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Fruit Quality, Yield and Shelf Life of "Kadota" Fig Fruits as Affected by Spraying with Some Potassium and Calcium Sources

A.M. El-Husseiny, Hend I. Ali and A.A. Hammad

Department of Olive and Semi-Arid Zone Fruits, Horticulture Research Institute,
Agricultural Research Center (ARC), Giza, Egypt

Abstract: The present study was conducted out during 2015 and 2016 growing seasons on 6 years-old fig trees (*Ficus carica* L.) cv. Kadota grown in a private orchard located at El-Esmailia governorate, Egypt. The aim of the present study was to assess the effect of pre-harvest spraying with different sources and concentrations of potassium and calcium on growth performance, plant nutrients, yield and fruit quality of fig (Kadota cv.) in relation to fruit shelf life. The trees were sprayed by the following treatments: control (water only), calcium chloride or calcium nitrate or potassium silicate or Mono-potassium phosphate or mixture of Calcium chloride + Mono-potassium. The treatments were sprayed 3 times at 1st May, 1st June and 1st July at a concentration of 1 or 2 %. Most of the applied treatments have a positive impact on the vegetative growth parameters and nutrient content compared with the control. Calcium chloride and Mono potassium phosphate (MKP) at 2 % significantly increased fruit weight, length and width. The highest significant records of fruit firmness, No. of retained fruits, yield/tree (kg) and leaves content of nitrogen and phosphor was noticed by ($CaNo_3$) at 2%. Also, a mixture from ($CaCl_2$ 2 % + MKP 2%) produced the richest fruits in TSS and total sugars. Both ($CaCl_2$) and ($CaNO_3$) at 2 % concentration decreased the fruit decay % after 7 and 15 days of cold storage at 5°C. Accordingly, it can be recommended spraying fig trees with calcium nitrate ($CaNO_3$) at 2 %, 4/L for each/tree, three times/season for improving growth, fruit yield and quality as well as decrease fruit decay and weight loss after cold storage at 5°C for 15 days and increasing the net profit for farmer.

Key words: Fig trees · Calcium nitrate · Potassium silicate · Vegetative growth · Fruit yield · Quality

INTRODUCTION

The Fig tree (*Ficus carica* L.) is one of the important fruit species in the Mediterranean areas. Its value is as significant as to be named in Muslim Quran and Christian sacred books. They were first selected by the Arabs in south west Asia and transmitted to Syria, Mediterranean region, Greece, Italy and Spain [1]. The Mediterranean basin climate with hot dry summer and cool wet winter predominates in the fig trees region of origin and characterized as a temperate subtype climate. The Fig fruit referred to as the oldest species of the fruit trees cultivated for over 5000 years ago [2, 3]. Figs have been grown in Egypt since ancient times and their fruits are of the major fruits for local consumption. Egypt is considered the second producing country of fig in the world [4]. Fig fruit is an excellent source of vitamins, amino acids and polyphenols. In addition, figs contain higher levels of potassium (14%), calcium (15.8%) and iron (30%) than those usually found in other common fruits such as bananas, grapes, oranges, strawberries and apples [5-7]. Also, figs are free of sodium, fat-free and, like other fruits, cholesterol free [8-10] but its quality is highly affected by nutrient especially calcium and potassium [11]. Several studies focused on pre-harvest practice which have a positive impact on fig fruit quality as spraying calcium and potassium whether individually or in combination. Both of Ca and K played an important role on productivity and fruit quality [12, 13]. Potassium, Calcium played a positive role in increasing fig yield, TSS, firmness and prolongs shelf life as well as contributes in blocking physiological disorders, decreasing of the respiration rate, delaying development and fruit tissues [13-15]. Adding of limited doses of N, K and Ca lead to organize fig fruit growth and create a state of water balance between ecrap and inside fruit tissues

Corresponding Author: A.M. El-Husseiny, Department of Olive and Semi-Arid Zone Fruits, Horticulture Research Institute, Agricultural Research Center (ARC), Giza, Egypt.

and maintain fruit cell walls plasticity and firmness [16]. In addition to the above, application of Ca to many fruits by pre-harvest spraying have reduced the rate of ripening and reduced fruit softening during storage. While, K/Ca balance is the main decisive factor where K affect through water use while Ca overtakes a significant role in the cell wall structure in the form of calcium pectate [17]. Moreover, spraying cv. Stanley and cv. D'browicka Prune (*Prunus domestica* L.) by calcium resulted in significantly increase of fruit firmness at harvest and consequently a slower softening during long-term storage at low temperature [13, 15]. In plant nutrition, calcium is known to create consequent physiological disorders due to its slow translocation as a plant nutrient [18]. Calcium applications are also known to regulate the activities of the plant growth substances mainly of indole acetic acid IAA that is formed in the ape and that plays a regulatory role in cell division and thus enhance growth rate [19-21]. Potassium activates numerous enzymes, which are critical for various metabolic processes, such as biosynthesis, transport and transformation of sugar and starch [22-26]. Furthermore, K is an essential nutrient involved in the phloem translocation of assimilates, including sucrose movement from shoot to root and to sink tissues such as fruit [27]. It is generally considered as a quality element, which could increase fruit development with higher quality and longer shelf life by enhancing synthesis and translocation of carbohydrates in plants [28]. For example, the fruit of 'Kinnow' mandarin (Citrus deliciosa• Citrus nobilis) became larger and harder with increasing K supply. In contrast, the number of fruit cells, fruit size and the SSC were significantly reduced by K deficiency [29]. Thus, the aim of the present study was to assess the effect of pre-harvest spraying with different sources and concentrations of potassium and calcium on growth performance, plant nutrients, yield and fruit quality of fig (Kadota cv.) in relation to fruit shelf life. In addition, the economic feasibility of the transactions under study will be involved.

MATERIALS AND METHODS

The present study was conducted out during 2015 and 2016 growing seasons on 6-years-old fig trees (*Ficus carica* L.) Kadota cv. grown in a private orchard located at El-Esmailia governorate. Thirty-three trees with similar size and growth were selected and divided into eleven treatments with three replicates /treatment; each replicate was presented by one tree. The selected trees were planted at (5 x 4 m) apart and received the same horticultural management. The trees were irrigated with drip irrigation system and the recommended water quantities for fig trees (2000-25000 cubic meter/fed) and the recommended fertilization were applied through drip irrigation system. Farm fertilization (80 unit/K, 68 unit/N and 25 unit/P) were added for all the trees all over the growth season per feddan through drip irrigation system and each tree involved in this experiment had been annually given 15 kg of farmyard manure during November. Physical and chemical properties of the experimental soil were determined and presented in Table (1).

The experimental trees were subjected to the following treatments:

- Control (water only).
- Calcium chloride ($CaCl_2$) 1 %.
- Calcium chloride ($CaCl_2$) 2 %.
- Calcium nitrate ($CaNO_3$) 1 %.
- Calcium nitrate ($CaNO_3$) 2 %.
- Potassium silicate (K_2SiO_3) 1 %.
- Potassium silicate (K_2SiO_3) 2 %.
- Mono-potassium phosphate (MKP) 1 %.
- Mono-potassium phosphate (MKP) 2 %.
- Mixture from (Calcium chloride 1% + Mono-potassium 1 %).
- Mixture from (Calcium chloride + Mono-potassium) 2 %.

The trees of treatments (2 to 11) were sprayed 3 times with 4/L for each tree (at 1st of May, 1st of June and 1st of July) during both experimental seasons.

Field Observations and Laboratory Measurements Were Carried out as Follows

Vegetative Growth Parameters

Leaf Characteristics: Leaf area (cm) was determined at the end of each growing season in the first week of September according to Ahmed and Morsy [30]. Estimated area of leaf blade (W x L) in cm^2 as recommended by Condit [32]. Leaf shape index = Blade length (L) in cm / Blade width (W) in cm. Leaf fresh and dry weight (g) was determined as A.O.A.C. [31].

Fruit Physical Characteristics: In both studied seasons, samples from the mature fig fruits of each treatment were collected when the skin color is light green to determine the physical properties of fruits as follow:

Average fruit length (cm), average fruit diameter (cm), average fruit weight (g) and firmness of fig fruits was also estimated as mentioned by A.O.A.C. [31].

Table 1: Physical and chemical characteristics of the tested soil sample collected from the experimental area

Physical characteristics			
Texture	Sandy (%)	Silt (%)	Clay (%)
Sandy	90.25	3.00	6.75

Chemical characteristics								
		Soluble cations (m/ g 100g soil)			Soluble anions (m g / 100g soil)			
PH	E.C	Ca^{++}	Mg^{++}	Na^{+}	Co_3-	HCO_3^-	Cl^-	SO_4^-
8.05	1.4 ds m^{-1}	14.63	15.48	0.45	0.06-	0.78	1.60	28.43

Fruit Yield (kg) and Percentage of F ruit Dropping: For each tree under study the fruits were harvested when the skin color is light green and total yield (main crop) for each tree (kg) was estimated. Fruits for each tree were counted and the percentage of dropping was calculated according to the following formula:

Percentage of dropping = Total number of fruits - number of fruits dropping / Total number of fruits X 100.

Leaf Chemical Analysis: At the first week of August of each season, leaf samples were taken from mid of the current of growing shoots [33], washed and dried at 70°C until constant weight and then grounded for determining the following nutrient elements (percentage as dry weight). N, P, K and Ca were determined using the methods outline by Wilde *et al*. [34]. Total nitrogen by semi-micro Kjeldahl method as outlined by Pregl [35]. Total phosphorus using Spekal spectrophotometer at 882.0 μv according to the method described by Murphy & Riely [36]. Potassium was estimated by flame photometrically using methods recommended by Brown & Lilleland [37]. Calcium was determined in fig fruits by Wilde *et al*. [34].

Assessment of Fruit Shelf Life: Mature fruits from each treatment were picked in early morning packed in shallow plastic boxes and immediately transported to the laboratory. Fruits were sorted and packed in foam trays, having an average weight of half kilogram. Three trays of each treatment were covered in a sealed way by shrink film 20 micron. Each tray represented a replicate and stored at 5°C and 80-90 % R.H [38]. The following parameters were estimated:

Chemical properties of fig fruits were determined before and after storage for 2 weeks at 5°C. Total sugars (%) content in fresh fruits were determined by phenol sulfuric method according to Dubois *et al*. [39]. Total soluble solids (TSS) % was determined using a Carl Zeiss hand refractometer. Total titratable acidity percentage: was estimated in fruit as percentage of tartaric acid according to A.O.A.C. [31].

Decay percentage was determined after 1 and 2 weeks stored and calculated according to the following formula:

Decay (%) = Weight fruits decayed/Weight of fruits healthyX100.

Weight loss was determined after 1 and 2 weeks of storing and calculated according to the following formula: Percent loss in weight = Initial weight – Final weight / Initial weight X 100.

Economical Study (Feddan): Was calculated according to the national market prices of all the production inputs and outputs.

Statistical Analysis: The obtained date was statistically subjected to analysis of variance (ANOVA) in a Randomized Complete Blocks [40] and significant differences between the means were determined by Duncan's Multiple Range t-Test [41] for means comparison.

RESULTS AND DISCUSSION

Leaf Characteristics: Data in Table (2) showed that, calcium nitrate 2% significantly increased leaf area and leaf shape index in both seasons. Regards leaf fresh weight, calcium nitrate at both 1, 2 % concentrations, potassium silicate at 1, 2% concentration (1st season) and calcium nitrate 2%, potassium silicate at 2% concentration (2nd season) surpassed other treatments. Calcium nitrate (1 and 2%) had a positive significant effect on leaf dry weight. As well as, calcium nitrate 1 % was the next in its effect on leaf area and leaf shape index (both seasons) and leaf fresh weight (2nd season).On the contrary, the untreated trees and that were sprayed with calcium chloride (1%) resulted significantly in the lowest values of all the above mentioned investigated characters during the two seasons of study. These results were supported by findings of Mazher *et al*. [42] and Roy *et al*. [43] they showed that, calcium nitrate treatments at high concentrations increased leaf fresh weight, leaf area

Table 2: Effect of different sources of potassium and calcium minerals foliar application on some leaf parameters of fig fruits cv "Kadota" during 2015 and 2016 seasons

		Character							
		Leaf area (cm)		Leaf shape index (L/W)		Leaf fresh weight (gm.)		Leaf dry weight (gm.)	
Treatments		2015	2016	2015	2016	2015	2016	2015	2016
T1	Control	169.9I	173.4J	0.82H	0.85F	2.14E	3.42E	1.31G	1.50F
T2	Calcium chloride ($CaCl_2$) 1 %.	220.0H	223.6I	0.85G	0.89E	3.37D	3.90C	1.55E	1.60E
T3	Calcium chloride ($CaCl_2$) 2 %.	228.3G	225.9H	0.88F	0.89E	3.45D	3.51E	1.59E	1.62E
T4	Calcium nitrate ($CaNO_3$) 1 %.	304.4B	310.3B	1.02B	1.13B	4.15A	4.22B	2.05A	2.07A
T5	Calcium nitrate ($CaNO_3$) 2 %	311.8A	323.1A	1.04A	1.90A	4.25A	4.50A	2.06A	2.08A
T6	Potassium silicate (K_2SiO_3) 1%.	231.2F	238.5G	0.92E	1.00D	4.19A	4.25B	1.47F	1.60E
T7	Potassium silicate (K_2SiO_3) 2 %.	231.1F	240.0F	0.92E	1.00D	4.21A	4.36AB	1.56E	1.72D
T8	Mono-potassium (MKP) 1 %	264.0E	280.5G	0.96D	1.02D	3.65C	3.72D	1.68D	1.85C
T9	Mono-potassium (MKP)2%	276.4C	285.2D	0.97D	1.03D	3.88B	4.30B	1.72CD	1.90BC
T10	Mixture from ($CaCl_2$ 1.0 % + MKP 1%)	275.1D	284.8D	1.00C	1.00D	3.66C	3.72D	1.77C	1.92BC
T11	Mixture from ($CaCl_2$ 2 % + MKP 2%)	276.9C	292.8C	1.01BC	1.10C	3.69C	3.75CD	1.93B	1.97B

Means having the same letter(s) within the same column are not significantly differ at the probability of 5 % level according to Duncan's Multiple Range Test at 5 % level.

Table 3: Effect of different sources of potassium and calcium minerals foliar application on some physical characteristics of fig fruits cv "Kadota" during 2015 and 2016 seasons

		Character							
		Fruit weight (g)		Fruit length (cm)		Fruit width (cm)		Fruit firmness	
Treatments		2015	2016	2015	2016	2015	2016	2015	2016
T1	Control	35.50I	36.00H	4.00F	4.10E	3.90D	3.97E	1.55F	1.62G
T2	Calcium chloride ($CaCl_2$) 1 %.	39.50H	40.30G	4.16EF	4.30D	4.50C	4.53D	3.40B	3.60C
T3	Calcium chloride ($CaCl_2$) 2 %.	40.60G	40.80G	4.20E	4.32D	4.56C	4.58D	3.50B	4.00AB
T4	Calcium nitrate ($CaNO_3$) 1 %.	45.00D	45.00E	4.33DE	4.43D	4.58C	4.60D	3.00C	3.20D
T5	Calcium nitrate ($CaNO_3$) 2 %	44.70DE	45.58D	4.46D	4.47D	4.76B	4.83B	3.60AB	3.80BC
T6	Potassium silicate (K_2SiO_3) 1%.	42.00F	42.46F	4.23E	4.27DE	4.71B	4.73C	2.42D	2.48E
T7	Potassium silicate (K_2SiO_3) 2 %.	42.18F	42.70F	4.25E	4.30D	4.75B	4.79BC	2.55D	2.57E
T8	Mono-potassium (MKP) 1 %	47.16C	48.50C	4.70C	4.90C	4.80B	4.86B	2.00E	2.00F
T9	Mono-potassium (MKP)2%	49.00B	49.20B	5.00B	5.10B	4.95A	4.97A	2.40D	2.50E
T10	Mixture from ($CaCl_2$ 1.0 % + MKP 1%)	44.30E	44.80E	4.28DE	4.36D	4.56C	4.59D	3.50B	3.70C
T11	Mixture from ($CaCl_2$ 2 % + MKP 2%)	49.80A	50.50A	5.40A	5.60A	4.97A	5.00A	3.80A	4.20A

Means having the same letter(s) within the same column are not significantly differ at the probability of 5 % level according to Duncan's Multiple Range Test at 5 % level.

however leaf dry weight decreased with these treatments. On the other hand, Gislerod [44] mentioned that, foliar application with calcium is considered an alternative and prompt method to recover calcium deficiency.

Fruit Physical Characteristics: Data in Table (3) proved that, either mixed treatment (Calcium chloride and Mono potassium phosphate (MKP) at 2 %) significantly increased fruit weight, length and width followed by Mono potassium phosphate at 2 %. The highest significant of fruit firmness was noticed by the highest concentration of mixture in partnership with ($CaNo_3$) at 2% in the 1st season and ($CaCl_2$) in the 2nd season. In this concern, the opposite was clear with the control (untreated) as it recorded the lowest values. This may be due to K+ and Ca2+, ions are needed for cell division and cell expansion to ultimately control the growth Marschner, [20, 21]. These results corroborated other reports on fig fruits, i.e. Mimoun *et al*. [45] who reported that, potassium foliar application significantly increased fruit weight compared to the control. Moreover, Irget *et al*. [46] examined foliar application of Ca, K and K + Ca on fruit quality of Sarilop variety, Potassium application affected fruit size and firmness positively. In addition, spraying 1.0 % Ca increased fig fruit firmness and this proved when spraying calcium gave positive role in increasing of calcium pictat and fruit firmness because it plays an important role in strengthening the cell walls through its role in enhancing pectin coherence which increases the thickness of cell wall, which makes it more strength and stiffness to resist pectin analysis enzymes [47].

Retained Fruits, Dropping Percentage and Yield (Main Crop): Referring to Table (4), $CaNO_3$ at 2 %treatment significantly increased number of retained fig fruits and fruit yield/tree (18.3, 18.9 kg/tree) in both seasons, respectively followed by $CaCl_2$ 2% + MKP 2%. On the other hand, control treatment significantly induced the highest fruit dropping percentage. In this concern, fruit dropping (%) ranged from 8.0, 6.0 % by ($CaNO_3$) at 2% to reach 18.75, 17.50 % by control in both studied seasons.

Calcium sprays during fruit growth and development is an important issue in decreasing fruit drop and raising fruit retention as previously reported by Rizk-Alla and Meshreki [48]. Also, calcium is known to improve rigidity of cell walls and to obstruct enzymes such as polygalcturonase from reaching their active sites, thereby, retarding the occurrence of abscission zone [48, 49]. The increase in yield per tree was explained by reducing fruit drop and increasing fruit retention by calcium nitrate sprays. These results are consistent with the reports of Kumar *et al*. [50] and Hafle *et al*. [51] who reported that foliar spray of calcium nitrate at 2% recorded the highest number of fruits per tree. This might be due to that calcium sprays well maintained the middle lamella between plant cells which lead to decrease fruit drop [52].

Leaf Nutrients Content: Data in Table (5) illustrated that, spraying calcium nitrate ($CaNO_3$) 1 %, 2% led to a significant increase in content of leaves from nitrogen and phosphor. Also, mono-potassium (MKP) 2% either alone or mixed with $CaCl_2$ + MKP at 2 % significantly and effectively increased leaf content of potassium. Whereas, either ($CaCl_2$) at 2 % or ($CaNO_3$) at 2 % and a mixture from $CaCl_2$ 1 % + MKP 1% and a mixture from $CaCl_2$ 2 % + MKP 2% significantly recorded the highest values of calcium. Contrarily, the untreated trees produced the poorest leaves in leaves N, P, K and Ca. This was true in both studied seasons.

From the above mentioned results, it is obvious that spraying calcium or potassium increased N, P, K and Ca contents. The obtained results are in line with those reported by Abd El-Migeed [53] on Washington Navel orange trees who found potassium foliar sprays enhanced the levels of N, P and K in the leaves. Moon *et al*. [54] working on persimmon cv. Fuyu trees, they reported that calcium contents of leaf, fruit peel and flesh were increased by spraying $CaCO_3$.

Fruits Chemical Analysis:

K and Ca Content in Fruits: Data presented in Table (6) showed significantly increased fig fruits in potassium content. The highest results (0.87 and 0.87 %) were cleared in MKP (Mono potassium phosphate 2 %) followed by the treatments of MKP 1 % and mixture from $CaCl_2$ 2 % + MKP 2 %. On the other hand, the mixture of $CaCl_2$ 2% + MKP 2% lead to the highest significantly increased in calcium content of fig fruits (0.55 and 0.58%). While mixture from $CaCl_2$ 1% + MKP 1% and $CaCl_2$ 2% was the same effect and the fig fruit content with calcium. Whereas, the control trees produced the lowest records of K (0.40, 0.42) and Ca (0.28, 0.31) in both seasons, respectively. The obtained results are in line with those reported by Cooper *et al.* [55] and Koutinas *et al*. [56] on kiwifruit who found the K and Ca concentration of fruit increased by spraying different sources of K and Ca treatments compared to non-treated trees.

Assessment of Fruit Shelf Life

TSS and Acidity Contents: It is visible in Table (7) the effect of the present treatments on some chemical characteristics of cv. "Kadota before and after fruits storage. Mono-potassium (MKP) at 2% and a mixture from $CaCl_2$ 2% + MKP 2 % in both seasons in partnership with Mono-potassium (MKP) at 1% in the first season have significantly increased TSS before storage of fig fruits for 2 weeks. While, after storage of fig fruit the highest significant TSS was occurred by mixture from $CaCl_2$ 2% + MKP 2 % in both seasons in partnership with Mono-potassium (MKP) at 1 or 2% in the first season. On the other hand, the control trees produced the poorest fruits in TSS (%). Mono-potassium 1 % and 2 % significantly decreased fresh fruit acidity before and after storage. However, the untreated trees in both seasons also, that received-(K_2SiO_3) 1%.before storage and ($CaCl_2$) 1 % in the 1st season produced fruits rich in acidity (%).The control trees also was the highest in fruit acidity after storage. The possible reason of increase in TSS is adequate potassium nutrients to the plant, which hydrolyzed starch into sugar and helpful to increase the TSS of fruit. A higher increase in TSS content with foliar application of potassium is related with role of potassium in translocation of sugar from leaves to fruits, which results better quality fruits in term of total soluble solid.

Table 4: Effect of different sources of potassium and calcium minerals foliar application on retained fruits, yield (kg) and fruit dropping (%) of fig cv "Kadota" during 2015 and 2016 seasons

		Character					
		No. of retained fruits		Yield/tree (kg)		Fruit dropping (%)	
Treatments		2015	2016	2015	2016	2015	2016
T1	Control	303.0I	308.0I	10.75J	11.08I	18.75A	17.50A
T2	Calcium chloride ($CaCl_2$) 1 %	354.0E	358.0E	15.82F	16.31E	11.50F	10.50E
T3	Calcium chloride ($CaCl_2$) 2 %	357.0D	360.0D	16.24E	16.59D	10.75G	9.67F
T4	Calcium nitrate ($CaNO_3$) 1 %	363.0B	370.0B	17.11C	17.94B	9.25I	7.50H
T5	Calcium nitrate ($CaNO_3$) 2 %	368.0A	376.0A	18.30A	18.98A	8.00J	6.00I
T6	Potassium silicate (K_2SiO_3) 1%	348.0G	353.0F	13.74I	14.22H	13.00D	11.75D
T7	Potassium silicate (K_2SiO_3) 2 %	351.0F	357.0E	14.25G	14.56G	12.25E	10.75E
T8	Mono-potassium (MKP) 1 %	324.0H	326.0H	14.35G	14.60FG	14.25B	13.50B
T9	Mono-potassium (MKP)2%	325.0H	328.0G	13.97H	14.76F	13.75C	12.75C
T10	Mixture from ($CaCl_2$ 1.0 % + MKP 1%)	360.0C	367.0C	16.56D	17.32C	10.00H	8.25G
T11	Mixture from ($CaCl_2$ 2 % + MKP 2%)	362.0B	368.0C	17.73B	18.03B	9.50I	8.00G

Means having the same letter(s) within the same column are not significantly differ at the probability of 5 % level according to Duncan's Multiple Range Test at 5 % level.

Table 5: Effect of different sources of potassium and calcium minerals foliar application on leaf nutrients content of fig cv "Kadota" during 2015 and 2016 seasons

		Character							
		N (%)		P (%)		K (%)		Ca (%)	
Treatments		2015	2016	2015	2016	2015	2016	2015	2016
T1	Control	1.60G	1.72G	0.22E	0.25E	0.83D	0.86E	1.30D	1.40C
T2	Calcium chloride ($CaCl_2$) 1 %.	1.80F	1.84F	0.33D	0.35D	1.05C	1.07D	1.63AB	1.65A
T3	Calcium chloride ($CaCl_2$) 2 %.	1.83F	1.87F	0.34CD	0.36CD	1.00C	1.02D	1.64A	1.67A
T4	Calcium nitrate ($CaNO_3$) 1 %.	2.42A	2.43A	0.41AB	0.42AB	1.17B	1.20C	1.56BC	1.57B
T5	Calcium nitrate ($CaNO_3$) 2 %	2.45A	2.45A	0.45A	0.45A	1.15B	1.19C	1.57AC	1.60AB
T6	Potassium silicate (K_2SiO_3) 1%.	1.86EF	1.90F	0.36B-D	0.36CD	1.20B	1.22BC	1.53C	1.53B
T7	Potassium silicate (K_2SiO_3) 2 %.	1.97E	2.07E	0.39B	0.40BC	1.23B	1.25BC	1.56BC	1.57B
T8	Mono-potassium (MKP) 1 %	2.27BC	2.30BC	0.38BC	0.38BD	1.25B	1.29B	1.50C	1.53B
T9	Mono-potassium (MKP)2%	2.34AB	2.40AB	0.41AB	0.42AB	1.46A	1.47A	1.52C	1.54B
T10	Mixture from ($CaCl_2$ 1.0 % + MKP 1%)	2.2D	2.17DE	0.37B-D	0.38B-D	1.25B	1.26BC	1.61AB	1.64A
T11	Mixture from ($CaCl_2$ 2 % + MKP 2%)	2.20CD	2.23CD	0.39B	0.40BC	1.40A	1.44A	1.64A	1.66A

Means having the same letter(s) within the same column are not significantly differ at the probability of 5 % level according to Duncan's Multiple Range Test at 5 % level.

Table 6: Effect of different sources of potassium and calcium minerals foliar application on fig fruit nutrients contents cv."Kadota" during 2015 and 2016 seasons

		Character			
		K (%) in fruits		Ca (%) in fruits	
Treatments		2015	2016	2015	2016
T1	Control	0.40G	0.42E	0.28I	0.31I
T2	Calcium chloride ($CaCl_2$) 1 %.	0.58F	0.60D	0.48BC	0.49CD
T3	Calcium chloride ($CaCl_2$) 2 %.	0.64DE	0.64CD	0.52AB	0.54AB
T4	Calcium nitrate ($CaNO_3$) 1 %.	0.59F	0.61CD	0.43DE	0.43EF
T5	Calcium nitrate ($CaNO_3$) 2 %	0.62EF	0.62CD	0.44CD	0.46DE
T6	Potassium silicate (K_2SiO_3) 1%.	0.68CD	0.71B	0.38FG	0.38GH
T7	Potassium silicate (K_2SiO_3) 2 %.	0.70C	0.72B	0.39EF	0.40FG
T8	Mono-potassium (MKP) 1 %	0.82B	0.83A	0.33H	0.35HI
T9	Mono-potassium (MKP)2%	0.87A	0.87A	0.34GH	0.36GH
T10	Mixture from ($CaCl_2$ 1.0 % + MKP 1%)	0.65DE	0.65C	0.51AB	0.53BC
T11	Mixture from ($CaCl_2$ 2 % + MKP 2%)	0.82B	0.84A	0.55A	0.58A

Means having the same letter(s) within the same column are not significantly differ at the probability of 5 % level according to Duncan's Multiple Range Test at 5 % level.

Table 7: Effect of different sources of potassium and calcium minerals foliar application on fruits chemical characteristics before and after storage of cv."Kadota" during 2015 and 2016 seasons

Treatments		TSS (%) Before storage		TSS (%) After storage		Acidity (%) Before storage		Acidity (%) After storage	
		2015	2016	2015	2016	2015	2016	2015	2016
T1	Control	12.00D	13.20E	15.13G	15.70I	0.324AB	0.368A	0.385A	0.395A
T2	Calcium chloride ($CaCl_2$) 1 %.	15.50C	15.00D	17.30F	17.50H	0.315AB	0.330B	0.351BC	0.365B
T3	Calcium chloride ($CaCl_2$) 2 %.	15.60C	16.00D	18.00E	18.70G	0.276CD	0.268C	0.355AB	0.303D
T4	Calcium nitrate ($CaNO_3$) 1 %.	15.60C	16.00D	19.10D	19.40F	0.283CD	0.292B	0.315CD	0.335C
T5	Calcium nitrate ($CaNO_3$) 2 %	17.00B	17.50C	21.12B	21.50CD	0.291BC	0.300B	0.320CD	0.342C
T6	Potassium silicate (K_2SiO_3) 1%.	17.00B	18.00C	21.55B	22.00C	0.330A	0.370A	0.300D	0.342C
T7	Potassium silicate (K_2SiO_3) 2 %.	17.40B	18.00C	19.60D	20.00E	0.250DE	0.280BC	0.280D	0.310CD
T8	Mono-potassium (MKP) 1 %	19.50A	20.00B	22.80A	22.90B	0.211F	0.219D	0.230E	0.255E
T9	Mono-potassium (MKP)2%	19.70A	21.00A	23.00A	23.00B	0.200F	0.217D	0.210E	0.241EF
T10	Mixture from ($CaCl_2$ 1.0 % + MKP 1%)	17.00B	18.50C	20.30C	21.00D	0.220EF	0.237CD	0.200E	0.213F
T11	Mixture from ($CaCl_2$ 2 % + MKP 2%)	20.00A	21.50A	23.00A	24.00A	0.260CD	0.290B	0.220E	0.222F

Means having the same letter(s) within the same column are not significantly differ at the probability of 5 % level according to Duncan's Multiple Range Test at 5 % level.

A marked influence in total soluble solid by these nutrients (K and Ca) in current study is supported by Shirzadeh and Kazemi [57] in Apple, Dhatt and Mahajan [58] in Pear and Mahajan *et al.* [59] in plum. Otherwise, the decrease in the acidity might be due to reduction in the activities of enzyme by foliar application of potassium and calcium nutrients that increasing leaf content in nitrogen might have modified the vegetative growth, which in turn increase sugar metabolism and consequently decrease the acidity due to conversion of acid into sugar which resulted decrease in the acidity of fruits. The reduction in the acidity under potassium treatment might be owing to increased TSS of the fruits. Titratable acidity is directly related to the concentration of organic acids present in the fruit, which are an important parameter in maintaining the quality of fruits. These results also elucidate the finding of Gill *et al.* [60] in pear.

Total Sugars Content (%): Table (8) clears the effect of the present treatments on storage ability of fig fruits total sugars content. Generally, all treatments improved total sugar content. A mixture from $CaCl_2$ 2 % + MKP 2 % significantly increased total sugars content before and after storage fig fruits for two weeks in both seasons. While, the control fruits were the lowest. Whereas, the mixture from ($CaCl_2$ 1.0 % + MKP 1%) and Mono-potassium (MKP) 2% came the next significantly effect on total sugars content before storage. The possible reason for increase in total sugar content of fruits may be ascribed to hydrolysis of polysaccharides to simpler form, that is, mono and disaccharides and better transportation of nutrients to plant by potassium due to it important role in the transport of assimilates and nutrients to the plant from leaves to their place of utilization, which helps to increase availability of nutrition and conclusively better quality evolution in term of total sugar content of fruits. These results are in agreement with Kumar *et al.* [61] in grape, Bhat *et al*. [62] in pear, Kaur and Dhillon [63] in guava and Motty *et al.* [64] in apricot.

Fruit Decay and Fruit Weight Loss (%): It is cleared from Table (9) that both ($CaCl_2$) and ($CaNO_3$) at 2 % concentration decreased the percentage of fruit decay after 7 days. The previous treatments and ($CaNO_3$) at 1% were the best in decreasing decay % after 15 days of cold storage. Besides, the percentage fruit weight loss after 7 or 15 days of cold storage decreased by application of ($CaCl_2$) at 1 % and 2 %. Conversely, increasing values of fruit decay and fruit weight loss after 7 or 15 days of cold storage was consistent with the control (untreated) fruits. It is also clear that percentage of fruit decay and fruit weight loss clearly increased after 15 days than after 7 days of fruit storage at 5°C. Conway *et al*. [65] reported the effect of Ca in reducing decay and maintaining fruit quality is associates with maintaining cell wall structure by dealing or modifying chemical changes in cell wall composition. Also, the weight loss had correlation with respiration, transpiration rate and water pressure gradient between the tissue of fruit and storage temperature [66, 67]. The reduction of weight loss after Ca treatment is related to reduced respiration and transpiration temperature [66] as well as increased stability of cell walls and the stability of cell membranes [68]. In addition, Ca is an essential plant nutrient, since the divalent Ca is

Table 8: Effect of different sources of potassium and calcium minerals foliar application on fruit total sugars content before and after storage of cv."Kadota" during 2015 and 2016 seasons

		Character			
		T. sugars (%) before storage		T. sugars (%) after storage	
Treatments		2015	2016	2015	2016
T1	Control	10.00 G	10.66 H	12.60 H	13.00 H
T2	Calcium chloride ($CaCl_2$) 1 %.	11.50 E	12.40 G	15.00 G	15.30 G
T3	Calcium chloride ($CaCl_2$) 2 %.	12.10 E	13.30 F	15.50 F	18.00 E
T4	Calcium nitrate ($CaNO_3$) 1 %.	12.50 E	13.00 F	18.50 D	16.00 F
T5	Calcium nitrate ($CaNO_3$) 2 %	14.00 D	15.00 E	17.80 E	19.00 D
T6	Potassium silicate (K_2SiO_3) 1%.	15.00 C	16.50 D	18.80 CD	19.67 C
T7	Potassium silicate (K_2SiO_3) 2 %.	15.50 C	17.5 BC	19.00 C	19.7 C
T8	Mono-potassium (MKP) 1 %	16.50 B	17.00 CD	19.20 C	19.80C
T9	Mono-potassium (MKP) 2%	16.50 B	17.70 B	19.80 B	20.00 BC
T10	Mixture from ($CaCl_2$ 1.0 % + MKP 1%)	16.90 B	17.70 B	19.00 C	20.40 B
T11	Mixture from ($CaCl_2$ 2 % + MKP 2%)	17.50 A	18.33 A	20.50 A	21.50 A

Means having the same letter(s) within the same column are not significantly differ at the probability of 5 %level according to Duncan's Multiple Range Test at 5 % level.

Table 9: Effect of different sources of potassium and calcium minerals foliar application on fruit quality through storage: fruit decay % and fruit weight loss% of cv."Kadota" during 2015 and 2016 seasons

		Character							
		Decay (%) after 7 days		Decay (%) after 15 days		Weight loss (%) after 7 days		Weight loss (%) after 15 days	
Treatments		2015	2016	2015	2016	2015	2016	2015	2016
T1	Control	6.55A	5.95A	15.55A	15.34A	3.65A	3.55A	8.57A	8.47A
T2	Calcium chloride ($CaCl_2$) 1 %.	3.95D	3.75F	10.53E	10.44F	1.80E	1.77E	5.25G	5.00G
T3	Calcium chloride ($CaCl_2$) 2 %.	3.51G	3.48H	10.32EF	10.20G	1.85DE	1.80E	5.40FG	5.32F
T4	Calcium nitrate ($CaNO_3$) 1 %.	3.70EF	3.64FG	10.40EF	10.22G	2.01D	1.97D	5.56EF	5.52E
T5	Calcium nitrate ($CaNO_3$) 2 %	3.60FG	3.55GH	10.20F	10.05G	1.87DE	1.84E	5.50F	5.45EF
T6	Potassium silicate (K_2SiO_3) 1%.	4.50C	4.30D	13.20C	13.00C	2.25C	2.24C	6.90D	6.83D
T7	Potassium silicate (K_2SiO_3) 2 %.	4.03D	3.95E	13.07C	12.81C	2.26C	2.15C	6.82D	6.75D
T8	Mono-potassium (MKP) 1 %	4.85B	4.71B	13.55B	13.40B	2.43B	2.37B	7.57B	7.47B
T9	Mono-potassium (MKP)2%	4.60C	4.55C	13.26C	13.00C	2.22C	2.20C	7.27C	7.07C
T10	Mixture from ($CaCl_2$ 1.0 % + MKP 1%)	3.80E	3.75F	11.23D	11.20D	1.87DE	1.82E	5.70E	5.62E
T11	Mixture from ($CaCl_2$ 2 % + MKP 2%)	3.74E	3.60GH	11.10D	11.00E	1.84DE	1.80E	5.55EF	5.46EF

Means having the same letter(s) within the same column are not significantly differ at the probability of 5 % level according to Duncan's Multiple Range Test at 5 % level.

required for structural roles in the cell wall and membranes, as a counter-cation and as an intracellular messenger in the cytosol. Ca readily enters the apoplasm and is bound in an exchangeable form to cell walls and to the exterior surface of the plasma membrane [69]. The main reasons by which preharvest Ca reduces fruit weight loss are closely related to the increased Ca bound to the cell wall [66]. The obtained results are in this concept go in line with findings of Choudhury *et al*. [70] on Sapota cv. Serrano *et al*. [71] on peaches and nectarines. They realized that the loss in fruit weight during storage of peaches was greatly reduced due to pre-harvest sprays of calcium in the form of calcium chloride at or calcium nitrate.

Economic Study (Feddan): It can be shown from the data presented in Table (10) that, all treatments gave better net profit than the control. In this concern, the maximum net

Table 10: Economic evaluation on Kadota fig trees sprayed by different resources of calcium and potassium

Treatments	Yield (Ton/Fed)	Cross income / treatment (EPG/Fed)	Price of Spraying /Fed	Fixed cost /Fed	Total cost (LE)	Net profit (LE)/Fed
Control	2.292	16045	----	12000	12000	4045.1
Calcium chloride ($CaCl_2$) 1 %.	3.374	23616	31.86	12000	12031.86	11583.7
Calcium chloride ($CaCl_2$) 2 %.	3.447	24130	63.72	12000	12063.72	12066.3
Calcium nitrate ($CaNO_3$) 1 %.	3.680	25762	23.88	12000	12023.88	13737.9
Calcium nitrate ($CaNO_3$) 2 %	3.914	27401	47.79	12000	12047.79	15353.0
Potassium silicate (K_2SiO_3) 1%.	2.936	20551	63.72	12000	12063.72	8486.9
Potassium silicate (K_2SiO_3) 2 %.	3.025	21175	127.47	12000	12127.47	9047.9
Mono-potassium (MKP) 1 %	3.040	21278	31.86	12000	12031.86	9246.4
Mono-potassium (MKP)2%	3.017	21117	63.72	12000	12063.72	9052.8
Mixture from ($CaCl_2$ 1.0 % + MKP 1%)	3.557	24902	95.58	12000	12095.58	12806.2
Mixture from ($CaCl_2$ 2 % + MKP 2%)	3.755	26284	191.16	12000	12191.16	14092.4

profit/Fed. was registered in ascending order by ($CaNO_3$) 1% (13737.9 LE); ($CaCl_2$) 2% + (MKP) 2% (14092.4 LE) and ($CaNO_3$) 2% (15353.0 LE). However, the minimum net profit/Fed. was recorded in the untreated trees (4045.1L.E). The highest production was consistent with the treatment of calcium nitrate ($CaNO_3$) 2% (3.91 ton/fed.) and the lowest with the control (2.29 ton/fed).

RECOMMENDATION

Hence, we can recommend from this study for fig growers to spray their trees with Calcium nitrate ($CaNO_3$) 2 %, 4/L for each/tree, three times/season at (1st of May, 1st of June and 1st of July) to stimulate vegetative growth, leaf mineral status, fruit yield, fruit quality as well as decrease fruit decay and fruit weight loss after cold storage at 5°C for 15 days. In addition to improving fruit quality and yield with this transaction it lead to increasing the net profit for farmer.

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