

Effect of Foliar Spraying with Gibberellic Acid on Fruit Cracking of Pomegranate (*Punica granatum* L.)

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Abstract - Fruit cracking is one of the most important obstacles that pomegranate cultivation suffers from, which inflicts great damage on the crop, sometimes reaching more than 60%. The research was carried out in the 2018-2019 agricultural season in a field planted with pomegranate trees, with the aim of studying the effect of foliar spraying with gibberellic acid in reducing fruit cracking. The experiment was conducted according to a complete randomized block design. We had three treatments for concentrations of gibberellic acid (0, 100, and 200 ppm) and four treatments for the number of spraying times (0, 1, 2, and 3 times). The results showed the superiority of all treatments of spraying with gibberellic acid over the control treatment in most of the studied traits (early flowering and ripening time, increasing the percentage of fruit-set, improving the quality of fruits, increasing productivity). Increasing the number of spraying with gibberellic acid reduced the percentage of fruit cracking, as it reached 73.96%, 24.08%, 13.81%, and 12.98% in treatments of 0, 1, 2 and 3 spraying times respectively. The increase of the spraying concentration also achieved a significant reduction in the percentage of cracking fruits, which amounted to 18.28% and 13.75% in the treatments of concentrations A and B, respectively.

Keywords: *Punica granatum*, Fruit-Cracking, Foliar Spraying, Gibberellic Acid, Concentration, Spraying Times.

I. INTRODUCTION

The pomegranate tree (*Punica granatum* L.), of the Punicaceae family, is native to Central Asian regions, and from there it moved to the countries of the world (Chandler, 1957; Levin, 1994). It is currently cultivated in many different geographical areas including the Mediterranean basin, Asia, the USA and India (Bankar and Prasad, 1992; Holland *et al.*, 2009).

The fruit cracking is one of the most important physiological diseases affecting pomegranates (Malhotra *et al.*, 1983). As the cracked fruits are not desirable to the consumer. In addition, the high percentage of this disorder in

some varieties of pomegranate and in some years, leads to reluctance to reap the fruits. Where (Panwar *et al.*, 1994; Singh, 1995) showed that when the fruits crack, they are susceptible to infection with bacteria and fungi, and thus lose their marketing value and may become unfit for human consumption, causing a very large economic loss for pomegranate farmers and marketers alike (Finkel and Holbrook, 2000; Schrader *et al.*, 2002).

Furthermore, about 25-40% of the fruits crack at the time of ripeness (Singh *et al.*, 2006; Bankar and Prasad, 1992). The crack rate varies between 10-70% depending on climatic conditions, which reduces production to 50%, and this is harmful to the farmer (Anonymous, 1983).

The cause of pomegranate cracking is mainly due to genetic factors (variety), in addition to 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 fruit 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. The correlation of the fruit cracking with irregular irrigation and lack of nutrients has also been emphasized (Ghariesheikhbayat, 2006; Khalil and Aly, 2013; Saeiet *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 in the stage of ripening (Hoda and Hoda, 2013; Shulman *et al.*, 1984; Yazici and Kaynak, 2006).

An imbalance between auxins, gibberellins and cytokinins causes the fruit cracking (Rai *et al.*, 2002). Healthy fruits contain a higher level of gibberellin and a lower level of ABA, as the imbalance between them in the peel of the fruits causes the fruit cracking (Sharma and Dhillon, 2002). Yazici and Ozguven (2006) showed the existence of a physiological relationship to hormones such as ABA (abscisic acid), IAA (Indole Acetic Acid) and GA3 (Gibberellic acid) with the cracking of immature fruits before harvesting in some pomegranate varieties.

Josanet *et al.* (1998) indicated that treatment with GA3 and NAA (Naphthalene Acetic Acid) led to a decrease in the percentage of cracking in lemon fruits, and the content of ABA was high in the control that contained the highest percentage of cracked fruits. El-Sese (1988) found that spraying with GA3 gave great fruit weights, increased soluble solids percentage, significantly augmented total acidity percentage, and reduced cracking ratio compared to control. Al-Dulaimi (1999) found that when spraying Slimy acid pomegranate variety after 80% of the flowers had appeared and 30 and 60 days after the first spraying with GA3 at concentrations of (0, 125, 250 ppm), the third concentration reduced the percentage of cracked fruits from 15.63% to 9.35%. Also, Yilmaz and Ozguven (2009) showed the significant effect of GA3 in the percentage of cracked fruits, as it led to a decrease in the rate of juice in the fruits, reduced the internal pressure on the peel, and thus decreased the percentage of cracked fruits, the effect was greater when treated with pinolene accompanied by gibberellin.

II. RESEARCH AIM

Pomegranate is grown in Syria to a fair degree, and its cultivation is self-sufficient with the export of part of the production. However, pomegranate cultivation in Syria in general and northern Syria in particular is exposed to many problems that affect the quantity and quality of production, the most important of which is the problem of fruit cracking. The degree of sensitivity to this problem varies according to the variety. The French variety is considered one of the most important cultivars cultivated in northern Syria in terms of cultivated area and in terms of local demand for the fruits of this variety. However, due to the sensitivity of this variety to the problem of fruit cracking, the areas cultivated with it began to decrease and to move towards the cultivation of other crops. Accordingly, this research has been conducted to study the effect of spraying with gibberellic acid (different concentrations and different number of spraying times) to reduce the fruit cracking of the French variety with the aim of preserving this locally desired variety.

III. MATERIALS AND METHODS

3.1 Research Location

The research was carried out during the years 2018-2019 in a private orchard in the city of Sarmada in the Idlib governorate, which is about 40 km north of Idlib, where the city of Sarmada is located at a latitude 36° north and a longitude 36° east. It rises about 383 meters. The total precipitation during the research season was 693 mm, and the precipitation was concentrated in the winter months. The average minimum temperatures for the coldest month were 2°C (January), and the average maximum temperatures for the

warmest month were 35°C (July and August), and the relative humidity ranged between 90% (January) and 25% (May).

3.2 Plant Material

The experiment was conducted on a French pomegranate variety of 10-year-old trees planted at a distance of 4 x 4 m. As this variety is characterized by large fruits that are spherical to flat, the peel is red, the color of the fruits is bloody red, the neck of the fruit is long, the leaf is elongated, the branches have thorns, and its fruits are subject to cracking.

3.3 Experimental Design and treatments

The experiment was executed in the 2018-2019 agricultural season in a field planted with French pomegranate trees at the age of 10 years and dimensions 4 x 4 m. The complete randomized block design was used.

The trial included three treatments for the concentrations of gibberellic acid and four treatments for the number of foliar spraying times with gibberellic acid, according to the following:

1. Gibberellic acid concentrations: 0, 100 ppm (A), and 200 ppm (B).
2. 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 contract (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.

3.4 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 peels (g).
- Internal tissue weight (g).
- Weight of seeds (g).
- Weight of juice (g).

4. Fruit quality characteristics

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

3.5 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%).

IV. RESULTS AND DISCUSSION

4.1 Study of the fruit cracking in the French variety

The percentage of cracked fruits of the French variety at the site of the experiment was 73.96%. This high value indicates the high sensitivity of the French variety towards fruit cracking. This value is greater than what was mentioned in previous studies. Singh *et al.* (2017) stated that the crack rate ranges between 18-62%, and Pant (1976) stated that this percentage generally varies according to the varieties, and in the early ripening varieties it is about 34%, while it reaches 63% in late-ripening varieties. Regarding the cracking types observed on the fruits of the French pomegranate variety were longitudinal cracking, transversal cracking, and sun blight cracking.

The fruit cracking had a negative effect on the overall characteristics of the fruit, as the weight of the peel decreased from 63.39g in the healthy fruits to 61.03g in the cracked fruits, the internal tissue weight decreased from 62.45g in the healthy fruits to 55.79g in the cracked fruits. Similarly, there was a big difference between the weight of the seeds which were 145.25g in healthy fruits and 126.76g in cracked fruits. The total weight of juice also decreased from 74.92g in healthy fruits to 65.04g in cracked fruits. The decrease in the aforementioned traits is explained by the increase in water loss and evaporation in the cracked fruits compared to the healthy ones, which was reflected in all the physiological processes in the fruit and thus led to a decrease in the weight and thickness

of the external peel and a decrease in the weight of the inner tissues, seeds and juice (Hepaksoyet *al.*, 2001; Galindo *et al.*, 2014; Singh *et al.*, 2020).

As for the size and weight of the fruit, they were also clearly affected, as the diameter of the fruit decreased from 8.71 cm in healthy fruits to 7.94 cm in cracked fruits, and the weight of the fruit decreased from 271.09g in healthy fruits to 243.58g in cracked fruits. The decrease in the diameter and weight of the fruit explains that they are also affected by the water condition of the fruit on the one hand and are directly related to the characteristics of the weight and thickness of the outer peel and the weight of the inner tissues, seeds and juice on the other hand (Saeiet *al.*, 2014).

Otherwise, the percentage of total soluble solids (T.S.S.) increased, due to the effect of cracking, from 15.38% in healthy fruits to 16.12% in cracked fruits. The acidity level also increased, and the pH reached 2.64 in healthy fruits and 2.53 in cracked fruits. The increase in acidity (lower pH value) is explained by the lower moisture content in fruits that cracked due to evaporation and dehydration compared to the non-cracked fruits, which retain their moisture more due to the closing and the impermeability of their outer peel (Yilmaz and Ozguven, 2009; Hoda and Hoda 2013).

The fruit cracking had a very significant effect on reducing the productivity of the French variety, as the productivity per tree was 13.01 kg, of which only 3.38 kg were non-cracked and 9.63 cracked fruits (equivalent to 74.02% of cracked fruits). The high weight of cracked fruits indicates the great degree of damage that results from the cracking, and negatively affects the characteristics of the fruits and the economic and marketing value of these fruits. El-Sayed *et al.* (2014) stated that the percentage of economic damage resulting from the fruit cracking reaches more than 50%, while Pal *et al.* (2017) stated that the economic loss resulting from fruit cracking ranges between 10-40% on average, and sometimes it reaches 70%.

4.2 Effect of spraying concentration with gibberellin on the studied characteristics

Table 1: Effect of spraying concentration with gibberellin on the studied characteristics

Trait	0	100	200	LSD (5%)
Flowering	52.00	50.50	49.00	0.11
Ripening	151.00	146.50	143.54	0.12
Number of total flowers	287.33	457.48	493.65	1.89
Percentage of hermaphrodite flowers	25.75	40.69	41.32	0.43
Percentage of fruit-set	21.62	39.57	43.61	1.1
Diameter of fruit (cm)	8.32	11.73	12.29	0.14
Weight of fruits (g)	256.12	395.94	432.83	1.33

Weight of fruit peel (g)	60.99	91.33	96.38	0.58
Internal tissues weight (g)	59.12	79.56	89.11	0.84
Weight of seeds (g)	136.01	225.05	247.34	1.26
Ratio of juice (%)	27.32	35.16	38.86	0.19
Acidity of juice (pH)	2.98	3.39	3.51	0.03
Total Soluble Solids (T.S.S.%)	15.22	15.77	16.78	0.17
Productivity/tree (kg)	11.36	18.22	20.36	1.2

Table (1) shows that all the concentrations of foliar spraying with gibberellin exceeded the control in the number of days required to reach flowering (the value in the control was 52.00 days). The treatment of concentration B (200 mg/L) by 49.00 days outperformed the treatment of concentration A (100 mg/L) by 50.50 days. 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 (200 mg/L) by 145.50 days outperformed the treatment of concentration A (100 mg/L) by 143.54 days.

The total number of flowers in the control reached 287.33; the percentage of hermaphrodite flowers was 25.75%. The treatment of concentration A achieved a significant difference over the control with 457.48 flowers, which was also superior to the percentage of hermaphroditic flowers, which amounted to 40.69%, while the treatment of concentration B achieved a significant difference above the treatment of concentration A in the total flowers (493.65 flowers), and in the percentage of hermaphrodite flowers also which amounted to 41.32%, (Table 1). Our study agrees with (Shaheen, 1995) who showed that increasing the spraying concentration led to an increase in the percentage of hermaphroditic flowers in pomegranate.

Concerning the fruit-set, the foliar spraying with gibberellin and the increase in the spraying concentration have a positive effect on the fruit-set percentage, as the it was 21.62% in the control, 39.57% in the A concentration (100 mg/L), and 43.61% in the B concentration (200 mg/L), and the differences were significant between all treatments (Table 1). The effect of foliar spraying with gibberellin was significant on the weight and diameter of the pomegranate fruit, as the weight of the fruit in the control reached 256.12g and the diameter was 8.32 cm. The treatment of concentration A achieved a significant difference on the control, as the weight of the fruit was 395.94g and the diameter of the fruit was 11.73 cm. Also, the treatment of concentration B achieved a significant difference above the treatment of concentration A, as the weight of the fruit was 432.83g and the diameter of the fruit was 12.29 cm, (Table 1).

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 concentration A and B achieved a significant difference over the control. As the weight of the peel was 91.33g and the internal tissue weight was 79.56g in the treatment of concentration A, and the weight of the peel was 96.38g and the internal tissue weight was 89.11g in the treatment of concentration B. Noting that the treatment of concentration B is superior to the treatment of concentration A with significant differences.

Moreover, the weight of the seeds was increased by the effect of foliar spraying with gibberellin, reaching 136.01g, 225.05g, and 247.34g in the control, treatment of concentration A, and treatment of concentration B, respectively (Table 1).

As for the percentage of juice, all the concentrations of spraying with gibberellin outperformed the treatment of the control, in which the juice percentage was 27.32%. The treatment of concentration B (200 mg/L) outperformed the treatment of concentration A (100 mg/L) with juice of 38.86% and 35.16%, respectively, (Table 1). Our study coincides with Fayed (2010) who showed that increasing the spraying concentration of pomegranate trees (Manfalouty cultivar), from 700 mg/L to 1000 mg/L, this led to a significant increase in the percentage of juice in the fruit, and all treatments were significantly superior above the control.

The acidity of the juice decreased (the pH increased) due to the effect of foliar spraying with gibberellin, where the pH value was 2.98 in the control, 3.39 in the treatment of concentration A (100 mg/L), and 3.51 in the treatment of concentration B (200 mg/L). The differences were significant between all treatments. The T.S.S. also increased due to the effect of foliar spraying with gibberellin, as its value in the control reached 15.22%. All the treatments outperformed the control, as the T.S.S. in the treatment of concentration B had reached 16.78%, and it outperformed the treatment of concentration A, which had 15.77% (Table 1).

Table (1) indicates the significant effect of spraying with gibberellin on the productivity of the French pomegranate variety, as the productivity of the control reached 11.36 kg/tree. The treatment of concentration A (100 mg/L) achieved a significant increase over the control and the productivity reached 18.22 kg/tree. The treatment of concentration B (200 mg/L) achieved a significant increase over the treatment of concentration A with a productivity of 20.36 kg/tree. The differences were significant between all treatments. Thus, the spraying treatments achieved an increase in productivity over the control by 160.39% and 179.23% in the treatments of concentration A and B, respectively.

4.3 Effect of spraying times with gibberellin on the studied characteristics

Table 2: Effect of spraying times with gibberellin on the studied characteristics

Trait	0	1	2	3	LSD (5%)
Flowering	52.00	51.00	50.22	49.00	0.13
Ripening	151.00	148.20	146.65	145.78	0.15
Number of total flowers	287.33	413.70	459.54	492.66	2.02
Percentage of hermaphrodite flowers	25.75	39.85	40.44	41.26	0.50
Percentage of fruit-set	21.62	39.51	40.96	42.30	1.04
Diameter of fruit (cm)	8.32	11.63	11.81	12.14	0.11
Weight of fruits (g)	256.12	361.99	396.43	429.03	1.58
Weight of fruit peel (g)	60.99	89.70	91.78	94.23	0.67
Internal tissues weight (g)	59.12	71.67	79.46	88.57	0.75
Weight of seeds (g)	136.01	200.62	225.19	246.23	1.37
Ratio of juice (%)	27.32	36.18	37.90	39.00	0.24
Acidity of juice (pH)	2.98	3.34	3.40	3.49	0.02
Total Soluble Solids (T.S.S.%)	15.22	15.68	16.19	16.78	0.19
Productivity/tree (kg)	11.36	17.01	18.89	20.74	1.07

Table (2) shows the superiority of all spraying treatments over the control in the number of days required to reach flowering (as the value in the control was 52.00 days). The increase in the number of spraying times also had a positive effect in this aspect, as the treatment of three times spraying needed to 49.00 days higher than the treatment of spraying twice with 50.22 days, which outperformed the treatment of spraying once by 51.00 days. Table (2) also shows the significant effect of spraying in reaching the stage of fruit ripeness, as 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. As the treatment of three times spraying (145.78 days) outperformed the treatment of spraying twice (146.65 days), which outperformed the treatment of spraying once (148.20 days).

Also, the increase in the number of spraying with gibberellin had a significant effect in 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 hermaphrodites. The treatment of spraying once achieved a significant superiority over the treatment of the control, and the total number of flowers in it was 413.70, with a percentage of hermaphroditic 39.85%. The treatment of spraying twice achieved a significant superiority over the treatment of spraying once, as the number total of flowers in it was 459.54, from which 40.44% were hermaphroditic. While the treatment of three times spraying outperformed all treatments, as the total number of flowers was 492.66, from which 41.26% was a hermaphrodite (Table 2).

Spraying and increasing the number of spraying times have a clear significant effect on the percentage of fruit-set, as it ratio reached 21.62%, 39.51%, 40.96%, and 42.30%, in the control, the treatment of spraying once, the treatment of spraying twice, and in the treatment of the three times spraying respectively, as the differences were significant between all treatments (Table 2).

Spraying and increasing the number of spraying times have a significant effect on increasing the weight and diameter of the fruit, as the weight of the fruit in the control reached 256.12g and the diameter reached 8.32cm. The treatment of spraying once made a significant difference above the control, and the weight of the fruit in it was 361.99 g and the diameter of the fruit was 11.63 cm. Also, the treatment of spraying twice achieved a significant difference over the treatment of spraying once, as the weight of the fruit was 396.43g and the diameter of the fruit was 11.81cm. The treatment of three times spraying achieved a significant difference above the treatment of spraying twice, as the weight of the fruit was 429.03g and the diameter of the fruit was 12.14 cm (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 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 94.23 g and the internal tissue weight was 88.57g in the treatment of three times spraying. While, in the treatment of spraying twice, the weight of the fruit peel was 91.78g and the weight of the internal tissues was 79.46g. As for the treatment of spraying once, the weight of the peel was 89.70g and the weight of the

internal tissues was 71.67g. The differences were significant between all treatments.

Table (2) shows the significant positive effect of spraying and of increasing the number of spraying times in increasing the weight of seeds, compared to the control in which the seed weight reached 136.01 g. The treatment of spraying once outperformed the control, and the seed weight was 200.62g. The treatment of spraying twice also achieved a significant increase over the treatment of spraying once, and the seed weight was 225.19g. The treatment of three times spraying achieved a significant increase over the treatment of spraying twice and outperformed all treatments, as the seed weight was 246.23g.

Table (2) also shows the significant effect of spraying and the increase in the number of spraying times in the ratio of juice, as this percentage in the treatments reached 27.32%, 36.18%, 37.09%, and 39.00% in of the control, the treatment of spraying once, the treatment of spraying twice, and the treatment of three times spraying, respectively. Additionally, the treatment of three times spraying outperformed all treatments, and the differences were significant between all of these treatments.

Foliar spraying with gibberellin decreased the acidity of the juice (an increase in the pH value), with a pH value of 2.98. The increase in the number of spraying times achieved significant differences in this characteristic between the spraying treatments themselves. The treatment of spraying once significantly exceeded the control, with a pH of 3.34. Also, the treatment of spraying twice outperformed the treatment of spraying once, with a pH of 3.40. The treatment three times spraying outperformed all treatments, with a pH value of 3.49 (Table 2).

The T.S.S. increased due to the effect of foliar spraying with gibberellin, as its value in the control reached 15.22%. All the treatments were significantly superior to the control, as the T.S.S. in the treatment of three times spraying reached

16.78%. It was significantly superior to the treatment of spraying twice, in which the T.S.S. was 16.19%, which significantly outperformed the treatment of spraying once, in which the T.S.S. was 15.68% (Table 2).

Table (2) indicates the significant effect of increasing the number of spraying with gibberellin on the productivity of the French pomegranate variety, as the productivity in the control reached 11.36 kg/tree. The treatment of spraying once achieved a significant increase over the control, and the productivity reached 17.01 kg/tree. The treatment of spraying twice achieved a significant superiority over the treatment of spraying once, with a productivity of 18.89 kg/tree. While the treatment of the three times spraying significantly outperformed all treatments, its productivity reached 20.74 kg/tree. Consequently, the spraying treatments achieved an increase in productivity over the control by 149.64%, 166.29%, and 182.57% in the treatments of spraying once, twice, and tree times, respectively.

Our results are consistent with several studies on the effect of gibberellin foliar spray in improving pomegranate yield. Where gibberellin stimulates the elongation of plant cells, and leads to overcoming the genetic dwarfism of the stem, and increases the production of lateral branches, especially flowering, which increases the number of flowers and fruits and thus leads to increased production, in addition, that the gibberellin has an important role in increasing the size of fruits (Davies, 1995).

4.4 Effect of interaction between the spraying concentrations and spraying times with gibberellin on the studied characteristics

The interaction between the concentrations of spraying with gibberellin (concentration 100 mg/L, and the concentration 200 mg/L) and the number of spraying times with gibberellin (spraying once, spraying twice, and spraying three times) had a clear significant effect on all the studied characteristics compared with the control (Table 3).

Table 3: Effect of interaction between the spraying concentrations and spraying times with gibberellin on the studied characteristics

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		21.63	60.99	257.32	8.32	27.17	15.22	2.58	6.51
1	100 ppm	38.41	89.70	370.21	11.56	34.93	15.21	3.34	16.35
	200 ppm	41.79	93.70	397.53	11.97	38.04	16.12	3.40	18.32
2	100 ppm	39.65	91.15	396.19	11.70	36.20	15.73	3.39	18.76
	200 ppm	43.78	96.32	410.47	12.21	39.45	16.77	3.49	19.88
3	100 ppm	40.64	93.17	410.49	11.92	37.59	16.38	3.44	19.53
	200 ppm	45.25	99.14	421.51	12.68	40.82	17.37	3.63	22.88
L.S.D. (5%)		2.08	1.33	3.86	0.22	0.48	0.38	0.04	1.10

The reaction binary of concentration B and three times spraying outperformed the rest of all interactions, in the characteristics of the fruit-set ratio 45.25%, the weight of the fruit peel 99.14g, the weight of the fruit 421.51g, the diameter of the fruit 12.68 cm, the proportion of juice 40.82%, the T.S.S. 17.37%, the pH 3.63, and the yield per tree 22.88 kg/tree. Then came the binaries of concentration B with spraying twice, concentration B with spraying once, concentration A with three times spraying, concentration A with spraying twice, then finally, concentration A with spraying once, respectively, in most of the studied characteristics. These results show a larger effect of the spraying concentration with gibberellin compared with the effect of the number of spraying times with gibberellin, 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.

4.5 Effect of spraying with gibberellin on the fruit cracking of French pomegranate variety

Foliar spraying with gibberellin resulted in a significant decrease in fruit cracking percentage compared to the control (Fig. 1). The percentage of cracked fruits in the control reached 73.96%, and the treatment of concentration A (100 mg/L) achieved a significant decrease compared to the control, as the percentage of cracked fruits in the control reached 18.28%. Also, the treatment of concentration B (200 mg/L) achieved a significant decrease in the percentage of cracking compared to the treatment of concentration A, which amounted to 13.75%.

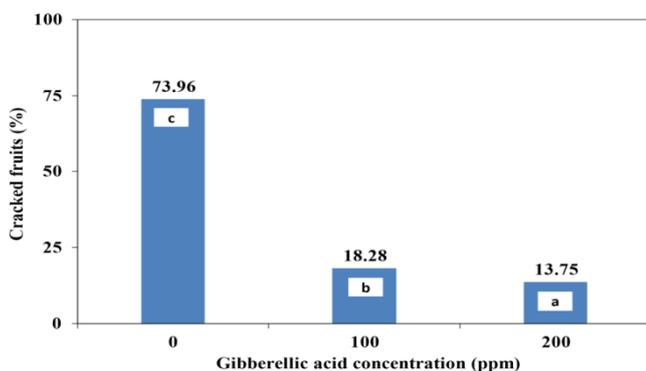


Figure 1: Effect of spraying concentration with gibberellin on the fruit cracking (LSD_(5%)=0,33)

Spraying and increasing the number of spraying times have a significant effect on reducing the percentage of cracked fruits compared to the control. The treatment of spraying once achieved a significant decrease over the control, and the percentage of cracked fruits reached 24.08%. Also, the treatment of spraying twice treatment also achieved a significant decrease in the cracking rate, which reached

13.81% compared to the treatment of spraying once. The largest decrease in the percentage of cracked fruits was in the treatment of the three times spraying, as the percentage of cracked fruits in this treatment was 12.98%, which significantly outperformed all treatments (Fig. 2).

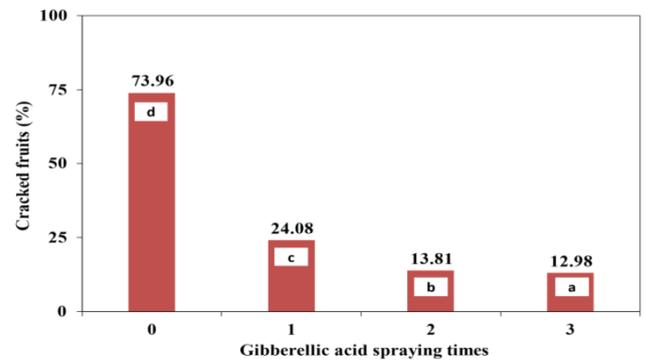


Figure 2: Effect of spraying times with gibberellin on the fruit cracking (LSD_(5%)=0,23)

As for the interaction between the concentrations of spraying with gibberellin (0, 100, and 200 mg/L) and the number of spraying times with gibberellin (0, 1, 2, and 3 times), the effect was significant in reducing the percentage of fruit cracking of the French pomegranate variety compared to the control, in which the rate of cracking is 73.96%, (Fig. 3). The binary reaction of concentration B and the three times spraying outperformed the remaining reactions by 17.82%, followed by the binary interaction of concentration B with the spraying twice by 20.52%. Then followed by the binary interaction of concentration A with the three times spraying, at a rate of 27.39%, followed by the binary reaction of concentration A with the spraying twice at a ratio of 33.32, then the binary reaction of concentration B with spraying once at a rate of 44.19%, finally the binary interaction of concentration A with spraying once at a ratio of 48.96%. Consequently, the differences were significant between all these interactions.

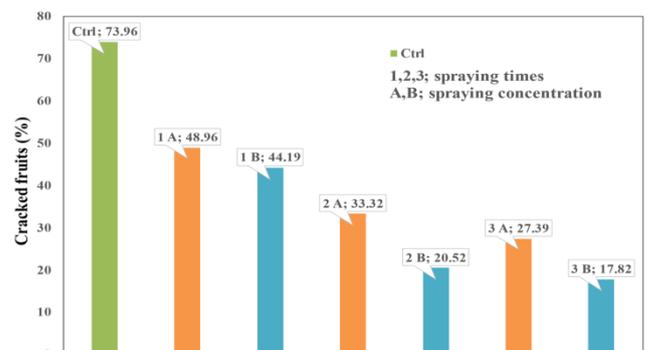


Figure 3: Effect of interaction between the spraying concentration and spraying times with gibberellin on the fruit cracking (LSD_(5%)=0,7)

Our results coincide with many studies that showed the importance of spraying with gibberellin in reducing the percentage of cracked pomegranate fruits and its negative

effects. El-Sese, (1988) showed that the spraying with gibberellin decreased the percentage of cracking of pomegranate fruits compared to the control. In an experiment conducted by Al-Dulaimi (1999) when spraying pomegranate trees of the Slimy acid variety three times: the first after the appearance of 80% of flowers, the second and third 30 and 60 days (respectively) after the first spraying, the spray was done with gibberellin GA3 at concentrations (0, 125, and 250 ppm), he found that the third concentration was found to reduce the percentage of split fruits from 15.63% to 9.35%.

Also, Yilmaz and Ozguven (2009) showed the significant effect of gibberellic acid in reducing the percentage of cracked fruits, as it led to a decrease in the rate of fruit juice, reduced the internal pressure on the peel, so reducing the percentage of cracked fruits. The effect was greater when the fruit treated with Pinolene (Anti-Transpiration) escorted with the gibberellin.

V. CONCLUSIONS

1. All treatments of spraying with gibberellin outperformed the control treatment in most of the studied characteristics (early flowering and ripening time, increasing the ratio of fruit-set, improving the quality of fruits).
2. The increase in the number of spraying times with gibberellin had a significant positive effect in increasing the productivity compared to the control, as the augmentations was 149.74%, 166.29% and 182.57% in the treatment of spraying once, twice, and three times, respectively.
3. The increase in the spraying concentrations had a positive significant effect in improving the productivity correlated to the control, as the improvements was 160.39% and 179.23% in the treatments for the concentrations A and B, respectively.
4. The increase in the number of spraying with gibberellin reduced the percentage of fruit cracking compared to the control, as the percentage of fruit cracking reached 24.08%, 13.81%, 12.98%, in the treatment of spraying once, twice, and three times, respectively.
5. The increase in the spraying concentration with gibberellin led to a reduction in the percentage of fruit cracking compared to the control, as the percentage of fruit cracking was 18.28% and 13.75% in the treatments of concentration A and B, respectively.

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