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Effect of Some Treatments on Cracking and Fruit Quality of Manfalouty Pomegranate Fruits

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Abstract: This investigation was carried out during the two successive seasons 2022 and 2023 on 10 years old Manfalouty pomegranate trees (*Punica granatum* L.) grown in a private orchard located at Sahel Selim district, Assiut Governorate, Egypt. The aim of this research was to investigate the effect of foliar application of nature oils such as jojoba oil at (2 and 3 %) and olive oil at (2 and 3 %), determine their effectiveness, and compare them with the chemical substances such as calcium boron at (1.5 and 3 %) and potassium silicate at (1.5 and 3 %) to increase the productivity and fruit quality especially reducing cracking and sunburn percentage of Manfalouty pomegranate fruits. The treatments were done at three application times; after fruit set (mid-May), in mid-June and mid of August. Results indicated that foliar application of calcium boron, potassium silicate, jojoba oil and olive oil significantly increased yield and fruit quality of Manfalouty pomegranate trees. The superior treatments were foliar application with potassium silicate at 3 % and calcium boron at 3 % in increasing the yield and fruit quality as well as decreasing the percentage of fruit cracking and sunburn percentage of 'Manfalouty' pomegranate trees. Foliar application of potassium silicate at 3 % treatment increased total soluble solids, Vitamin C and reduced sugars as well as decreased fruit juice acidity compared with the control in both seasons.

Key words: Manfalouty pomegranate, calcium boron, potassium silicate, jojoba oil, olive oil, yield, cracking fruits, fruit quality.

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INTRODUCTION

The Pomegranate (*Punica granatum* L.) is one of the oldest cultivated fruits. It was mentioned in the holy Quran and in ancient Egyptian myths. In the Latin language, pomegranate means "seeded apple". It is a small tree or shrub with brilliant red spring flowers (**Lansky and Newman 2007**) and it is also one of the edible fruits, very important to human health due to its antioxidant activity (**Gil *et al.*, 2000**).

Manfalouty cv. is one of the most important pomegranate cultivars grown in Assiut governorate. According to the statistics **Egyptian Ministry of Agriculture (2022)** the total area allocated to pomegranate

in Assiut governorate was 10894 Fadden and fruiting area was 10828 fadden producing about 185452 tons with an average for 17.13 tons /fadden.

Despite the significant expansion in pomegranates cultivation in Egypt during the past two decades, the production and cultivated areas increased from 2902 fad., in 2000 to 79893 fad., in 2022 according to **Ministry of Agriculture and Land Reclamation, Economic affairs sector 2022**, pomegranate trees still suffers from some physiological disorders in addition to fruiting problems such as, cracking or splitting of fruits, sunscald sunburn damage to fruits, excessive abscission of flowers and fruits, and poor discoloration of the skin and arils which facing the pomegranate producers.

Fruit cracking causes huge loss to farmers by reducing the total yield by up to 50% and deteriorating the fruit quality so much that it becomes unmarketable (**Bankar and Prasad, 1992; El-Salhy, 1996 and Singh and Kingsly, 2006**). Cracking may be due to the hardening of peel of the fruit during prolonged drought, high evapotranspiration, low relative air humidity (RH), water imbalance and sharp temperature fluctuation in day and night during fruit growth and development, and then sudden expansion in the inner part of fruit after heavy irrigation (**Abd EL-Rahman, 2010 and Kumar *et al.*, 2010**).

Fruit cracking can be caused by a variety of reasons, including changes in soil moisture regimes and cultural practices like mineral nutrition, pruning, irrigation, fruit thinning, and foliar applications of Ca, N, B, and salicylic acid (**Sing and Kingsly, 2006; Abubakar and Ashraf, 2013**; **Ahmed *et al.*, 2014 and Kamal *et al.*, 2017**), and growth regulators such as GA_3 (**Singh *et al.*, 2003**) are exerted much influence on pomegranate cracking control.

Calcium is the most important mineral in ensuring cell structure stability and mechanical strength (**Elmer *et al.*, 2007**). Application of calcium to fruits provides protection against physiological deterioration, delayed ripening and improves fruit quality (**Hernandez-Munoz *et al.*, 2006; Lanaouskas and Kvikliene, 2006; Bonomelli and Ruiz, 2010; Chen *et al.*, 2011 and Irfan *et al.*, 2013**). Calcium plays an important role in regulating the uptake of water by plant roots. Calcium treatments have been reported to reduce cracking in pomegranate (**Sharma, 2011; El-Akkad *et al.*, 2016 and Masoud *et al.*, 2017**).

Other nutrients such as boron play a major role in cell wall membrane function, cell wall strength and development, cell division, fruit and seed development, and sugar transport. The borax response was effective in managing fruit cracking and increasing the yield of pomegranate trees (**Soni *et al.*, 2000 and Lal *et al.*, 2011**). Also, Potassium silicate is a source of highly soluble potassium and silicon. It is used to enhance tree yield and fruit quality (**Epstein, 1999; Wassel *et al.*, 2015 and Ahmed *et al.*, 2015**).

Jojoba oil is one of the antitranspirants, which create a thin wax layer on the plant leaves thus causing decreasing water loss by transpiration and evaporation from plant foliage (**Abd El-Hady and Doklega, 2017**). **Abd El-Moneim and Abd El-Mageed (2006)** on Washington Navel orange and **Abd-Allah *et al.* (2012)** on persimmon, they found that coated fruits with jojoba oil reduced fruit decay and increasing fruit storage life. Jojoba oil and olive oil are used to improve the appearance and modifying atmosphere around the fruit's surface to reduce respiration rate of fruits and improve the environmental conditions such as temperature and humidity (**Baldwin *et al.*, 1995**). **Shaheen *et al.* (2018)** reported that spraying fig trees with olive oil led to increase the yield and fruit quality. The positive effect of used olive oil can be attributed to the essential role of fatty acids that promote formation of the growth regulators that may improve the component of fruit **(Owino *et al.*, 2006).**

These studies aimed to use some spray treatments including nature oils such as jojoba oil and olive oil, determine their effectiveness, and compare them with the chemical substances such as calcium boron and potassium silicate to increase the productivity and fruit quality especially cracking percentage and sunburn fruits of Manfalouty pomegranate fruits.

MATERIALS AND METHODS

The present experiment was carried out in a private pomegranate orchard in Sahel Selim district, Assiut governorate, during two consecutive seasons 2022 and 2023. Fifty-four of uniform trees, free from various physiological and visible pathological disorders of "Manfalouty" pomegranate trees, 10 years old, spaced 5 x 5 m apart, were selected for this study. Soils of the studied site are classified as having clay texture and are presented in Table (1).

Table (1). Physical and chemical properties of the experimental soil

Character	Value	Character	Value
Particle size distribution %		EC (mm/cm)	1.811
Clay	7.2	pH (1: 2.5)	7.41
Silt	18.6	organic matter %	0.08
Sand	74.2	CaCo3	5.0
Texture	clay		
Available macronutrients		Available micronutrients (ppm)	
N %	0.26	Fe	29.88
P (ppm)	29.2	Zn	5.02
K (ppm)	348.1	Mn	16.1

The trees were irrigated with surface irrigation and received all recommended horticultural practices. Nile River water (EC of 1.1ds m-1) was used to irrigate the experiment site. The treatments were carried out as follows:

T1: Spraying tap water (control).

T2: Spraying Calcium boron at 1.5 %.

T3: Spraying Calcium boron at 3 %.

T4: Spraying Potassium silicate at 1.5 %.

T5: Spraying Potassium silicate at 3 %.

T6: Spraying Jojoba oil at 2 %.

T7: Spraying Jojoba oil at 3 %.

T8: Spraying Olive oil at 2%.

T9: Spraying Olive oil at3 %.

Calcium boron (as a source of 20 % Ca and 2.5 % Bo) and potassium silicate (as a source 10 % K_2O and 25 % Si_2O) solution were prepared by dissolving the assigned amount in the required water. Jojoba oil was prepared as oil suspension and used at (2 or 3 %) according to the method described by **Aly *et al.* (2013)**. Olive oil was emulated in water at (2 or 3 %) as described by **Abdel Kader *et al.* (2006).** The composition of jojoba oil and olive oil were carried out according to the methods of **AOAC, (2002) and Ewa *et al.*, (2015)** respectively, as shown in Tables (2 and 3).

Table (2). Physical and chemical analysis of jojoba oil

Components	Values	Components	Values
Iodine value	92.13	Palmitic acid	1.91
Peroxide value	1.05	Plamitioleic acid	0.25
Crude oil (%)	46.23	Stearic acid	0.39
Moisture (%)	4.35	Vaccinic acid	0.96
Crude protein (%)	12.50	Oleic acid	9.88
Crude fiber (%)	12.20	Linoleic acid	1.17
Ash (%)	1.86	Linolenic acid	0.35
		Gadoleic acid	72.32

Table (2). Chemical analysis of olive oil

Constituent	Values	Constituent	Values
Tri–cycloglycerol l (%)	95.00	Oleic (%)	22.40
Palmitic (%)	17.60	Linoleic (%)	22.40
Palmitoleic (%)	2.40	Linolenic (%)	1.00
Stearic (%)	54.30	Arachidic	0.06

The trees received solutions with triton B as a wetting agent, using a hand held spray wand until run-off 5 L per tree in the morning at three times from each substance after fruit set (Mid - May), in mid of June and mid of August of each season. Treatments were arranged in a completely randomized block design. Three replications were used for each treatment and two pomegranate trees represented one replication, thus fifty-four trees were employed to this study in each season.

The number of fruits per tree in each treatment was counted every month starting from July to September to calculate the percentages of cracking and the percentage of sunburn.

At harvest time, in the second week of October during 2022 and 2023 seasons, the fruit Samples (10 fruits) were collected from each tree, and carefully transported from the orchard to the laboratory as quickly as possible to determine the following traits.

Tree productivity

1- Total Yield: for each season, harvesting was completed within the second week of October, and yield (Kg/tree) was noted.

2- Yield increment (%): yield increase than control percentage was calculated by using **Abdelnaby *et al.* (2019)** equation.

$$\text{Yield increment \%} = \frac{\text{Fruit yield (kg)/treatment - Fruit yield (kg)/control}}{\text{Fruit yield (kg)/control}} \times 100$$

3- Fruit cracking % was calculated by using **El-Akkad *et al.* (2016)** equation:

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

4- Fruit sunburn %: At harvest time, the number of fruits per tree in each treatment were recorded and also each fruit was evaluated visually for the degree of sunburn damage and calculated as a percentage relative to the total number of fruits on the tree by the following equation: **Hegazi *et al.* (2014)**

$$\text{Fruit sunburn \%} = \frac{\text{No. of sunburn fruits}}{\text{Total No. of fruits}} \times 100$$

5- Marketable fruits according to **Hegazi *et al.* (2014**)

Marketable fruits % = Total N. of fruits – (No. of cracked + sunburn fruits) x 100

Fruit properties

Physical properties:

1- Average fruit weight (g) the average weight of ten fruits of each replication was determined by a digital scale (RADWAG, wlc6/A2).

2- Fruit height and fruit diameter (cm) were measured using a Vernier caliper.

3- Arils weight percentage was calculated.

4- Juice volume (cm^3).

Chemical properties:

1- The percentage of total soluble solids (T.S.S %) were estimated in pomegranate fruit juice using a digital refractometer.

2- The total acidity was determined based on estimated tartaric acid by titration of NAOH at 0.1N according to **A.O.A.C (2000).**

3- Vitamin C was determined as mg ascorbic acid per 100 ml juice using the method of **Egan *et al.* (1981)**.

4- Total sugars were determined by using the phenol sulfuric acid method **(Smith, 1956), a**nd the concentration was calculated from a standard curve of glucose (mg. per g) fresh weight of fruit tissue.

5- Total anthocyanin content in juice (mg/100 ml): Extract was prepared by the method described by **Rababah *et al.* (2005)** and total anthocyanin content in juice was determined according to **Ranganna (1979).**

6- Total anthocyanin in peel of fruit: Peel anthocyanin content (mg/100 g) was assessed according to the method of **Fuleki and Francis (1968).**

General evaluation of the studied treatments

Scoring for the treatments tested was determined on a 100 unit's basis that was shared by some measurements of the creaking percentage, yield and fruit quality. Hundred units were divided among the studied treatments; units for cracking percentage and yield, 30 units for the physical properties of fruits (fruit weight, arils percentage and Juice volume) and 50 units for fruit chemical properties (TSS, total acidity, Vit. C, reducing sugars and anthocyanin) 10 units for each. This method was described by **El-Salhy *et al.* (2023)**. Within each of these characters, the trait was recorded the maximum values given 10 units and relative values due to the other tested treatments were calculated. The following equation was used to estimate these traits.

$$Trait = \frac{B}{A}\ x\ score$$

Where:

A= The highest values recorded for studied traits.

B= Value recorded for the specific trait of considered treatments.

Score: the value given to the studied character.

Statistical analysis

The experiment was designed as a randomized complete block design with three replicates, two trees each. The analysis of variance (ANOVA) was applied according to **Snedecor and Cochran (1989)**. Duncan test at 5% level was used to compare the differences between the treatment means **(Duncan, 1955).**

RESULTS

Tree productivity

Total yield and fruit cracking percentage

Table (4) presents the effect of spraying calcium boron, potassium silicate, jojoba and olive oils on yield/tree and fruit cracking of Manfalouty cv. pomegranate fruits during 2022 and 2023 seasons. It was clear from the data that the results took the same trend in the two studied seasons. The differences between the studied treatments were significant in this respect. As for fruit cracking percentage, a significant decrease was shown by using all sprayed substances comparing with the control in the two studied seasons. The trees sprayed with calcium boron at 3 % gave the lowest percentage of cracking (5.63 and 5.25 %), followed by those sprayed with potassium silicate at 3 % (6.21 and 6.02 %) during 2022 and 2023 seasons, respectively, as compared with control which had 16.08 and 18.11 % in the two seasons of study, respectively. Concerning, the yield kg/tree, data in Table (4) showed that, the studied treatments were significantly increased fruit yield Kg/tree in both studied seasons. The highest fruit yield was recorded with spraying potassium silicate at 3 % followed by calcium boron at 3 %, whereas, the yield was 85.31 and 81.83 kg & 115.31 and 110.62 kg, respectively in the first & second seasons, respectively. However, the unsprayed trees yield recorded 71.24 and 88.12 kg, in 2022 and 2023 seasons, respectively. Hence, the corresponding increment % over unsprayed ones were (10.36, 14.87, 12.45, 19.75, 7.01, 9.98, 6.71 and 8.38 %) and (7.30, 25.28, 23.26, 30.86, 3.35, 6.24, 3.89 and 5.45 %) during 2022 and 2023 seasons, respectively due to spraying with calcium boron at 1.5, 3 %, potassium silicate at 1.5, 3 %, jojoba oil at 2, 3 % and olive oil at 2, 3, % respectively.

Table (4). Effect of some treatments on cracking (%), yield (kg/tree) and yield increment (%) of Manfalouty pomegranate trees during 2022 and 2023 seasons

Characters / Treatments	Cracking (%)		Total yield (kg/tree)		Yield increment (%)	
	2022	2023	2022	2023	2022	2023
Control	16.08 a	18.11a	71.24 e	88.12 f	0.00f	0.00f
Calcium boron 1.5 %	6.80de	6.64ef	78.62cd	94.55 c	10.36d	7.30c
Calcium boron 3 %	5.63 e	5.25 f	81.83 b	110.40 b	14.87b	25.28b
Potassium silicate 1.5%	6.89 de	7.16de	80.11 bc	108.62 b	12.45c	23.26b
Potassium silicate 3 %	6.21 e	6.02 ef	85.31 b	115.31 a	19.75a	30.86a
Jojoba oil 2 %	8.47cd	7.15de	76.24 d	91.07 e	7.01e	3.35e
Jojoba oil 3 %	9.43 bc	8.35cd	78.35 cd	93.62 cd	9.98d	6.24cd
Olive oil 2%	10.80 b	11.34b	76.02 d	91.55 de	6.71e	3.89de
Olive oil 3%	8.97 bc	8.81 c	77.21cd	92.92 cde	8.38de	5.45cde

Means within a column followed by the same letter are not significantly different (p 0.05) according to Duncan's multiple range test.

The results in Table (5) showed that all treatments in general significantly decreased the percentage of sunburn fruits as compared to the control during 2022 and 2023 seasons. The lowest significant percentage of sunburn fruits was obtained from calcium boron at 3 % (7.59 and 5.79) followed by potassium silicate at 3 % (8.32 and 6.83) in the first and second seasons, respectively. While the highest percentage of sunburn fruits was recorded with untreated trees in both seasons.

As for the effect of studied treatments on the percentage of marketable fruits was cleared in Table (5). In this regard, all treatments in general significantly raised the percentage of marketable fruits as compared with the control in both seasons. Trees sprayed with calcium boron at 3 % and had the highest values of the marketable fruits percentage (86.78 and 88.96) followed by those treated with potassium silicate at 3 % (85.47 and 87.15) during 2022 and 2023 seasons, respectively. However, the control recorded the lowest percentage in both seasons.

Table (5). Effect of some treatments on sunburn fruits (%) and marketable fruits (%) of Manfalouty pomegranate trees during 2022 and 2023 seasons

Characters / Treatments	Sunburn fruits (%)		Marketable fruits (%)	
	2022	2023	2022	2023
Control	13.29a	13.04a	70.63f	68.85e
Calcium boron 1.5 %	8.35d	7.03cd	84.85b	86.33b
Calcium boron 3 %	7.59d	5.79d	86.78a	88.96a
Potassium silicate 1.5 %	10.15c	7.59c	82.96c	85.25b
Potassium silicate 3 %	8.32d	6.83cd	85.47ab	87.15ab
Jojoba oil 2 %	11.30bc	9.82b	80.23d	83.03c
Jojoba oil 3 %	10.88bc	9.50b	79.69d	82.15c
Olive oil 2%	12.12ab	10.13b	77.08e	78.53d
Olive oil 3%	11.39bc	9.68b	79.64d	81.51c

Means within a column followed by the same letter are not significantly different (p 0.05) according to Duncan's multiple range test.

Fruit properties

A- Physical characteristics

Data in Table (6 & 7) show the effect of spraying with calcium boron, potassium silicate, jojoba and olive oils on fruit weight, fruit height and diameter, arils weight percentage and juice volume. The results in Table (6) showed that a significant fruit weight was obtained with the use of all spraying substances compared to the control treatment. The heaviest fruit weight (388.14 and 368.42) was achieved by applying potassium silicate at 3 % followed by calcium boron at 3 % & potassium silicate at 1.5 % which recorded 380.38 and 356.69 & 376.35 and 343.12 in the first and second seasons, respectively. The lowest fruit weight (300.11 and 290.01) recorded in control treatment in both seasons.

As for fruit height (cm) and fruit diameter (cm) of Manfalouty pomegranate trees, Table (6) display obviously that different applied treatments calcium boron, potassium silicate, jojoba and olive oils significantly increased fruit height and diameter compared to the control treatment during both seasons. However, potassium silicate at 3 % significantly increased fruit height and fruit diameter, statistically followed by using calcium boron at 3 % and potassium silicate at 1.5 % during both 2022 and 2023 seasons. On the other hand, the control treatment gave the lowest values in this respect in both seasons.

Also, the data presented in Table (7) demonstrated that all treatments in both seasons significantly surpassed than control in arils weight percentage. Potassium silicate at 3 % produced the highest percentage of arils and recorded 65.33 and 69.12 % statistically followed by second significantly increased with using potassium silicate at 1.5 % (63.39 and 67.50) and calcium boron at 3% (62.17 and 65.10) during both 2022 and 2023 seasons, respectively. However, the rail's weight % of control recorded 54.81 and 56.36 % in both seasons. Also, the data in Table (7) showed that the application of all studied spraying substances gave a significant increase in volume of Manfalouty fruit juice in both seasons. The highest values (45.64 and 46.2) were obtained from the fruit of the tree subjected to potassium silicate at 3 % followed by the trees sprayed with calcium boron at 3 % (45.11 and 45.82) during 2022 and 2023 seasons, respectively. The untreated trees produced fruit that had a lower value of juice volume, and recorded (42.34 and 41.02 %) in both seasons, respectively.

Table (6). Effect of some treatments on fruit weight (g), fruit height (cm) and fruit diameter (cm) of Manfalouty pomegranate trees during 2022 and 2023 seasons

Treatments	Fruit weight (g)		Fruit height (cm)		Fruit diameter (cm)	
	2022	2023	2022	2023	2022	2023
Control	300.11 h	290.01 f	7.52 f	6.81 f	8.20 f	7.79 d
Calcium boron 1.5 %	361.62c	340.25 c	7.66 e	7.11 e	8.74 cd	8.31 c
Calcium boron 3 %	380.38 b	356.69 b	7.98 ab	7.56 ab	8.82 bc	8.75 ab
Potassium silicate 1.5 %	376.35 b	343.12 c	7.81 cd	7.12 e	8.93 b	8.76 ab
Potassium silicate 3 %	388.14 a	368.42 a	8.09 a	7.72 a	9.12 a	8.83 a
Jojoba oil 2 %	342.71 e	339.25 c	7.81 cd	7.21de	8.62 de	8.23 c
Jojoba oil 3 %	351.91 d	342.15 c	8.02 ab	7.43bc	8.81 bc	8.77 ab
Olive oil 2%	308.76 g	300.89 e	7.72 de	7.25de	8.46 e	8.31 c
Olive oil 3%	316.31 f	311.45 d	7.93 bc	7.36cd	8.71cd	8.65 b

Means within a column followed by the same letter are not significantly different (p 0.05) according to Duncan's multiple range test.

Table (7). Effect of some treatments on arils % and juice volume (cm3) of fruits of Manfalouty pomegranate trees during 2022 and 2023 seasons

Treatments	Arils (%)		Juice volume (cm^3)	
	2022	2023	2022	2023
Control	54.81 f	56.36 f	42.34 g	41.02 i
Calcium boron 1.5 %	60.62c-e	62.88 d	44.88 c	44.32 d
Calcium boron 3 %	62.17bc	65.10 c	45.11 b	45.82 b
Potassium silicate 1.5 %	63.39 b	67.50 b	44.35 d	45.69 c
Potassium silicate 3 %	65.33 a	69.12 a	45.64 a	46.21 a
Jojoba oil 2 %	59.70 de	62.88 d	42.51 f	41.80 f
Jojoba oil 3 %	61.38 cd	64.46 c	43.70 e	42.99 e
Olive oil 2%	56.56 f	57.33ef	42.38fg	41.12 h
Olive oil 3%	58.76 e	58.01 e	42.50 f	41.39 g

Means within a column followed by the same letter are not significantly different (p 0.05) according to Duncan's multiple range test.

B- Chemical properties

The effect of calcium boron, potassium silicate, jojoba and olive oils spraying on chemical fruit characteristics of Manfalouty pomegranate trees are presented in Table (8). Results showed that total soluble solids percentage (TSS %) was significantly increased by different studied treatments in both seasons, whereas the highest values were recorded in trees sprayed with potassium silicate at 3 % (16.86 and 16.80) and calcium boron at 3 % (16.76 and 16.81) in 2022 and 2023 seasons, respectively. No significant differences between the last treatments, potassium silicate at 3 % and calcium boron at 3 % in both seasons. On the other side, the control treatment significantly decreased the total soluble solids. As for the total acidity of fruit juice of Manfalouty pomegranate trees treated with potassium silicate at 3 % had the minimum value (1.21 and 1.20) in this respect. On the other hand, the control recorded the highest value of total acidity that recorded (1.42 &1.49 %) in the two seasons, respectively. Moreover, the results in Table (8) indicated that the highest values of Vit. C content (30.22 and 31.12) were recorded in the trees treated with potassium silicate at 3 % in both studied seasons, respectively. Also, the untreated trees recorded the lowest values of Vit. C content that recorded (22.15 and 25.11) in both seasons, respectively.

Data presented in Table (9) show the effect of spraying of calcium boron, potassium silicate, jojoba oil and olive oil on increasing sugars and anthocyanin of Manfalouty pomegranate fruits. Trees sprayed with potassium silicate at 3 % gave the highest values (12.45 and 12.51) of reducing sugars percentage. On the other hand, control treatment recorded the lowest values (11.11 and 11.21) in the first and second season, respectively. Also, data in Table (9) clear that spraying with calcium boron, potassium silicate jojoba oil and olive oil significantly increased the anthocyanin percentage in pomegranate fruit compared with control. Trees sprayed with potassium silicate at 3 % gave the maximum value followed by calcium boron at 3 % and potassium silicate at 1.5 %. On the other hand, untreated trees gave the lowest values of anthocyanin percentage in pomegranate fruit during the two studied seasons.

Generally, significant differences were found between the foliar application of calcium boron at 1.5

and 3 %, potassium silicate at 1.5 and 3 %, Jojoba oil at 2 and 3 % and olive oil at 2 and 3 %. So, it can be concluded that the foliar application either of potassium silicate at 3 or calcium boron at 3 % three times at after fruit set (mid – May), on mid of June and mid of August were more effective in increasing the yield of Manfalouty pomegranates trees and reducing cracking percentage and sunburn fruits as well as improved the quality of fruits.

Table (8). Effect of some treatments on TSS %, total acidity % and Vitamin C (mg/100ml) of Manfalouty pomegranate fruits during 2022 and 2023 seasons

Treatments	TSS %		Total acidity %		Vit. C (mg/100ml)	
	2022	2023	2022	2023	2022	2023
Control	15.21 c	15.36 e	1.42 a	1.49 a	22.15 e	25.11 f
Calcium boron 1.5 %	15.81 bc	15.92 c	1.30 d	1.31 c	27.34 bc	28.01 cd
Calcium boron 3 %	16.76 a	16.81 a	1.28 de	1.29 c	29.42 a	28.89 bc
Potassium silicate 1.5 %	16.56ab	16.12 b	1.24 ef	1.22 d	28.72ab	29.83 ab
Potassium silicate 3 %	16.86 a	16.80 a	1.21 f	1.20 d	30.22 a	31.12 a
Jojoba oil 2 %	15.76 bc	15.63 d	1.31 cd	1.30 c	24.34cd	25.89 ef
Jojoba oil 3 %	15.81 bc	16.10 b	1.28 de	1.33 bc	26.23 d	26.81 de
Olive oil 2%	15.29 c	15.41 e	1.37 b	1.36 b	25.31cd	25.81 ef
Olive oil 3%	15.80 bc	15.55 d	1.35 bc	1.33 bc	25.66cd	26.35 ef

Means within a column followed by the same letter are not significantly different (p 0.05) according to Duncan's multiple range test.

Table (9). Effect of some treatments on reducing sugars %, anthocyanin in juice and in the peel of Manfalouty pomegranate fruits during 2022 and 2023 seasons

Treatments	Reducing sugars (%)		Anthocyanin in juice (mg/100 ml)		Anthocyanin in peel (mg/100g)	
	2022	2023	2022	2023	2022	2023
Control	11.11 c	11.21 d	20.64 e	18.31 f	17.11f	16.55e
Calcium boron 1.5 %	11.89 b	11.93 bc	28.01 b	29.16 b	26.23ab	26.89ab
Calcium boron 3 %	12.02 ab	12.21ab	30.1 a	30.82a	27.84a	28.13a
Potassium silicate 1.5 %	12.25 ab	12.34 a	27.13 b	28.79 b	24.09bc	23.21c
Potassium silicate 3 %	12.45 a	12.51 a	29.89a	30.96 a	25.76ab	25.88b
Jojoba oil 2 %	11.36 c	11.40 d	23.83cd	24.66 cd	20.41de	21.45cd
Jojoba oil 3 %	11.96 b	11.82 c	24.75 c	25.90 c	22.18cd	23.33c
Olive oil 2%	11.24 c	11.30 d	22.31de	22.62 e	19.25ef	19.54d
Olive oil 3%	11.32 c	11.33 d	23.96cd	23.88 de	20.02de	20.94d

Means within a column followed by the same letter are not significantly different (p 0.05) according to Duncan's multiple range test.

General evaluation of the studied treatments

Numerical evaluation of studied treatments, Tables (10 & 11) showed that, spraying potassium silicate at 3 & 1.5 % or spraying calcium boron at 3 % and jojoba oil at 3 % registered the highest units.

The total score (65 units) for marketable fruits, yield, fruit weight, arils % and juice volume of Manfalouty pomegranate fruits was significantly varied according to use of the studied treatments. Using potassium silicate at 3 % gave the highest values compared with other treatments.

In general, the results indicated that foliar application of Manfalouty pomegranate trees with potassium silicate at 3 % and calcium boron at 3 % had to increase the yield and the percentage of marketable fruits in comparison with control treatment. In addition, these treatments increased the general total of score in Table (11) and its values were 97.93 and 96.88, respectively.

Table (10). General evaluation of some treatments effects on some marketable fruits (%), yield, fruit weight, arils and juice volume of Manfalouty pomegranate trees as average of both studied seasons

Characters / Score	Marketable fruits %	Yield (kg/ tree)	Fruit weight (g)	Arils (%)	Juice volume (cm^3)	Total
	20	25	5	5	10	65
Control	15.87	19.86	3.90	4.14	9.08	52.85
Calcium boron 1.5 %	19.48	21.58	4.64	4.59	9.71	60
Calcium boron 3 %	20.00	23.96	4.87	4.73	9.90	63.46
Potassium silicate 1.5 %	19.14	23.52	4.76	4.87	9.80	62.09
Potassium silicate 3 %	19.65	25.00	5..00	5.00	10.00	64.65
Jojoba oil 2 %	18.58	20.85	4.51	4.56	9.18	57.68
Jojoba oil 3 %	18.42	21.43	4.59	4.68	9.44	58.56
Olive oil 2%	17.71	20.88	4.03	4.24	9.09	55.95
Olive oil 3%	18.34	21.20	4.15	4.34	9.13	57.16

Table (11). General evaluation of some treatments effects on some of the fruit quality parameters of Manfalouty pomegranate trees as an average of two studied seasons

Characters	TSS (%)	Total acidity (%)	Vit. C (mg/100 ml)	Reducing sugars (%)	Anthocyanin in juice (mg/100g)	Total	G. Total
Score	5.00	10.00	5.00	5.00	10.00	35.00	100.00
Control	4.55	10.00	3.85	4.47	8.30	31.17	84.02
Calcium boron 1.5 %	4.71	8.97	4.51	4.77	9.71	32.67	92.67
Calcium boron 3 %	4.99	8.83	4.75	4.85	10.00	33.42	96.88
Potassium silicate 1.5 %	4.85	8.45	4.77	4.93	9.61	32.61	94.70
Potassium silicate 3 %	5.00	8.28	5.00	5.00	10.00	33.28	97.93
Jojoba oil 2 %	4.66	8.97	4.09	4.56	9.04	31.32	89.00
Jojoba oil 3 %	4.74	8.97	4.32	4.76	9.2.0	31.99	90.55
Olive oil 2%	4.56	9.38	4.17	4.95	8.76	31.82	87.77
Olive oil 3%	4.65	9.21	4.24	4.54	8.99	31.63	88.79

DISCUSSION

Pomegranate production in Assiut governorate faces many problems, including lack of productivity, cracking of fruits, and low quality characteristics. Therefore, in this study, a number of substances were used to increase productivity and increase the quality of fruits, including spray compounds such as calcium boron, potassium silicate, jojoba oil, and olive oil which have a lot of benefits in fruit trees yields (**Abd El-Rzek *et al.* (2011)** on 'Canino' Apricot Trees, **Abd-Allah *et al.*, 2012** on Costata Persimmon and **El Kholy *et al.*, 2018** on Loquat trees) i.e., improving the fruiting and yield quality in pomegranates cvs. in this respect a number of researchers presented their studies which agreement with the results of this study such as **Abd El-Aziz *et al.* (2001); Hasaballa (2002); Abd Elaal (2007); Sheikh and Manjula (2012); El-Akkad *et al.* (2016), Farag et al. (2018), Masoud *et al.* (2018), Badawy, Ibtesam *et al.* 2019, Mohamed, *et al.* (2020) and Abd El-wahed *et al.* (2022)** who mentioned that using calcium boron, potassium silicate, jojoba and olive oils were effective in reducing fruit cracking (%) and increasing yield and fruit quality in various pomegranate cvs. Such results may be due to the positive action of calcium in reducing fruit cracking percentage lies in its role in the stabilization of membrane systems, the formation of calcium pectates and cell walls which increase rigidity of the middle portion and cell wall of the fruit (**Sheikh and Manjula, 2012**). Calcium promotes fruit growth and maintains water balance **Lane *et al.*, (2000)**. Calcium affects the improvement of growth and absorption of nutrients, thus improving the food synthesized that translocated to fruit and enhances their maturation and improves the contents of chemical constituents. In the current study, foliar application of 3 % potassium silicate resulted in an increase of about 19.75 and 30.86 % in the yield over the control while sprayed of calcium boron at 3 % reduced the fruit cracking percentage by 64.99 and 71.01 % than the control in both seasons, respectively. These results are in agreement with **Abdi Rady and Prasad (2012), Digrase *et al.* (2016); Khalil and Aly (2013); Korkmaz *et al.* (2016) and El-Akkad *et al.* (2016)**.

The effect of reducing on fruit cracking (%) in response to boron use is mainly attributed to its important physiological role in the extension of plant cell walls through pectin building as well as enhancing IAA and water absorption **(Yagoden, 1990)**. In addition, the use of boron achieved several advantages such as building, transporting of carbohydrates, promoting photosynthesis, pollen germination and cell division **(Kaneko *et al.*, 1997)**. Boron is responsible for increasing the elasticity of cell membranes and preventing the breakdown of plant tissues. Thus, this decrease in fruit cracking may be due to the borate bridging with cell wall constituents, giving elastic response to it (**Singh *et al.*, 2005)**. Spraying pomegranate cvs. with boron decreased percentage of fruit splitting (**Soni *et al.*, 2000; Lal *et al.*, 2011; Farag *et al.*, 2018 and Abd El-Wahed *et al.*, 2022**)

Potassium silicate is a source of highly soluble potassium and silicon. Potassium plays an indispensable role in regulating several metabolic and physiological processes of plants. Application of silicon is beneficial in increasing the tolerance of plants to stresses as well as enhancing photosynthesis and leaf water potential. In this investigation, spraying potassium silicate increased yield and decreased the percentage of fruit carking as well as improved fruit quality of Manfalouty pomegranate trees, these findings agreement with that of (**Epstein, 1999; Ahmed *et al.*, 2015; Wassel *et al.*, 2015**; **El Kholy *et al.*, 2018 and Masoud *et al.*, 2018**). Potassium nutrition contributes in enhancing tree yields, fruit size, fruit color, soluble solids, shelf life and shipping quality (**Singh *et al.*, 1990 and Hamouda *et al.*, 2015**).

Foliar application with jojoba oil and olive oil on fruit trees improved yield and fruit quality, these substances are used in this study and resulted such improvement in yield and fruit quality of Manfalouty pomegranate fruits which may be due to its role in improving appearance, modifying atmosphere around the surface of fruits to reduce fruit respiration rate and improve the environmental conditions such as temperature and humidity (**Nagvi, *et al.*, 1990; Baldwin *et al.*,1995; Reynolds, 2005; Abd Abd El-Moneim and Abd El-Mageed, 2006 and Abd- Allah *et al.*, 2012**). These conditions provide a semi permeable barrier to enhance rates of carbon dioxide and rates of reducing oxygen and there to reduce respiration retard the ripening, reducing decay and water loss, decrement the oxidation reaction rates

and metabolic activities, especially transpiration and respiration. Spraying olive oil is recommended to improve productivity and fruit quality **(Abd El-Rzek *et al.*, 2011)** on Canino apricot trees; **Shaheen *et al.*, (2018)** on fig trees. The positive effect of used olive oil can be attributed to the essential role of fatty acids that promote formation of the growth regulators that may improve the component of fruit **(Owino *et al.*, 2006).**

Conclusion

In general, it could be concluded that foliar application either of potassium silicate at 3 % or calcium boron at 3 % thrice after fruit set (mid – May), at mid of June and at mid of August were more effective in reducing fruit cracking and sunburn percentage fruits of Manfalouty pomegranates and higher yield with good fruit quality

REFERENCES

A.O.A.C. (2000). Association of Official Agriculture Chemists. Official Methods of Analysis Chemists. Washington, DC, USA.

A.O.A.C. (2002). Association of Official Analytical Chemists: International. Guidelines for Single Laboratory Validation of Chemical Methods for Dietary Supplements and Botanicals; Arlington, VA, USA.

Abd EL- Rahman, I.E. (2010). Physiological studies on cracking phenomena of Pomegranate. Journal of Applied Sciences Research, 6(6): 696-703.

Abd Elaal, E.H.A. (2007). Effect of fruit thinning and spraying with some chelated elements and calcium on yield and fruit quality of Manfalouty pomegranate M. Sc. Thesis, Fac. Agric. Assiut Univ., Egypt.

Abd El-Aziz, F.H.; Ahmed, F.F. and Marsy, M.H. (2001). Relation of potassium, calcium and boron with productivity and fruit cracking of Manfalouty pomegranate trees. 5th Arabian Hort. Conf. Ismailia, 24- 28 Mar. Egypt, 21- 29.

Abd El-Hady, M. A. and Samar M. A. Doklega (2017). Response of Two Eggplant cultivars to irrigation intervals and foliar application with some antitranspirants. J. Plant Production, Mansoura Univ., Vol. 8 (12): 1395- 1401.

Abd El-Kader, A.M.; Saleh, M.M.S. and Ali, M.A. (2006). Effect of soil moisture levels and some antitranspirants on vegetative growth, leaf mineral content, yield and fruit quality of Williams banana plants. J. Applied Sciences Res., 2(12): 1248-1255.

Abd El-Moneim, E.A.A. and Abd El-Mageed, M.A. (2006). Effect of some oil emulsions and wax treatment on prolonging storage period of Washington Navel orange fruits and its volatile components. J. Applied Sci. Res., 2: 405-417.

Abd El-Rzek, M. E.; Abd El-Migeed, M.M. and Abdel-Hamid, N. (2011). Effect of Spraying Garlic Extract and Olive Oil on Flowering Behavior, Yield and Fruit Quality of 'Canino' Apricot Trees. American-Eurasian J. Agric. & Environ. Sci., 11 (6): 776-781, 2011

Abd El-wahed, A. N.; Abd –Alrazik A. M. and Khalifa, S. M. (2022). Effect of some nutrients on growth, Yield and fruit quality of "Wonderful" cultivar pomegranate. Al-Azhar Journal of Agricultural Research, 46 (1):1-15

Abd-Allah, A.S.E.; Eman, A.A.; Abd El-Moneim, M.M.S. Saleh and El-Naggar, M.A.A. (2012). Effect of jojoba oil emulsion on prolonging storage periods of Costata persimmon fruits. Asian J. Agric. Sci., 4: 465-468.

Abdelnaby, A.; Abdelkhalek, A.M. and El-Naggar, Y.I. (2019). Effect of melatonin, GA3 and NAA on vegetative growth, yield and quality of 'Canino'apricot fruits. Acta Scientiarum Polonorum. Hortorum Cultus, 18: 167-174.

Abdi Reddy, P. and D.M. Prasad, (2012). Effect of plant growth regulators on fruit characters and yield of pomegranate (*Punica granatum* L.) cv. Genesh. International Journal of Plant, Animal and Environmental Sciences, Vol. 2, Issue 2, p. 91-93. acids, vitamins B and silicon. World Rural Obser, 73: 91-95.

Abubakar A.R.; Ashraf, N. and Ashraf, M. (2013). Effect of plant bio stimulants on fruit cracking and quality attributes of Pomegranate cv. Kandhari Kabuli. Sci.Res. Essays, 8 (44): 2171- 2175.

Ahmed, F.F.; Mohamed, M.M.; Abou elkhashab, A.M.A. and Aeed, S.H.A. (2014). Controlling fruit splitting and improving productivity of Manfalouty pomegranate trees by using salicylic acid and some nutrients. World Rural Observations, 6 (1): 87-93.

Ahmed, M.; Akl, M.; Moawad, A.; Mohamed, A.; Hamdy, M.; Ibrahim, I. and Mohamed, H. (2015). Productive capacity of Manfalouty pomegranate trees in relation to spraying of silicon and vitamins B. World Rural Observ., 7 (1), 108-118.

Aly, A. A.; Mohamed, H. I.; Mansour, M. T. and Omar, M. R. (2013). Suppression of powdery mildew on flax by foliar application of essential oils. J. Phytopathology, 161: 376-381.

Badawy, F.M. Ibtesam; Eman A.A. Abou-Zaid and Esraa M.E. Hussein (2019). Cracking and fruit quality of "Manfalouty" pomegranate as affected by pre-harvest of Chitosan, Calcium chloride and Gibbrellic acid spraying. Middle East Journal of Agriculture Research, 08(03): 873-882.

Baldwin, E.A.; Niesperos, M.O.; Shaw, P.E. and Burns, J.K. (1995). Effect of coatings and prolonged storage conditions on fresh orange flavour volatiles, degrees brix and ascorbic acid levels. Journal of Agriculture and Food Chemistry, 43(5):1321-1331. *https://doi.org/10.1021/jf00053a037*

Bankar, G.J. and Prasad, R.N. (1992). Performance of important pomegranate cultivars in arid region. Annals Arid Zone, 31:181-03.

Bonomelli, C. and Ruiz, R. (2010). Effect of foliar soil calcium application on yield and quality of table grape cv. Thompson seedless. J. Plant Nutr., (33):299- 314.

Chen, F.; Liu, H.; Yang, B.; Hou, H.; Yao, Y.; Zhang, S.; Bu, G. and Deng, Y. (2011). Quality attributes and cell wall properties of Strawberries (Fragaria x Ananasa Duch.) under calcium chloride treatment. Food Chem., (1260): 450- 459.

Digrase, S.S.; Tambe, T.B.; Kadam, A.S. and Kalalband, B.M. (2016). Effect of different plant growth regulators and chemicals on growth and yield of pomegranate (*Punica granatum* L.) cv. Bhagwa. Adv. Res. Crop Improv., 7 (1): 96-99.

Duncan, D.B.C. (1955). Multiple Ranges and Multiple F test. Biometrics, 11: 1-24.

Egan, H.; Kirk, R.S. and Sawyer, R. (1981). Pearson's Chemical Analysis of Food: Churchill Livingstone, Edinburgh London, Melbourne and New York, 591.

El Kholy, M. F.; Mahmoud, A. A. and Mehaisen, S.M.A. (2018). Impact of Potassium Silicate Sprays on Fruiting, Fruit Quality and Fruit Storability of Loquat trees. Middle East Journal of Agriculture Research, 7 (01) :139-153.

El-Akkad, M.M.; Gouda, F.E.Z.M. and Ibrahim, R.A. (2016). Effect of GA3, calcium chloride and vapor guard spraying on yield and fruit quality of Manfalouty pomegranate trees. Assiut J. Agric. Sci., 6(1), 181-190.

Elmer, P.A.G.; Spiers, T.M. and Wood, P.N. (2007). Effects of pre – harvest foliar calcium sprays on fruit calcium level and brown rot of peaches. Crop protect, (26): 11-18.

El–Salhy, A.M.; Fatma El- Zahraa M.A. Gouda; El – Bolok, T. KH. and Mohamed, M.M. (2023). Effect of irrigation levels on growth and fruiting of Manfalouty pomegranate trees grown in new reclaimed regions. Assiut J. Agric. Sci., 54(3): 119-134.

Epstein, E. (1999). Silicon, Annl. Rev. Plant Physiol. Plant Mol. Bio, 50: 641-664.

Ewa, S.; Igorkhmelinskii, H. and Marek, S. (2015). Analysis of olive oils by Fluorescence spectroscopy: Methods and applications. Faculty of chemistry, Mickiewicz University, Poland.

Farag, K.M.; Neven, M.N. Nagy; ElSheikh, M.H. and Abada, H.S. (2018). Reducing cracking and enhancing coloration and quality of Wonderful pomegranates cultivar by safe treatments. Zagazig J. Agric. Res., Vol. 45 No. (4): 1245- 1265.

Fuleki, T. and Francis, F.J. (1968). Quantitative methods for anthocyanins. Determination of total anthocyanin and degradation index for cranberry juice. *Journal of food science*, *33*(1), 78-83.

Gil, M.I.; Tomas- Barberan, F.A.; Hess- pierce; Holcroft, D.M. and Kader, A.A. (2000). Antioxidant activity of Pomegranate juice and its relationship with phenolic composition and processing. J. Agric. Food Chem., (48): 4581- 4589.

Hamouda, H.A.; Abdel Motty, E.Z. and Zahran, N.G. (2015) Nutritional Status and Improving Fruit Quality by Potassium, Magnesium and Manganese Foliar Application in Pomegranate Shrubs', International Journal of ChemTech Research, 8(6): 858-867.

Hasaballa, M.A.M. (2002). Effect of spraying some nutrients and vitamin C on fruit splitting, yield and quality of Manfalouty pomegranate trees. M. Sc. Thesis Fac. Agric. Minia Univ., Egypt.

Hegazi, A.; Samra, N.R.; Elbaz, E.E.T.; Khalil, B.M. and Gawish, M.S. (2014). Improving fruit quality of Manfaloty and Wonderful pomegranates by using bagging and some spray treatments with gibberellic acid, calcium chloride and kaolin. Journal of Plant Production, 5(5), 779-792.

Hernandez- Munoz, P.; Almena, E.; Ocio, M.J. and Gavara, R. (2006). Effect of calcium dips and chitosan coating on postharvest life of Strawberries (Fragaria x Ananassa). Bostharv.Bio.Tech., (39): 247- 253.

Irfan, P.K.; Vanjakshi, V.; Keshava Prakash, M.N.; Ravi, R. and Kudachikar, V.B. (2013). Calcium chloride extends the keeping quality of fig fruit (*Ficus carica* L.) during storage and shelf – life. Postharv. Biol.Tech., (82):70-75.

Kamal, H.M.; Elisa, M.A. and Mohammed, A. A. (2017). Effect of some mineral compounds on yield and fruit quality of pomegranate', Bioscience Research, 14(4): 1197-1203.

Kaneko, S.; Ishil, T. and Matsung, T. (1997). A boron rhamnoyalcafuronan II- complex from bamboo shot cell walls. Phytochem., 49: 243- 248.

Khalil, H. and Aly, H.S.H. (2013). Cracking and fruit quality of Pomegranate (*Punica granatum* L.) as affected by pre- harvest sprays of some growth regulators and Mineral Nutrients. Journal of Horticultural Science and Ornamental plants. 5(2): 71-76.

Korkmaz, N., M.A. Askin, S. Ercisli and V. Okatan, (2016). Foliar application of Calcium Nitrate, Boric acid and Gibberellic acid affects yield and quality of Pomegranate (*Punica granatum* L.) Acta Sci. Pol. Hortorum Cultus, 15(3): 105- 112.

Lal, S.; Ahmed, N. and Mir, J.I. (2011). Effect of different chemicals on fruit cracking in pomegranate under karewa condition of Kashmir Valley. Indian J. Plant Physiol., 16 (3&4): 326-330.

Lanaouskas, J. and Kvikliene, N. (2006). Effect of calcium foliar application on some fruit quality characteristics of "Sinap Orlovskij" apple. Agron. Res., (4):31- 36.

Lane, W.D.; Mehriuk, M. and McKenzie, D.L. (2000). Fruit cracking of a susceptible, an intermediate, and a resistant sweet cherry cultivar. Hort. Sc., 35 (2): 239-242.

Lansky, E.P. and Newman, R.A. (2007). *Punica granatum* (pomegranate) and its potential for prevention and treatment of inflammation and cancer. J Ethnopharmacol,109(2): 177-206.

Masoud, A.A.B.; Radwan, E.M.A. and Eman A.A. Abou- Zaid (2018). Effect of some Micro-nutrients, Silicon and GA3 spraying on Yield and Fruit Quality of Pomegranate. Assuit J. Agric. Sci., 49 (3): 97- 106.

Mohamed, A.K.A.; Abdel-Galil, H. A. and Naglaa H. Galal (2020). Effect of some nutrients and amino acids spraying on yield and fruit quality of Manfalouty pomegranate. SVU-International Journal of Agricultural Science, 2 (2): 18-29.

Nagvi, H.H. and Ting, I.P. (1990). Jojoba: A Unique Liquid Wax Producer from the American Desert. In: Advances in New Crops, Janick, J. and J.E. Simon (Eds.). Timber Press, Portland, pp: 247-251.

Owino W.O.; Manabe, Y., Mathooko, F.M.; Kubo, Y. and Inaba, A. (2006). Regulatory mechanisms of ethylene biosynthesis in response to various stimuli during maturation and ripening in fig fruit. Plant Physiol. and Biochem., 44: 335-342.

Rababah, T.; Erefe, J.K.I. and Howard, L. (2005). Effect of ascorbic acid and dehydration on concentration of total phenolic, antioxidant capacity, anthocyanin, and color in fruits J. Agri. Food Chem.,53:4444- 4447.

Ranganna, S. (1979). Manual of analysis of fruit and vegetable products. New Delhi India Tanta Mc Graw Hill Publishing Company. Limited Chapter 4: 77-83.

Reynolds, A.G. (2005). Effects of Canola Oil and Jojoba Wax Sprays on Powdery Mildew, Bunch Rot, and Vine Performance of 'Auxerrois' and 'Riesling' Grapevines. Small Fruits Review, 4:4, 49-72.

Shaheen, S. A.; El-Soda, A. S. and El-Bolok, T.K. (2018). Effect of spraying hydrogen cynamide, garlic oil, olive oil and jasmine oil on earliness of budburst, yield and fruit quality of fig (Sultani cv.). Bull. Fac. Agric., Cairo Univ., 69: 155-166

Sharma N. and Belsare, C. (2011). Effect of plant bio- regulators and nutrients on fruit cracking and quality in pomegranate (*Punica granatu*m L.) 'G-137' in Himachal Pradesh. Acta Hort. 890: 347-352.

Sheikh, M.K. and Manjula, N. (2012). Effect of chemicals on control of fruit cracking in pomegranate (*Punica granatum* L.) var. Ganesh. In: Melgarejo P. (ed.), Valero D. (ed.). II Int. Symposium on the Pomegranate. Zaragoza: CIHEAM/ Universidad Miguel Hernández. p. 133-135.

Sing, D.B. and Kingsly, A.R.P.A. (2006). Efficiency of boron application on control of fruit cracking and improvement in yield and quality of pomegranate fruits. Paper presented in National Symposium on Improving Input Use Efficiency in Horticulture held during 9-11 August, Bangalore.

Sing, D.B.; Sharma, B.D. and Bhargava, R. (2003). Effect of Boron and GA3 to control fruit cracking in Pomegranate (*Punica granatum* L.). Curr. Agric., (27):125- 127.

Singh, A.K.; Sharma, P.; Sharma, R.M. and Tiku, A.K. (2005). Effect of plant bioregulators and micronutrients on tree productivity, fruit cracking and aril proportion of litchi (*Litchi chinesis* Sonn.) cv. Dehradun. Haryana J. Hort. Sci., 34 (3-4): 220-221.

Singh, R.P.; Sharma, Y.P. and Awasthi, R.P. (1990). Influence of different cultural practices on premature fruit cracking of pomegranate. Progrssive Hort., 22: 92.96.

Smith, F. (1956). Colorimetric method for determination of sugar and related substance. Anal. Chem., 28: 350-356.

Snedecor, G.W. and Cochran, W.G. (1989). Statistical Methods, Eighth Edition, Iowa State University Press.

Soni, A.K.; Gupta, N.K. and Paliw, R. (2000). Response of borax with irrigation at different intervals on fruit cracking and yield of pomegranate. Annals Arid Zone, 39: 1256-128.

Wassel, A.H.; Gobara, A.; Ibrahiem, H. and Shaaban-Mai, M. (2015). Response of wonderful pomegranate trees to foliar application of amino

Yagoden, B.A (1990). Agriculture Chemistry Mir Publishers Moscow, 278-281.