EFFECT OF SPRAYING USING SOME CALCIUM SOURCES ON PRODUCTIVITY AND FRUIT QUALITY OF POMEGRANATE TREES (*PUNICA GRANATUM* L.)

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This investigation aimed to study the effect of spraying by some calcium sources on productivity and quality of pomegranate fruits. The experiment was, arranged in a split-plot design on Wonderful cv. of pomegranate trees grown at Hegazy private orchard located at kilo 57 west of Cairo-Alexandria desert road, Giza governorate,de Egypt during two successive seasons of 2019 and 2020. All spraying treatments with calcium gave positive results in terms of vegetative growth and productivity, whether it was sprayed once every week, two weeks, or three weeks during the stage of complete growth to maturity from mid of May until mid of August in both seasons, compared to the control treatments that were treated with water only. On the other hand, all the tested applications significantly increased the growth of trees as well as significantly improved the yield and fruit quality and reduced the unmarketable fruit and cracking percentage. Spraying calcium nitrate at 4% sprayed once weekly gave the highest values of growth traits, yield and fruit quality. It is recommended to spray Wonderful pomegranate trees with calcium sources once a week to get better vegetative growth, high yield with good fruit quality.

Keywords: Wonderful pomegranate, *Punica granatum*, calcium sources, productively, fruit quality

INTRODUCTION

Pomegranate (*Punica granatum* L.), a lovable fruit and ornamental of Mediterranean cultivation, it is considered as substantial minerals and one of the most suitable fruits of tropical and sub-tropical regions. The acceptability of a pomegranate to the consumer and processor depends on a combination of several quality attributes that are related to physicochemical and mechanical properties such as attractive skin, small seeds in the aril, skin color, smoothness, sugar, vitamin C, anthocyanin contents and free of cracking, as well as fruit sunburn incidence, which cause dark-brown to black discoloration of the

affected skin area (Al-Said et al., 2009). In Egypt, the total area of pomegranate trees was reached 79893 feddan and produced about 672827 tons. El-Nobaria city is considered the main cultivated area 57455 feddan producing about 415803 ton according to M.A.L.R. (2021).

Reducing pomegranate production due to cracking the fruit is very high. This problem is due to improper water management and deficiency of micronutrients. Fruit cracking is one of the main problems facing pomegranate producers. It resulted in huge losses to farmers by reducing the total yield to 30-50%. It also resulted in a significant deterioration in fruit quality leading to a non-marketable yield (Singh and Kingsly, 2006). Plant nutrients foliar spraying has many beneficial effects on pomegranate therefore, foliar sprays of nutrients in adequate quantity should be applied at appropriate times for optimum growth, yield, fruit quality, and control of fruit cracking. Foliar application has the advantage of a regular divide of fertilizer materials and quick response (El-Salhy et al., 2022). The 4% calcium nitrate application reduced the sunburn in the pomegranate fruits and the 2% calcium nitrate application increased the amount of the total soluble solids (TSS) (Korkmaz et al., 2016).

Calcium treatment was the most effective for improving fruit qualitative characteristics including TSS and reducing the cracking disorder (Hosein-Beigi et al., 2019). The application of calcium to fruits protects against physiological deterioration, retardation of maturity, and improvement of fruit quality (Irfan et al., 2013). Calcium plays an important role in regulating the absorption of water by plant roots. Calcium treatments have been reported to reduce the cracking in pomegranate (Sharma and Belsare, 2011 and El-Akkad et al., 2016). Foliar sprays of calcium improved the yield and fruit quality and reduced fruit cracking thus resulting in significantly increased economic returns (Sheikh and Manjula, 2012; Goargious, 2016; Korkmaz et al., 2016 and Morwal and Das, 2021). Calcium chloride alone or in combination enhanced vegetative growth parameters, yield, fruit quality traits and reducing fruit cracking and sunburn damage through increasing vegetative development and thereby improving protection of the fruits from direct sunlight and the role of calcium in controlling physiological disorders of fruit (Bakeer, 2016). Moreover, Al-Hmadawi et al. (2011) mentioned that trees were sprayed with calcium chloride and GA_3 in single way or combined together with nitrogen produced a significant increase in leaf area and total chlorophyll. In addition, the foliar spray of nitrogen contributed in building new chlorophyll molecule primary, which led to increasing leaf total chlorophyll content (Johnson et al., 2005 and Ramezanian et al., 2009).

This investigation aimed to study the effect of spraying some calcium sources on productivity and quality of Wonderfull cv. of pomegranate fruits (*Punica granatum* L.).

MATERIALS AND METHODS

The study has been conducted (2019 and 2020) on Wonderful cultivar grown in a private farm located at Kilo 57 west of Cairo Alex. desert road, Egypt. The pomegranate plants were 5 years old and planted with 3 × 3 meters between and within rows. This experiment consists of seven spraying treatments; 1- Control (water only), 2- Calcium nitrate at 2%, 3- Calcium nitrate at 4%, 4- Calcium carbonate at 2%, 5- Calcium carbonate at 4%, 6- Calcium chloride at 2%, 7–Calcium chloride at 4% the spraying of this treatments starting from mid-May until mid-August, and the spraying was repeated (once every week - once every two weeks - once every three weeks), the experiment was designed as a split-plot design provided that the number of spraying times in the main plot and the spraying treatments are in the subplot. Each treatment replicated three with two trees in each replicate. The trees were irrigated by a drip irrigation system and received all the recommended horticultural practices.

At harvest time (1st of October), some fruits from each tree were taken as samples to determine the effect of the studied the treatments were evaluated through the following parameters:

The area of leaves was determined by using portable area planimeter Mod Li-3100C Area Meter (Li-Cor), total chlorophyll contents by using Minolta chlorophyll meter SPAD- 502 minolta- was read (as an indication for chlorophyll content), and leaf dry weight percentage was determined. At the harvest time in both seasons, yield/tree (kg) was calculated as $\text{No. of fruit per tree } X \text{ fruit average weight.}$ Marketable fruit percentage and unmarketable fruit percentage were estimated as follow:

Marketable and Unmarketable fruits according to Hegazi et al. (2014).

$$\text{Marketable fruits \%} = \frac{\text{Total No. of fruits} - (\text{No. of cracked} + \text{sunburn fruits})}{\text{Total No. of fruits}} * 100$$

$$\text{Unmarketable fruits \%} = \frac{\text{No. of cracked} + \text{sunburn fruits}}{\text{Total No. of fruits}} * 100$$

$$\text{Fruit cracking \%} = \frac{\text{No. of cracked fruits}}{\text{Total no. of fruits}} * 100$$

Five fruits per each labeled branch from four directions of each tree were randomly selected for carrying out the fruit quality, including the following parameters: fruit weight (g), fruit length (cm) and fruit width (cm) according to (A.O.A.C., 2005). Also, fruit peel (%), fruit aril (%) and weight of 100 aril (g) and volume juice (ml). Total soluble solids (TSS) content was tested using a hand refractometer, total acidity as a percentage and TSS/acid

ratio were estimated according to A.O.A.C. (2005). Vitamin C (V.C) was determined by titration with chlorophenol indophenol blue dye and expressed as mg vitamin C /100 ml juice. Also, total anthocyanin content in fruit juice was determined as described by Rabino and Mancinelli (1986). All the obtained data during both the 2019 and 2020 experimental seasons were subjected to analysis of variances (ANOVA) according to Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

1. Effect on Some Growth Parameters

Data represented in Table (1) illustrate the effect of different sources of calcium, number of spraying times and their interaction on some growth parameters of Wonderful pomegranate in 2019 and 2020 seasons.

Leaf area was affected significantly by calcium sources during the two growing seasons trees received foliar spray with calcium nitrate at 4% gained the highest leaf area (5.31 and 5.03 cm^2) in both seasons, respectively. As for number of spraying times pomegranate tress sprayed once every one week or once every two weeks achieved the highest leaf area in the first season. Moreover, in the second season, trees sprayed once every week gave the highest leaf area. Concerning the interaction, pomegranate trees sprayed with calcium nitrate at 4% once every week or once every two weeks showed a prominent significant increase in leaf area (5.52 and 5.26 cm^2) in the first season compared with control and other treatments. Furthermore, trees sprayed with calcium nitrate at 4% once every week had the highest value (5.53 cm^2) in the second season.

Data obvious that, values of total chlorophyll and leaf dry matter percentage were affected significantly by calcium sources in both seasons. Wonderful pomegranate trees sprayed with the highest rate of calcium nitrate at 4% recorded the highest values of total chlorophyll (64.2 and 61.2%) and leaf matter percentage (60.19 and 58.55%). On the contrary, untreated trees achieved the lowest values in the two seasons. Concerning the number of spraying times data clarify that, trees sprayed once a week gained the highest significant leaf total chlorophyll in both seasons and the highest leaf dry matter percentage in the second season only. Moreover, trees sprayed once every one week or once every two weeks exhibited the highest leaf dry matter in the first season. As for the interaction, the greatest significant leaf total chlorophyll was recorded by spraying trees once every week with calcium nitrate at 4% in both seasons. Meanwhile spraying trees once every week with calcium nitrate at 4% achieved the highest leaf dry matter percentage in the second season only. Furthermore, in the first season treatment of calcium nitrate at 4% sprayed once every week, once every two weeks had the highest leaf dry matter percentage as compared to untreated trees and other treatments.

The superior performance of calcium included treatments against control might be because of the nitrogen present in calcium nitrate, which resulted in the lush growth of pomegranate plants. Thus helping the plants to grow and develop their leaves, stems, and other vegetative components (Bloom, 2015). Calcium is essential for proper cell division, cell elongation, and cell wall formation promoting tissue development and growth (Naser, 2021). These results are in harmony with those obtained by El-Salhy et al. (2022), who found that calcium and boron sprayed significantly increased the growth of pomegranate trees. Plant nutrients foliar spraying has many beneficial effects on pomegranate therefore; foliar sprays of nutrients in adequate quantity should be applied at appropriate time for optimum growth. Foliar application has the advantage of regular division of fertilizer materials and quick response. Also, Al-rawi et al. (2014) found that spraying Salemy pomegranate cv. with $CaCl_2$ at 100 ppm in the last week of May and first week of June increased leaf area (cm^2) as compared with control. While El-Said (2015) demonstrated that, foliar applications with kaolin and $CaCO_3$ significantly increased vegetative growth characteristics.

2.Yield and its Components

Data regarding yield and its components shown in Table (2) clear that, the number of fruits/tree; fruit weight (g) and yield/tree (kg) were significantly affected by different calcium sources, the number of spraying times and their interaction in the two seasons.

As for different calcium sources, it could be revealed that spraying Wonderful pomegranate trees with calcium nitrate at 4% in the two seasons or calcium chloride at 4% in the second season showed a prominent significant increase in number of fruits/tree (61.2, 52.2 and 51.6), fruit weight (351.9, 291.6 and 280.9 g) and yield/tree (21.42, 14.85 and 14.58 kg). with respect to the number of spraying times, it is obvious that, in most cases in both seasons, spraying the trees once weekly proved to give the highest significant number of fruits/tree (52.1 and 52.6), fruit weight (301.9 and 290.1) and yield/tree (15.96 and 15.32). Concerning the interaction, the least significant values of all characters were given by unsprayed trees (control) under all number of spraying times. On the contrary, a significant effect was found on yield and its components due to spraying trees with calcium nitrate at 4% in both seasons or calcium chloride at 4% in the second season once weekly resulted in the highest number of fruits/tree (69.3, 57.7 and 56.0), fruit weight (372.3, 328.3 and 316.0 g) and yield/tree (25.40, 18.44 and 17.75 kg).

3. Effect on Some Fruit Quality Properties

Data in Table (3) demonstrate that, different calcium sources, number of spraying times, and their interaction affected marketable fruits percentage, unmarketable fruits percentage and fruit cracking percentage in the two seasons of 2019 and 2020.

Regardless of marketable fruits percentage, it is obvious that as for calcium sources, data clarify that, calcium nitrate at 4% in both seasons or calcium chloride at 4% in the second season gained the highest significant marketable fruits percentage (87.4-84.6 and 83.6%) in both seasons, respectively.

Table (1). Effect of calcium spraying; the interval between sprays and their interaction on leaf area (cm^2), total chlorophyll, leaf dry mater (%) and leaf Calcium content of Wonderful cv. pomegranate trees during 2018 and 2019 seasons.

Treatment	One week	Two weeks	Three weeks	Mean	One week	Two weeks	Three weeks	Mean
	Leaf area (cm^2)							
	1st Season				**2nd Season**			
Control	4.28^{hi}	4.27^{hi}	4.08^{i}	**4.21^{D}**	4.17^{ij}	4.14^{ij}	3.97^{i}	**4.09^{E}**
2% Ca $(NO_3)_2$	4.89^{b-f}	4.83^{c-f}	4.79^{c-f}	**4.84^{BC}**	4.98^{b}	4.87^{b-e}	4.37^{hi}	**4.74^{BC}**
4% Ca $(NO_3)_2$	5.52^{a}	5.26^{ab}	5.14^{a-c}	**5.31^{A}**	5.53^{a}	4.93^{bc}	4.62^{e-g}	**5.03^{A}**
2% $CaCO_3$	4.53^{f-h}	4.40^{g-i}	4.28^{hi}	**4.40^{D}**	4.94^{b}	4.65^{d-f}	4.17^{h-j}	**4.59^{D}**
4% $CaCO_3$	4.78^{c-g}	4.77^{c-g}	4.71^{d-g}	**4.75^{BC}**	5.03^{b}	4.88^{b-d}	4.38^{g-i}	**4.76^{BC}**
2% $CaCl_2$	4.71^{d-g}	4.70^{e-g}	4.58^{e-h}	**4.66^{C}**	4.98^{b}	4.67^{c-f}	4.33^{hi}	**4.66^{CD}**
4% $CaCl_2$	5.09^{b-d}	4.91^{b-e}	4.90^{b-f}	**4.97^{B}**	5.07^{b}	4.93^{bc}	4.42^{f-h}	**4.81^{B}**
Mean	**4.83^{A}**	**4.73^{AB}**	**4.64^{B}**		**4.96^{A}**	**4.72^{B}**	**4.32^{C}**	
	Leaf total chlorophyll							
	1st Season				**2nd Season**			
Control	46.3^{h}	45.9^{h}	45.4^{h}	**45.8^{F}**	49.0^{h-j}	47.9^{ij}	46.2^{j}	**47.7^{D}**
2% Ca $(NO_3)_2$	60.7^{b-d}	60.6^{cd}	58.8^{de}	**60.0^{B}**	64.5^{ab}	56.3^{cd}	51.8^{f-h}	**57.5^{C}**
4% $Ca(NO_3)_2$	67.1^{a}	63.1^{b}	62.4^{bc}	**64.2^{A}**	66.5^{a}	63.0^{b}	54.1^{d-g}	**61.2^{A}**
2% $CaCO_3$	54.8^{fg}	54.7^{fg}	53.5^{g}	**54.3^{E}**	63.9^{ab}	54.9^{d-f}	50.9^{g-i}	**56.6^{C}**
4% $CaCO_3$	58.7^{de}	58.4^{de}	58.0^{e}	**58.4^{C}**	66.1^{ab}	56.8^{cd}	52.2^{e-h}	**58.4^{BC}**
2% $CaCl_2$	57.5^{e}	56.4^{ef}	54.9^{fg}	**56.3^{D}**	64.4^{ab}	55.6^{de}	51.2^{g-i}	**57.0^{C}**
4% $CaCl_2$	62.2^{bc}	60.8^{b-d}	60.7^{b-d}	**61.2^{B}**	66.4^{ab}	59.2^{c}	53.8^{d-g}	**59.8^{AB}**
Mean	**58.2^{A}**	**57.1^{B}**	**56.2^{C}**		**63.0^{A}**	**56.2^{B}**	**51.5^{C}**	
	Leaf dry mater (%)							
	1st Season				**2nd Season**			
Control	53.52^{i}	53.61^{i}	52.71^{i}	**53.28^{F}**	51.76^{jk}	50.74^{k}	50.12^{k}	**50.87^{E}**
2% Ca $(NO_3)_2$	59.49^{a-d}	59.40^{a-d}	59.13^{b-e}	**59.34^{B}**	58.99^{bc}	57.87^{c-e}	54.72^{g-i}	**57.19^{BC}**
4% Ca $(NO_3)_2$	60.30^{a}	60.18^{a}	60.10^{a}	**60.19^{A}**	60.83^{a}	58.50^{b-d}	56.31^{e-h}	**58.55^{A}**
2% $CaCO_3$	56.25^{g}	55.80^{c-f}	55.20^{h}	**55.75^{E}**	58.52^{b-d}	56.45^{e-g}	53.40^{ij}	**56.12^{D}**
4% $CaCO_3$	58.80^{c-f}	58.80^{c-f}	58.67^{d-f}	**58.76^{C}**	59.40^{a-c}	57.90^{c-e}	54.87^{g-i}	**57.39^{BC}**
2% $CaCl_2$	58.20^{ef}	58.20^{ef}	58.17^{f}	**58.19^{D}**	58.80^{bc}	57.00^{d-f}	54.60^{hi}	**56.80^{CD}**
4% $CaCl_2$	60.00^{ab}	59.70^{a-c}	59.13^{b-e}	**59.61^{B}**	59.70^{ab}	58.50^{b-d}	55.50^{f-h}	**57.90^{AB}**
Mean	**58.08^{A}**	**57.96^{A}**	**57.59^{B}**		**58.29^{A}**	**56.71^{B}**	**54.22^{C}**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

Table (2). Effect of calcium spraying; the interval between sprays and their interaction on no. of fruits/ tree, fruit weight (g) and yield/tree (kg) of Wonderful cv. pomegranate trees during 2018 and 2019 seasons.

Treatment	One week	Two weeks	Three weeks	Mean	One week	Two weeks	Three weeks	Mean
	No. of fruits/ tree							
	1st Season				**2nd Season**			
Control	41.7^{jk}	38.3^{k}	38.0^{k}	**39.3^{F}**	44.3^{g-i}	42.7^{hi}	42.3^{i}	**43.1^{C}**
2% Ca $(NO_3)_2$	52.3^{c-e}	52.3^{c-e}	52.3^{c-e}	**52.3^{C}**	52.7^{bc}	48.7^{d-f}	46.0^{f-h}	**49.1^{B}**
4% Ca $(NO_3)_2$	69.3^{a}	57.3^{b}	57.0^{b}	**61.2^{A}**	57.7^{a}	50.7^{c-e}	48.3^{d-f}	**52.2^{A}**
2% $CaCO_3$	46.0^{hi}	45.0^{h-j}	44.0^{ij}	**45.0^{E}**	51.7^{cd}	48.3^{d-f}	45.7^{f-i}	**48.6^{B}**
4% $CaCO_3$	51.7^{c-f}	51.3^{d-f}	50.0^{e-g}	**51.0^{C}**	53.0^{bc}	49.0^{d-f}	46.7^{fg}	**49.6^{B}**
2% $CaCl_2$	48.3^{f-h}	48.0^{f-h}	47.3^{g-i}	**47.9^{D}**	52.7^{bc}	48.0^{ef}	45.7^{f-i}	**48.8^{B}**
4% $CaCl_2$	55.3^{bc}	54.7^{b-d}	54.7^{b-d}	**54.9^{B}**	56.0^{ab}	51.0^{c-e}	47.7^{e-g}	**51.6^{A}**
Mean	**52.1^{A}**	**49.6^{B}**	**49.0^{B}**		**52.6^{A}**	**48.3^{B}**	**46.0^{C}**	
	Fruit weight (g)							
	1st Season				**2nd Season**			
Control	218.0^{j}	213.0^{j}	208.0^{j}	**213.0^{F}**	192.3^{ij}	189.3^{ij}	172.0^{j}	**184.6^{E}**
2% Ca $(NO_3)_2$	310.7^{c-f}	308.7^{c-f}	308.0^{c-g}	**309.1^{BC}**	309.3^{ab}	260.0^{de}	216.7^{fg}	**262.0^{C}**
4% Ca $(NO_3)_2$	372.3^{a}	343.7^{ab}	339.7^{bc}	**351.9^{A}**	328.3^{a}	290.0^{bc}	256.3^{e}	**291.6^{A}**
2% $CaCO_3$	275.7^{gh}	258.0^{hi}	240.3^{ij}	**258.0^{E}**	284.0^{c}	252.0^{ef}	198.3^{hi}	**244.8^{D}**
4% $CaCO_3$	307.3^{c-g}	305.3^{d-g}	299.7^{e-g}	**304.1^{CD}**	310.7^{ab}	281.0^{cd}	234.7^{fg}	**275.4^{B}**
2% $CaCl_2$	293.0^{fg}	287.3^{f-h}	286.0^{f-h}	**288.8^{D}**	290.3^{bc}	254.7^{ef}	198.7^{hi}	**247.9^{D}**
4% $CaCl_2$	336.0^{b-d}	325.7^{b-e}	317.0^{b-f}	**326.2^{B}**	316.0^{a}	281.0^{cd}	245.7^{ef}	**280.9^{AB}**
Mean	**301.9^{A}**	**291.7^{AB}**	**285.5^{B}**		**290.1^{A}**	**258.3^{B}**	**217.5^{C}**	
	Yield/tree (kg)							
	1st Season				**2nd Season**			
Control	9.05^{lm}	8.20^{m}	7.89^{m}	**8.38^{F}**	8.41^{jk}	8.05^{jk}	7.46^{k}	**7.97^{E}**
2% Ca $(NO_3)_2$	16.23^{e-g}	15.95^{fg}	16.19^{e-g}	**16.12^{C}**	16.23^{b}	12.67^{ef}	9.88^{hi}	**12.93^{C}**
4% Ca $(NO_3)_2$	25.40^{a}	19.68^{b}	19.19^{bc}	**21.42^{A}**	18.44^{a}	14.32^{cd}	11.79^{fg}	**14.85^{A}**
2% $CaCO_3$	12.57^{ij}	11.07^{jk}	10.58^{kl}	**11.41^{D}**	14.61^{cd}	12.11^{f}	9.03^{ij}	**11.92^{D}**
4% $CaCO_3$	15.87^{fg}	15.88^{fg}	14.95^{gh}	**15.57^{C}**	16.48^{b}	13.48^{de}	10.88^{gh}	**13.61^{B}**
2% $CaCl_2$	14.12^{hi}	13.80^{hi}	13.60^{hi}	**13.84^{D}**	15.30^{bc}	12.18^{f}	9.04^{ij}	**12.17^{D}**
4% $CaCl_2$	18.46^{b-d}	17.75^{c-e}	17.26^{d-f}	**17.83^{B}**	17.75^{a}	14.26^{cd}	11.73^{fg}	**14.58^{A}**
Mean	**15.96^{A}**	**14.62^{B}**	**14.24^{B}**		**15.32^{A}**	**12.44^{B}**	**9.97^{C}**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

Concerning the number of spraying times, spraying trees once a week resulted in the highest marketable fruit percentage (82.0-84.4%) in both seasons, respectively. With respect to the interaction, pomegranate trees sprayed with calcium nitrate at 4% once a week or once every two weeks exhibited higher values (88.2-87.2%) in the first season. While in the second season, trees sprayed with calcium nitrate at 4% or calcium chloride at 4% once a

week gave higher significant values (87.6- 85.7). On the contrary, untreated trees achieved the lowest values (70.5-77.6%) in both seasons, respectively.

Concerning unmarketable and cracking fruits percentages, data revealed that values of unmarketable and cracking fruits percentages were significantly affected by calcium sources. Spraying pomegranate trees with calcium nitrate at 4% showed a prominent decrease in both characters (12.6, 15.4-6.89 and 5.91%) in the first and second seasons, respectively than untreated trees which gave the highest values. With respect to the number of spraying times, the least significant unmarketable and cracking fruits percentage was recorded by spraying trees once a week (18.0, 15.6-8.72 and 5.89) in two studies seasons, respectively. Regarding the combination of the two factors, it could be observed that spraying trees with calcium nitrate at 4 % once a week in both seasons or once every two weeks in the first season resulted in the lowest unmarketable fruit percentage (11.8 and 12.8-12.4%). Also, treatment of calcium nitrate at 4% once a week gained the lowest cracking percentage (5.30-4.84%) in both seasons, respectively. On the other hand, untreated trees had the highest values in both seasons.

These results are in full agreement with those obtained by Bakeer (2016), Korkmaz et al. (2016) and El-Salhy et al. (2022). These proved that calcium chloride alone or in combination enhanced vegetative growth parameters, yield, fruit quality traits and reducing fruit cracking and sunburn damage through increasing vegetative development and thereby improve the protection of the fruits from direct sunlight and the role of calcium in controlling physiological disorders of fruit. Moreover, foliar sprays of calcium improved the yield and fruit quality and reduced fruit cracking thus resulting in significantly increased economic returns (Sheikh and Manjula, 2012; Goargious, 2016; Korkmaz et al., 2016; Masoud et al., 2018 and Morwal and Das, 2021).

4. Effect on Fruit Physical Properties

Data in Tables (4 and 5) represent the effect of different sources of calcium, the number of spraying times and their interaction on some fruit physical properties of Wonderful pomegranate cv. in 2019 and 2020 seasons.

As for fruit length and fruit diameter, it could be noticed that, as for calcium sources data showed that, pomegranate trees received foliar spray with calcium nitrate at 4% recorded the highest values (8.03, 7.47-8.67 and 8.18 cm) in both studies seasons, respectively. Concerning the number of spraying times, spraying trees once every week exhibited the highest fruit length and fruit diameter (7.49, 7.57-8.26 and 8.24 cm) in the first and second seasons, respectively. With respect to the interaction, data illustrate that, spraying trees with calcium nitrate at 4% once every week or once every two weeks achieved higher fruit length and fruit diameter in the first season (8.23, 8.07-8.83 and 8.63 cm) as compared with untreated trees which gained the lowest values (5.90-7.13 cm). Moreover, in the second season, treatment of

calcium nitrate at 4% or calcium chloride at 4% once a week gained higher fruit length and fruit diameter (8.07, 7.97-8.63 and 8.47 cm).

Table (3). Effect of calcium spraying; the interval between sprays and their interaction on marketable fruits %, unmarketable fruits % and cracking fruits % of Wonderful cv. pomegranate trees during 2018 and 2019 seasons.

Treatment	One week	Two weeks	Three weeks	Mean	One week	Two weeks	Three weeks	Mean
	Marketable fruits %							
	1st Season				**2nd Season**			
Control	72.8^{k}	72.1^{k}	70.5^{k}	**71.8^{G}**	78.4^{gh}	78.0^{h}	77.6^{h}	**78.0^{D}**
2% Ca $(NO_3)_2$	84.6^{cd}	83.1^{de}	82.7^{d-f}	**83.5^{C}**	85.0^{a-c}	82.9^{b-e}	80.3^{e-h}	**82.7^{BC}**
4% Ca $(NO_3)_2$	88.2^{a}	87.2^{ab}	86.8^{a-c}	**87.4^{A}**	87.6^{a}	84.3^{b-d}	81.8^{d-f}	**84.6^{A}**
2% $CaCO_3$	79.0^{hi}	77.2^{ij}	75.6^{j}	**77.3^{F}**	84.5^{b-d}	81.8^{d-f}	78.4^{gh}	**81.5^{C}**
4% $CaCO_3$	82.3^{d-g}	81.0^{e-h}	80.5^{f-h}	**81.3^{D}**	85.1^{a-c}	83.3^{b-e}	80.6^{e-h}	**83.0^{A-C}**
2% $CaCl_2$	80.4^{f-h}	79.8^{g-i}	79.0^{hi}	**79.7^{E}**	84.7^{a-d}	82.2^{c-f}	79.7^{f-h}	**82.2^{BC}**
4% $CaCl_2$	86.7^{a-c}	84.7^{b-d}	84.6^{cd}	**85.3^{B}**	85.7^{ab}	84.1^{b-d}	81.0^{e-g}	**83.6^{AB}**
Mean	**82.0^{A}**	**80.7^{B}**	**80.0^{B}**		**84.4^{A}**	**82.4^{B}**	**79.9^{C}**	
	Unmarketable fruits %							
	1st Season				**2nd Season**			
Control	27.2^{a}	27.9^{a}	29.5^{a}	**28.2^{A}**	21.6^{a-c}	22.0^{ab}	22.4^{a}	**22.0^{A}**
2% Ca $(NO_3)_2$	15.4^{h-j}	16.9^{gh}	17.3^{f-h}	**16.5^{E}**	15.0^{g-i}	17.1^{e-h}	19.7^{a-e}	**17.3^{BC}**
4% Ca $(NO_3)_2$	11.8^{k}	12.8^{jk}	13.2^{i-k}	**12.6^{G}**	12.4^{i}	15.7^{f-h}	18.2^{d-f}	**15.4^{D}**
2% $CaCO_3$	21.0^{cd}	22.8^{bc}	24.4^{b}	**22.7^{B}**	15.5^{f-h}	18.2^{d-f}	21.6^{a-c}	**18.5^{B}**
4% $CaCO_3$	17.7^{e-h}	19.0^{d-g}	19.5^{d-f}	**18.7^{D}**	14.9^{g-i}	16.7^{e-h}	19.4^{b-e}	**17.0^{B-D}**
2% $CaCl_2$	19.6^{d-f}	20.2^{c-e}	21.0^{cd}	**20.3^{C}**	15.3^{f-i}	17.8^{d-g}	20.3^{a-d}	**17.8^{BC}**
4% $CaCl_2$	13.3^{i-k}	15.3^{h-j}	15.4^{hi}	**14.7^{F}**	14.3^{hi}	15.9^{f-h}	19.0^{c-e}	**16.4^{CD}**
Mean	**18.0^{B}**	**19.3^{A}**	**20.0^{A}**		**15.6^{C}**	**17.6^{B}**	**20.1^{A}**	
	Cracking fruits %							
	1st Season				**2nd Season**			
Control	12.36^{a}	12.64^{a}	12.67^{a}	**12.56^{A}**	9.14^{a}	9.23^{a}	9.69^{a}	**9.35^{A}**
2% Ca $(NO_3)_2$	7.76^{g}	8.02^{e-g}	8.28^{d-g}	**8.02^{E}**	5.58^{f-h}	6.37^{b-f}	7.27^{bc}	**6.41^{BC}**
4% Ca $(NO_3)_2$	5.30^{h}	7.68^{g}	7.70^{g}	**6.89^{F}**	4.84^{h}	5.96^{e-h}	6.94^{b-e}	**5.91^{C}**
2% $CaCO_3$	10.73^{b}	11.23^{b}	12.04^{a}	**11.33^{B}**	5.86^{e-h}	6.85^{b-e}	7.43^{b}	**6.71^{B}**
4% $CaCO_3$	8.30^{c-g}	8.52^{c-f}	8.66^{c-e}	**8.50^{D}**	5.08^{gh}	6.28^{c-f}	7.11^{b-d}	**6.16^{BC}**
2% $CaCl_2$	8.88^{cd}	8.92^{c}	8.92^{c}	**8.91^{C}**	5.84^{e-h}	6.37^{b-f}	7.29^{bc}	**6.50^{BC}**
4% $CaCl_2$	7.71^{g}	7.84^{g}	7.98^{fg}	**7.84^{E}**	4.90^{h}	6.12^{d-g}	6.96^{b-e}	**6.00^{C}**
Mean	**8.72^{B}**	**9.27^{A}**	**9.46^{A}**		**5.89^{C}**	**6.74^{B}**	**7.53^{A}**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

Concerning aril and peel percentage, it is worth to mention that, with respect to calcium sources data obvious that, calcium nitrate at 4% resulted in the highest aril percentage in both seasons (63.1-61.0%), respectively, while the same treatment gained the lowest peel percentage in the first and second seasons (36.9-39.0%), respectively. Regarding to the number of spraying times, spraying trees once a week achieved the highest aril percentage and the lowest peel percentage in both seasons. As for the interaction, pomegranate trees sprayed with calcium nitrate at 4% once a week or once every two weeks recorded the highest significant aril percentage in the first season (63.2-63.0%) on the contrary the same treatment exhibited the lowest peel percentage in the first season (36.8-37.0%). In the second season, the greatest significant aril percentage was recorded by calcium nitrate at 4% once a week, on the other hand the same treatment had the lowest peel percentage.

Data in Table (5) illustrate that data concerning of weight of 100 aril (g) and juice volume of 100 aril (ml) were significantly affected with calcium sources and number of spraying times and their interaction. Regarding to calcium sources, the highest weight of 100 aril (g) and juice volume of 100 aril (ml) were found by calcium nitrate at 4% through the two study seasons (37.44-34.11 g and 26.34-24.17 ml), respectively. Regarding the number of spraying times, spraying pomegranate trees once a week or once every two weeks had a higher weight of 100 aril (g) and juice volume of 100 aril (ml) in the first season. Moreover, in the second season, spraying pomegranate trees once a week gained the highest values. As for interaction, during the two growing seasons treatment of calcium nitrate at 4% once a week resulted in the highest weight of 100 aril (g) and juice volume of 100 aril (ml) opposite to untreated trees which gained the lowest values.

5. Effect on Fruit Chemical Properties

Data in Tables (6 and 7) show the effect of different sources of calcium, the number of spraying times, and their interaction on some fruit chemical properties of Wonderful pomegranate in 2019 and 2020 seasons.

Data in Table (6) reveal that, data regarding V.C (mg/100 ml) and anthocyanin (mg/100 ml) were affected significantly with calcium sources and number of spraying times and their interaction. Concerning calcium sources, in both seasons of the study pomegranate trees received calcium nitrate at 4% proved to give the highest V.C and anthocyanin (mg/100 ml) (43.04-41.28 and 15.44-15.18 mg/100 ml), respectively as compared with control and other treatments. Regarding the number of spraying times, spraying trees once a week had the highest V.C in both seasons and the highest anthocyanin in the second season. Moreover, in the first season, the difference between spraying trees once a week or once every two weeks lacked significance.

Table (4). Effect of calcium spraying; the interval between sprays and their interaction on fruit length, fruit diameter, aril (%) and peel (%) of Wonderful cv. of pomegranate trees during 2018 and 2019 seasons.

Treatment	One week	Two weeks	Three weeks	Mean	One week	Two weeks	Three weeks	Mean
	Fruit length (cm)							
	1st Season				**2nd Season**			
Control	6.17^{h}	6.07^{h}	5.90^{h}	**6.04^{E}**	6.63^{m-o}	6.50^{no}	6.45^{o}	**6.53^{D}**
2% Ca $(NO_3)_2$	7.70^{b-d}	7.63^{c-e}	7.60^{c-e}	**7.64^{BC}**	7.57^{cd}	7.10^{h-j}	6.80^{k-m}	**7.16^{C}**
4% Ca $(NO_3)_2$	8.23^{a}	8.00^{ab}	7.87^{bc}	**8.03^{A}**	8.07^{a}	7.33^{d-g}	7.00^{i-k}	**7.47^{A}**
2% $CaCO_3$	7.33^{ef}	7.07^{fg}	6.87^{g}	**7.09^{D}**	7.43^{d-f}	7.00^{i-k}	6.70^{l-n}	**7.04^{C}**
4% $CaCO_3$	7.60^{c-e}	7.57^{c-e}	7.53^{de}	**7.57^{C}**	7.80^{bc}	7.20^{f-i}	6.90^{j-l}	**7.30^{B}**
2% $CaCl_2$	7.53^{de}	7.53^{de}	7.50^{de}	**7.52^{C}**	7.50^{de}	7.07^{h-j}	6.73^{l-n}	**7.10^{C}**
4% $CaCl_2$	7.87^{bc}	7.80^{b-d}	7.70^{b-d}	**7.79^{B}**	7.97^{ab}	7.30^{e-h}	7.00^{i-k}	**7.42^{AB}**
Mean	**7.49^{A}**	**7.38^{AB}**	**7.28^{B}**		**7.57^{A}**	**7.07^{B}**	**6.80^{C}**	
	Fruit diameter (cm)							
	1st Season				**2nd Season**			
Control	7.33^{l}	7.30^{l}	7.13^{l}	**7.26^{E}**	7.17^{jk}	7.10^{jk}	7.00^{k}	**7.09^{E}**
2% Ca $(NO_3)_2$	8.57^{bc}	8.40^{c-g}	8.33^{d-h}	**8.43^{B}**	8.40^{bc}	7.93^{e}	7.53^{gh}	**7.96^{BC}**
4% Ca $(NO_3)_2$	8.83^{a}	8.63^{ab}	8.53^{b-d}	**8.67^{A}**	8.63^{a}	8.20^{d}	7.70^{fg}	**8.18^{A}**
2% $CaCO_3$	8.10^{ij}	8.03^{jk}	7.87^{k}	**8.00^{D}**	8.27^{cd}	7.83^{ef}	7.27^{ij}	**7.79^{D}**
4% $CaCO_3$	8.30^{e-i}	8.23^{f-j}	8.20^{g-j}	**8.24^{C}**	8.40^{bc}	7.97^{e}	7.57^{g}	**7.98^{BC}**
2% $CaCl_2$	8.20^{g-j}	8.13^{h-j}	8.07^{j-k}	**8.13^{C}**	8.37^{b-d}	7.93^{e}	7.37^{hi}	**7.89^{CD}**
4% $CaCl_2$	8.50^{b-e}	8.43^{b-f}	8.30^{e-i}	**8.41^{B}**	8.47^{ab}	7.97^{e}	7.63^{g}	**8.02^{B}**
Mean	**8.26^{A}**	**8.17^{B}**	**8.06^{C}**		**8.24^{A}**	**7.85^{B}**	**7.44^{C}**	
	Aril (%)							
	1st Season				**2nd Season**			
Control	53.0^{ij}	52.9^{ij}	51.9^{j}	**52.6^{F}**	52.1^{jk}	51.4^{k}	50.8^{k}	**51.4^{E}**
2% Ca $(NO_3)_2$	58.7^{cd}	58.5^{d}	58.1^{de}	**58.4^{C}**	59.9^{cd}	57.6^{ef}	55.4^{h}	**57.6^{C}**
4% Ca $(NO_3)_2$	63.2^{a}	63.0^{a}	63.0^{a}	**63.1^{A}**	66.9^{a}	59.1^{c-e}	57.1^{fg}	**61.0^{A}**
2% $CaCO_3$	56.2^{gh}	55.4^{h}	54.0^{i}	**55.2^{E}**	59.2^{cd}	57.3^{f}	53.3^{ij}	**56.6^{D}**
4% $CaCO_3$	57.7^{d-f}	57.6^{d-f}	57.2^{e-g}	**57.5^{D}**	60.1^{c}	57.6^{ef}	55.5^{gh}	**57.7^{C}**
2% $CaCl_2$	57.2^{e-g}	56.7^{f-h}	56.6^{f-h}	**56.8^{D}**	59.3^{cd}	57.5^{f}	53.8^{i}	**56.9^{CD}**
4% $CaCl_2$	62.7^{a}	60.9^{b}	59.9^{bc}	**61.2^{B}**	62.5^{b}	58.4^{d-f}	55.6^{gh}	**58.8^{B}**
Mean	**58.4^{A}**	**57.9^{B}**	**57.2^{C}**		**60.0^{A}**	**57.0^{B}**	**54.5^{C}**	
	Peel (%)							
	1st Season				**2nd Season**			
Control	47.0^{ab}	47.1^{ab}	48.1^{a}	**47.4^{A}**	48.0^{ab}	48.6^{a}	49.2^{a}	**48.6^{A}**
2% Ca $(NO_3)_2$	41.3^{gh}	41.5^{g}	41.9^{fg}	**41.6^{D}**	40.1^{hi}	42.4^{fg}	44.6^{d}	**42.4^{CD}**
4% Ca $(NO_3)_2$	36.8^{j}	37.0^{j}	37.0^{j}	**36.9^{F}**	33.1^{k}	40.9^{g-i}	42.9^{ef}	**39.0^{F}**
2% $CaCO_3$	43.8^{cd}	44.6^{c}	46.0^{b}	**44.8^{B}**	40.8^{hi}	42.7^{f}	46.7^{bc}	**43.4^{B}**
4% $CaCO_3$	42.3^{e-g}	42.4^{e-g}	42.8^{d-f}	**42.5^{C}**	39.9^{i}	42.4^{fg}	44.5^{d}	**42.3^{D}**
2% $CaCl_2$	42.8^{d-f}	43.3^{c-e}	43.4^{c-e}	**43.2^{C}**	40.7^{hi}	42.5^{f}	46.2^{c}	**43.1^{BC}**
4% $CaCl_2$	37.3^{j}	39.1^{i}	40.1^{hi}	**38.8^{E}**	37.5^{j}	41.6^{f-h}	44.4^{de}	**41.2^{E}**
Mean	**41.6^{C}**	**42.1^{B}**	**42.8^{A}**		**40.0^{C}**	**43.0^{B}**	**45.5^{A}**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

Table (5) Effect of calcium spraying; the interval between sprays and their interaction on weight 100 aril and Volume of juice/100 aril of Wonderful cv. of pomegranate trees during 2018 and 2019 seasons.

Treatment	One week	Two weeks	Three weeks	Mean	One week	Two weeks	Three weeks	Mean
	Weight 100 aril (g)							
	1st Season				**2nd Season**			
Control	31.67^{gh}	31.00^{h}	30.33^{h}	**31.00^{E}**	30.33^{g-i}	30.00^{hi}	29.67^{i}	**30.00^{C}**
2% Ca $(NO_3)_2$	34.67^{cd}	34.33^{c-e}	34.33^{c-e}	**34.44^{BC}**	34.00^{d-g}	32.33^{c-f}	31.67^{e-h}	**32.67^{B}**
4% Ca $(NO_3)_2$	39.67^{a}	37.00^{b}	35.67^{bc}	**37.44^{A}**	37.33^{a}	33.00^{b-e}	32.00^{d-g}	**34.11^{A}**
2% $CaCO_3$	32.33^{e-h}	32.33^{e-h}	32.00^{f-h}	**32.22^{D}**	33.33^{b-e}	32.00^{d-g}	30.67^{f-i}	**32.00^{B}**
4% $CaCO_3$	34.00^{c-f}	34.00^{c-f}	34.00^{c-f}	**34.00^{BC}**	34.00^{bc}	32.33^{c-f}	31.67^{e-h}	**32.67^{B}**
2% $CaCl_2$	33.67^{c-g}	33.33^{d-g}	33.33^{d-g}	**33.44^{C}**	33.67^{b-d}	32.00^{c-g}	31.00^{f-i}	**32.22^{B}**
4% $CaCl_2$	35.33^{b-d}	35.00^{b-d}	34.67^{cd}	**35.00^{B}**	34.33^{b}	32.33^{c-f}	31.67^{e-h}	**32.78^{B}**
Mean	**34.48^{A}**	**33.86^{AB}**	**33.48^{B}**		**33.86^{A}**	**32.00^{B}**	**31.19^{C}**	
	Volume of juice / 100 aril (ml)							
	1st Season				**2nd Season**			
Control	22.58^{f-h}	22.15^{gh}	21.07^{h}	**21.93^{E}**	21.72^{fg}	21.50^{fg}	21.28^{g}	**21.50^{C}**
2% Ca $(NO_3)_2$	24.53^{b-d}	24.32^{c-e}	24.32^{c-e}	**24.39^{BC}**	24.10^{bc}	23.02^{b-f}	22.58^{c-g}	**23.23^{AB}**
4% Ca $(NO_3)_2$	27.78^{a}	26.05^{b}	25.18^{bc}	**26.34^{A}**	26.27^{a}	23.45^{b-e}	22.80^{b-g}	**24.17^{A}**
2% $CaCO_3$	23.02^{d-g}	23.02^{d-g}	22.80^{e-g}	**22.94^{D}**	23.67^{b-d}	22.80^{b-g}	21.93^{e-g}	**22.80^{B}**
4% $CaCO_3$	24.10^{c-f}	24.10^{c-f}	24.10^{c-f}	**24.10^{BC}**	24.10^{bc}	23.02^{b-f}	22.58^{c-g}	**23.23^{AB}**
2% $CaCl_2$	23.88^{c-f}	23.67^{c-g}	23.67^{c-g}	**23.74^{CD}**	23.88^{bc}	22.80^{b-g}	22.15^{d-g}	**22.94^{B}**
4% $CaCl_2$	24.97^{bc}	24.75^{bc}	24.53^{b-d}	**24.75^{B}**	24.32^{b}	23.02^{b-f}	22.58^{c-g}	**23.31^{AB}**
Mean	**24.41^{A}**	**24.01^{AB}**	**23.67^{B}**		**24.01^{A}**	**22.80^{B}**	**22.27^{B}**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

With respect to interaction, pomegranate trees sprayed with calcium nitrate at 4% once a week or once every two weeks exhibited higher V.C and anthocyanin (mg/100 ml) in the first season. Moreover, in the second season, trees sprayed with calcium nitrate at 4% once a week gave higher V.C and anthocyanin (mg/100 ml), opposite to untreated trees which had the lowest values.

Data in Table (7) demonstrate that TSS, total acidity percentage and TSS acid ratio were affected significantly by calcium sources and number of spraying times and their interaction. Concerning calcium sources, pomegranate trees sprayed with calcium nitrate at 4% had the highest TSS percentage and TSS acid ratio (15.70-14.62 and 16.35-15.40%) and gave the lowest total acidity percentage (0.96-0.99%) in both seasons, respectively. As for the number of spraying times, spraying trees once a week or once every two weeks resulted in a higher TSS percentage and TSS acid ratio. The same treatment

had a lower total acidity percentage in the first season. In the second season spraying trees once a week proved to give the highest TSS percentage, TSS acid ratio and gave the lowest acidity percentage. Regarding the interaction, pomegranate trees sprayed with calcium nitrate at 4% once a week achieved the highest TSS percentage, TSS acid ratio and lowest total acidity in both seasons of the study.

The similar findings have been observed in pomegranate trees by Bisen et al. (2014), Shah and Sajid (2017) and Kumar et al. (2021) and they found that greater chlorophyll and nutrient levels in the leaves may have resulted in increased metabolite synthesis and translocation to the fruits, resulting in higher TSS content in the fruits.

Table (6). Effect of calcium spraying; the interval between sprays and their interaction on vitamin C (V.C) and anthocyanin of Wonderful cv. of pomegranate trees during 2018 and 2019 seasons.

Treatment	One week	Two weeks	Three weeks	Mean	One week	Two weeks	Three weeks	Mean
	V.C (mg/100 ml)							
	1st Season				2nd Season			
Control	35.50^{i-k}	34.30^{jk}	33.07^{k}	**34.29^{D}**	33.50^{hi}	32.77^{hi}	31.53^{i}	**32.60^{D}**
2% Ca $(NO_3)_2$	42.00^{ab}	41.57^{bc}	40.87^{b-e}	**41.48^{B}**	42.70^{ab}	37.70^{d-f}	34.33^{f-i}	**38.24^{BC}**
4% Ca $(NO_3)_2$	44.63^{a}	42.37^{ab}	42.13^{ab}	**43.04^{A}**	44.40^{a}	40.67^{b-d}	38.77^{c-e}	**41.28^{A}**
2% $CaCO_3$	38.53^{d-h}	36.70^{g-j}	35.97^{h-j}	**37.07^{C}**	40.50^{b-d}	36.93^{e-g}	34.03^{g-i}	**37.16^{C}**
4% $CaCO_3$	41.00^{b-e}	39.77^{b-f}	39.23^{c-g}	**40.00^{B}**	43.77^{ab}	38.17^{de}	35.80^{e-h}	**39.24^{B}**
2% $CaCl_2$	38.10^{f-i}	38.33^{e-h}	37.43^{f-i}	**37.96^{C}**	41.77^{a-c}	37.37^{d-g}	34.10^{g-i}	**37.74^{BC}**
4% $CaCl_2$	41.80^{b}	41.30^{bc}	41.07^{b-d}	**41.39^{B}**	44.07^{a}	38.30^{de}	36.00^{e-h}	**39.46^{B}**
Mean	**40.22^{A}**	**39.19^{B}**	**38.54^{B}**		**41.53^{A}**	**37.41^{B}**	**34.94^{C}**	
	Anthocyanin (mg/100 ml)							
	1st Season				2nd Season			
Control	12.95^{i}	13.07^{i}	12.91^{i}	**12.97^{D}**	13.68^{gh}	13.13^{h}	12.99^{h}	**13.27^{C}**
2% Ca $(NO_3)_2$	15.30^{a-d}	14.86^{d-g}	14.72^{e-h}	**14.96^{B}**	15.29^{a-c}	15.00^{a-e}	14.19^{e-g}	**14.83^{AB}**
4% Ca $(NO_3)_2$	15.63^{a}	15.60^{ab}	15.09^{b-f}	**15.44^{A}**	15.77^{a}	15.17^{a-d}	14.60^{b-g}	**15.18^{A}**
2% $CaCO_3$	14.58^{f-h}	14.47^{gh}	14.32^{h}	**14.46^{C}**	15.17^{a-d}	14.64^{b-f}	13.84^{f-h}	**14.55^{B}**
4% $CaCO_3$	15.23^{a-e}	15.22^{a-e}	15.21^{a-e}	**15.22^{AB}**	15.40^{ab}	15.01^{a-e}	14.23^{d-g}	**14.88^{AB}**
2% $CaCl_2$	15.10^{b-e}	15.09^{b-f}	15.08^{c-f}	**15.09^{B}**	15.24^{a-c}	14.78^{b-f}	14.16^{e-g}	**14.73^{AB}**
4% $CaCl_2$	15.57^{a-c}	15.47^{a-c}	15.36^{a-d}	**15.46^{A}**	15.48^{ab}	15.17^{a-d}	14.39^{c-g}	**15.01^{AB}**
Mean	**14.91^{A}**	**14.82^{AB}**	**14.67^{B}**		**15.15^{A}**	**14.70^{B}**	**14.06^{C}**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

Table (7). Effect of calcium spraying; the interval between sprays and their interaction on fruit TSS%, Total acidity % and TSS acid ratio of Wonderful cv. of pomegranate trees during 2018 and 2019 seasons.

Treatment	One week	Two weeks	Three weeks	Mean	One week	Two weeks	Three weeks	Mean
	TSS (%)							
	1st Season				**2nd Season**			
Control	12.83^{j-l}	12.53^{kl}	12.36^{l}	**12.57^{E}**	12.42^{hi}	12.28^{hi}	12.01^{i}	**12.24^{E}**
2% Ca $(NO_3)_2$	14.32^{c-e}	14.23^{c-f}	14.15^{c-g}	14.23^{C}	14.82^{c}	13.70^{d-f}	12.73^{gh}	13.75^{C}
4% Ca $(NO_3)_2$	16.79^{a}	15.35^{b}	14.97^{bc}	15.70^{A}	16.61^{a}	14.03^{d}	13.21^{fg}	14.62^{A}
2% $CaCO_3$	13.25^{h-k}	13.13^{i-l}	12.95^{i-l}	13.11^{D}	14.17^{d}	13.29^{fg}	12.47^{hi}	13.31^{D}
4% $CaCO_3$	14.11^{c-h}	14.03^{d-h}	13.82^{e-i}	13.99^{C}	15.33^{bc}	14.00^{de}	12.74^{gh}	14.02^{BC}
2% $CaCl_2$	13.48^{e-j}	13.44^{f-j}	13.33^{g-k}	13.41^{D}	14.23^{d}	13.42^{ef}	12.50^{hi}	13.38^{D}
4% $CaCl_2$	14.95^{bc}	14.92^{bc}	14.79^{b-d}	14.89^{B}	15.57^{b}	14.02^{d}	13.14^{fg}	14.24^{B}
Mean	**14.25^{A}**	**13.95^{AB}**	**13.77^{B}**		**14.74^{A}**	**13.53^{B}**	**12.69^{C}**	
	Total acidity %							
	1st Season				**2nd Season**			
Control	1.31^{a}	1.33^{a}	1.39^{a}	1.34^{A}	1.54^{ab}	1.53^{a-c}	1.68^{a}	1.58^{A}
2% Ca $(NO_3)_2$	1.04^{d-h}	1.06^{d-g}	1.08^{d-g}	1.06^{DE}	0.90^{fg}	1.03^{ef}	1.34^{cd}	1.09^{B-D}
4% Ca $(NO_3)_2$	0.92^{h}	0.96^{gh}	1.01^{f-h}	0.96^{F}	0.81^{g}	1.00^{e-g}	1.16^{de}	0.99^{D}
2% $CaCO_3$	1.17^{b-d}	1.27^{a-c}	1.28^{ab}	1.24^{B}	0.94^{fg}	1.14^{bc}	1.47^{bc}	1.18^{B}
4% $CaCO_3$	1.11^{d-f}	1.11^{d-f}	1.13^{d-f}	**1.11^{CD}**	0.89^{fg}	1.03^{ef}	1.18^{de}	**1.03^{CD}**
2% $CaCl_2$	1.13^{d-f}	1.14^{c-e}	1.16^{b-d}	**1.14^{C}**	0.92^{fg}	1.05^{ef}	1.40^{bc}	**1.12^{BC}**
4% $CaCl_2$	1.01^{f-h}	1.01^{f-h}	1.03^{e-h}	**1.01^{EF}**	0.86^{fg}	1.01^{ef}	1.16^{de}	**1.01^{D}**
Mean	**1.10^{B}**	**1.13^{AB}**	**1.15^{A}**		**0.98^{C}**	**1.11^{B}**	**1.34^{A}**	
	TSS acid ratio							
	1st Season				**2nd Season**			
Control	10.25^{j-l}	9.44^{kl}	8.92^{l}	**9.54^{F}**	8.04^{kl}	8.21^{kl}	7.08^{l}	**7.78^{F}**
2% Ca $(NO_3)_2$	13.78^{c-e}	13.84^{c-e}	13.26^{d-g}	**13.63^{C}**	16.93^{c}	13.47^{fg}	9.54^{j}	**13.31^{C}**
4% Ca $(NO_3)_2$	18.32^{a}	15.91^{b}	14.84^{bc}	**16.35^{A}**	20.67^{a}	14.16^{ef}	11.37^{i}	**15.40^{A}**
2% $CaCO_3$	11.37^{h-j}	10.87^{i-k}	10.18^{j-l}	**10.81^{E}**	15.11^{de}	11.72^{hi}	8.52^{jk}	**11.78^{E}**
4% $CaCO_3$	12.76^{e-h}	13.64^{c-f}	12.35^{e-i}	**12.92^{C}**	17.31^{bc}	13.67^{fg}	10.83^{i}	**13.94^{BC}**
2% $CaCl_2$	11.99^{g-i}	12.16^{f-i}	11.67^{h-j}	**11.94^{D}**	15.63^{d}	12.76^{gh}	8.97^{jk}	**12.45^{D}**
4% $CaCl_2$	15.47^{b}	14.82^{bc}	14.42^{b-d}	**14.90^{B}**	18.48^{b}	13.91^{e-g}	11.37^{i}	**14.59^{B}**
Mean	**13.42^{A}**	**12.95^{A}**	**12.24^{B}**		**16.03^{A}**	**12.56^{B}**	**9.67^{C}**	

Means followed by the same letter (s) within each row, column or interaction are not significantly different at 5% level.

CONCLUSION AND RECOMMENDATION

It could be obviously concluded that, "Wonderful" pomegranate trees received different sources of calcium once a week, once every two weeks and once every three weeks enhance tree yield and fruit quality. In general, in most cases treatment of calcium nitrate at 4% once a week exhibited the highest values of yield, its component fruit quality and marketable fruits percentage. The same treatment gained the lowest cracking percentage and unmarketable fruits. In some cases, treatment of calcium nitrate at 4% once every two weeks showed higher values in leaf area, leaf dry matter, some fruit physical and chemical properties.

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تأثير الرش ببعض مصادر الكالسيوم في إنتاجية وجودة ثمار أشجار الرمان (*Punica granatum* L.)

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يهدف هذا البحث إلى دراسة تأثير الرش ببعض مصادر الكالسيوم على إنتاجية وجودة ثمار الرمان. تم تنفيذ التجربة بتصميم القطع المنشقة على أشجار الرمان صنف Wonderful المزروعة في مزرعة حجازي الخاص الواقعة في الكيلو ٥٧ غرب طريق القاهرة الإسكندرية الصحراوي، محافظة الجيزة، مصر خلال موسمين متتاليين عامي ٢٠١٩ و٢٠٢٠. أعطت جميع معاملات الرش بالكالسيوم نتائج إيجابية من حيث النمو الخضري والإنتاجية سواء تم رشه مرة واحدة كل أسبوع أو أسبوعين أو ثلاثة أسابيع من مرحلة النمو الكامل حتى النضج من منتصف مايو حتى منتصف أغسطس في كلا الموسمين مقارنة بمعاملات المقارنة التي تم معاملتها بالماء فقط. من ناحية أخرى، أدت جميع التطبيقات التي تم اختبارها إلى زيادة معنوية في نمو الأشجار وكذلك تحسين المحصول وجودة الثمار بشكل ملحوظ وتقليل نسبة الثمار غير القابلة للتسويق والتشقق. كما أعطى الرش بنترات الكالسيوم بنسبة ٤٪ مرة واحدة أسبوعيًا أعلى القيم في صفات النمو والمحصول وجودة الثمار. بالتالى ينصح برش أشجار الرمان صنف Wonderful بمصادر الكالسيوم مرة واحدة في الأسبوع للحصول على نمو نباتي أفضل وإنتاجية عالية وجودة ثمار جيدة.