Effect of Some Growth Regulators, Nutrient Elements and Kaolin on Cracking and Fruit Quality of Pomegranate 'Wonderful' Cultivar

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ABSTRACT: This study was carried out during two successive seasons 2016 and 2017 on six years old 'Wonderful' pomegranate trees (*Punica granatum* L.). Trees were grown on sandy loam soil conditions in a private orchard located at Burg El-Arab, Alexandria governorate, Egypt. The trees were spaced 4x5 m apart and irrigated by drip irrigation system and received similar cultural practices adapted in the orchard. The effect of some growth regulators, nutrient elements and kaolin on cracking and fruit quality of pomegranate 'Wonderful' cultivar was studied. The experiment was designed as randomized complete block design with five replicates. Each block contained 11 treatments (control, naphthalene acetic acid (NAA) at 25 and 50 mg/l, gibberellic acid (GA_3) at 100 and 150 mg/l, boric acid at 0.1% and 0.3%, calcium chloride at 1% and 2% and kaolin at 4% and 6%). Results revealed that, boric acid at 0.3% gave the highest mean values of fruit set (%), number of fruits/tree, yield (kg/tree) and anthocyanin; while, naphthalene acetic acid at 50 mg/l recorded the maximum mean values of fruit weight, fruit diameter, volume and grain weight, and gave the minimum mean values of fruit drop and fruit cracking (%). On other hand, gibberellic acid (GA_3) at 150 mg/l gave the maximum yield (kg/tree), in the second season and the minimum fruit cracking (%), whereas, calcium chloride at 2% gave the best results of TSS (%), acidity (%), and vitamin C, total and reducing sugars were higher than the control for all treatments. Finally, kaolin at 6% gave the lowest percentage of sunburn and the highest percentage of juice, as compared with the control and other treatments during both seasons.

Keywords: Pomegranate 'Wonderful', NAA, GA_3, calcium chloride, boric acid, kaolin, fruit set, fruit cracking, fruit sunburn, yield, fruit quality.

INTRODUCTION

Pomegranate (*Punica granatum* L.) is a fruit tree of the Punicaceae family, which is mainly grown in subtropical and tropical regions (Adsule and Patil, 1995; Naik and Chand, 2011). Pomegranate fruits are consumed fresh or processed, and they are considered as a healthy food because of the high content of antioxidant compounds (Legua *et al.,* 2012).

In Egypt, the total cultivated area of pomegranate is 34450 feddan with total fruit production of 106260 tons, according to the latest statistics of the Ministry of Agriculture and Land Reclamation (2013).

Pomegranate peel extracts have been found to be suitable for applications in the food industry as they are an important source of phenolics, flavonoids and tannins occurring as natural ingredients and co-products of pomegranate juice PJ-related preparations (Viuda-Martos *et al.,* 2010 and 2013). It is well known that pomegranate is a good source of anti-oxidants.

However, as Salgado *et al.* (2012) have shown the anti-oxidant content of other juices such as tomato and orange juice with strawberries can also be improved by the addition of as much as 0.5% dried pomegranate peel extracts to the juice.

Pomegranate responses well to Ca, B to increase fruit yield, fruit weight and considerably decreases cracking which is one of the major disorders of pomegranate (Khalil and Aly, 2013).

Boron roles in plants include effects on the germination of pollen grains, the elongation of pollen tube, fruit set and yield, and is also indirectly responsible for the activation of dehydrogenase enzymes, sugar translocation, nucleic acids and plant hormones (El-Sheikh *et al.,* 2007 and Marschner, 2012).

The application of a kaolin particle film reduces fruit temperature with tools of evaporative cooling and fewer direct sunlight happening on fruit surface. Decrease in fruit surface temperature can be correlated to the amount of kaolin residue on the fruit surface (Glenn and Prado, 2002). A 5 to 10 °C decrease in midday fruit surface temperatures by a kaolin based particle film was reduced almost 100% in some studies and had no effect in others, while the general trend was around a 50% decrease in sunlight impelled fruit damages which varied by location and cultivar (Glenn and Puterka, 2005).

Gibberellic acid was widely used in various horticultural crops for improving fruit set, fruit weight and dimensions, aril %, firmness, peel thickness, yield and its components, total sugars, vitamin C, total anthocyanins and total soluble solids percentage (Khalil and Aly, 2013 and Merwad *et al.,* 2016). Spraying pomegranate with various concentrations of GA_3 reduced the percentage of fruit cracking (El-Mahdy *et al.,* 2009 and Hegazi *et al.,* 2014).

Naphthalene acetic acid (NAA) is a synthetic auxin plant hormone that is routinely used for the vegetative propagation, flowering and fruiting in many fruit crops. The effect of NAA on plant growth is greatly dependent on the time of application and concentration. NAA has been shown to greatly increase cellulose fiber formation in plants. In majority of fruit plants, fruit drop is controlled by spraying of NAA in different concentrations. It is applied after blossom fertilization (Suman *et al*., 2017).

Fruit cracking is a serious problem of pomegranate. It is due to boron deficiency in young fruits while in developed fruits it may be caused due to extreme variations in day and night temperatures. Boron and calcium were highly effective in improving, nutritional status, yield and fruit quality of pomegranate trees. Foliar application of boron reduced the percentage of cracked fruits (Khalil and Aly, 2013).

Cracking damage is one of the most serious problem faces pomegranate growers. It causes loss about 50% of the marketable fruits. This problem is due to the improper water management and deficiency of micronutrients and Ca (Sheikh and Manjula, 2012). Calcium plays an important role in reducing fruit cracking; it improves fruit growth and creates a state of water balance between pericarp and inside fruit tissues, as well as maintains fruit cell wall elasticity and firmness (Mitra, 1997). Applying calcium before harvest improves various fruits quality (Pooviah, 1979 and Cheour *et al.*, 1990). Among different elite horticultural practices, growth regulators have been advantageously used recently to increase the fruit production and to improve the quality of several fruit crops (Cline and Trought, 2007, Amezquita *et al.,* 2008, Canli *et al.,* 2015). The effects of applying GA_3 on the pomegranate plants to improve plant growth, yield, fruit quality parameters and lessening of cracking as well as the retardation of maturity have been studied (Ameen Al-Imam, 2009 and Khalil and Aly, 2013).

The aim of this study was to examine the effect of some growth regulators (GA_3 and NAA), nutrient elements (boric acid and calcium chloride) and kaolin on cracking, sunburn, drop, yield and fruit quality of cv. 'Wonderful' pomegranate trees.

MATERIALS AND METHODS

This study was carried out during two successive seasons 2016 and 2017 on six years old 'Wonderful' pomegranate trees (*Punica granatum* L.). Trees were grown on sandy loam soil conditions in a private orchard located at Burg El-Arab, Alexandria governorate, Egypt. The trees were spaced 4x5 m apart and irrigated by drip irrigation system and received similar cultural practices adapted in the orchard. During the entire seasons, N, P and K fertilizer were added through drip irrigation system four times per week at a rate of 70 N unit/feddan in the form of ammonium sulphate (20% N), 100 K unit/feddan as potassium sulphate (48% K_2O) and 30 P unit/feddan as sulphoric acid (60 % P_2O_5).

Experimental design

The experiment was arranged in randomized complete block design on 55 trees as 11 treatments were applied and each treatment comprised of five trees arranged randomly in blocks.

The treatments can be illustrated as follows:

1- Control (Spraying with water).
2- 25 mg/l Naphthalene acetic acid (NAA).
3- 50 mg/l Naphthalene acetic acid (NAA).
4- 100 mg/l Gibberellic acid (GA_3).
5- 150 mg/l Gibberellic acid (GA_3).
6- 0.1% Boric acid (17% B).
7- 0.3% Boric acid (17% B).
8- 1% Calcium chloride (34% Ca).
9- 2% Calcium chloride (34% Ca).
10- 4% Kaolin.
11- 6% Kaolin.

Data recorded

A) Fruit set and drop (%):

- Fruit set (%):

Sixty days after flowering, final fruit set percentage was calculated in the same sequence mentioned above for the initial fruit set percentage according to this formula (Westwood, 1978).

$$\text{Fruit set (\%)} = \frac{No.\ of\ fruitlets}{No.\ of\ opened\ flowers} \text{X}\,100$$

- Fruit drop (%):

Fruit drop %: was calculated by counting the number of dropping fruits from the middle of June till the commercial harvesting time under experimental conditions, then expressed as a percentage from the whole number of fruits remained on the tree at the middle of June according to this formula:

$$\text{Fruit drop (\%)} = \frac{No.\ of\ dropped\ fruits}{No.\ of\ set\ fruitlets} \text{X}\,100$$

- Fruit cracking (%):

The percentage fruit cracking per tree was calculated before harvest time. The number of cracking fruits was counted on each tree and the percentage of fruit spilt was calculated according to the equation:

$$\text{Fruit cracking (\%)} = \frac{Number\ of\ cracked\ fruits/tree}{Total\ number\ of\ fruits/tree} \text{X}100$$

- Fruit Sunburn (%):

Fruit sunburn status was estimated as the percentage of sunburned fruits on each tree relative of the total number of fruits on the tree just before harvest according to Schupp *et al.* (2002) as:

$$\text{Sunburn (\%)} = \frac{Number\ of\ sunburn\ fruits/tree}{Total\ number\ of\ fruits/tree} \text{X}100$$

B) Yield (kg/tree):

At harvest date in beginning of October (190 days after flowering in both seasons), the number of fruits per tree in each treatment was counted and fruit yield in (kg/tree) was calculated.

The produced fruit yield on each replicate tree resulting from applied treatments was expressed as number of fruits/tree and weight of fruits (kg/tree) which was attained mature stag.

C) Physical fruit characteristics:

At harvest time, sample of 10 fruits per tree from each replicate was collected randomly, then transported to the laboratory of Plant Production Department, Faculty of Agriculture (Saba Basha), Alexandria University to determine its quality as follows:

- Fruit weight (g)
- Fruit length (cm)
- Fruit diameter (cm)
- Fruit volume (cm^3)
- Juice (%)

D) Chemical fruit characteristics:
Regarding chemical fruit characteristics, samples of 10 fruits from each replicate tree i.e. 50 fruits for each of the applied treatment were picked randomly at harvest to determine the following parameters:

- **Total soluble solids (TSS %):** was used to determine the percentage of TSS by hand refractometer according to Chen and Mellenthin (1981).

- **Total acidity (%):** was determined in fruit juice according to Chen and Mellenthin (1981). Five milliliters from the obtained juice were used to determine the titratable acidity. The titratable acidity was expressed as mg citric acid/100 milliliters fruit juice.

- **Total sugars (%):** were determined in fresh fruit samples according to Malik and Singh (1980). Sugars were extracted from 5 gram fresh weight and determined by phenol sulfuric and Nelson arsenate-molybadate colorimetric methods for total and reducing sugars, respectively. The non-reducing sugars were calculated by difference between total sugars and reducing sugars.

- **Vitamin C (mg/100 ml juice):** The ascorbic acid content of the juice was determined by titration with 2, 6- dichloro phenol-indo-phenol (AOAC, 1985) and calculated as milligrams per 100 ml of juice.

- **Anthocyanin content (mg/100 g):** Anthocyanin content was determined at the stage of coloration (mg/100g fresh weight) according to Rabino *et al*. (1977).

Statistical analysis:
Results of the measured parameters were subjected to computerized statistical analysis using MSTAT package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 according to Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

A) Fruit set and drop (%):

- Fruit set (%):

The observations on fruit set (%) in pomegranate as influenced by growth regulators, nutrient elements and kaolin are given in Table (1). Data showed that fruit set % increased significantly by most treatments and the maximum fruit set (25.26 and 19.55 %) was recorded by foliar application of 0.3% boric acid, which was significantly superior to all other treatments and was closely followed by foliar application of 0.1% boric acid (24.54 and 17.38 %), during both seasons 2016 and 2017, respectively. The minimum fruit set (14.56 and 10.49 %) was observed on untreated trees (control) which was significantly lower than most other treatments in 2016 and 2017 seasons. These results are in agreement with those obtained by Saadati *et al.* (2016) and Hikal *et al.* (2017). The present results indicated increasing fruit set with boric acid treatment compared with control treatment may attribute to role of boron in maintaining high pollen viability, germination and pollen tube cellulose elongation (Hassan, 2000).

- Fruit drop (%):

Data in Table (1) indicated that all foliar application treatments significantly reduced fruit drop as compared with the control and that control treatment recorded significantly highest the fruit drop percent (15.18 and 16.79 %), while, the lowest fruit drop (%) was observed in 50 mg/l NAA (4.96 and 6.33 %), respectively, during both seasons. These results are agreement with those obtained by Prajapati *et al*. (2016) and Suman *et al.* (2017). The auxins and gibberellins are used to control the fruit drop on citrus for improving the quality of fruit Almeida *et al.* (2004).

4.2.3 Fruit cracking (%):

It is clearly evident from the data in Table (1) that all treatments significantly decreased fruit cracking and the maximum fruit cracking (9.96 and 13.84 %) was observed by control treatment, in the first and second seasons, respectively. The minimum fruit cracking (4.66 and 4.65 %) recorded by treatment 50 mg/l NAA, in the first and second seasons, respectively. These results are in agreement with those obtained by Yilmaz and Özgüven (2016) and Kumar *et al.* (2017). Calcium is the most important mineral nutrient for the mechanical resistance and stability of the cell structure of fruit. In the calcium deficiency, middle lamellae enlarge, thin out and then cracking (Asgharzade and Babaeian, 2012). The effect of Ca application in decreasing pomegranate fruit cracking has been attributed to the role of Ca in the cohesion of cell walls, since it interacts with pectic acid (Bakeer, 2016).

4.2.4 Sunburn (%):

Data given in Table (1) revealed that sunburn percentage significantly was decreased by all treatments in comparison with the control and maximum sunburn (11.32 and 11.79 %) was observed by control treatment, in both years. The minimum sunburn (4.66 and 4.26 %) was recorded by treatment 6% Kaolin, in the first and second seasons, respectively. These results are agreement with those obtained by Ennab *et al.* (2017) and Mozaffarifard *et al.* (2017). The successful use of the Kaolin based sunscreen Surround to reduce losses in pomegranates due to sunburn has been reported by Melgarejo *et al.* (2004).

Table (1). Response of 'Wonderful' pomegranate fruit set, fruit cracking and sunburn percentages, to foliar application of some growth regulators, nutrients elements and kaolin treatments during 2016 and 2017 seasons

Treatments	Fruit set (%)		Fruit drop (%)		Fruit cracking (%)		Sunburn (%)	
	Seasons							
	2016	2017	2016	2017	2016	2017	2016	2017
Control	14.56^{d}	10.49^{de}	15.18^{a}	16.79^{a}	9.96^{a}	13.84^{a}	11.32^{a}	11.79^{a}
25 mg/l NAA	12.78^{d}	9.43^{e}	7.38^{e}	7.64^{f}	5.14^{ef}	5.80^{g}	7.14^{c}	6.88^{de}
50 mg/l NAA	11.92^{d}	8.35^{e}	4.96^{g}	6.33^{g}	4.66^{f}	4.65^{i}	5.76^{d}	6.09^{d}
100 mg/l GA_3	21.68^{bc}	14.47^{c}	7.42^{e}	9.53^{d}	5.56d^{ef}	6.74^{e}	8.36^{b}	9.89^{ab}
150 mg/l GA_3	22.30^{abc}	15.75^{bc}	6.58^{f}	8.57^{e}	4.46^{f}	5.21^{h}	8.48^{b}	9.10^{bc}
0.1% Boric acid	24.54^{a}	17.38^{b}	8.22^{d}	10.53^{c}	7.36^{bc}	7.85^{c}	7.26^{c}	9.13^{bc}
0.3% Boric acid	25.26^{a}	19.55^{a}	8.02^{d}	9.73^{d}	5.98^{de}	7.09^{d}	5.84^{d}	8.09^{c}
1% Calcium chloride	19.64^{c}	15.59^{bc}	8.34^{d}	9.24^{d}	6.56^{bcd}	7.82^{c}	7.98^{b}	8.71^{bc}
2% Calcium chloride	20.82^{c}	16.67^{bc}	8.00^{d}	8.42^{e}	5.38^{f}	6.08^{f}	6.94^{c}	7.09^{de}
4% Kaolin	14.66^{d}	10.52^{de}	10.94^{b}	11.71^{b}	7.78^{b}	8.50^{b}	5.68^{d}	5.58^{e}
6% Kaolin	14.74^{d}	10.65^{e}	10.38^{c}	10.56^{c}	5.86^{def}	7.68^{c}	4.66^{e}	4.26^{f}
LSD at 0.05	**2.81**	**1.88**	**0.54**	**0.43**	**1.09**	**0.21**	**0.59**	**1.20**

Means of each column designated by the same letter are not significantly different at 5% using least significant difference (L.S.D.)

B) <u>Yield:</u>

- <u>Number of fruits/tree:</u>

The effect of the different treatments on fruit number/tree is presented in Table (2). A significant increase in fruit number/tree was obtained in both seasons by foliar application of 0.3% boric acid (56.40 and 62.20 %), while, significant decrease in fruit number/tree was recorded by 50 mg/l NAA (25.60 and 33.60 %), in the first and second seasons, respectively. These results are in agreement with those obtained by Sarrwy *et al.* (2012), Lal *et al.* (2013) and Saadati *et al.* (2016).

- <u>Fruit weight (g):</u>

Data of both seasons showed significant increase in fruit weight by all sprayed chemicals compared to the control treatment, Table (2). The heaviest fruit weight (577.10 and 558.53 g) in first and second seasons was obtained by applying NAA at 50 mg/l in both seasons. On the other hand, the control trees showed the lowest values which recorded 326.19 and 315.83 g in the first and the second seasons, respectively. These results are in agreement with those obtained by Khalil and Aly (2013) and Hegazi *et al.* (2014).

- <u>Yield (kg/tree):</u>

Data presented in Table (2) showed that all spray treatments increased the yield and the greatest significant fruit yield was found with spraying boric acid at 0.3% (24.97 kg/tree) in the first season and GA_3 at 150 mg/l (28.18 kg/tree) in the second season, compared to control treatment which gave the lowest fruit yield (10.55 and 13.16 kg/tree), in 2016 and 2017 seasons, respectively. These results are in agreement with those obtained by Khalil and Aly (2013). They reported that the application of NAA increased fruit weight and yield due to cell elongation by enlargement of vacuoles and loosening of cell wall after increasing cell wall plasticity (Agrawal and Dikshit, 2008).

Table (2). Response of 'Wonderful' pomegranate fruit number/ tree, fruit weight and yield/tree to foliar application of some growth regulators, nutrients elements and kaolin treatments during 2016 and 2017 seasons

Treatments	Fruit number/tree		Fruit weight (g)		Yield (kg/tree)	
	Seasons					
	2016	2017	2016	2017	2016	2017
Control	32.20de	41.80h	326.19f	315.83h	10.55f	13.16g
25 mg/l NAA	28.20ef	37.4i	482.73b	478.46c	13.35e	18.18f
50 mg/l NAA	25.60f	33.6j	577.10a	558.53a	14.42e	19.18ef
100 mg/l GA_3	40.60c	51.20e	442.17c	446.16e	20.21c	23.21c
150 mg/l GA_3	45.00bc	54.60d	484.40b	512.40b	22.44b	28.18a
0.1 % Boric acid	49.40b	59.80b	417.10e	415.20f	21.23bc	24.36c
0.3 % Boric acid	56.40a	62.20a	443.53c	445.16e	24.97a	27.00ab
1% Calcium chloride	39.40c	50.20ef	426.07de	420.46f	16.61d	21.30d
2 % Calcium chloride	40.20c	56.40c	438.17cd	454.46d	17.68d	25.75b
4 % Kaolin	31.80d	46.00g	410.83e	402.86g	13.55e	18.53f
6 % Kaolin	32.20de	49.20f	416.07e	415.60f	14.01e	20.50de
LSD at 0.05	**5.71**	**1.57**	**15.43**	**6.24**	**1.31**	**1.39**

Means of each column designated by the same letter are not significantly different at 5% using least significant difference (L.S.D.)

C) <u>Physical fruit characteristics:</u>

- Fruit length (cm):

It is apparent from the data presented in Table (3) that the different doses of treatments exerted significant effect on fruit length. The highest fruit length (9.60 cm) was found under the treatment 50 mg/l NAA in the first season and (9.90 cm) under the treatment $CaCl_2$ at 2% in the second season, while the lowest fruit length (7.37 and 7.20 %) was recorded under control.

- Fruit diameter (cm):

Data in Table (3) illustrated significant impact of studied treatments on fruit diameter. The data indicated that, significant differences were found between all treatments and control. The maximum fruit diameter (10.53 and 10.53 cm) was found in treatment 50 mg/l NAA and which was followed by the treatment $CaCl_2$ at 2% (10.10 and 10.13 cm). Control (Spraying with tap water) treatment recorded minimum fruit diameter (8.23 and 8.10 cm), during both studied seasons. These results are agreement with those obtained by Kishor *et al.* (2017) and Shanmugasundaram and Balakrishnamurthy (2017). The significant increase in fruit length and fruit diameter obtained may be attributed to nature of auxins (NAA) to stimulate cell division, cell elongation and membrane permeability to water uptake (Chaudhary *et al.,* 2006).

- Fruit volume (cm^3):

Results in Table (3) indicated that, the maximum fruit volume was observed in the treatment 50 mg/l NAA (593.20 and 578.72 cm^3), as compared with the control treatment which recorded the minimum fruit volume (335.53 and

324.16 cm^3) in the first and second seasons, respectively. These results are in agreement with those obtained by Shanmugasundaram and Balakrishnamurthy (2017) and Singh *et al.* **(**2017).

- Grain weight (g):

The observations recorded on fruit grain are presented in Table (3), results revealed that all treatments had significant effect on fruit grain. The highest fruit grain was noted with 50 mg/l NAA (411.57 and 365.70 g), while, the lowest fruit grain (220.00 and 184.10 g) was recorded with control treatment, during both seasons, respectively. These results are in agreement with those obtained by Reddy and Prasad (2012) on pomegranate cv. 'Ganesh' and Anawal *et al.* (2015) on cv. 'Bhagwa', whereas increase in grain weight by NAA was also reported by Rahemi and Atahosseini (2004) on cv. 'Shishep Cup'.

- Juice (%):

It is evident from Table (3) that different treatments increased the juice percentage compared with the control increased significantly with the increase dose of Kaolin. The significantly highest juice percentage (77.32 and 79.07 %) was recorded with 6% Kaolin, while the control treatment recorded the lowest juice percentage (70.86 and 69.36 %), during both seasons, respectively. These results are in agreement with those obtained by Khalil and Aly (2013). Increased fruit juice as a result of kaolin treatments may be due to its protective effect from high temperature and reflection of solar radiation, especially UV wavelengths, which led to reduce heat stress on fruits, enhance fruit water content by decreasing transpiration from fruit surface (Glenn and Puterka, 2005).

D) Chemical fruit characteristics:

- Total soluble solids (TSS %)**:**

The effect of different sprayed substances on TSS% is presented in Table (4). A significant increase in total soluble solids (TSS) in comparison with the control was obtained in both seasons by all treatments. Calcium chloride at 2% recorded the highest TSS content (17.26 %) in the first season and boric acid at 0.3 % (18.23 %) in the second season, respectively. Control treatment recorded the lowest total soluble solids (15.26 and 16.07 %), during both seasons under this study. These results are in agreement with those obtained by Anawal *et al.* (2015), Hikal *et al.* (2017) and Davarpanaha *et al.* (2018). Improvement in TSS of fruits due to NAA and GA_3 spray may be explained from the fact that application of these growth regulators after fruit set probably improved the physiology of leaves, thereby causing better translocation of vital components in the fruit and assimilation/utilization of photosynthates by the developing fruit (Pandey, 1999).

- Total acidity (%)**:**

Data in Table (4) indicated that, fruit acidity percentage was significantly decreased by applying calcium chloride at 2% in the first season (0.77 %) and GA_3 at 150 mg/l (0.72 %) in the second season, respectively. On the other hand, the highest fruit acidity percentage (1.47 and 1.21%) was obtained from the control plants in both seasons. These results are in agreement with those obtained by Kishor *et al.* (2017) and Davarpanaha *et al.* (2018).

- Total sugars (%):

Results presented in Table (4) showed significant increase in total sugars with all treatments in comparison with the control in both seasons. NAA at 50 mg/l recorded the highest sugars content (11.96 %) in the first season and 0.3% boric acid (13.55%) in the second season. On the other hand, control treatment recorded the lowest sugars content (8.78 and 9.00 %) during 2016 and 2017 seasons, respectively. These results are in agreement with those obtained by Anawal *et al.* (2015) on pomegranate cv. ‘Bhagwa’ who indicated that application of NAA 40 mg/l resulted in increase in reducing, non-reducing and total sugars.

- Reducing sugars (%)**:**

It was appeared from data presented in Table (4) that the all treatments significantly influenced the reducing sugars %. The maximum reducing sugar (6.57%) was found under the treatment NAA at 50 mg/l in the first season and 0.3% boric acid (9.88 %) in the second season. The minimum reducing sugar % was recorded under control (5.43 and 6.69 %) during both seasons.

- Vitamin C (mg/100 ml juice):

It is evident from the data presented in Table (4) that foliar application of GA_3 at 150 mg/l recorded the maximum ascorbic acid content (16.00 mg/100 ml juice) in the first season and calcium chloride at 2% (20.33 mg/100 ml juice) in the second season, while, the control treatment recorded the minimum ascorbic acid content (10.67 and 11.67 mg/100 ml juice) in both seasons. These results are in agreement with those obtained by Korkmaz and Aşkin (2015), Hikal *et al.* (2017), Singh *et al.* **(**2017).

- Anthocyanin (mg/100g):

Results presented in Table (4) showed significant increase in anthocyanin with all treatments in comparison with the control in both seasons. NAA at 50 mg/l recorded the maximum anthocyanin content (0.84 mg/100g) than all other treatments in the first season and boric acid at 0.3% (0.88 mg/100g) in the second season, while, the control treatment recorded the minimum anthocyanin content (0.51 and 0.42 mg/100g) in both seasons. These results are in agreement with those obtained by Kishor *et al.* (2016) and Attia (2017).

Table (3). Response of 'Wonderful' pomegranate fruit physical parameters to foliar application of some growth regulators, nutrients elements and kaolin treatments during 2016 and 2017 seasons

Treatments	Fruit length (cm)		Fruit diameter (cm)		Fruit volume (cm^3)		Grain weight (g)		Juice (%)	
	Seasons									
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Control	7.37^{g}	7.20^{g}	8.23f	8.10^{g}	335.53^{g}	324.16^{h}	220.00^{e}	184.10^{h}	70.86d	69.36g
25 mg/l NAA	9.43^{abc}	9.13^{c}	10.23^{b}	10.23^{b}	498.83^{b}	487.75^{c}	335.63^{b}	299.93^{d}	73.68c	72.86ef
50 mg/l NAA	9.60^{a}	8.56^{c}	10.53^{a}	10.53^{a}	593.20^{a}	578.72^{a}	411.57^{a}	365.70^{a}	76.53ab	75.36c
100 mg/l GA_3	9.23^{de}	9.13^{c}	9.63^{d}	9.56^{d}	466.50^{c}	454.68^{e}	302.00^{cd}	298.16^{f}	73.57c	73.52de
150 mg/l GA_3	9.53^{abc}	9.56^{b}	9.87^{cd}	10.13^{b}	510.53^{b}	519.82^{b}	330.10^{b}	343.16^{b}	76.42ab	75.82c
0.1% Boric acid	9.23^{de}	8.03^{f}	9.70^{d}	8.86^{f}	437.77^{ef}	425.05^{f}	288.70^{d}	277.83^{e}	74.54c	72.37ef
0.3% Boric acid	9.40^{bcd}	8.63^{d}	9.83^{d}	9.43^{d}	466.53^{c}	454.64^{e}	312.23^{c}	298.73^{d}	75.89b	73.81d
1% Calcium chloride	9.37^{cd}	9.30^{b}	9.80^{d}	9.76^{c}	450.30^{de}	428.27^{f}	291.67^{d}	278.86^{e}	74.09c	75.32c
2% Calcium chloride	9.57^{ab}	9.90^{a}	10.10^{bc}	10.13^{b}	462.87^{cd}	465.13^{d}	289.53^{d}	305.53^{c}	76.53ab	78.34ab
4% Kaolin	8.47^{f}	8.43^{e}	9.27^{e}	9.10^{e}	431.07^{f}	415.21^{g}	290.30^{d}	249.10^{g}	76.83ab	78.22b
6% Kaolin	9.10^{e}	9.16^{c}	9.80^{d}	9.73^{c}	436.20^{f}	427.18^{f}	290.23^{d}	258.53^{f}	77.32a	79.07a
LSD at 0.05	**0.19**	**0.17**	**0.24**	**0.14**	**14.01**	**7.18**	**13.62**	**2.72**	**1.05**	**0.78**

Means of each column designated by the same letter are not significantly different at 5% using least significant difference (L.S.D.)

Table (4). Response of 'Wonderful' pomegranate fruit chemical parameters to foliar application of some growth regulators, nutrients elements and kaolin treatments during 2016 and 2017 seasons

Treatments	TSS (%)		Acidity (%)		Total sugars (%)		Reducing sugars (%)		Vitamin C (mg/100 ml juice)		Anthocyanin (mg/100g)	
	Seasons											
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Control	15.26f	16.07h	1.47a	1.21a	8.78f	9.00g	5.43c	6.69j	10.67e	11.67h	0.51f	0.42j
25 mg/l NAA	16.70abc	17.10f	1.03b	0.90b	11.43b	9.82ef	6.37b	7.10i	13.33d	14.67fg	0.77bc	0.65e
50 mg/l NAA	16.83bc	17.53c	0.85cd	0.86d	11.96a	9.99e	6.57a	7.62g	14.33bcd	17.00cd	0.84a	0.75c
100 mg/l GA_3	17.00ab	17.30d	0.88c	0.77e	10.15de	9.19g	6.36b	7.52h	15.33abc	16.00de	0.66d	0.61gh
150 mg/l GA_3	17.20ab	17.57c	0.93c	0.72f	10.85c	10.97d	6.42a	7.89f	16.00a	18.67b	0.73c	0.69d
0.1% Boric acid	16.10e	17.27de	0.92c	0.87bc	9.76e	12.35bc	6.29b	9.20b	14.00cd	14.33g	0.64de	0.82b
0.3% Boric acid	16.40de	18.23a	0.90c	0.82d	10.24d	13.55a	6.48a	9.88a	14.33bcd	16.67cde	0.81ab	0.88a
1% Calcium chloride	17.23ab	17.13ef	0.90c	0.89bc	9.94de	12.07c	6.32b	8.76d	14.67bcd	18.67b	0.61e	0.63g
2% Calcium chloride	17.26a	18.10ab	0.77d	0.77e	10.90c	12.33bc	6.30b	8.94c	15.67ab	20.33a	0.67d	0.66e
4% Kaolin	16.63cd	16.67g	0.92c	0.87bc	10.71c	10.87d	6.30b	8.60e	14.67abcd	15.67ef	0.62e	0.57i
6% Kaolin	17.20ab	18.03b	0.89c	0.81d	11.88ab	11.21d	6.38b	8.74d	15.33abc	17.67c	0.63de	0.60h
LSD at 0.05	**0.35**	**0.16**	**0.09**	**0.02**	**0.47**	**0.60**	**0.16**	**0.08**	**1.50**	**1.22**	**0.04**	**0.07**

Means of each column designated by the same letter are not significantly different at 5% using least significant difference (L.S.D.)

CONCLUSION

From the results of the preset experiment, it could be concluded that, 50 mg/l NAA followed by boric acid at 0.3%, calcium chloride at 2% and kaolin at 6% gave the highest fruit set, fruit cracking and sunburn percentages, yield, and fruit quality of 'Wonderful' pomegranate trees (*Punica granatum* L.).

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الملخص العربي

تأثير بعض منظمات النمو والعناصر الغذائية والكاولين على تشقق وجودة ثمار الرمان صنف 'وندرفول'

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أجريت هذه الدراسة خلال موسمين متتاليين ٢٠١٦ و٢٠١٧ على أشجار رمان صنف 'وندرفول' عمرها ست سنوات نامية في منطقة – برج العرب (محافظة الإسكندرية)، مصر. ومنزرعة على مسافة ٤×٥ م لدراسة تأثير بعض منظمات النمو والعناصر الغذائية والكاولين على تشقق وجودة ثمار الرمان صنف 'وندرفول'. وقد تم تصميم التجربة بنظام القطاعات العشوائية الكاملة بخمس مكررات. ويحتوي كل قطاع على ١١ معاملة (كنترول، نفثالين حمض الخليك بتركيز ٢٥، ٥٠ مجم/لتر، حمض الجبرلليك بتركيز ١٠٠، ١٥٠ مجم/لتر، حمض البوريك بتركيز ٠.١٪ ، ٠.٣٪ ، كلوريد الكالسيوم بتركيز ١٪ ، ٢٪ ، الكاولين بتركيز ٤٪ ، ٦٪).

وقد أظهرت النتائج أن معاملة حمض البوريك بتركيز ٠,٣٪ أعطت أعلى متوسط قيم للنسبة المئوية للعقد وعدد الثمار/شجرة وأعلى محصول (كجم/شجرة) وصبغة الأنثوسيانين، بينما سجل نفثالين حمض الخليك بتركيز ٥٠ مجم/لتر أعلى القيم لكل من الصفات الطبيعية للثمار (وزن، قطر، حجم الثمرة، وزن الحبات)، كما أعطت أقل نسبة تساقط الثمار والتشقق. ومن ناحية آخرى فإن حمض الجبرلليك بتركيز ١٥٠ مجم/لتر أعطى أعلى متوسط للمحصول (كجم/شجرة) في الموسم الثاني وأقل نسبة لتشقق الثمار في الموسم الأول بينما أعطى كلوريد الكالسيوم بتركيز ٢٪ أفضل النتائج للصفات الكيميائية للثمار(نسبة المواد الصلبة الذائبة الكلية والحموضة الكلية ومحتوى فيتامين C) واحتوت ثمار جميع المعاملات على أعلى نسبة من السكريات الكلية والمختزلة مقارنة بالكنترول وأخيراً أعطى الكاولين بتركيز٦٪ أقل نسبة للفحة الشمس في ثمار الرمان 'وندرفول' وأيضاً أعلى محتوى من العصير، مقارنة بالكنترول وغيرها من المعاملات الآخرى وذلك خلال موسمي الدراسة.