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Efficacy of Foliar Spraying with Calcium on the Fruit Cracking of the French Pomegranate Variety

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Abstract **- The research was carried out in the 2018 agricultural season in a field planted with pomegranate trees (French variety), with the aim of determining the effect of foliar spraying with calcium in reducing fruit cracking. We used for the experiment three treatments for calcium concentrations (0, 1000, 2000 ppm) and four treatments for the number of spraying times with calcium (0, 1, 2, and 3 times).The results showed that all the treatment of foliar spraying with calcium was superior to the control in most of the studied traits (early flowering and ripening time, increasing the percentage of fruit-set, improving the quality and the quantity of the production). Also, increasing the number of times spraying with calcium reduced the percentage of fruit cracking, as the percentage of cracked fruits reached 73.96%, 26.49%, 19.81%, and 15.74% in treatments of 0, 1, 2, and 3 spraying times respectively. Moreover, the increase in the spraying concentration achieved a significant reduction in the percentage of cracked fruits, which amounted to 21.23% and 18.24% in the treatments of concentrations A and B, respectively.**

Keywords: Calcium, Foliar spraying, fruit cracking, French pomegranate variety.

I. INTRODUCTION

The pomegranate (*Punicagranatum* L.) is one of the internationally important economic trees. It is native to Central Asian regions, and from there it moved to the other countries of the world (Chandler, 1957; Levin, 1994). Pomegranate tree is currently grown in many geographical areas including the Mediterranean basin, Asia and the USA (Bankar and Prasad, 1992; Holland et al., 2009).

The fruit cracking is the most important physiological problem that affects pomegranate fruits. Panwar et al. (1994) and Singh (1995) showed that cracked fruits are susceptible to infection by bacteria and fungi, and thus lose their marketing value and become unfit for human consumption, causing great economic loss for pomegranate farmers (Finkel and Holbrook, 2000; Schrader et al., 2002). Singh et al. (2006) and Bankar and Prasad (1992) confirmed that about 25–40% of the fruits crack at the time of ripeness, and these fruits lose their quality and become unfit for marketing and thus cause a great loss in production. The cracking rate may sometimes reach more than 70%, which reduces production to 50%, and this affects farms (Draie and Aboras, 2021a).

The cause of pomegranate cracking is mainly due to genetic factors (variety), environmental factors, and various agricultural treatments (Saad et al., 1988; Prasad et al., 2003; Chandra et al., 2011; Khadivi-Khub, 2014). Abd and Rahman (2010) indicated that the cracking is associated with high temperature, high transpiration rate, low humidity in the air and soil, and sharp fluctuations in temperature between day and night during fruit growth. Also, it has been confirmed that pomegranate cracking is associated with irregular irrigation and a lack of nutrients (Gharesheikhbayat, 2006; Khalil and Aly, 2013; Saei et al., 2014; Galindo et al., 2014). The degree of cracking varies according to the growth stages of the fruit, so cracking is more pronounced at the ripening stage of the fruits (Hoda and Hoda, 2013; Yazici and Kaynak, 2006).

Nutritional deficiencies such as calcium are directly related to cracking fruits in pomegranates (Gharesheikhbayat, 2006; Saei et a., 2014). Nutrients such as calcium are involved in some physiological processes during the growth period of fruits, and their deficiency leads to fruit cracking (Sheikh and Manjula, 2009). Several studies have shown that calcium chloride reduces cracking of fruits (Singh et al., 2003; Khalil and Aly, 2013). Abdel-Aziz et al. (2001) have shown that spraying Manfalouty pomegranate variety four times with calcium chloride 0.5% concentration, potassium bisulfate 0.5% concentration, and boric acid 0.05% concentration, alone or as a mixture, led to improved production and reduced fruit cracking.

Pomegranate is grown in Syria to a good degree. Pomegranate cultivation is self-sufficient with the export of a small part of the production. However, this tree is exposed to many problems that affect the quantity and quality of production, the most important of which is the problem of cracking fruits. The degree of sensitivity to this problem varies according to the cultivated variety. The French variety is one of the most important cultivated varieties in northern Syria in

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terms of cultivated area and in terms of local consumption. However, due to the sensitivity of this variety to the disorder of cracking fruits, the areas planted with it have begun to decrease. Accordingly, this research was conducted with the aim of studying the effect of foliar spraying with calcium element (different concentrations and different spraying times) on the possibility of reducing the fruit cracking of this variety.

II. MATERIALS AND METHODS

2.1 Experimental Location

The research was executed in an orchard planted with pomegranate trees in the city of Sarmada, which is located on the Syrian-Turkish border. The city of Sarmada is about 40 km to the north of Idlib, and it is approximately 383 meters high. The total rainfall during the research season was 693 mm.

2.2 Plant Materials

The experiment was carried out on French pomegranate trees, which have large, spherical to flattened fruits, with red skin and long necks. The seeds are surrounded by a bloody red pulp, the leaf is elongated, and the branches are spiny. The fruits of this variety are prone to cracking (Draie and Aboras, 2021a;b).

2.3 Experimental Design and treatments

The study was executed in the 2018agricultural season in a field planted with French pomegranate trees at the age of 10 years and dimensions 4 x 4 m. The complete randomized design (CRD) was used. The experiment involved three treatments for the concentrations of calcium and four treatments for the number of foliar spraying times with calcium, according to the following:

- Calcium solution concentrations: 0, 1000 ppm (A), and 2000 ppm (B).
- Number of foliar spraying times: 0, 1, 2, and 3 times:
  - Control without spraying.
  - Foliar spraying once after the beginning of flowering (1/5/2019).
  - Foliar spraying twice after the beginning of flowering (1/5/2019) and after the completion of the fruit set (1/6/2019).
  - Foliar spraying three times after the beginning of flowering (1/5/2019), after the completion of the fruit-set (1/6/2019), and when the fruits start to color (1/7/2019).

Five replicates per treatment, with one tree (French pomegranate variety) per replicate, were adopted. Consequently, the number of pomegranate trees used in the experimentation = 3 concentrations x 4 foliar spraying times x 5 replicates x 1 tree = 60 trees.

2.4 Measured Parameters

The following measurements were taken:

1. Flowering traits:

- Number of days until the starting of flowering.
- Number of total flowers.
- Number of hermaphrodite flowers.
- Ratio of hermaphroditic flowers (%).

2. Fruits-set and Yield characteristics:

- Ratio of fruit-set (%).
- Number of days until the date of fruits ripening.
- Productivity kg/tree.

3. Physical properties of fruits:

- Ratio of cracked fruits per tree (%).
- Diameter of fruit (cm).
- Weight of fruits (kg).
- Weight of fruit peel (g).
- Internal tissue weight (g).
- Weight of seeds (g).
- Weight of juice (g).

4. Fruitquality characteristics:

- Ratio of juice (%).
- Total Soluble Solids (T.S.S.%).
- Acidity of juice (pH).

2.5 Statistical analysis:

The results were analyzed by the statistical program (GenStat-12). The averages were compared by calculating the LSD at the level of significance (5%).

III. RESULTS AND DISCUSSION

3.1 Effect of spraying concentration with calcium on the studied characteristics

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Table (1): Effect of spraying concentration with calcium on the studied characteristics

Trait \ Concentration (ppm)	0	1000	2000	$LSD_{5\%}$
Flowering	52.00	51.00	50.50	0.11
Ripening	151.00	149.00	148.00	0.12
Number of total flowers	287.33	410.14	432.54	1.89
Hermaphrodite flowers (%)	25.75	40.64	41.02	0.43
Fruit-set (%)	21.62	30.25	33.61	1.1
Diameter of fruit (cm)	8.32	11.25	11.65	0.14
Weight of fruits (g)	256.12	330.98	361.02	1.33
Weight of fruit peel (g)	60.99	72.21	77.66	0.58
Internal tissues weight (g)	59.12	70.42	72.63	0.84
Weight of seeds (g)	136.01	188.35	210.73	1.26
Ratio of juice (%)	27.32	39.31	41.37	0.19
Acidity of juice (pH)	2.98	3.37	3.44	0.03
Total Soluble Solids (T.S.S.%)	15.22	15.57	16.23	0.17
Productivity/tree (kg)	11.36	12.73	14.62	1.2

From table (1) that all foliar spraying concentrations with calcium exceeded the control in the number of days required to reach flowering (the value in the control was 52 days). The treatment of concentration B (2000 ppm) by 50.50 days outperformed the treatment of concentration A (1000 ppm) by 51.00 days in the number of days required to reach flowering. The foliar spraying concentrations outperformed the control in reaching the ripeness of the fruits, as the control needed 151 days, and the increase in the used concentration led to significant differences between the spraying treatments themselves, as the treatment of concentration B (2000 ppm) by 148.00 days outperformed the treatment concentration A(1000 ppm) by 149.00 days.

The total number of flowers in the control reached 287.33, of which the percentage of hermaphrodite was 25.75%.The treatment of concentration A achieved a significant difference on the control with 410.14 flowers, which was also superior to the percentage of hermaphroditic flowers, which amounted to 40.64%.While the treatment of concentration B achieved a significant difference on the treatment of concentration A by the total number of flowers of 432.5and by the percentage of hermaphrodite flowers of 41.02%, (Table 1). Our study was in agreement with Shaheen (1995) who showed that increasing the spraying concentration led to an increase in the percentage of hermaphroditic flowers in pomegranate.

Regarding the percentages of fruit-set, it was 21.62% in the control, 30.25% in the treatment of concentration A (1000 ppm), and 33.61% in the treatment concentration A (2000 ppm), where the differences were significant between all treatments (Table 1). Our study is consistent with Ozkaya (2004) where it was found that foliar spraying with micro-elements has a positive effect in increasing the fruit-set through its positive role in increasing cell division and activating the biosynthesis of organic compounds.

The results of the statistical analysis according to Table (1) showed the significant effect of the concentrations used in the weight of the peel and the weight of the internal tissues of the fruit, as their weight in the control reached 60.99g and 59.12g, respectively. The treatments of concentrations A and B achieved a significant difference over the control. As the weight of the peel was 72.21 g and the internal tissue weight was 70.42 g in the treatment of concentration A. While the weight of the peel was 77.66 g and the internal tissue weight was 72.63 g in the treatment of concentration B, with the significant superiority of the treatment of concentration B over the treatment of concentration A.

The foliar spraying with calcium had a significant effect on the weight and diameter of the pomegranate fruit, as the weight of the fruit in the control reached 256.12 g and the diameter was 8.32 cm. The treatment of concentration A achieved a significant difference on the control, where the weight of the fruit was 330.98 g and the diameter of the fruit was 11.25 cm. Also, the treatment of concentration B with a weight of fruit of 361.02 g and a diameter of fruit of 11.65 cm, achieved a significant difference over the treatment of concentration A(Table 1). Similarly, the weight of the seeds was increased by the effect of foliar spraying with calcium, reaching 136.01g, 188.35g, and 210.73g in the control, in the treatment of concentration A, and in the treatment of concentration B, respectively (Table 1).

As for the percentage of juice, all calcium spraying concentrations outperformed the control treatment, in which the juice percentage was 27.32%. The treatment of concentration B (2000 ppm) outperformed the treatment of concentration A (1000 ppm) with juice percentage of 41.37%

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and 39.31%, respectively, (Table 1). Our study coincides with Fayed (2010), who showed that increasing the spraying concentration of pomegranate trees from 700 ppm to 1000 ppm, led to a significant increase in the percentage of juice in the fruit, and all treatments were superior to the control.

The acidity of the juice decreased (the pH value increased) due to the effect of the foliar spraying with calcium. The pH values reached in control 2.98, in the treatment of concentration A (1000 ppm) 3.37, and in the treatment of concentration B (2000 ppm)3.44. The differences were Significance between all the treatments (Table 1).

Also, the percentage of T.S.S. increased due to the effect of foliar spraying with calcium, as its value in the control reached 15.22%. All the treatments outperformed the control treatment. Moreover, the treatment of concentration B with a percentage of T.S.S. of 16.23% outperformed the treatment of concentration Awith a percentage of T.S.S. of15.57% (Table 1). These results are consistent with the fact that fertilizing pomegranate trees with fertilizers such as calcium, potassium, and boron, either alone or in combination, improved the physical and chemical properties of the fruits (Abdel-Aziz et al., 2001).

Table (1) also indicates the significant effect of spraying with calcium on the productivity of the French pomegranate variety, where the productivity of the control reached 11.36 kg/tree. The treatment of concentration A (1000 ppm) achieved a significant increase over the control and the productivity reached 12.73 kg/tree. The treatment of concentration B (2000 ppm) achieved a significant increase over the treatment of concentration A, with a productivity of 14.62 kg/tree. The differences were significant between all treatments. However, the spraying treatments with calcium achieved an increase in productivity over the control by 112.06%, and 128,70% in the treatments of concentrations A and B, respectively.

3.2 Effect of spraying times with calcium on the studied characteristics

Table (2): Effect of spraying times with calcium on the studied characteristics

Trait \ Number of spraying times	0	1	2	3	$LSD_{5\%}$
Flowering	52.00	51.25	51.00	51.00	0.13
Ripening	151.00	150.00	149.00	148.50	0.15
Number of total flowers	287.33	351.51	407.73	429.82	2.02
Hermaphrodite flowers (%)	25.75	39.02	40.56	41.00	0.50
Fruit-set (%)	21.62	30.04	31.48	32.28	1.04
Diameter of fruit (cm)	8.32	11.06	11.27	11.76	0.11
Weight of fruits (g)	256.12	305.54	333.76	352.10	1.58
Weight of fruit peel (g)	60.99	70.53	72.77	75.64	0.67
Internal tissues weight (g)	59.12	63.46	68.79	70.83	0.75
Weight of seeds (g)	136.01	171.55	192.20	205.63	1.37
Ratio of juice (%)	27.32	38.07	40.29	41.32	0.24
Acidity of juice (pH)	2.98	3.31	3.35	3.44	0.02
Total Soluble Solids (T.S.S.%)	15.22	15.28	15.84	16.41	0.19
Productivity/tree (kg)	11.36	12.22	13.66	13.93	1.07

It is evident from Table (2) that all spraying treatments exceeded the control in the number of days required to reach flowering (as the value in the control was 52 days). The increase in the number of spraying times also had a positive effect in this aspect, as the treatments of three-time spraying and twice spraying by 51 days (without significant differences between them) outperformed the treatment of once spraying by 51.25 days.

Table (2) also shows the significant effect of spraying with calciumin reaching the stage of fruit ripeness, where all treatments exceeded the control treatment, which required 151 days. The increase in the number of spraying times led to significant differences between the treatments. Where the treatment of three-time spraying (by 148.50 days) surpassed the treatment of twice spraying (by 149 days), which outperformed the treatment of once spraying (150 days).

Also, increasing the number of spraying times with calcium had a significant effect on increasing the number of total flowers and the percentage of hermaphroditic flowers. The total number of flowers in the control reached 287.33, of which 25.75% were hermaphroditic. The treatment of once spraying achieved a significant superiority over the treatment of the control, as the total number of flowers in it was 351.51, with a percentage of hermaphroditic flowers of 39.02%. The

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treatment of twice spraying achieved a significant superiority over the treatment of once spraying, as the number of total flowers reached 407.73, of which 40.56% were hermaphrodite. While the treatment of three-time spraying outperformed all treatments, and the total number of flowers was 429.82, of which 41.00% was a hermaphroditic flower (Table 2).

Spraying and increasing the number of spraying times had a significant effect on the percentage of fruit-set, as the ratios reached 21.62%, 30.04%, 31.48%, 32.28%, in the control, the treatment of once spraying, the treatment of twice spraying, and in the treatment of three-time spraying, respectively. The differences were significant between all treatments, (Table 2).

The results of the statistical analysis according to Table (2) showed the significant effect of increasing the number of spraying times on the weight of the peel and the weight of the internal tissues of the fruit, as their weight in the control reached 60.99g and 59.12g, respectively. All the foliar spraying treatments achieved a significant superiority over the control treatment, as the weight of the peel was 75.64 g and the internal tissue weight was 70.83 g in the treatment of three-time spraying. While, the weight of the peel was 72.77g and the weight of the internal tissues was 68.79 g in the treatment of twice spraying, whereas in the treatment of once spraying, the weight of the peel was 70.53g and internal tissue weight 63.46g. The differences were significant between all treatments.

Table (2) shows the significant positive effect of spraying and of increasing the number of spraying times on increasing the seeds weight compared to the control, in which the weight of the seeds reached 136.01g. The treatment of once spraying surpassed the control, with a seeds weight of 171.55g. Also, the treatment twice spraying achieved a significant increase over the treatment of once spraying, with a seeds weight of 192.20g. Whereas, the treatment of three-time spraying (by 205.63g) achieved a significant increase above the treatment of twice spraying and on all other treatments.

Spraying and increasing the number of spraying times had a significant effect on increasing the weight and diameter of the fruit, as the weight of the fruit in the control reached 256.12 g and the diameter was 8.32 cm. The treatment of once spraying (by a weight of fruit of 305.54g and a diameter of fruit of 11.06 cm) significantly surpassed the control. While the treatment of twice spraying achieved a significant difference above the treatment of once spraying, as the weight of the fruit was 333.76g and the diameter of the fruit was 11.27cm. Whereas, the treatment of three-time spraying achieved a significant difference over the treatment of twice spraying, as the weight of the fruit was 352.10g and the diameter of the fruit was 11.76 cm (Table 2).

Table (2) also shows the significant effect of spraying and the increase in the number of spraying times in the proportion of juice, as the percentage in the treatments reached 27.32%, 38.07%, 40.29%, and 41.32% in the control, in the treatment of once spraying, in the treatment of twice spraying, and three-time spraying, respectively. The treatment of three-time spraying outperformed all treatments, as the differences were significant between all treatments.

The foliar spraying with calcium reduced the acidity of the juice (higher pH), with the pH value of 2.98 in control. The increase in the number of spraying times achieved clear significant differences in this characteristic between the treatments themselves. The treatment of once spraying significantly exceeded the control with a value of pH of 3.31. While the treatment of twice spraying (by 3.35) outperformed the treatment of once spraying. Whereas the treatment of three-time outperformed all treatments with a pH value of 3.44, (Table 2).

Also, the percentage of T.S.S. increased due to the effect of foliar spraying with calcium, as its value in the control reached 15.22%. All the treatments were significantly superior to the treatment of the control, as the T.S.S. percentage in the three-time spraying treatment reached 16.41%, and significantly surpassed the treatment of twice spraying in which the T.S.S. was 15.84%. While the treatment of twice spraying exceeded the treatment of once spraying with a T.S.S. value of15.28%, (Table 2).

Table (2) indicates the significant effect of increasing the number of spraying times with calcium on the productivity of the French pomegranate variety, as the productivity of the control reached 11.36 kg/tree. The treatment of once spraying achieved a significant increase over the control with a productivity of 12.22 kg/tree. While the treatment of twice spraying significantly surpassed the treatment of once spraying with a productivity of 13.66 kg/tree. Whereas the treatment of three-time spraying significantly outperformed all the treatments with a productivity of 13.93 kg/tree. However, the spraying treatments achieved an increase in productivity over the control by 107.57%, 120.25%, and 122.62% in the treatments of once, twice, and three-time spraying, respectively.

3.3 Effect of interaction between the spraying concentrations and spraying times with calcium on the studied characteristics

The interaction between the concentrations of spraying with calcium (concentration 1000 ppm, and the concentration

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2000 ppm) and the number of spraying times with calcium (spraying once, spraying twice, and spraying three times) had a significant effect on the whole studied characteristics compared with the control (Table 3).

Table (3): Effect of interaction of the spraying concentrations and spraying times with calcium

Spraying times	Spraying concentration	fruit-set (%)	Peel weight (g)	Fruit weight (g)	Fruit diameter (cm)	Juice ratio (%)	T.S.S. (%)	Juice pH	Yield (kg/tree)
Control		21.62	60.99	256.12	8.32	27.32	15.22	2.98	11.36
1	1000 ppm	29.23	69.45	315.57	11.10	34.33	15.52	3.32	11.86
	2000 ppm	32.02	75.60	355.67	11.31	37.18	15.75	3.37	13.24
2	1000 ppm	30.41	71.99	338.06	11.21	35.61	15.60	3.36	13.08
	2000 ppm	34.06	77.46	362.60	11.62	38.81	16.27	3.42	15.11
3	1000 ppm	31.12	75.20	360.68	11.43	37.11	16.18	3.44	13.26
	2000 ppm	34.74	79.93	370.01	12.02	40.21	16.84	3.52	15.51
$LSD_{5\%}$		2.08	1.33	3.86	0.22	0.48	0.38	0.04	1.10

The binary interaction of concentrations B and three-time spraying outperformed the other interactions, in the fruit-set ratio with a value of 34.74%, in the weight of the fruit peel with a value of 79.93g, in the weight of the fruit with a value of 370.01g, in the diameter of the fruit with a value of 12.02 cm, in the ratio of juice with a value of 40.21%, in the percentage of T.S.S. with a value of 16.84%, in the acidity of juice with a value of 3.52, and in the global yield per tree by 15.51 kg.

Then came the binaries of the concentration B with twice spraying, concentration B with once spraying, concentration A with three-time spraying, concentration A with the twice spraying, and finally, concentration A with once spraying, respectively, in most of the studied traits. These results show the greater effect of the calcium spraying concentration factor compared to the calcium spraying times factor, as doubling the spraying concentration achieved greater effectiveness and led to the improvement of the studied characteristics compared to the increase in the number of spraying times.

3.4 Effect of spraying with calcium on the fruit cracking

Calcium foliar spraying significantly reduced the percentage of fruit cracking compared to the control (Figure 1). Where the percentage of cracked fruits reached 73.96% in the control, 21.23%.in the treatment of concentration A (1000 ppm), and 18.24% in the treatment of concentration B (2000 ppm). The differences were significant between the treatments, (Figure 1).

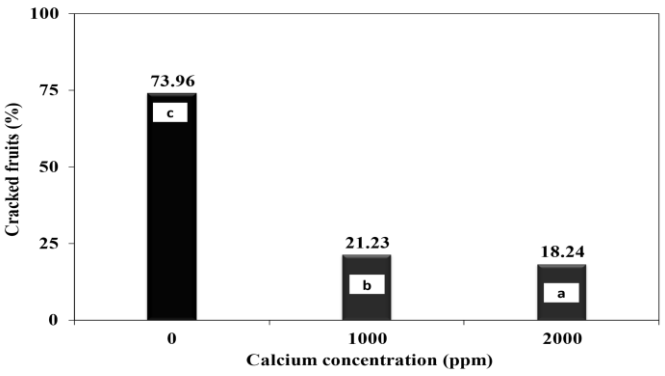

Figure 1: Effect of spraying concentration with calcium on the fruit cracking ($LSD_{5\%}$=0,24)

Also, spraying and increasing the number of spraying times with calcium had a significant effect in reducing the percentage of cracked fruits compared to the control. Where the percentage of cracked fruits reached 73.96% in the control, 26.49%.in the treatment of once spraying, 19.81% in the treatment of twice spraying, and 15.74% in the treatment of three-time spraying. The differences were significant between the treatments, (Figure 2).

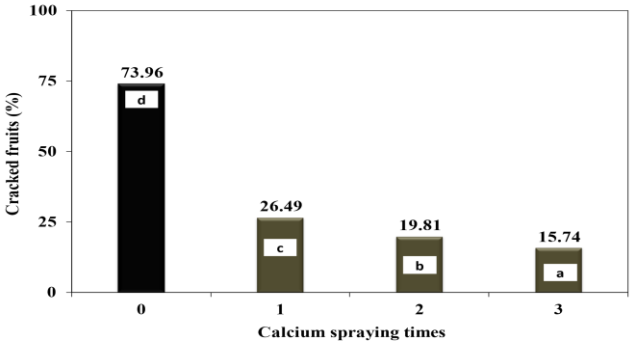

Figure 2: Effect of spraying times with calcium on the fruit cracking ($LSD_{5\%}$=0.35)

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Regarding the interaction between the concentrations of spraying with calcium (0, 1000, and 2000 ppm) and the number of spraying with calcium (0, 1, 2, and 3 spraying times), the effect was significant in reducing the rate of fruit cracking of the French pomegranate variety compared to the control in which the percentage of cracked fruits was 73.96%, (Figure 3). The binary interaction of the concentration B with three-time spraying by 26.98% outperformed the other interactions, followed by the interaction of the concentration A with three-time spraying by 31.98%, followed by the interaction of the concentration B with twice spraying by 33.15%, then the interaction of the concentration A with twice spraying by 41.97%,then the interaction of the concentration B with once spraying by 44.32%, then finally the interaction of the concentration A with once spraying by 48.46%, where the differences were significant between all these interactions.

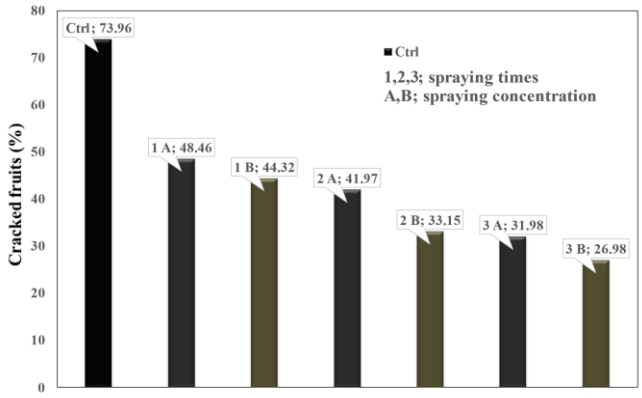

Figure 3: Effect of interaction between the spraying concentration and spraying times with calcium on the fruit cracking ($LSD_{5\%}$=0,64)

Our results coincide with many studies that showed the importance of spraying with calcium in reducing the percentage of cracking of the pomegranate and its negative effects. Abdel-Aziz et al. (2001) confirmed that four times spraying of pomegranate trees with calcium chloride at 0.5% concentration, potassium sulfate at 0.5% concentration, and boric acid at 0.05% concentration, alone or as a mixture, improved production and reduced the percentage of fruit cracking.

Calcium is an essential element for proper plant growth and development because it has photosynthetic functions in absorbing nutrients and participates in resisting abiotic and biotic stress. Calcium, a component in the cell wall, contributes to the cohesion between cells and the strength of cell walls (Brett and Waldron, 1990). It may contribute to increasing the elasticity, strength, and thickness of the skin cell walls. Calcium also helps with the deposition of pectin, so that fruits are better able to resist cracking under the high-pressure levels that appear during water stress (Choi et al., 2010). Calcium and magnesium are responsible for strengthening the bonds between the epidermis and other fruit cells resulting in better strength and less cracking (Poovaiah, 1986). In addition to the role of calcium in stopping the formation of the separation zone between the neck of the fruit and the bearing branches, as well as the activation of enzymes and photosynthesis (Tony and John, 1994; Mighani et al., 1995, Jackman and Stanley, 1995).

IV. CONCLUSIONS

1) All treatments of spraying with calcium outperformed the control treatment in most of the studied traits (early flowering and ripening time, increasing the percentage of fruit-set, improving the traits of fruits).
2) The increase in the number of spraying times with calcium had a significant effect in increasing the productivity compared to the control. The increase was 107.57%, 120.25%, and 122.62% in the treatment of once, twice, and three-time spraying, respectively.
3) The increase in the calcium concentration had a significant positive effect in increasing the productivity compared to the control. Where, the increase was 112.05% and 128.70% in the treatments of concentrations A and B, respectively.
4) The increase in the number of spraying times with calcium reduced the percentage of fruit cracking compared to the control, as it reached 26.49%, 19.81%, 15.74%, in the treatment of once, twice, and three-time spraying, respectively.
5) The increase in the calcium concentration led to a reduction in the percentage of fruit cracking compared to the control, as it was 21.23% and 18.24% in the treatments of concentrations A and B, respectively.

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