 \times 4.448$) according to (A.O.A.C., 1990).

Storability studies

The remaining fruit samples of each treatment were divided into four groups each one packed in carton boxes; each box contained 2 kg of fruits. The boxes were stored at 0±1°C with 90 – 95 % RH for 28 day. Fruit quality parameters were conducted every 7 days under cold storage as follow:

Weight loss (%)

Weight loss (%) of fruit was calculated according to the initial weight of fruits (fruit weight before storage) and fruit weight after each storage period. Weight loss % was calculated by using the following equation:

$$\text{Fruit weight loss \%} = (W_I - W_S) / W_I \times 100,$$

Where,

W_I = fruit weight before storage and Ws = fruit weight after each storage period.

Fruit decay %

Fruit decay % was calculated as the number of fruit decay after each storage period per the number of fruits at picking date. Fruit decay % was calculated by using the following equation:

$$\text{Fruit decay \%} = \{\text{NO. of decayed fruits} \div \text{Initial NO. of stored fruits}\} \times 100.$$

Fruit firmness

Fruit firmness was measured as showed previously (Newton).

SSC%, total acidity % and SSC/ acid ratio

Fruit SSC% was determined with the help of handy refractometer. However, juice acidity % was determined using titration method with the help of phenolphthalein indicator and expressed as mg of malic acid/ 100ml of fruit juice according to A.O.A.C. (1990). SSC/ acid ratio was calculated according the data of SSC% and acidity %.

Ascorbic acid

Ascorbic acid was determined according to Jacobs (1951) by titration with 2, 6 dichlorophenol indophenol pigment and expressed as mg/ 100ml fruit juice.

Statistical analysis

The experiment treatments were arranged as randomized complete blocks design. The collected data were statistically analyzed as recommended by according to Snedecor and Cochran (1990) by using SAS software Version 9.1. The differences among treatments means were compared by Duncan's multiple range tests (DMRT) at 5% level according to Duncan (1955).

RESULTS AND DISCUSSION

Yield

The results in Figure 1 showed that foliar application of potassium sulphate (K_2SO_4) at 1.5%,

calcium chloride ($CaCl_2$) at 2% and their interaction significantly increased fruit yield of Canino apricots expressed as kg/tree and ton/feddan in both seasons. The highest fruit yield was obtained from trees sprayed with K_2SO_4 at 1.5% + $CaCl_2$at 2% followed by those sprayed with K_2SO_4 at 1.5% as compared to control in both seasons. Whereas, the lowest fruit yield was recorded on trees sprayed with control in both seasons. These results are agreed with Taha and Sherif (2015) and Nagy (2018) on "Canino" apricot trees. In this respect, Al-Hadethi *et al.* (2014) reported that foliar application of potassium sulphate alone or combined with soil application of bio-fertilizer significantly increased yield of Apricot trees. These results are in a line with Mosa *et al.* (2016) investigated the effect of potassium and boron on yield and fruit quality of "Florida prince" peach trees and observed an increase in yield with potassium application. Sindha *et al.* (2018) found that, Custard apple increased in yield as response to spraying with K_2SO_4 and $CaCl_2$. Increase in fruit yield might be due to a vital role of potassium and calcium as macronutrient in apricot tree growth and productivity (Obaid, 2012 and Mohamed *et al.,* 2020). Spraying potassium and calcium are highly effective in improving, nutritional status, total yield and quality of fruits in several fruit crops (Brunetto *et al.,* 2015 and Abd-Elall and Hussein, 2018). Besides, high potassium concentration in a plant affects carbohydrate accumulation and increase yield and improving chemical fruit quality like total soluble solids, total sugar and ascorbic acid (Asma *et al.*, 2007 and Preciado-Rangel *et al.,* 2018).

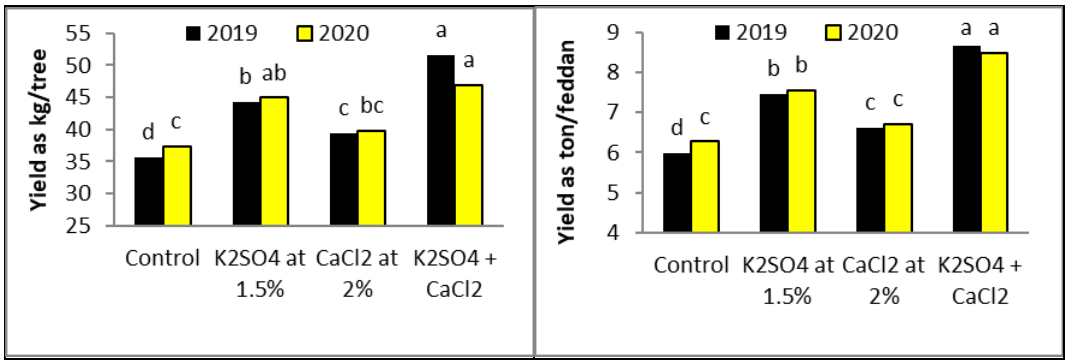

Figure 1. Effect of pre-harvest application of potassium sulphate, calcium chloride and their combination on yield of Canino apricot fruits during 2019 and 2020 seasons

Some physical fruit quality

The results in Table 1 showed significant differences among treatments of K_2SO_4 at 1.5%, $CaCl_2$ at 2% and their interaction on some physical properties of fruits of Canino apricot trees in both seasons. Spraying Canino apricot trees with 1.5% K_2SO_4 + 2% $CaCl_2$ showed the highest fruit weight, fruit size, fruit height and fruit width followed in a descending order by spraying with K_2SO_4 at 1.5% and $CaCl_2$ at 2% in both seasons, respectively. On the other hand, the lowest values were obtained from control in both seasons. Moreover, the result showed that spraying Canino apricot trees three times with 1.5% K_2SO_4 or combined with 2% $CaCl_2$ significantly increase all physical fruit parameters as compared with 2% $CaCl_2$ only. Similar results were obtained by Abd El-Megeed *et al.* (2013) and Kuchay *et al.* (2018). Moreover, Solhjoo *et al.* (2017) showed that, spraying apple trees at five times with KCl, K_2SO_4, KNO_3, $CaCl_2$, and their combinations significantly increased fruit weight, height, width and firmness. Generally, our results showed that, a combined foliar application of K_2SO_4 and $CaCl_2$ was more effective on the improvement of physical fruit quality in terms of fruit weight, fruit size, fruit height and fruit width as compared to the case when either K_2SO_4 or $CaCl_2$ was applied individually. This conclusion agree with the findings of Jaishankar *et al.* (2018) who reported that, spraying Custard apple trees with $CaCl_2$ at 2% and potassium silicate at 0.6% found to increase fruit weight, height, width, volume and specific gravity. The increment of fruit weight and size may be attributed to a vital role of K^+ and Ca^{2+} ions in cell division and cell expansion (Lehtonen and Volanto-Lumppio, 1996).

Table 1. Effect of pre-harvest application of potassium sulphate, calcium chloride and their combination on some physical fruit quality of Canino apricot fruits during 2019 and 2020 seasons

Treatments	Fruit weight(g)		Fruit size(ml)		Fruit height(cm)		Fruit width(cm)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control (tap water)	34.41 d	34.78 d	26.51 d	26.71 c	3.74 d	3.92 b	3.62 d	3.88b
K_2SO_4 at 1.5%	51.56 b	52.94 b	39.11 b	40.13 b	4.14 b	4.56 a	3.92 b	4.46 a
$CaCl_2$ at 2%	36.73 c	36.41c	27.91 c	28.15 c	3.90 c	4.16 b	3.72 c	3.98 b
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	54.56 a	57.17 a	41.33 a	43.26 a	4.40 a	4.68 a	4.28 a	4.56 a

Means followed by different letter are significantly different within columns by Duncan's multiple range tests, P≤0.05.

Storability studies

Physical parameters:

Data in Tables2, 3 and 4 showed the effect of preharvest spraying with potassium sulphate (K_2SO_4) at 1.5%, calcium chloride ($CaCl_2$) at 2% and their combination on weight loss% of fruit, decay% and firmness of fruits during cold storage at 0 ± 1°C with 90 - 95% RH for 28 days. The results in Table 2 revealed that fruit weight loss % increased as the storage period progressed from 5.14 to 16.62% and 4.92 to 16.30 in both seasons, respectively. Also, spraying with a combined 1.5% K_2SO_4 + 2% $CaCl_2$ was more effective treatment in

reducing weight loss % followed by sprayed with $CaCl_2$ and K_2SO_4 in both seasons, respectively. In this respect, the highest weight loss% of fruits was noticed in control fruits. Generally, the results indicated that combined application of $CaCl_2$ and K_2SO_4 were superior in reducing fruit weight loss percentage as compared to other treatments. Similar results were obtained by Abd El-Wahab (2015) on Canino apricot. Also, Abd El-Motty *et al.* (2007) showed that, pre-harvest foliar spraying of CaCl2 at 2%, chelated calcium at 2% and boric acid at 0.5% reduced weight loss% of fruit, decay% and maintained the firmness of "Canino" apricot fruits under cold storage at 0 ± 1°C for 40 days.

With regard to the effect of preharvest treatments on fruit decay percentage, data in Table 3 revealed that fruit decay % increased with the incidence of storage period as for all treatments from 2.62 to 15.74 and 3.08 to 13.86 in both seasons, respectively and also noted that the highest decay % was noticed in control in both seasons. The obtained results showed that, spraying with K_2SO_4 at 1.5% and $CaCl_2$at 2% as individually or together had a significant decrease decay % as compared with control during all cold storage periods. In this respect, spraying $CaCl_2$ alone or combined with K_2SO_4 treatment did not show any decay% until 14 days of cold storage in the first season, while only combined treatment show this effect in the second season compared to control. In general, CaCl2 alone or combined with K_2SO_4 cleared the lowest fruit decay% in both seasons. Our results are in agreement with those obtained by Lal *et al.* (2011) on apricot. Also, Abd-rabboh (2012) who found that the preharvest treatment with Ca $(NO_3)_2$ at 2%, decreased the fruit decayed percentage of Canino apricot under cold storage at 0 °C and 90 - 95% relative humidity for thirty days.

The results in Table 4 showed that, fruit firmness of Canino apricot was enhanced with preharvest application of $CaCl_2$, $K_2SO_4$and $CaCl_2$ + K_2SO_4 as compared with control during the both seasons. Also, fruit firmness was decreased with the incidence storage time as for all treatments from 29.36 to 12.42 and 28.71 to 12.14 in both seasons, respectively. Preharvest spraying of $CaCl_2$ recorded the highest values of fruit firmness followed by spraying with K_2SO_4 as compared with control during the both seasons. On the other hand, control treatment showed the minimum values of fruit firmness in both seasons. Similar results were obtained by Nagy (2018) who concluded that spraying $CaCl_2$ at 2% maintaining fruit firmness of "Canino" apricots stored at 0°C for 30 days. Also, Gill *et al.* (2012) concluded that, potassium applications at different levels increased significantly the firmness of Pear fruits as compared to control.

Table 2. Effect of pre-harvest treatments of potassium sulphate, calcium chloride on weight loss % of Apricot fruits "Canino" cv stored at 0 ±1°C with 90 – 95 % RH.

Treatments	Weight loss %					
	Storage periods (day)					
	0	7	14	21	28	Mean
			2019 season			
Control (tap water)	0.00 a	7.35 a	9.98 a	15.13 a	18.79 a	10.25 a
K_2SO_4 at 1.5%	0.00 a	5.56 b	7.27 b	13.22 c	16.14 c	8.43 b
$CaCl_2$ at 2%	0.00 a	4.32 c	6.92 c	14.81 b	15.00 d	8.21 c
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	0.00 a	3.33 d	6.32 d	12.86 d	16.55 b	7.81 d
Mean	0.00e	5.14d	7.62c	14.00 b	16.62a	
			2020 season			
Control (tap water)	0.00 a	6.65 a	10.29 a	16.14 a	19.27 a	10.47 a
K_2SO_4 at 1.5%	0.00 a	5.00 b	5.91 c	14.61 b	16.50 b	8.40 b
$CaCl_2$ at 2%	0.00 a	3.87 d	6.37 b	12.34 c	15.17 c	7.55 c
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	0.00 a	4.18 c	5.72 d	11.75 d	14.27 d	7.18 d
Mean	0.00 e	4.92 d	7.07 c	13.71 b	16.30 a	

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P≤0.05.

Table 3. Effect of pre-harvest treatments of potassium sulphate, calcium chloride on fruit decay % of Apricot fruits "Canino" cv stored at 0 ±1◦C with 90 – 95 % RH.

Treatments	Decay %					
	Storage periods (day)					
	0	7	14	21	28	Mean
			2019 season			
Control (tap water)	0.00 a	10.48 a	14.53 a	16.86 a	21.77 a	12.72 a
K_2SO_4 at 1.5%	0.00 a	0.00 b	7.28 b	9.41 b	17.55 b	6.84 b
$CaCl_2$ at 2%	0.00 a	0.00 b	0.00 c	6.15 c	13.00 c	3.83 c
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	0.00 a	0.00 b	0.00 c	4.88 d	10.67 d	3.11 d
Mean	0.00 e	2.62 d	5.45 c	9.32 b	15.74 a	
			2020 season			
Control (tap water)	0.00 a	9.35 a	12.54 a	14.17 a	20.47 a	11.30 a
K_2SO_4 at 1.5%	0.00 a	2.00 b	8.32 b	10.23 b	15.81 ab	7.27 b
$CaCl_2$ at 2%	0.00 a	1.00 c	4.68 c	7.8 c	10.88 b	4.87 c
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	0.00 a	0.00 d	0.00 d	5.39 d	8.28 c	2.73 d
Mean	0.00 e	3.08 d	6.38 c	9.39 b	13.86 a	

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P≤0.05.

Table 4. Effect of pre-harvest treatments of potassium sulphate, calcium chloride on firmness (Newton) of Apricot fruits "Canino" cv stored at 0 ±1◦C with 90 – 95 % RH.

Treatments	Firmness (Newton)					
	Storage periods (day)					
	0	7	14	21	28	Mean
			2019 season			
Control (tap water)	20.37 d	15.17 d	14.10 d	11.12 d	10.58 d	14.27 d
K_2SO_4 at 1.5%	29.05 c	24.24 c	20.28 b	16.06 b	13.56 b	20.64 b
$CaCl_2$ at 2%	36.47 a	26.33 a	23.44 a	19.39 a	14.81 a	24.09 a
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	31.53 b	26.15 b	17.30 c	13.16 c	10.72 c	19.77 c
Mean	29.36 a	22.97 b	18.78 c	14.93 d	12.42 e	
			2020 season			
Control (tap water)	19.48 d	13.79 d	13.34 d	10.67 d	10.23 d	13.50 d
K_2SO_4 at 1.5%	31.04 b	25.22 b	20.37 b	16.10 b	13.03 b	21.15 b
$CaCl_2$ at 2%	36.29 a	26.28 a	23.35 a	18.32 a	14.45 a	23.74 a
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	28.02 c	21.13 c	14.32 c	13.12 c	10.85 c	17.49 c
Mean	28.71 a	21.61 b	17.85 c	14.55 d	12.14 e	

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P≤0.05.

Generally, it is obvious from data in Tables 2, 3 and 4 that preharvest foliar applications of $CaCl_2$, K_2SO_4 and $CaCl_2$ + K_2SO_4 on three times had significant effects in improving physical fruit quality in terms of fruit weight loss, decay and firmness of Canino apricot during cold storage period at 0±1°C with 90 - 95 % RH for 28 days compared to control in both seasons. The combined treatment of $CaCl_2$ and K_2SO_4 was the superior treatment in reducing weight loss% of fruits and decay % as well as increasing fruit firmness at picking date and maintaining it under cold storage as compared to other treatments. The enhancement effect of treatments may be refer to the known role of Calcium on maintain cell membrane functionality, reduces the losses of phospholipids (Abd-rabboh, 2012). Also, potassium nutrient enhances fruit firmness by increase the pressure potentiality of fruit tissues (Lester *et al.* 2006). Similar results were obtained by Abd El-Gayed *et al.* (2017) and Sharma and Pratima (2018).

Chemical parameters:

Data presented in Tables 5, 6, 7 and 8 showed the effect of spraying with K_2SO_4 at 1.5%, $CaCl_2$ at 2% and their interaction on contents of SSC%, acidity %, SSC/ acid ratio and vitamin C in Canino apricot fruit juice during cold storage. The results in Table 5 showed that, the SSC % of apricot fruit was increased with the incidence of cold storage times from 12.65 to 16.11 and 12.86 to 16.75 in both seasons, respectively, and the rates of increment were significantly differed among preharvest treatments in both seasons. The highest SSC% were recorded in fruits taken from trees sprayed with K_2SO_4 followed by treatment of combination between K_2SO_4 and $CaCl_2$ and control treatment in both seasons, respectively. Whereas, the lowest values of SSC% were recorded in fruits taken from trees sprayed with $CaCl_2$ in both seasons. Moreover, it is noted that soluble solids content was the highest in fruit treated with K_2SO_4; this behavior showed the ripening acceleration effect of K_2SO_4 and retarding effect of $CaCl_2$. These results were agreement with Abd El-Wahab (2015) and Nagy (2018) they reported that preharvest spraying with $CaCl_2$ maintained fruit TSS as compared with control through reducing the ripening incidences on the apricot fruits.

As for the effect of different treatments on fruit acidity%, data in Table 6 revealed that fruit acidity % was significantly decreased with the incidences of storage periods from 1.42 to 0.80 and 1.47 to 0.80 in both seasons, respectively. The fruits obtained from preharvest spraying with combined treatment between $CaCl_2$ and K_2SO_4 showed significantly higher values of acidity % at the picking date and during cold storage periods as compared with control treatment. In contrast, the lowest fruit acidity% was detected in fruits taken from control treatment in both seasons. The effect of treatments on physical and chemical quality of fruits could be explained according to the effect of Calcium in retarding the fruit ripening that reduces the accumulation of sugars, retard fruit softening and also, reduced fruit respiration rate (Martin-Diana *et al.*, 2007 and Jan *et al.*, 2015). These results came true with those of Abd-rabboh (2012) and Solhjoo *et al.* (2017).

Table 5. Effect of pre-harvest treatments of potassium sulphate, calcium chloride on SSC% of Apricot fruits "Canino" cv stored at 0 ±1◦C with 90 – 95 % RH.

Treatments	SSC%					
	Storage periods (day)					
	0	7	14	21	28	Mean
			2019 season			
Control (tap water)	12.61 b	13.25 c	14.13 c	14.75 c	15.61 c	14.07 b
K_2SO_4 at 1.5%	12.81 a	14.10 a	14.70 a	15.55 a	17.31 a	14.89 a
$CaCl_2$ at 2%	12.48 c	12.91 d	13.32 d	14.68 d	14.98 d	13.67 c
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	12.68 b	13.53 b	14.47 b	15.41 b	16.55 b	14.53 ab
Mean	12.65 d	13.45 c	14.16 bc	15.10 b	16.11 a	
			2020 season			
Control (tap water)	12.83 b	13.50 c	14.23 b	14.90 c	15.52 d	14.20 bc
K_2SO_4 at 1.5%	13.00 a	14.16 a	14.86 a	15.91 a	18.21 a	15.23 a
$CaCl_2$ at 2%	12.70 c	12.79 d	13.16 c	14.85 c	15.71 c	13.84 c
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	12.90 ab	13.80 b	14.84 a	15.20 b	17.54 b	14.86b
Mean	12.86 e	13.56 d	14.27 c	15.22 b	16.75 a	

Means followed by different letter are significantly different within columns by Duncan's multiple range tests, P≤0.05.

Table 6. Effect of pre-harvest treatments of potassium sulphate, calcium chloride on acidity % of Apricot fruits "Canino" cv stored at 0 ±1◦C with 90 – 95 % RH.

Treatments	Acidity %					
	Storage periods (day)					
	0	7	14	21	28	Mean
			2019 season			
Control (tap water)	1.18 b	0.97 c	0.77 c	0.64 c	0.60 c	0.83 c
K_2SO_4 at 1.5%	1.48 a	1.19 b	0.90 b	0.89 b	0.76 c	1.04 b
$CaCl_2$ at 2%	1.46 a	1.21 b	0.92 b	0.87 b	0.78 b	1.05 b
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	1.56 a	1.48 a	1.38 a	1.06 a	1.04 a	1.30 a
Mean	1.42 a	1.21 b	0.99 cd	0.87 d	0.80 d	
			2020 season			
Control (tap water)	1.22 b	1.02 c	0.82 c	0.66 d	0.62 d	0.87 c
K_2SO_4 at 1.5%	1.56 a	1.27 b	0.98 b	0.78 c	0.74 c	1.07 b
$CaCl_2$ at 2%	1.49 a	1.23 b	0.98 b	0.93 b	0.82 b	1.09 b
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	1.60 a	1.51 a	1.42 a	1.09 a	1.01 a	1.33 a
Mean	1.47 a	1.26 b	1.05 c	0.87 d	0.80 d	

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P≤0.05.

Table 7. Effect of pre-harvest treatments of potassium sulphate, calcium chloride on SSC/acid ratio of Apricot fruits "Canino" cv stored at 0 ±1◦C with 90 – 95 % RH.

Treatments	SSC/ acid ratio					
	Storage period (days)					
	0	7	14	21	28	Mean
			2019 season			
Control (tap water)	10.68 a	13.66 a	18.35 a	23.12 a	26.08 a	18.38 a
K_2SO_4 at 1.5%	8.67 b	11.85 b	16.37 b	17.49 b	22.81 b	15.44 b
$CaCl_2$ at 2%	8.56 b	10.67 c	14.51 c	16.87 b	19.23 c	13.97 c
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	8.12 b	9.14 d	10.48 d	14.54 c	15.92 d	11.64 d
Mean	9.01 e	11.33 d	14.93 c	18.01 b	21.01 a	
			2020 season			
Control (tap water)	10.52 a	13.24 a	17.36 a	22.64 a	25.11 a	17.77 a
K_2SO_4 at 1.5%	8.52 b	11.15 b	15.18 b	20.44 a	24.61 b	15.98 b
$CaCl_2$ at 2%	8.33 b	10.40 c	13.43 c	15.97 b	19.17 c	13.46 c
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	8.08 b	9.14 d	10.45 d	13.94 b	17.31 d	11.78 d
Mean	8.86 e	10.98 d	14.11 c	18.25 b	21.55 a	

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P≤0.05.

Table 8. Effect of pre-harvest treatments of potassium sulphate, calcium chloride on vitamin C contents of Apricot fruits "Canino" cv stored at 0 ±1◦C with 90 – 95 % RH.

Treatments	Vitamin C (mg/100ml juice)					
	Storage periods (day)					
	0	7	14	21	28	Mean
			2019 season			
Control (tap water)	15.52 c	11.47 c	8.91 c	7.77 d	5.97 d	9.93 c
K_2SO_4 at 1.5%	17.49 a	14.65 a	11.81 a	9.17 b	6.53 c	11.93 a
$CaCl_2$ at 2%	15.94b	13.09 b	9.58 c	8.11 c	7.31 b	10.81 b
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	14.86 d	13.28 b	10.06 b	9.51 a	7.52 a	11.05 a
Mean	15.95 a	13.12 b	10.09 c	8.64 d	6.83 e	
			2020 season			
Control (tap water)	15.98 d	11.58 d	9.14 d	7.73 d	6.00 c	10.09 d
K_2SO_4 at 1.5%	17.66 a	14.79 a	11.91 a	9.24 b	7.53 b	12.23 a
$CaCl_2$ at 2%	16.84 c	12.46 c	9.69 c	8.28 c	7.43 b	10.94 c
K_2SO_4 at 1.5% + $CaCl_2$ at 2%	17.35 b	13.29 b	10.29 b	9.77 a	7.75 a	11.69 b
Mean	16.96 a	13.03 b	10.26 c	8.76 d	7.18 e	

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P≤0.05.

Concerning the effect of preharvest spraying with K_2SO_4 at 1.5%, $CaCl_2$ at 2% and their combination on SSC/acid ratio in Canino apricot fruits, data of Table 7 revealed that, as the cold storage period extended, as the SSC/acid ratio increased from 9.01 to 21.01 and 8.86 to 21.55 in both seasons, respectively. Pre-harvest treatment by $CaCl_2$ or K_2SO_4 individually or in combination cleared a significant decrease in SSC/acid ratio as compared with control at the picking date and under cold storage until 28 days. The combined treatment of $CaCl_2$ and K_2SO_4 had the lowest SSC/ acid ratio, whereas the highest values of SSC/acid ratio were detected in control treatment during storage period. The obtained results agree with those of El-Dengawy *et al.* (2019) they observed that, application of CaCl2 in combined with K_2SO_4 cleared the lowest TSS/acid ratio value of peach fruits during the cold storage.

With regard to the effect of preharvest treatments on fruit vitamin C content, data in Table 8 revealed that, vitamin C content in Canino apricot fruits gradually decreased with increasing storage period from 15.95 to

6.83 and 16.96 to 7.18 in both seasons, respectively. Preharvest sprays of K_2SO_4 or $CaCl_2$ alone or in combination showed the highest values of fruit vitamin C content when compared to control. Also these treatments cleared the higher vitamin C values than the control during cold storage periods. The apricot trees treated by K_2SO_4 at 1.5 % showed the highest values of vitamin C content at picking date and after 7 and 14 days under cold storage in both seasons. Similar results were cleared by Abd El-Motty *et al.* (2007) and Lal *et al.* (2011) on apricot.

In generally, it is clear from data in Tables 5, 6, 7 and 8 that foliar application of K_2SO_4 at 1.5%, $CaCl_2$ at 2% and their interaction at three times enhances fruit contents of SSC%, acidity, SSC/acid ratio and vitamin C in Canino apricot fruit juice during cold storage at 0 ± 1°C and from 90 to 95% RH. until 28 days. A combination treatment of K_2SO_4 and $CaCl_2$ produced significantly higher values of SSC %, acidity %, SSC/acid ratio and vitamin C content as compared to control in both seasons.

CONCLUSION

Finally, from our results, we can concluded that, spraying Canino apricot trees at pre-harvest with potassium sulphate at 1.5 % in combined with calcium chloride at 2 % was more efficient than the individual on increasing yield and improving fruit weight, fruit size, fruit height and fruit width at harvest plus maintaining firmness and other physical and chemical qualities consequently, extending the storability of Canino apricot stored at 0 ±1°C and from 90 to 95% RH until 28 days.

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معاملات ما قبل الحصاد على أشجار المشمش صنف كانينو لتحسين المحصول و جودة الثمار عند الجمع و أثناء التخزين.

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أجريت هذه الدراسة على أشجار مشمش صنف كانينو عمرها ثمانية عشر عامًا تنمو فى بستان خاص بمركز مطوبس - محافظة كفر الشيخ - مصر خلال موسمي 2019 و 2020 و ذلك لدراسة تأثير الرش بكبريتات البوتاسيوم بنسبة1.5٪ وكلوريد الكالسيوم بنسبة2 ٪ بمفردهم أو خليط منهما على المحصول و جودة الثمار عند الحصاد وأثناء التخزين البارد على درجة مئوية 0 ± 1 و رطوبة نسبية 90-95٪ لمدة 28 يومًا. تم رش أشجار المشمش صنف كانينو ثلاث مرات بدءًا من الإزهار الكامل ، وتكوين الثمار ، وأخيراً قبل الحصاد بعشرة أيام بإحدى المعاملات التالية: الكنترول (ماء الصنبور) و كبريتات البوتاسيوم بنسبة 1.5٪ و كلوريد الكالسيوم بنسبة 2٪ وكبريتات البوتاسيوم بنسبة 1.5٪ + كلوريد الكالسيوم بنسبة 2٪. أظهرت النتائج المتحصل عليها أن الرش قبل الحصاد بكبريتات البوتاسيوم أو كلوريد الكالسيوم أو كليهما كان أكثر فاعلية في زيادة المحصول وتحسين وزن الثمار وحجمها وطولها وقطرها عند الحصاد بالمقارنة مع معاملة الكنترول. أدى الرش بكبريتات البوتاسيوم 1.5٪ إلى الحصول على ثمار بها أعلى محتوى من فيتامين ج والنسبة المؤية للمواد الصلبة الكلية الذائبة بعد 7 و 14 و 21 يوم من التخزين البارد في الموسمين. بينما أظهرت الاشجار التي تم رشها بـ 2٪ من كلوريد الكالسيوم القيم الاعلى لصلابة الثمار عند الحصاد وبعد 28 يومًا من التخزين البارد وأقل القيم لكل من النسبة المؤية للثمار التالفة والنسبة المؤية للمواد الصلبة الذائبة في جميع فترات التخزين خلال عامى الدراسة. أدى الرش بكبريتات البوتاسيوم 1.5% وكلوريد الكالسيوم 2% إلى الحصول على ثمار بها أعلى محتوى من فيتامين ج والحموضة القابلة للمعايرة وكذلك أقل القيم لنسبة المواد الصلبة الكلية الذائبة إلى الحموضة وكذا النسبة المئوية للفقد فى وزن الثمار فى الثمار بعد 21 و 28 يومًا من التخزين البارد خلال عامى الدراسة. و بعد عرض نتائج البحث نوصى بالرش بكبريتات البوتاسيوم بنسبة 1.5٪ وكلوريد الكالسيوم بنسبة 2٪ على أشجار المشمش صنف كانينو قبل الحصاد ثلاث مرات لزيادة المحصول وتحسين الجودة الطبيعية والكيميائية للثمار عند الحصاد والحفاظ عليها أثناء التخزين البارد على درجة مئوية 0 ± 1 و رطوبة نسبية 90-95٪ لمدة 28 يومًا.