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Cracking and Fruit Quality of Pomegranate (*Punica granatum* L.) As Affected by Pre-Harvest Sprays of Some Growth Regulators and Mineral Nutrients

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Abstract: An experiment was carried out during 2011 and 2012 seasons to study the effect of foliar application by using some growth regulators (paclobutrazol at 300 ppm, gibberellic acid (GA_3) at 80 ppm and NAA at 40 ppm) and mineral nutrients (3% Ca as calcium chloride ($CaCl_2$), 0.3 % boron as boric acid and 0.3 % Zn as zinc sulphate ($ZnSO_4$) after two and eight weeks from full bloom on yield, fruit cracking% and quality in pomegranate cultivar 'Manfalouty'. The extent of fruit cracking was reduced significantly with application of 300 ppm pacloputrazol, while grain %, fruit juice %, TSS % and acidity % were increased. Yield and fruit weight were increased with applying pacloputrazol or by using (3 % Ca + 0.3 % B + 0.3 % Zn). Application of 40 ppm NAA and 80 ppm GA_3 significantly increased fruit length and fruit diameter. Application of 80 ppm GA_3 significantly increased total anthocyanin %, while tannins % was not affected by other two growth regulators.

Key words: Pomegranate · Growth regulators · Cracking · Anthocyanin · Mineral nutrients

INTRODUCTION

Pomegranate (*Punica granatum* L.) is one of the oldest known edible fruits, among the fruit kinds mentioned in the Holy Quran. It is native to Iran and grown extensively in arid and semi-arid regions worldwide [1]. Pomegranate is also important in human medicine and its components have a wide range of clinical applications [2]. The anthocyanins from pomegranate fruit have been shown to have higher antioxidant activity than vitamin E (α-tocopherol), vitamin C (ascorbic acid) or β-carotene [3]. Moreover, commercial pomegranate juice has been shown to have three times higher antioxidant activity than green tea and red wine [4]. It is a known fact that some fruits crack during the latter period of growth. Cracking causes a major fruits loss, which is a serious commercial loss to farmers. Fruit cracking, seems to be a problem that lessens the marketability to a great extent. Manfaluty pomegranate is considered one of the most important pomegranate cultivars grown successfully in Egypt. The pomegranate area in Egypt was estimated to be about 90,000 Faddan (37500 ha) [5]. Fruit cracking is one of the physiological disorders wherever pomegranate trees are grown. It may be due to moisture imbalances as this fruit is very sensitive to variation in soil moisture prolonged drought causes hardening of peel and if this is followed by heavy irrigation the pulp grows then peel grows and cracks [6]. Among different elite horticultural practices, growth regulators have been advantageously used in the recent time to increase the fruit production and to improve the quality of several fruit crops. Reddy and Prasad [7] found that pomegranate trees applied of 40 ppm 2, 4-D and 75 ppm GA_3 increased fruit size, aerial development and yield. Many investigations studied the effect of spraying macro and micronutrients on growth, yield and fruit quality such as nitrogen, phosphorus, potassium and magnesium. However boron, zinc and calcium were highly effective in improving, nutritional status yield and fruit quality of pomegranate trees. Bambal [8] found that foliar application of some micronutrients such as Fe, B, Mn and Zn increased fruit yield, whereas B reduced the percentage of cracked fruits. Although, the effect of foliar applied chemicals on yield and fruit quality have been studied by many workers the information of such effect on pomegranate fruit is very scanty. Hence, the present investigation was undertaken to study the effect of

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pre-harvest sprays of some growth regulators and mineral nutrients on the yield and the fruit quality of pomegranate trees.

MATERIALS AND METHODS

This experiment was conducted during two successive seasons of 2011and 2012 at a private farm in El-hamam region, near Alexandria City, Egypt. Twenty one uniform healthy pomegranate trees of Manfalouty cv. fifteen years old were chosen for this study. Trees grown on sandy soil, drip irrigation system was used and planted at 4.5 x 4.5. A regular pest management program was maintained. In both seasons, the selected trees were divided into different seven treatments included the control treatment. The treatments were arranged as follows:

- Control (sprayed with water only)
- Paclobutrazol at 300ppm
- Gibberellic acid (GA_3) at 80ppm
- NAA at 40ppm
- Calcium chloride ($CaCl_2$) at 3% Ca
- Boric acid at 0.3% B
- Zinc sulphate ($ZnSO_4$) at 0.3% Zn
- Calcium chloride (3% Ca) + boric acid at (0.3% B) + zinc sulphate at (0.3% Zn)

The experiment was designed as a completely randomized blocks design with three replicates and each replicate was replicates by one tree. All treatments were applied as spraying twice/year (two and eight weeks after full bloom). Fruits were picked at mid September in both seasons. At harvest time number of fruits per tree in each treatment was counted and the fruit yield (kg) per tree was calculated, also the percentage of fruit cracking/tree in three stages (10 days before harvest time, at harvest time and 10 days after harvest time). Fifteen normal fruits were taken from each tree for quality determination. Average fruit length (cm), diameter (cm) was measured and also, grain weight (%), juice volume (%), peel weight (%) of total fruit weight and peel thickness (cm). The juice was extracted and total soluble solids percentage (TSS %) was determined by using hand refractometer. Total acidity percentage was determined by titrating 5ml juice against 0.1 NaOH using phenolphthalein as indicator. Total anthocyanine content in fruit juice as described by Harborne [9]. Tannins content was determined in each sample by Swain and Hillis [10].

Statistical Analysis: All data were tested for treatments effects on analyzed parameters by the one-way analysis of variance (ANOVA) technique. Differences between treatments were compared by Duncan's multiple range test according to Snedecore and Cochran [11]. The statistical analysis was performed using Costat software package for Windows.

RESULTS AND DISCUSSION

Fruit Cracking %: The effect of the different treatments on fruit cracking percentage is presented in Fig. 1 and 2. A significant decrease in fruit cracking percentage in all the studied stages was obtained in both seasons by using all sprayed substances compared to control. In this concern, applying 300 ppm paclobutrazol resulted in the lowest significant fruit cracking percentage in the first stage (4.50 and 5.15%), second stage (10 and 11.70%) and third stage (17.73 and 15.20%) in both seasons, respectively. However, applying GA_3 or $CaCl_2$ had similar and significantly lower fruit cracking percentage during the 3rd stage than all other sprayed compounds, except pacloputrazole. The highest percentages of cracking fruits were obtained from untreated trees in all studied stages which reached (49.50 and 48.50%) in both seasons. These results are in agreement with those obtained by El–Khawaga [12] who reported that cracking fruits in Manfalouty pomegranate cultivar were reduced by applying of paclobutrazol. In addition, GA_3 may be influencing cell wall strength or elasticity [13]. Moreover, Ca attributed to the stabilization of membrane systems and the formation of calcium pectates and cell wall which increase rigidity of the middle portion and cell wall of the fruit [14]. Yeshitela [15] reported that paclobutrazol increased fruit set; fruit set showed a direct impact on yield depending on number of fruit retained. The impact of higher rates of paclobutrazol in enormously suppressing vegetative growth, especially during peak fruit development stage, contributed to the superior yield.

Fruit Yield (Kg/Tree): Data presented in Table 1 showed that, the greatest significant fruit yield was found with spraying paclobutrazol at the rate of 300 ppm in the 1st season followed by (3 % Ca + 0.3 % B + 0.3 % Zn), where the fruits yield were (28.8 and 26.68 kg/tree, respectively). In the second season, application of 300 ppm paclobutrazol significantly higher fruit yield (33.20 kg/tree) than other sprayed substances followed by 3% Ca, 0.3% B and (3 % Ca + 0.3 % B + 0.3 % Zn),

Table 1: Effect of some growth regulators and mineral nutrients on fruits yield, fruit weight and fruit juice percentage of Manfalouty pomegranate during 2011 and 2012 seasons.

	Yield (kg / tree)		Fruit weight (g)		Fruit juice (%)	
Treatments	2011	2012	2011	2012	2011	2012
T1 (Control)	15.60e	21.75cd	255.00e	230.00g	28.11abc	27.35b
T2 (Paclobutrazol at 300 ppm)	28.80a	33.20a	287.00c	257.00a	30.14a	32.11a
T3 (Gibberellic acid at 80 ppm)	14.56e	20.16d	265.23d	270.66f	28.65abc	31.10a
T4 (NAA at 40 ppm)	20.00d	24.65c	221.00f	232.00g	27.12bc	27.11b
T5 (Calcium chloride at 3% Ca)	23.57c	26.11b	310.00b	311.00d	23.71d	24.00c
T6 (Boric acid at 0.3% B)	24.90c	28.11b	310.00b	341.00c	26.12cd	27.50b
T7 (Zinc sulphate at 0.3% Zn)	14.50e	21.00d	281.00c	295.00e	27.64abc	28.13b
T8 (T5 + T6 + T7)	26.68b	27.11b	340.00a	352.00b	29.10ab	31.55a

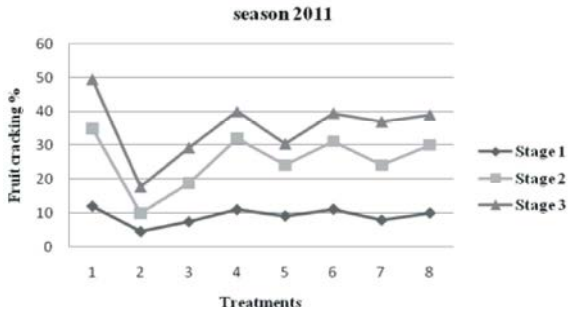

Fig. 1: Effect of some growth regulators and mineral nutrients on fruit cracking percentage of Manfalouty pomegranate during 2011 season.

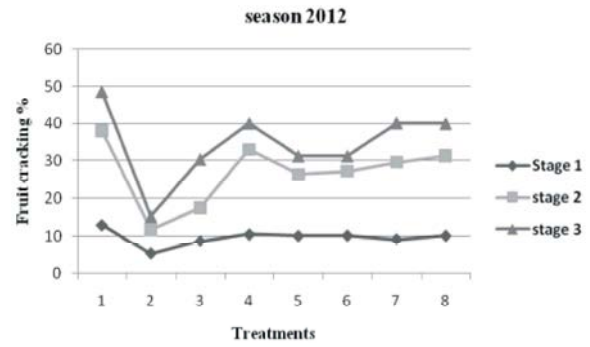

Fig. 2: Effect of some growth regulators and mineral nutrients on fruit cracking percentage of Manfalouty pomegranate during 2012 season.

which did not significantly differ among each other. The obtained results are in line with the findings of Habib *et al*. [15] Also, paclobutrazol has been used as abroad spectrum growth retardant which controls tree vigour, enhance productivity through increasing fruit set, reducing fruit drop and increasing fruit yield as reported by Zhai and Zhang [16] and Ahmed *et al*. [17] on pomegranate. Yeshitela [18] reported that paclobutrazol increased fruit set; fruit set showed a direct impact on yield depending on number of fruit retained. The impact of higher rates of paclobutrazol in enormously suppressing vegetative growth, especially during peak fruit development stage, contributed to the superior yield.

Fruit Quality:

Physical Properties:

Fruit Weight: Data of both seasons presented a significant increase in fruit weight by all sprayed chemicals compared to the control treatment (Table 1). The heaviest fruit weight (340 g) was obtained by applying 300 ppm paclobutrazol in the first season, while in the second season applying (3 % Ca + 0.3 % B + 0.3 % Zn) was the superior (352 g). On the other hand, the control trees showed the lowest values which recorded 255 and 230g during 2011 and 2012 seasons.

Fruit Length and Diameter: The effect of the different treatments on fruit length and diameter is presented in Table 2. A significant increase in fruit length and diameter was obtained in both seasons by all sprayed compounds compared to the control. In both seasons, the highest fruit length and diameter (9.23 and 9.90cm, respectively) were obtained by spraying 40 ppm NAA followed by spraying 80 ppm GA_3(8.71 and 9.35cm) in comparison to control or other treatments (Table 2). This can be attributed to nature of auxins (NAA) to stimulate cell division, cell elongation and membrane permeability to water uptake [19]. Gibberellins are involved in cell division and cell elongation. They are known to influence fruit size [20]. Gibberellic acid is also reported to promote growth by increasing plasticity of the cell wall followed by the hydrolysis of starch into sugars which reduces the cell water potential, resulting in the entry of water into the cell and causing elongation [21].

Table 2: Effect of some growth regulators and mineral nutrients on fruit length, fruit diameter, fruit grain percentage and fruit peel percentage of Manfalouty pomegranate during 2011 and 2012 seasons.

	Fruit length (cm)		Fruit diameter (cm)		Fruit grain (%)		Fruit peel (%)	
Treatments	2011	2012	2011	2012	2011	2012	2011	2012
T1 (Control)	6.22d	7.50d	6.60c	7.00e	51.00c	50.00d	49.00a	50.00a
T2 (Paclobutrazol at 300 ppm)	7.55c	8.93bc	7.50c	7.60d	57.50a	56.00a	42.50c	44.00d
T3 (Gibberellic acid at 80 ppm)	8.71ab	9.35ab	8.84a	8.50ab	54.50b	52.11bcd	45.50b	47.88abc
T4 (NAA at 40 ppm)	9.23a	9.90a	8.85a	8.62a	54.32b	52.78bc	45.66b	47.22bc
T5 (Calcium chloride at 3% Ca)	8.00bc	8.90bc	7.98ab	8.13c	54.93ab	54.00ab	45.07bc	46.00cd
T6 (Boric acid at 0.3% B)	7.45c	8.20cd	7.52b	7.39d	54.44b	52.77bc	45.55b	47.23bc
T7 (Zinc sulphate at 0.3% Zn)	7.50c	8.90bc	7.76b	7.40d	52.50bc	50.62cd	47.50ab	49.38ab
T8 (T5 + T6 + T7)	8.45abc	8.93bc	8.00ab	8.34bc	54.30b	54.11ab	45.70b	45.89cd

Table 3: Effect of some growth regulators and mineral nutrients on T.S.S %, acidity %, anthocyanin % and tannins % of Manfalouty pomegranate during 2011 and 2012 seasons.

	T.S.S (%)		Acidity (%)		Anthocyanin (%)		Tannins (%)	
Treatments	2011	2012	2011	2012	2011	2012	2011	2012
T1 (Control)	14.00d	15.00e	1.15c	1.18c	0.321e	0.339f	2.40a	2.80a
T2 (Paclobutrazol at 300 ppm)	15.28a	17.11a	1.45a	1.38a	0.366d	0.398d	2.70a	2.79a
T3 (Gibberellic acid at 80 ppm)	14.60bc	16.20bc	1.35ab	1.43a	0.498a	0.590a	2.40b	2.72a
T4 (NAA at 40 ppm)	14.42cd	16.00bcd	1.17c	1.20c	0.350d	0.370e	2.41b	2.80a
T5 (Calcium chloride at 3% Ca)	14.50bcd	15.80cd	1.24bc	1.30b	0.390c	0.420c	2.37b	2.79a
T6 (Boric acid 0.3% B)	14.30cd	15.82cd	1.15c	1.20c	0.320e	0.340f	2.30b	2.73a
T7 (Zinc sulphate at 0.3% Zn)	14.31cd	15.61d	1.17c	1.17c	0.280f	0.340f	2.40b	2.80a
T8 (T5 + T6 + T7)	14.98ab	16.53b	1.23bc	1.22c	0.411b	0.450b	2.41b	2.90a

Fruit Grain% and Fruit Peel %: Data in Table 2 indicated that the fruit grain percentage reached to the maximum values as by using 300 ppm paclobutrazol treatment with an average (57.50 and 56.00 %), while the lowest (51.00 and 50.00 %) were obtained from untreated trees in both seasons, respectively. Meanwhile, fruit peel percentage had the highest (49.00 and 50.00%) values with untreated trees, while, the lowest (42.50 and 44.00%) were obtained from trees sprayed with 300 ppm paclobutrazol treatment in the 1st and 2nd seasons, respectively. These findings are in line with earlier reported by Rahemi and Atahosseini [22] on pomegranate.

Fruit Juice %: Data in Table 1 indicated that, fruit juice percentage was more affected significantly by applying 300 ppm paclobutrazol in the 1st season and by 300 ppm pacloputrazole or 80 ppm GA_3 in the 2nd season. On the other hand, the lowest fruit juice percentage was obtained from tress sprayed with $CaCl_2$ at 3% Ca in both seasons. Such results may be due to the effect of pacloputrazol in increasing fruit grain percentage. These results are in harmony with those obtained by Fucik and Swietlik [23] who found that paclobutrazol increased fruit juice in grapefruit.

Chemical Properties:

T.S.S% and Acidity%: The effect of different sprayed substances treatment on TSS% and acidity% is presented in Table 3. A significant increase in total soluble solids (TSS %) in comparison with the control was obtained in both seasons by all sprayed compounds, except the treatment received 40 ppm NAA, 3% Ca, 0.3% B and 0.3% Zn showed a decrease in TSS %. Paclobutrazol spraying resulted in higher TSS content than all other sprayed substances in both seasons. These results are in agreement with those obtained by El-Khawaga [12] who found that paclobutrazol increased TSS% in pomegranate. Data in Table 3 also indicated that acidity % was not affected by any of the sprayed substances except, paclobutrazol and GA in the first and second season or by applying $CaCl_2$ in the second one, showed an increased in acidity content as compared with the control. The results obtained are in agreement with Singh and Sant [24] and Yeshitela [18] on mango and El-Khawaga [25] on pomegranate. Besides, Arzani and Roosta [26] mentioned that foliar spray of paclobutrazol treatment could control excessive vegetative growth, indicating positive effects on fruit growth, yield and fruit quality, which is possibly related to the allocation of more carbohydrates to the fruits at the expense of reduction in shoot growth.

Total Anthocyanin % and Tannins Content %: Data in Table 3 revealed that, application of 80 ppm GA_3 significantly increased total anthocyanin (0.498 and 0.590%) as compared to control or to other treatments in both season, respectively. However, the lowest total anthocyanin values were obtained by spraying 0.3% Zn in the first and second season or by 0.3% B in the second one. Data in Table 3 also indicated that, in general, tannins% was not affected by any of the sprayed substances, except applying 80 ppm paclobutrazol increased significantly the percentage of tannins in the first season only.

CONCLUSION

It might be concluded that preharvest application of some growth regulators and mineral nutrients such as pacloputrazol, GA_3, NAA, $CaCl_2$, boric acid and $ZnSO_4$ at the early stages of fruit growth in pomegranate trees had a positive influence in decreasing fruit cracking% and improving fruit characteristics of Manfalouty pomegranate cultivar. It can be recommended from results of the present study to consider spraying paclobutrazol and combination of the studied minerals nutrients during two and eight weeks after full bloom have an efficient effect on improving characteristics of pomegranate fruit quality.

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