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RESEARCH ARTICLE

Improving the quantitative and qualitative of Manfalouty pomegranate cultivar.

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Abstract

One of the major physiological disorders for pomegranate cultivation is the excessive of fruit cracking. lately, a pomegranate physiological syndrome called ‘aril paleness’ in which a part or all of the arils appear discoloration, affect the quality of fruit and such fruits are not desired for consumer. The present research designed to evaluate the effects of methyl jasmonate (MJ), humic acid (HA) and potassium (K) on reducing these disorders and improving fruit quality. Seven treatments including MJ (5 and 10 ppm), HA (50 and 100 ppm), Liquid K (1 and 2%) and control, were tested on pomegranate trees spraying three times, at the beginning of flowering (during April), after full bloom (end of June) and before harvesting (mid-September), during the two seasons of study. Different parameters including yield, fruit cracking and fruit quality were measured. The obtained results indicated that spraying HA at 100 ppm and MJ at 10 ppm are considered the best in their effects on the yield components, fruit quality and anthocyanin content, however for decreasing the fruit cracking, it could be recommended to spray the fruits with K at 1% or MJ 10 ppm compared to the rest of the treatments.

Keywords*:* Methyl jasmonate, Humic acid, Potassium, Anthocyanin, Fruit splitting

Introduction

Pomegranate (*Punica granatum* L.) is one of the most important fruit trees in tropical and sub-tropical regions and grown successfully in Egypt, not only in the old lands but also in the newly reclaimed lands. It is an important commercial fruit crop that is extensively cultivated in many parts of Asia, North Africa, the Mediterranean and the Middle East regions (Sarkhosh *et al.*, 2006). Pomegranate fruits are extensively consumed fresh or managed into juice, jams, syrup and sauce. The edible part (arils) of fruit is about 55-60% of the total fruit weight and consists of about 75-85% juice and 15-25% seeds (Pareek *et al.*, 2015). Manfalouty is considered as the most imperative pomegranate cultivars established successfully in Upper Egypt and particularly in Assiut Governorate which ranks the second in the area compare to another fruit crops. The increasing amount of pomegranates fruit which spread were recently augmented in the last decade, due to its highly content of antioxidants, some vitamins and minerals which exhibit protective effects against many diseases including different cancers, vascular disorders, and inflammatory problems (Heber

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et al., 2006; Ozgen *et al.*, 2008; O'Grady *et al.*, 2014).

Fruit cracking is the most serious problem influencing the productivity of pomegranate trees in economic terms. It is a physiological disorder that occurs because of the different growth rats between skin and flesh of fruit (Yilmaz and Özgüren, 2009). There are many factors that cause fruit cracking such as unbalanced irrigation, hot dry weather, soil moisture, climatic conditions, tree nutrition and cultivars (Abd- El-Rahman, 2010; Kumar *et al*., 2010; Sheikh and Manjula, 2012; Hegazi *et al.*, 2014). This problem caused a significant loss in the productivity of some pomegranate cultivars and may reach more than 50% in some cultivars (Sheikh and Manjula, 2012).

The use of phytohormones, organic materials and growth regulators during production stages has been considered as a new policy to improve different crop quality parameters and decrease the vulnerability to postharvest losses (Kucuker *et al.*, 2014; Ahammed *et al.*, 2015; Asghari and Zahedipour 2016; Sun *et al.*, 2019). Jasmonic acid signaling molecules in plants make the plant responsive to various biotic and abiotic stresses, involved in fruit ripening, control pollen maturation and accidental damage in plants (Jin *et al.*, 2009; Meng *et al.*, 2009; Wasternack and Hanse, 2013; Zhou *et al.*, 2013). Meaningfully, methyl jasmonate (MJ) application on fruit increases the red color, anthocyanin and β-carotene contents, and several phenolic compound gaining, and the ethylene and lots of ester compound (Wang and Zheng, 2005; Wang *et al.*, 2008; Mukkun and Singh, 2009).

Humic acid is a multifaceted organic material resulting from the decomposition of plant matter that exists as a mixture of soluble substances. These organic supplements can be used to adjust hormone levels, improve nutritional uptake, and enhance stress tolerance (Khattab *et al.*, 2012; Lotfi *et al.*, 2015; Moghadam, 2015). It also can be used for maintainable agriculture with the aim of diminish the cost of production and help protect the environment through replacement it instead of chemical fertilizers instead of it (Hatami *et al.*, 2018).

Potassium is one of the supreme vital macro elements which highly movable in plants at all levels. It plays a most important role in enzyme activation, protein synthesis, stomatal function photosynthesis and transport of metabolites. Potassium develops fruit quality by increasing fruit size, juice content, color and juice flavor (Tiwari, 2005; Ashraf *et al.*, 2010).

Therefore, the current study was intended to evaluate the effect of methyl jasmonate (MJ), humic acid (HA) and potassium (K) spraying on yield components, fruit splitting and some fruit quality parameters of Manfalouty pomegranate cultivar.

Materials and Methods

2.1. Plant materials and treatments

The present study was executed during two successive seasons of 2018 and 2019 on Manfalouty pomegranate cultivar grown at the Experimental Orchard of Faculty of Agriculture, Assiut University. The soil was heavy loam. Regular agricultural managements were applied to all experimental trees as recommended. The trees space was 5x5 apart and they were 40 years old at the start of the experiment. Twenty-eight uniform trees were selected and divided into seven treatments including the control, each treatment was executed on four trees (Replicates). Seven treatments category were as follows

1- Spraying methyl jasmonate (MJ) at 5 ppm
2- Spraying methyl jasmonate (MJ) at 10 ppm.
3-Spraying Humic acid (HA) at 50 ppm
4- Spraying Humic acid (HA) at 100 ppm.
5- Spraying Liquid Potassium (K) at 1%
6- Spraying Liquid Potassium (K) at 2%.
7- The control (water only).

Treatments were dissolved according to the pre-mentioned concentrations. The trees were sprayed with knapsack sprayer. A total volume of 20 L was adequate for spraying 4 trees until runoff. The spraying treatments executed three times, at the beginning of flowering (during April), after full bloom (end of June) and before harvesting (mid-September), through the two seasons. The subsequent parameters were recorded.

2.2. Plant measurements

2.2.1. Vegetative growth parameters

Five mature leaves on tagged shoots were picked for calculating the leaf area utilizing the succeeding equation outlined by (Ahmed and Morsy, 1999).

$$\textit{Leaf area } (cm^2) = 0.41\ (L \times W) + 1.83$$

Where: L= leaf length (cm), W= leaf width (cm)

The total chlorophyll content in fresh leaves was determined as said by the method defined by Betemps (2012) using Minolta chlorophyll Meter Spad. 502 (Minolta Camera, LTD Japan). Equation shows how total chlorophyll content is calculated

$$Chl_{a+b} = 22.12\ E_{652} + 2.71\ E_{665}$$

Where: E is the rate of absorption of the sample at the wavelength of the subtitle E. for example, E_{652} is the absorption at a wavelength of 652 nm.

2.2.2. Yield components

The fruits of all treated trees were picked at mid-October in the two seasons. Fruits per tree were counted and weighted to estimate the total number of fruits and yield weight (kg/tree), and then the fruits were graded into three grades as following:

- Grade I (fruits of 400-500 g or above in the weight)
- Grade II (fruits of 300-400 g in the weight)
- Grade III (fruits of 200-300 g or less in the weight)

The commercial and non-commercial fruits were estimated and the percentage was calculated. As well as cracked fruits were sorted, counted, weighted and the percentage of fruit splitting was calculated relative to the total yield weight or the total number of fruits.

2.2.3. Physical properties

Samples of four fruits per tree were collected randomly and the fruit weight was measured using an electronic balance so as to determine peel and arils weight percentage, fruits were peeled and the weight of total arils and peel were estimated, and then the percentage of arils relative to the fruit weight was calculated. Also, the 100 arils weight (g) and Juice volume/100 arils (ml) were calculated.

2.2.4. Fruit sensory attributes

Total acidity was determined using titration by NaOH at 0.1 N and phenolphthalene as an indicator and then, expressed as citric acid, along with the subsequent equation (A.O.A.C., 1995):

$$\text{Acidity \%} = \frac{\text{NaOH volume in titration x NaOH molarity x equivalent weight of citric acid}}{\text{1000 x sample volume}} \text{ x 100}$$

Where: Equivalent weight of citric acid = 64, NaOH molarity = 0.1M, Sample vol. = 5 ml.

Total soluble solids (TSS %) was measured using the hand refractometer and then, TSS/Acid ratio was calculated. The percentage of reducing and total sugars in juice was determined, according to A.O.A.C. (1995).

2.2.5. Total anthocyanin content (TAC) of peel and juice

Extracts were prepared by the method described by(Onayemi *et al.* 2006). 1 g fruit skin samples were pulverized with 20 ml of 85 Ethanol and 1.5 M HCL (by volume) solution. The samples were covered and kept overnight in the deep freeze. The extracts were completed to 50 ml of the solvent and then absorbance of the solution was measured at a wave length of 530 nm, using spectrophotometer (Unico 1200-USA). Result is expressed as mg/100 g of fresh fruit. Total santhocyanin was calculated using the succeeding equation developed by(Lees and Franci 1971).

$$Total\ anthocyanin\ (mg/100\ g\ fruit\ skin) = \frac{A\ 530\ x\ V}{98.2\ x\ W}$$

Where: A_{530} is the rate of absorption of the sample at the wavelength of the subtitle A. for example, A_{530} is the absorption at a wavelength of 530 nm., V= total volume of extract (ml), W= weight of fresh sample (g),

2.3. Statistical analysis

The experiment was set as a complete randomized blocked design (CRBD) including seven treatments and four replicates per each treatment. Combined analysis over seasons was used. The analysis of variance (ANOVA) was applied using Proc Mixed of SAS package version 9.2 (SAS, 2008) and means were compared by using the revised L.S.D. values at 5% level of the probability (Snedecor and Cochran, 1990).

Results

3.1. Vegetative growth parameters

The results showed that all the treatments had a positive effect and caused a significant increase in the leaf area compared to the control during the two seasons of study (Fig. 1). In addition, the best influencing treatment on the leaf area was HA at 100 ppm followed by potassium at 1%, MJ at 5 ppm, and MJ at 10 ppm, which gave an average leaf area of 6.99, 6.97, 6.63 and 6.60 cm^2 with an increment of 16.9, 16.6, 10.9 and 10.4% over the control treatment, respectively, with no significant differences between them. Whereas, the lowest impact aspect was the control treatment which gave 5.98 cm^2 as an average of both seasons.

For the total chlorophyll content, the results represented that K at 2% gave the highest value of total chlorophyll content, followed by the HA at 50 ppm without significant differences between them. They gave 71.2, 70.8, with an increment of 25.8, 25.1% over the control, respectively as an average of the two seasons of the study, whereas the control treatment gave the lowest value (Fig. 1). In general, the K at 2% treatment and HA at 50 ppm are considered the best in their effect on the total chlorophyll attribute compared to the rest of the treatments.

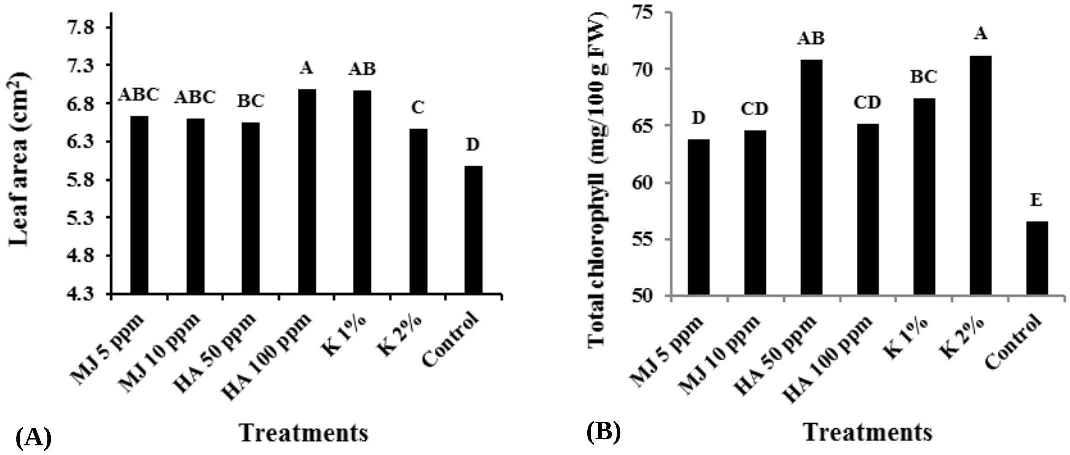


Figure 1. Effect of (MJ), (HA) and (K) spraying on vegetative growth: (A) leaf area (cm^2), (B) total chlorophyll (mg/100 g fresh weight) of Manfalouty pomegranate cultivar during 2018 and 2019 seasons.

3.2. Yield components and fruit splitting

3.2.1. The yield weight (kg/tree)

The results displayed that all the treatments had a significant effect on the total yield/tree compared to the control (Fig. 2). Importantly, the highest yield (109.3 kg/tree) was obtained from HA at 100 ppm treatment, which led to 53.9% increase over the control (71.0 kg/tree) as an average of the two successive seasons, followed by each of MJ at 5 ppm, K at 1%, MJ at 10 ppm, and then potassium at 2% treatments. They recorded 100.3, 94.8, 93.4 and 92.3 kg/tree with an increment of 41.3, 33.5, 31.5 and 30.0% over the control, respectively, while the lower impact influences were HA at 50 ppm treatment, which gave (82.4 kg/tree). On the other side, the control trees produced the lowest yield.

The same Figure reported that HA at 100 ppm treatment caused a significant increase in the yield of grade I, II and a decrease in cracking fruits compared to other treatments and control as an average for the two successive seasons. The values of yield of grade I and II were 54.3 and 29.9 kg/tree with an increment of 78.0 and 77.98% over the control, respectively. As for the yield of grade II, III and cracking fruits, the results revealed that there were no significant differences between HA at 100 ppm and MJ at 5 ppm, whereas HA at 50 ppm gave the lowest values for yield of grade II and III and the highest values for cracking fruits compared to other spraying treatments.

3.2.2. Commercial, Non-commercial fruits and fruit splitting %

The results presented in Fig. 3 indicated that all the treatments resulted in a significant increase in the percentage of commercial fruits and a significant decrease in the percentage of non-commercial fruits compared to the control.

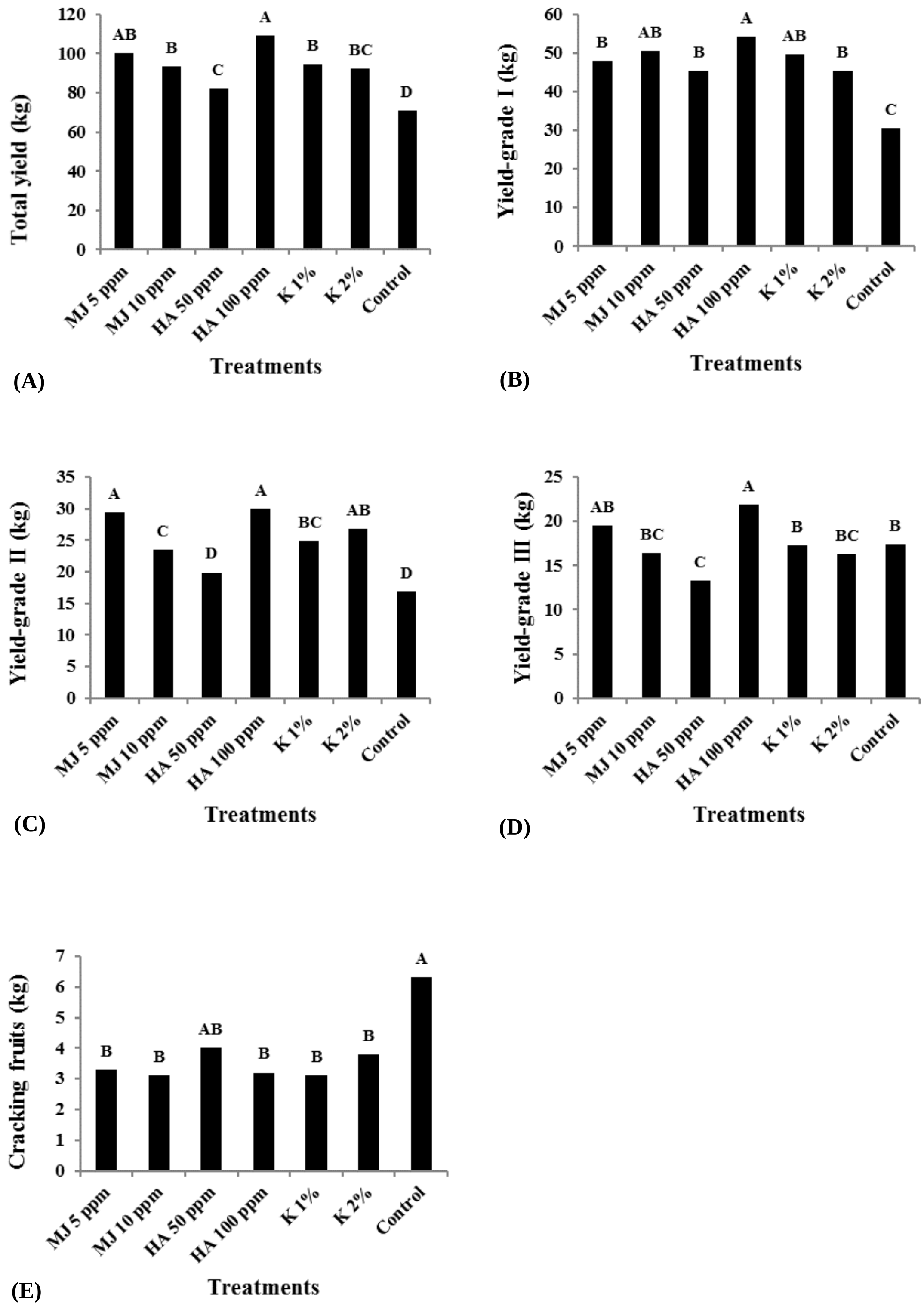


Figure 2. Effect of (MJ), (HA) and (K) spraying on the yield (kg): (A) total yield, (B) yield-grade I, (C) yield-grade II, (D) yield-grade III and (E) cracking fruits of Manfalouty pomegranate cultivar during 2018 and 2019 seasons.

As for fruit splitting percentage, the results indicated that all the treatments caused a reduction in the percentage of fruit cracking compared to the control, and these differences were significant as an average of two successive seasons. Likewise, the K at 1% treatment is considered the best in obtaining the least fruit cracking percentage compared to other spraying treatments and the control. It gave 4.5% of splitting fruits with a decrement of 57.1% than the control, followed by each of HA at 100 ppm, MJ at 5 ppm, K at 2% and MJ at 10 ppm with no significant differences between them, while, HA at 50 ppm gave the higher values (7.2%) compared to other spraying treatments as an average of the two seasons. On the other side, the control treatment produced the highest value of splitting fruits.

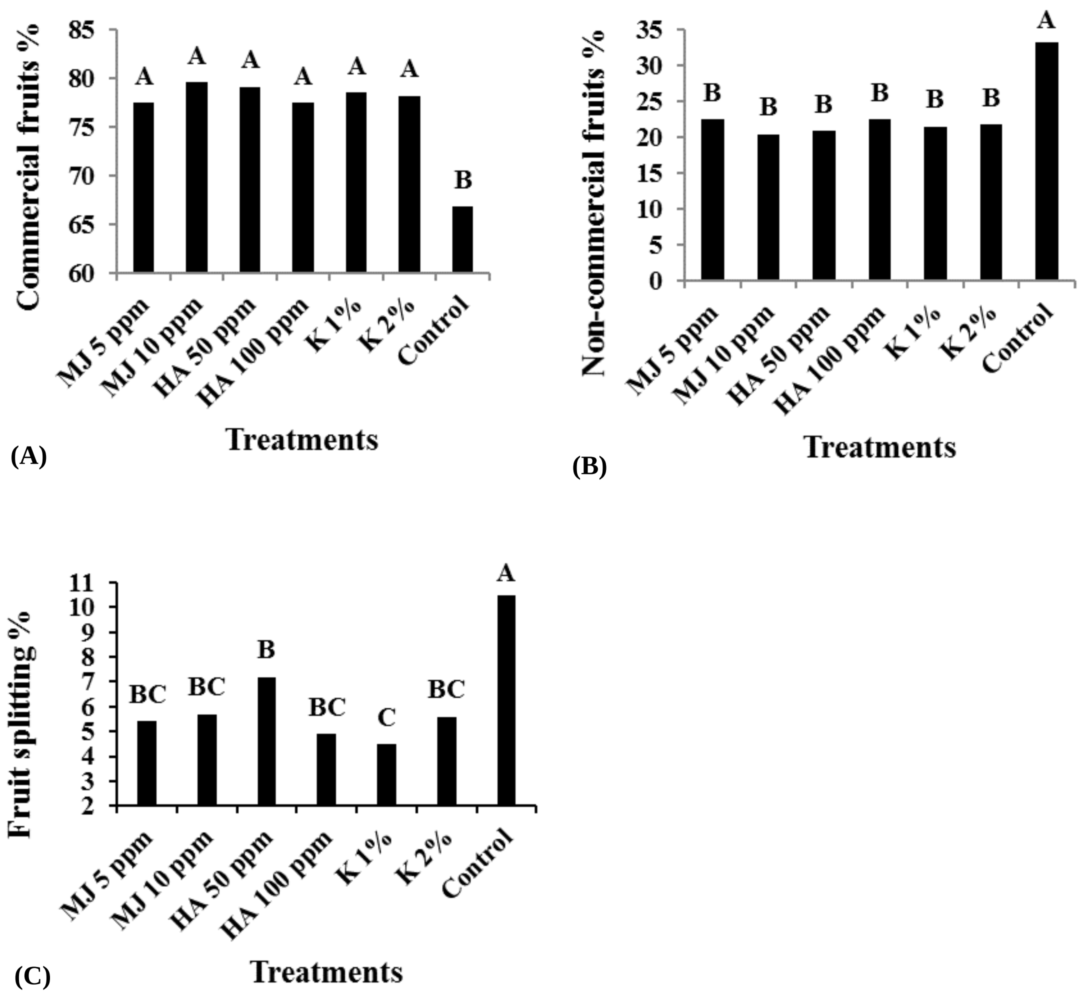
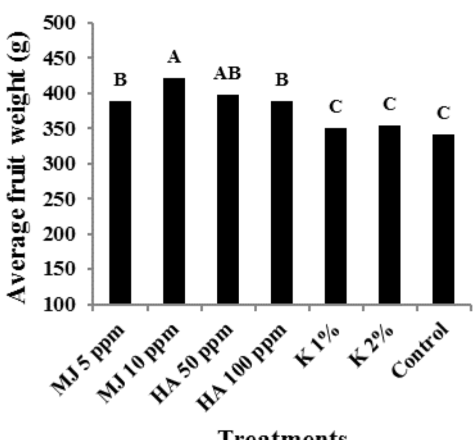


Figure 4. Effect of (MJ), (HA) and (K) spraying on (A) commercial fruits %, (B) non-commercial fruits %, (C) fruit splitting % of Manfalouty pomegranate cultivar during 2018 and 2019 seasons.

3.3. Physical properties

3.3.1. Fruit weight (g)

The results revealed that all the treatments had a positive effect on the average fruit weight compared to the control, and these effects were significant (Fig. 4). Moreover, the best treatment in its effect on the average fruit weight was the MJ at 10 ppm, which gave the highest enormousness average fruit weight (420.7 g) with an increment of 23.5% over the control, followed by HA at 50 ppm which gave an average fruit weight of 397.5 g with an increment of 16.7%, whereas, the control treatment gave the lowest value as an average of the two seasons of study. In addition, MJ at 10 ppm treatment produced a significant increase in the average fruit weight of grade I and II compared to other treatments and the control as an average for the two successive seasons (Fig. 4). The values of the average fruit weight of grade I and II were 540.1 and 381.7 g, which gave an increment of 26.0 and 7.8% over the control, respectively, followed by HA at 50 ppm treatment which gave the average fruit weight 470.1 and 379.1 g, respectively, whereas K at 1% treatment gave the lower value compared to other spraying treatments. On the other side, the control treatment gave the lowest value as an average of the two seasons of study. For fruit weight of grade III, the best treatment was MJ at 5 ppm which gave the fruit weight of 312.6 g with an increment of 19.3% over the control, followed by each of HA at 100 ppm and HA at 50 ppm which gave the values of 312.5 and 306.3 g, respectively, while the K at 1% treatment obtained the lowest value as an average of the two seasons of study. In general, the MJ at 10 ppm and then HA at 50 ppm treatments are considered the superlative in their effect on the average fruit weight compared to other treatments.



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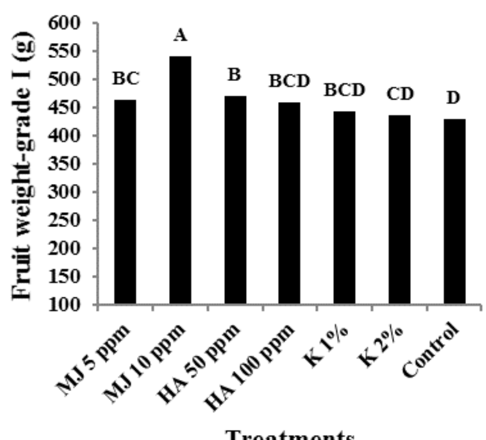

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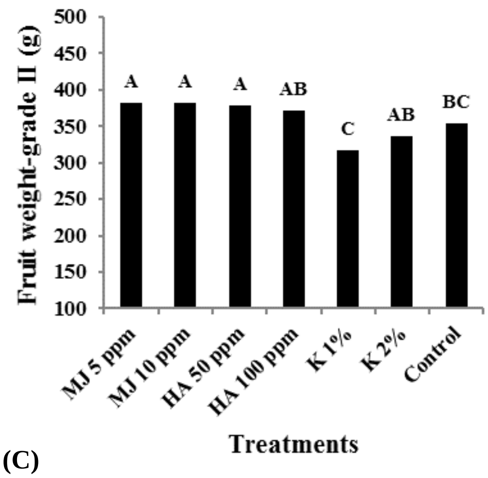

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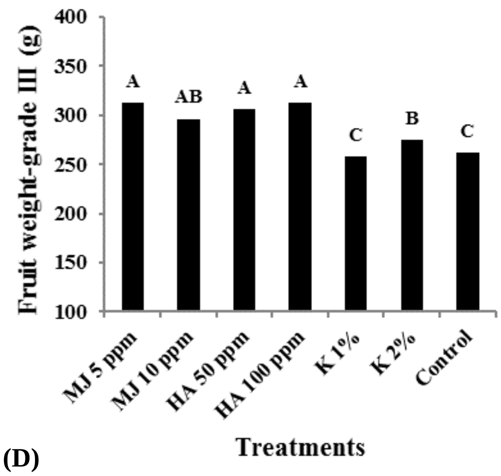
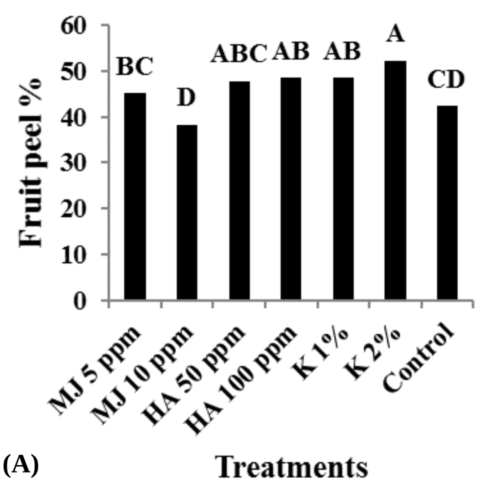


(D)

Figure 4. Effect of (MJ), (HA) and (K) spraying on the fruit weight (g): (A) average fruit weight, (B) fruit weight-grade I, (C) fruit weight-grade II and (D) fruit weight-grade III of Manfalouty pomegranate cultivar during 2018 and 2019 seasons**.**

3.3.2. Fruit peel and arils %

Fig. 5 showed that there were no significant differences between HA, K and the control treatments in their effects on fruit peel %. On the other side, MJ at both concentrations decreased fruit peel % comparing to the rest of treatments. The same Figure showed that there was a significant decrease in the fruit arils % during the two seasons of study. MJ at 10 ppm treatment gave the highest significance of fruit arils percentage compared to the other treatments and the control followed by MJ at 5 ppm treatment. They gave the highest fruit arils % (61.7 and 54.9%) compared to other treatments and the control as an average of the two successive seasons.



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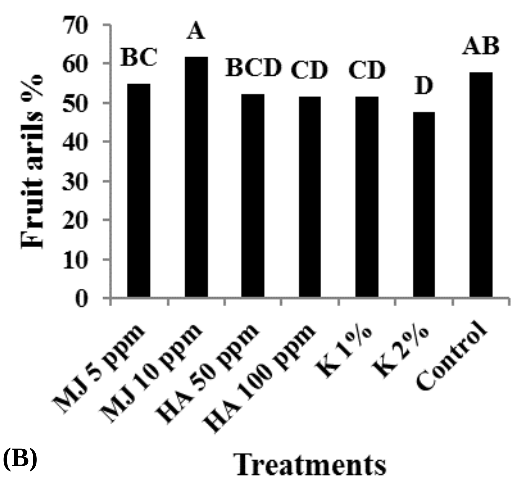


(B)

Figure 5. Effect of (MJ), (HA) and (K) spraying on (A) fruit peel %, (B) fruit arils % of Manfalouty pomegranate cultivar during 2018 and 2019 seasons.

3.3.3. 100 arils weight (g) and Juice volume (cm^3)

It is clear from Fig. 6 that the best treatments in this respect were MJ at 5 ppm and 10 ppm, HA at 50 ppm and then K at 2%. They recorded 35.5, 35.5, 35.3 and 33.3 g with an increment of 8.6, 8.6, 8.0 and 1.8%, respectively. The differences between the above-mentioned treatments were not significant.

Similarly, it is obvious that there were a significant difference between MJ at 5, and 10 ppm and HA at 50 ppm treatments in their effect on juice volume of 100 arils compared to the control.

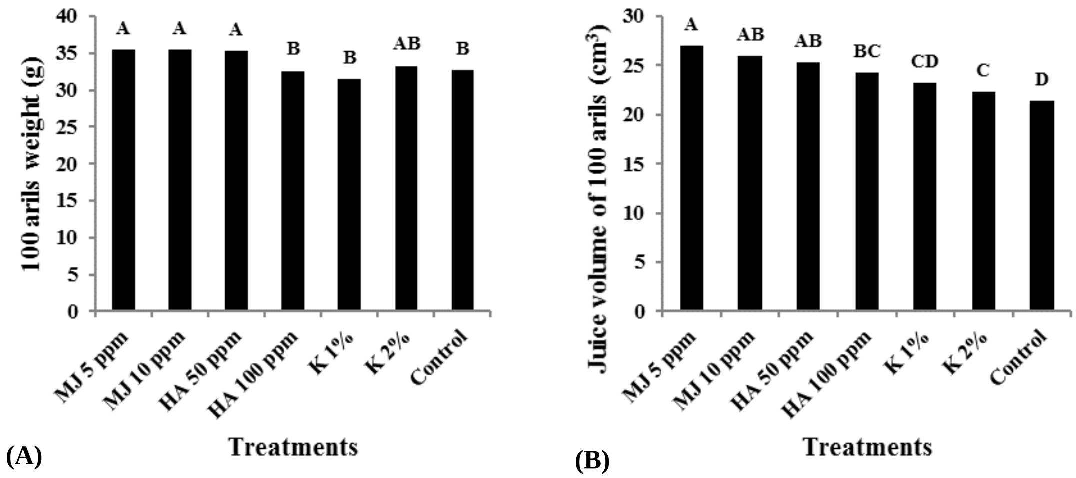


Figure 6. Effect of (MJ), (HA) and (K) spraying on (A) 100 arils weight (g), (B) juice volume of 100 arils (cm^3) of Manfalouty pomegranate cultivar during 2018 and 2019 seasons.

They recorded values of 27.0, 25.9 and 25.3 cm^3 with an increment of 26.2, 21.0 and 18.2%, respectively, followed by HA at 100 ppm treatment which recorded value of 24.3 cm^3 with an increment of 13.6% over the control, while the control treatment recorded the lowest value (21.4 cm^3) as an average of the two successive seasons.

3.4. Fruit sensory attributes

3.4.1. Total soluble solids (TSS) %, total acidity % and TSS/acid ratio

Data illustrated in Fig. 7 showed that ,all the treatments caused a significant increase in the TSS % compared to the control during the two successive seasons. In addition, there were no significant differences between MJ, HA and K at 2% treatments in their effect on the TSS %. The most effective treatments respecting the TSS % were HA at 100 ppm, MJ at 5 ppm, MJ at 10 ppm and K at 2%. The percentages of these later treatments were 17.4, 17.2, 17.1 and 17.0% as an average of the two seasons of study, respectively, while the control treatment gave the lowest value (15.8%).

Furthermore, K at 2% treatment gave the lowest acidity percentage (1.30%) compared to the other treatments, followed by MJ at 5 ppm treatment which gave a total acidity percentage of 1.57%, while the control gave the highest value of total acidity percentage (2.14%). Also, there were no significant differences between each of HA at 50 ppm, MJ at 10 ppm, HA at 100 ppm and K at 1% treatments in their effect on the total acidity percentage of Manfalouty pomegranate cultivar as an average of the two successive seasons.

Data found in such Fig. showed that the highest ratio was taken from K at 2% treatment followed by MJ at 10 ppm treatment. They gave ratio of 13.5 and 12.3, respectively, while the control gave the lowest ratio (8.1) as an average of the two studied seasons. Moreover, there were no significant differences between MJ at 5 ppm and HA at 100 ppm treatments, as well as between HA at 50 ppm and K at 1% treatments in their effect on TSS/acid ratio.

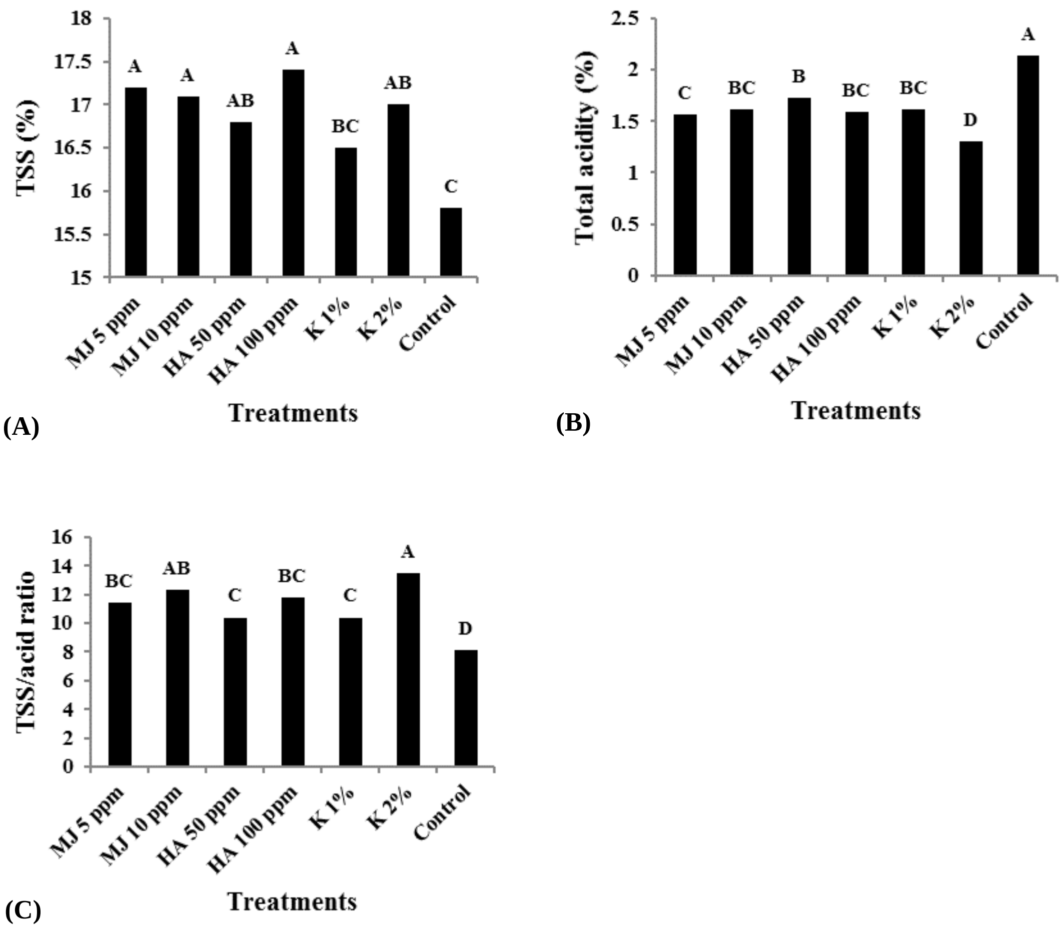


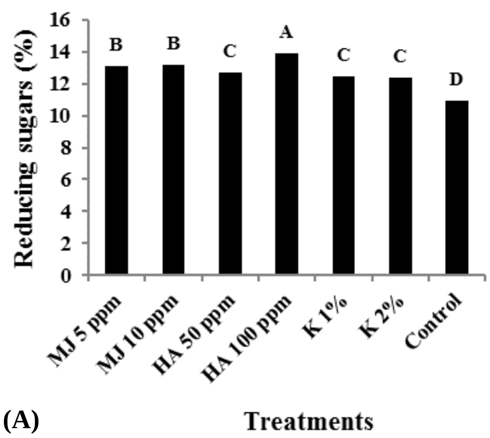
Figure 7. Effect of (MJ), (HA) and (K) spraying on fruit sensory attributes: (A) TSS %, (B) total acidity, (C) TSS/acid ratio of Manfalouty pomegranate cultivar during 2018 and 2019 seasons.

3.4.2. Sugars content

The results showed that all the treatments had a positive effect and caused a significant increase in total and reducing sugars % compared to the control treatment, however, there were no significant effect between most of the treatments for non-reducing sugars % during the two seasons of study (Fig. 8). The best influencing treatment on the reducing sugars % was HA at 100 ppm which gave an average of 13.88 with an increment of 27.0% over the control followed by MJ at 10 ppm and MJ at 5 ppm treatments which gave an average of 13.18 and 13.11% with an increment of 20.6 and 20.0% over the control, respectively, with no significant differences between them, whereas the lowest value was the control treatment which gave 10.93% as an average of both seasons of the study. In addition, the best influencing treatments on the total sugars % were HA at 100 ppm and MJ at 5 ppm which gave an average of 15.75 and 15.73% with an increment of 20.6 and 20.4%, respectively, with no significant differences between them followed by MJ at 10 ppm which gave an average of 14.94% with an increment of 14.4% over the control treatment, whereas the lowest percentage was the control treatment which gave 13.06% as an average for both seasons of the study. Likewise, there were no significant differences between most of the treatments and the control in their effect on the percentage of non-reducing sugars.

3.5. Anthocyanin content

There was an increase in the anthocyanin content in both the peel and arils of the pomegranate fruits compared to the control during the two seasons of study. In addition, the treatments of MJ Surpassed the rest of the treatments in their effect on the anthocyanin content followed by HA treatments, whereas, the K treatments gave the lowest values (Fig. 9).



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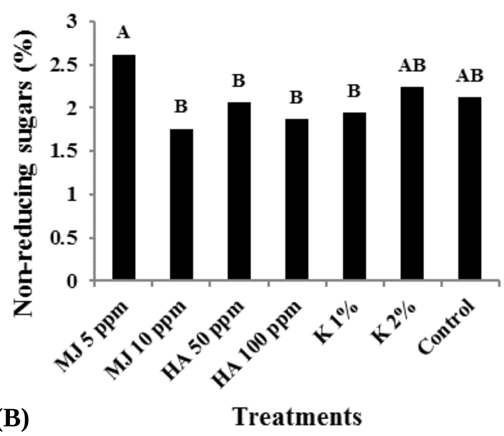

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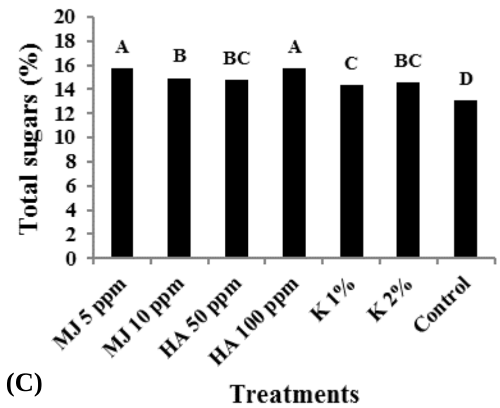

Figure 8. Effect of (MJ), (HA) and (K) spraying on sugars content: (A) reducing sugars %, (B) non-reducing sugars %, (C) total sugars % of Manfalouty pomegranate cultivar during 2018 and 2019 seasons.

Likewise, the MJ at 10 ppm treatment gave the highest value of anthocyanin content in both peel and arils of pomegranate fruits. They gave value of 113.8 and 8.6 mg with an increment of 196.4 and 163.5% followed by MJ at 5 ppm treatment which gave the value of 77.1 and 6.38 mg with an increment of 100.8 and 95.7% over the control in both peel and arils, respectively as a general average for the two years of study. On the other side, the control treatment gave the lowest values.

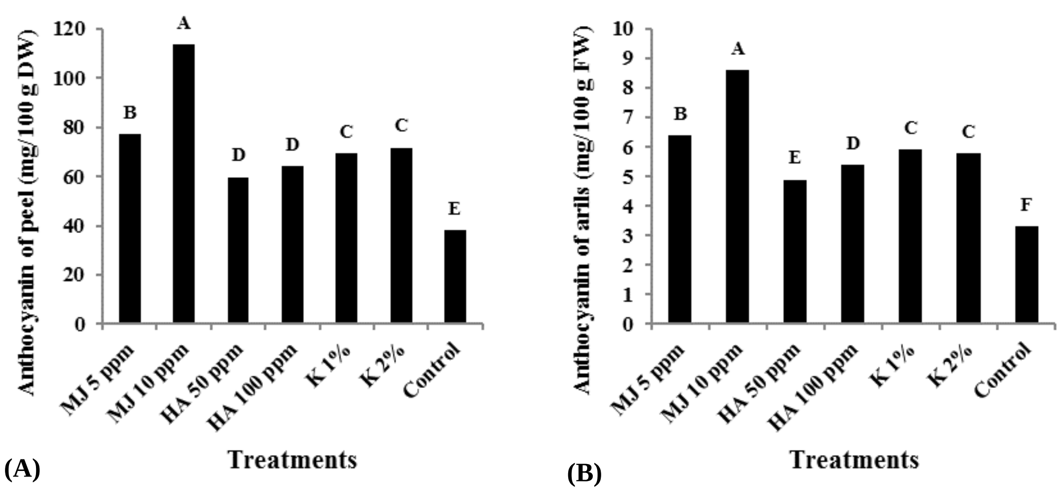

Figure 9. Effect of (MJ), (HA) and (K) spraying on anthocyanin content: (A) anthocyanin of peel (mg/100 g driy weight), (B) anthocyanin of arils (mg/100 g fresh weight) of Manfalouty pomegranate cultivar during 2018 and 2019 seasons.

Discussion

Based on preceding reports with respect to the negative impacts of JAs on photosynthesis and plant growth (Wasternack and Hanse, 2013; Hakeem *et al.*, 2014 and Yan *et al.*, 2015), we were anticipating to record a diminished fruit growth and yield in response to MJ treatment, but fascinatingly our results showed the positive effects of this phytohormone on both yield and quality parameters of pomegranate fruit.As a sequence of exciting results, foliar application of pomegranate with MJ at 10 ppm caused a significant increase in fruit qualitative parameters such as TSS, sweetness, juice content, phytochemicals, bioactive compounds including total anthocyanin and chlorophyll content and quantitative ones such as fruit weight and aril weight. Actually, MJ at 10 ppm not only enhanced phytochemical compounds and quality parameters of the fruit but also improved the productivity, demonstrating that MJ plays critical roles in different growth and developmental processes of the pomegranate trees and fruits.

It appears that MJ helps pomegranate trees to keep up photosynthesis capacity by directly closing the stomata during the warm hours of the days. In addition, MJ, by cross-talking with other phytohormones and affecting different metabolic routes, increases the facility of pomegranate trees in responding to environmental stimuli, and allows the fruit to slow down respiration rate and water loss and accumulate enough amounts of assimilates for growing under adverse growth conditions (Pareek *et al.*, 2015). Moreover, Inferior levels of total acids and higher levels of soluble sugars rise the fruit sweetness and are very significant for producing pomegranates with a higher sensory quality (Wang *et al.*, 2009; Fawole and Opara, 2013). It seems that MJ decreases the levels of insufficient oxidation in photosynthetic assimilates causing diminished total acidity. It has been stated that the endogenous jasmonates increase during ripening representing the role of this phytohormone in changing acids to sugars (Khan and Singh, 2007).

Different phenolics are of key anti-stress and antioxidant components donating in nutritional capacity of pomegranates (Tehranifar *et al.*, 2010 and Çam *et al.*, 2014). Some of these compounds are careful as the main components of crop quality parameters counting pigments, taste and nutritional quality. Vatanparast *et al.* (2012) reported that 0.5% of MJ meaningfully augmented the phenolic compound, antioxidant activity and the color of fruit peel of pomegranate fruits compared to control. Merikhi *et al.*, 2019 concluded that foliar application with 0.5 mmol L^{-1} methyl jasmonate may be considered as an effective nonchemical method for enhancing pomegranate fruit quality attributes and phytochemical compounds. Additionally, García-Pastor *et al.* (2020) confirmed that MJ treatments enhanced arils color due to increased concentration of total and individual anthocyanins, at harvest and during storage. Appropriately, MJ treatments driven to build up of anthocyanins and other polyphenol compounds in several plants as a result of improved phenylalanine ammonialyase (PAL) activity and expanded expression of genes codifying enzymes involved in anthocyanin biosynthesis pathway (Jia et al., 2016; Wei et al., 2017).

Cracking is a physiological disorder that happens due to the different growth rats between skin and flesh of fruit (Yilmaz and Özgüren, 2006). There are several aspects that cause fruit cracking such as hot dry weather, soil moisture, climatic, tree nutrition and cultivars (Kumar *et al*., 2010; Sheikh and Manjula, 2012). The quick assimilation of water when irrigation is continued to severely stressed fruit leads to cracking of the skin as water is occupied to the aril and greater stress is placed on the water-deficient skin. It has also been proposed that asymmetrical stretching of the skin happens as the aril fills with water. This leads to splitting on the same side of the swelling aril (Galindo et al., 2014). This problem caused a noteworthy misfortune within the productivity of some pomegranate cultivars may reach more than 50% (Sheik and Manjula, 2012). Applying biofertilizers such as Humic acids (HA) which considered the most divisions of humic substances (HS) and the foremost active components of soil and compost organic matter (Ferrara and Brunetti, 2010), can be valuable for expanding the productivity and quality of pomegranate fruits. Humic acid, a byproduct of plant decay, has various bio-stimulatory properties that work to reduce damage from abiotic stress (Canellas et al., 2015; Moghadam, 2015). It is additionally able intervene shifts in essential and secondary metabolism forms to balance development and increment water-use proficiency. Application of humic acid particularly at 100 ppm diminished fruit splitting of pomegranate under our conditions in both seasons of study. Our results in assention with the past investigates conducted on different pomegranate cultivars by (Ghanbarpour et al., 2019 and Nurbhanej, 2019).

Our results obviously showed that HA application particularly at 100 ppm increased the productivity of pomegranate under our conditions in both seasons of study. The increases in total yield maybe related to the influence of HA fertilization as it aided in inspiring plant growth and subsequently yield by performing on mechanisms included in: cell respiration, photosynthesis, protein synthesis, water and nutrients uptake and enzyme activities, this result in permitting to the preceding studies specified by (Khattab *et al.*, 2012; Lotfi *et al.*, 2015; Moghadam, 2015; Hatami *et al.*, 2018). Also our results in covenant with the previous researches showed on different pomegranate cultivars by (Khattab *et al*., 2012; 2014; Abd El-Rahman, 2017; Kamal *et al.*, 2017; Mansour, 2018; Ghanbarpour *et al.*, 2019; Nurbhanej, 2019), as they indicated that HA fertilization augmented the yield of pomegranate.

The nutrients plays main role in improving plant development and fruit quality occurrence in pomegranate. Fertilization is allowing for the main agricultural performs which had major sound effects on fruit quality, in this situation potassium is vital plant mineral nutrients having a significant effect on many human-healths related quality compounds in fruits and vegetable (Tiwari, 2005; Ashraf *et al.*, 2010). Potassium is an important macronutrient in pomegranate and its concentration in peel and aril of pomegranate fruits was the highest associated to other macronutrients (Mirdehghan and Rahemi, 2007). It is also recognized as the excellence nutrient for its significant effects on quality aspects (Lester *et al.,* 2006). Soares, *et al.*, (2005) reported that potassium soil application significantly increased antioxidant activity and reduced oxidative impairment. Furthermore, the fruits chemical characteristics mainly total soluble solids, total sugars, ascorbic acid and anthocyanin contents plays a most important role in crop due to their essentiality in fruit quality and postharvest life of harvested produce (Aly *et al.*, 2015).

For instance, to the effect of treatments, it is clear that all concentrations of potassium treatments meaningfully augmented the total yield/tree (Kg), the quality of fruit and abridged cracking (%) than the control in the two seasons. The greatest actual treatment which gave the lowest crack and highest yield with good quality of fruits was K 2% during the two seasons of study. Tehranifar and Tabar (2009) found that K application at the highest concentration considerably increased the peel and juice of fruit, acidity, total soluble solids and total sugar content than those in the other treatments. It also produced a considerably increased the content of anthocyanin, phenolic compounds and antioxidant activity of fruit juice. Mirdehghan and Vatanparast (2012) found that preharvest treatments of pomegranate trees with potassium may well be considered as appropriate tools to evade whiteness of pomegranate arils with higher bioactive compounds and antioxidant activity as compared to control fruit. Davarpanah *et al.* (2014) on "Malas-e-Saveh" pomegranate cultivar stated that foliar application of mono and di-potassium phosphate at concentration of 0.1% resulted in significant increase in yield/tree, fruit number, titrable acidity compared to control treatment. Likewise, foliar application of mono and di-potassium phosphate caused a significant improvement in aril juice and color intensity and total soluble solid. Ismail *et al.* (2018) detected that the uppermost values of total yield/tree, fruit weight, number of arils/fruit, TSS, total sugars and the minimum cracking values were gotten by application of potassium silicate at 5000 ppm on "Wonderful" pomegranate trees.

Optimistic influence of K fertilization on pomegranate fruit yield might be attributed to its noteworthy parts in different processes in plants containing biosynthesis of chlorophyll, proteins like cytochrome and ferredoxin, nitrogen fixation, electron transport chain complex, and structure of enzymes involved in nitrate absorption (Al-Bamarny *et al.*, 2010; Marschner, 2012; Hamouda *et al.*, 2016). Also, potassium increases synthesis of carboxylation enzyme, which stimulates CO_2 fixation and increases photosynthesis (Almeselmani *et al.*, 2009). In addition, Increase in fruit size after K fertilization can be related to the vital roles of K in plants, in specific the role it plays in cell expansion that leads to the formation of a large central vacuole in fruit cells (Talaie, 2008). The increase in total anthocyanin contents as a result of K foliar application are in line with the results of Davarpanah *et al.* (2017); Chater and Garner (2018, 2019), who informed that the contents of anthocyanin in pomegranate increased by K fertilizers. Potassium plays crucial roles in anthocyanin synthesis through increasing the translocation of sugars into fruits, in addition to act as a cofactor and stimulator of some enzymes like UDP galactose: flavanoide-3-o-glicosil transferase (Delgado *et al.*, 2006).

Conclusion

From the gotten results of the present study it could be recommended that spraying HA at 100 ppm and MJ at 10 ppm are considered the best in their effect on the yield components, fruit quality and anthocyanin content, however for decreasing the fruit cracking, it could be spraying the fruit with liquid K at 1% or MJ 10 ppm compared to the rest of the treatments.

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