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"Wonderful" Pomegranate Fruit Quality in Relation to Foliar Spraying with Growth Regulators, Amino Acids and Salicylic Acid

Abd El-Hameed M.M. Wassel; Hamdy I.M. Ibrahim*; F.F. Ahmed and Mai M.S. Teleb

Horticulture Dept. Fac. of Agric. Minia University, **Egypt.**

***Corresponding author:** hamdy_france@yahoo.com

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Abstract: The present investigation was carried out during 2019 and 2020 on Wonderful pomegranate grown in sandy soil at new reclamation land in El-Minia Governorate. Three materials, Mega flowers (as a source of three growth regulators namely: NAA, NAD and β-NOA) at 250 ppm, 500 ppm and 750 ppm, mixture of three amino acids (glutamin, proline and Arginine) at 100 ppm and salicylic acid (SA) at 100 ppm were examined as foliar application. The obtained results during this study clearly explained the major role of spraying Mega flowers, amino acids and SA treatments in enhancing Wonderful pomegranate fruit quality. Where, it was found that spraying the three examined materials significantly improved the physic-chemical characteristics of fruit. It is worth to mention that, the combined application of the three materials (Mega flowers + amino acids + SA) showed remarkable and significant superiority over the individual application of each one alone. However, the trees received Mega flowers at 750 ppm + amino acid at 100 ppm + SA at 100 ppm produced the best fruit quality. Moreover, non-significant were observed between the two higher concentrations of Mega flowers. On the opposite side, untreated trees presented the lowest fruit physical and chemical properties, during the two experimental seasons.

Key words: Wonderful pomegranate, amino acids, amino acids, growth regulators, fruit quality.

INTRODUCTION

The Pomegranate tree (*Punica granatum L.*) belongs to family *Punicaceae* **(Levin, 2006)**. It has a high economic value in recent years due to the large volume of in vivo and in vitro studies attributing numerous health benefits to the fruit and its products **(Holland *et al.*, 2001; El-Kar *et al.*, 2011; Drogoudi *et al.*, 2012; Preece & Moersfelder, 2016 and Omar, 2019)**. Consequently, pomegranate production has expanded to new regions where the available water is poor quality; including recycled or saline water **(Holland *et al.*, 2009 and Preece & Moersfelder, 2016)**. Furthermore, pomegranate has a highly valuated fruit crop for its health-promoting effects and it is mainly cultivated in semi-arid areas **(Catola *et al.*, 2016 and Wassel *et al.*, 2015)**. The pomegranate tree requires a long hot and dry season in order to produce good yield of high-quality fruit, these conditions are fully compatible with the Egyptian climate. Then, currently many new orchards are planted in the reclamation desert regions in Egypt **(Ibrahim *et al.*, 2019 and Omar, 2019)**.

The Role of growth regulators, such as NAA, NAD and β-nathoxthy acetic acid "β-NOA" (Mega flowers compound), have been reported to influence productivity and fruit quality of different fruit trees. Many reports have been published regarding NAA, NAD and β-NOA and demonstrating its effects on fruit trees productivity and fruit quality: NAA Molecular Formula is $C_{10}H_7CH_2CO_2H$ is plant hormone widely used on different fruit trees **(Naduvilpurakkal *et al.*, 2014)**. NAA present in the environment undergoes oxidation reactions with hydroxyl radicals and sulfate radicals **(Navalon *et al.*, 1997)**. Naphthalene acetamid (NAD) is a synthetic auxin widely used in agriculture especially in enhancing fruit physic-chemical properties. It is a derived auxin its Molecular Formula is $C_{12}H_{11}NO$. β-Nphthoxyacetic acid (β-NOA) also is a plant hormone derived from NAA, and it's molecular Formula is $C_{12}H_{10}O_3$.

The present investigation aimed to study the effect of Mega flowers (as a source of NAA, NAD and β-NOA), mixture of amino acids (glutamin, proline and Arginine) and salicylic acid as a foliar application on fruit physical and chemical parameterizes of "Wonderful" pomegranate grown in sandy soil, under Minia Governorate conditions.

MATERIALS AND METHODS

This field experiment was carried out during two seasons 2019 and 2020 on forty-eight "Wonderful" pomegranate trees (Punica granatum L.) uniform in vigor (16 treatment in 3 replicate, one tree per replicate). The chosen trees were grown in private orchard located beside the Assiut Western desert road in the face of Minia district, Minia Governorate, Egypt. Where, the soil texture is sandy. The trees are fifteen years old, planted at 3 X 4 meters apart, multi trunk (3 trunk/tree) an open vase system with 4 to 6 principal branches and at least two principal layers of production. Drip irrigation system was adopted by using underground well. The chosen "Wonderful" pomegranate trees are subjected to conventional horticulture practices that were commonly used in pomegranate orchards such as fertilization, hoeing and pest management.

Soil and water analysis

The orchard soil, where the present experiment carried out, was sandy (Table 1). Composite samples of soil and irrigation water were collected and subjected to physic- chemical analysis according to **Walsh & Beaton (1986)** and **Buurman *et al.* (1996)**. The data are shown in Table (1).

Table (1). Physical and chemical analysis of soil and irrigation water

Soil analysis		Water analysis	
Constituents	**Values**	**Constituents**	**Values**
Sand %	84	**E.C (mmhos/cm/25C)**	1. 6
Silt %	7	Hardness	14.5
Clay %	9	pH	7.65
Texture	Sandy	Ca (mg/L)	39.4
EC (1:2.5 extract) mmhos/cm/ 25 C	5.8	Mg (mg/L)	28.3
Organic matter %	0.31	K (mg/L)	4.02
pH (1 : 2.5 extract)	8.09	Na (mg/L)	99.6
Active lime %	8% **($CaCO_3$)**	**Sum of Cations (mg/L)**	8.26
N (mg/kg)	194	Alkalinity (mg/L)	189
Phosphorus (ppm)	8.80 ppm	Chlorides (mg/L)	132
Available Ca (meq/100g)	17.7	Nitrate (mg/L)	11.0
Available Mg (meq/100g)	2.49	Sulphates (mg/L)	59.6
Available K (meq/100g)	0.46	**Sum of anions (mg/L)**	7.79

Experimental work

In order to study the effect of spraying three materials namely: Mega flower "MF" (NAA at 0.4 %, NAD at 1.3% and β-NOA at 1.5%), amino acids (mixture of glutamin, proline and Arginine) at 100 ppm and salicylic acids (SA) at 100 ppm on "Wonderful" pomegranate trees. Mega flower at three concentrations namely 250 ppm, 500 ppm and 750 ppm, one concentration 100 ppm of amino acids or SA were used as a foliar spraying three times yearly, during 2019 and 2020 seasons. So, the present study included the following sixteen treatments from the three examined materials as well as their possible combination, as follows: untreated trees (Control); MF at 250 ppm; MF at 500 ppm; MF at 750 ppm; Amino acids at 100 ppm; SA at 100 ppm; MF at 250 ppm + Amino acids at 100 ppm; MF at 500 ppm + Amino acids at 100 ppm; MF at 750 ppm + Amino acids at 100 ppm; MF at 250 ppm + SA at 100 ppm; MF at 500 ppm + SA at 100 ppm; MF at 750 ppm + SA at 100 ppm; Amino acids at 100 ppm + SA at 100 ppm; MF at 250 ppm + Amino acids at 100 ppm + SA at 100 ppm; MF at 500 ppm + Amino acids at 100 ppm + SA at 100 ppm; MF at 750 ppm + Amino acids at 100 ppm + SA at 100 ppm. Each of the previous concentrations was sprayed three times during the growth season (i.e. just after start of vegetative growth, full blooming and just after fruit setting). So, each treatment was replicated four times, one tree per each. The treatments were arranged in a randomized complete block design (RCBD).

Different determination

The flowering physic-chemical parameters were achieved during 2019 and 2020 experimental seasons. During the two experimental seasons, the fruits were harvested when fruits become fully colored and the TSS / acid ratio in the juice of the check treatment reached 3 to 3.5 (According to **Hegazi *et al.*, 2014; Ibrahim *et al.*, 2019 and Omar, 2019)**. During harvesting time, the number of cracked and sunburned fruits was counted and recorded. Then, the percentage of cracked and sunburned fruits percentages was calculated, as follow:

$$\text{Cracking fruits } \% = \frac{Number\ of\ creacked\ fruit}{Total\ number\ of\ fruits}\ X\ 100$$

$$\text{Sunburned fruits } \% = \frac{Number\ of\ sunburnd\ fruit}{Total\ number\ of\ fruits}\ X\ 100$$

For each tree, four pomegranates fruits were randomly picked at maturation (Last week of September), relying on fruit colour, as well as the number of days from full blooming.

Physical characteristics

Average fruit weight (g), was achieved by sensitivity balance with 0.1g accuracy. Fruit dimensions (i.e. fruit height "without calyx" and fruit diameter "cm"), was achieved by using vernier caliper with 0.01 cm accuracy. Then, fruit shape index was determined according to the following equation:

$$\text{shape Index} = \frac{Fruit\ height\ (cm)}{Fruit\ Diameter\ (cm)}$$

Peel plus carpellary membranes weight (g) was achieved by using sensitivity balance with 0.01g accuracy. Peel thickness (mm), was determined by using vernier caliper with 0.01cm accuracy. Grains weight (0.01 g), mathematically calculated by subtracting the pericarp weight (included carpellary membranes) from fruit weight. Juice percent, mathematically calculated according the following equation:

$$\text{Juice } \% = \frac{Juice\ weight\ (g)}{Grains\ weight\ (g)} X\ 100$$

Juice chemical characteristics

200 g of arils were taken randomly from each replicate from homogenized sample. The sample pressed by Electric Extractor for extracting the juice. Then the following chemical characteristics were determined: total soluble solids percentage (TSS %) were determined by refractometer at 20 °C, and

expressed as a percentage (Brix), according to **Ranganna (1977)**. Percentage of total titratable acidity (TA), expressed as grams citric acid per 100 grams of juice, by using titration against with 0.1 N NaOH, using 1 ml diluted juice in 10 ml distilled H_2O. The results expressed as gram citric acid/100 grams of fresh juice **(A.O.A.C., 2000)**. Reducing sugars and total sugars percentages were determined by Lane and Eynone volumetric method, according to **Ranganna (1977)**. The total anthocyanins of fruit juice were extracted and determined according to **Fulcki and Frabcis (1968)**.

Statistical analysis of data

The obtained data were tabulated and subjected to proper statistical analysis; by analysis of variance (ANOVA) by using the statistical package MSTATC Program. Comparisons between means were made by least significant differences (New L.S.D) at $p = 0.05$ according to **Snedecor and Cochran (1990)**.

RESULTS AND DISCUSSION

Fruit physical properties

Fruit dimensions

Data concerning the effect of Mega flowers (at 250, 500 and 750 ppm), amino acids (at 100 ppm) and SA (at 100 ppm) on Wonderful pomegranate fruit height grown in new reclamation sandy soil, fruit diameter and shape index, during 2019 and 2020 seasons are illustrated in (Table 2). The obtained data revealed that, spraying "Wonderful" pomegranate trees with Mega flowers, amino acids or SA individually, significantly increased fruit height (cm) and fruit diameter (cm) rather than the control treatment. These findings were true during the two experimental seasons. Contrary, all individual or combined application of the three examined materials (MF, AA and SA) failed to vary the shape index of "Wonderful" pomegranate fruits significant, neither in the first season nor in the second season. This might be due to almost similar increases in fruit height (cm) and fruit diameter (cm).

It is noticed that, the fruit height and diameter of "Wonderful" pomegranate significantly differed due to varied Mega flowers treatments, individually or in combination with amino acids and SA. Spraying Mega flowers at 750 ppm along with amino acids at 100 ppm significantly enhanced the fruit height (8.95 cm & 8.95 cm) and diameter (9.75 cm & 9.79 cm). The least fruit height (7.24 cm & 7.31 cm) and fruit diameter (8.10 cm & 8.18 cm) was noticed with untreated trees. On the other hand, the individual or combined applications of these three examine materials showed that spraying amino acids alone or combined with Mega flowers was more effective on the fruit height and fruit diameter than those of SA alone or combined with Mega flowers. Results in the same table showed that, all combined applications of these three materials (MF, AA and SA) were more effective in enhancing fruit dimensions rather than the individual application of each. These data were true during the two experimental seasons.

Ratios of Peel, arils, juice and pomacein fruits

Results concerning the response of Wonderful pomegranate fruits (ratios of Peel, arils, juice and pomace in fruit) to foliar spraying with Mega flowers at 250 ppm, 500 ppm and 750 ppm, amino acids at 100 ppm and SA at 100 ppm are illustrated in (Table 3). The obtained data of the both experimental seasons revealed that, spraying Wonderful pomegranate trees with Mega flowers, amino acid and/or SA significantly improved fruit physical properties in terms of increased arils %, juice % and pomace %, as well as decreasing peel thickness (cm) and peel % (w/w). These data were true during the two experimental seasons. Increasing Mega flowers concentration from 250 ppm to 750 ppm was parallel combined with increasing arils %, juice % and pomace % as well as decreasing peel thickness (cm) and peel % in comparison to fruits of untreated trees. In the same context, spraying amino acids at 100 ppm or SA at 100 ppm was capable to improving all fruit physical parameters. However, spraying amino acid was more effective rather than spraying SA.

Table (2). Effect of spraying Mega flowers (M.F.), amino acids (A.A.) and salicylic acid (S.A.) on fruit dimensions of Wonderful pomegranate trees, during 2019 and 2020 seasons

Treatments	Fruit height (cm)		Fruit diameter (cm)		Shape index	
	2019	2020	2019	2020	2019	2020
Control	7.24	7.31	8.10	8.18	0.89	0.89
M.F 250 ppm	7.53	7.86	8.43	8.77	0.89	0.90
M.F 500 ppm	7.87	7.91	8.73	8.78	0.90	0.90
M.F 750 ppm	7.93	7.98	8.80	8.78	0.90	0.90
A.A. 100 ppm	7.47	7.54	8.36	8.85	0.89	0.89
S.A. 100 ppm	7.40	7.47	8.28	8.44	0.89	0.89
M.F 250 ppm + A.A 100 ppm	8.21	8.28	9.11	8.36	0.90	0.91
M.F 500 ppm + A.A 100 ppm	8.46	8.53	9.30	910	0.91	0.91
M.F 750 ppm + A.A 100 ppm	8.66	8.79	9.52	9.36	0.91	0.92
M.F 250 ppm + S.A 100 ppm	7.97	8.06	8.84	9.58	0.90	0.90
M.F 500 ppm + S.A 100 ppm	8.33	8.37	9.24	8.94	0.90	0.91
M.F 750 ppm + S.A 100 ppm	8.51	8.64	9.36	9.20	0.91	0.91
A.A 100ppm + S.A 100 ppm	8.12	8.17	9.01	9.06	0.90	0.90
M.F 250 ppm +AA 100 ppm+ SA 100 ppm	8.76	8.85	9.54	9.64	0.92	0.92
M.F 500 ppm + AA 100 ppm+ SA 100 ppm	8.81	8.91	9.60	9.71	0.92	0.92
M.F 750 ppm + AA 100 ppm+ SA 100 ppm	8.95	8.95	9.75	9.79	0.92	0.92
LSD at 5%	**0.02**	**0.03**	**0.02**	**0.03**	**NS**	**NS**

Concerning the fruit physical properties during the two experimental seasons, all combined applications of the three materials were effective rather than using each of them alone. While, the best physical parameters (0.33 & 0.33 cm for peel thickness, 32.3 & 31.3% peel%, 67.7 and 68.6% for arils%, 28.0 & 39.5% for juice% and 29.6 & 29.2% for pomace%) were obtained from the trees received Mega flowers at 750 ppm combined with 100 ppm amino acids and 100 ppm SA, during the two experimental seasons respectively. On the opposite side, the minimum fruit physical parameters were obtained from untreated trees (0.52 & 0.51 cm for peel thickness, 44.3 & 43.3% for peel%, 56.0 & 56.7% for arils%, 28.3 & 28.5 % for juice% and 27.7 & 28.2 % for pomace%).

The previous results including fruit physical parameters (in terms fruit dimensions, increasing arils %, juice % and pomace % as well as decreasing peel thickness and peel%) could be attributed to the role of Mega flowers (NAA, NAD and β-NOA) in enhancing cells elongations and widening by increasing photosynthetic activity **(Suman *et al.*, 2017 and Greenberg *et al.*, 2006)**, this may be lead to proper supply of carbohydrates to the fruits. Similar findings were also obtained on other pomegranate cultivars **Kishor *et al.* (2017)** on "Bhagwa" pomegranate trees; **Mohamed (2017)** on "Manfalouty" pomegranate; **Garcia-Pastor *et al.* (2020)** on "Mollar de Elche" pomegranate; **Hussein and Hasan (2020)** on "wonderful" Pomegranate and **El-Beltagi *et al.* (2023)** on Manfalouty pomegranate. Also similar finding was observed on other deciduous by **Michell and Whitehead (1998)** on some other fruits trees, when they studied the effect of Naphthoxy acetic acid on fruits. **Ibrahim (2019)** mentioned the same results when he studied the effect of spraying salicylic acid on "Sultani" fig trees. Similar interesting results were obtained by **Yazdanpanah *et al.* (2021)** when studied the response of some pomegranate trees grown under cold stress to amino acids treatments. Furthermore, these findings were consistent with the results of **Suman *et al.* (2017)** on different fruit trees, through its review article concerning the role of NAA on growth and fruiting of fruit trees. Also, **Greenberg *et al.* (2006)** found the same results on "Nova" mandarin trees and its response to foliar application with NAA at 150 ppm, the authors confirmed this positive effect on fruit physical parameters.

Table (3). Effect of spraying Mega flowers (MF), amino acids (AA) and salicylic acid (SA) on peel thickness, peel %, arils %, juice % and pomace % of Wonderful pomegranate fruits, during 2019 and 2020 seasons

Treatments	Peel thickness (cm)		Peel %		Arils %		Juice %		Pomace %	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control	0.52	0.51	44.3	43.3	56.0	56.7	28.3	28.5	27.7	28.2
M.F 250 ppm	0.48	0.45	40.0	39.1	60.0	61.0	31.1	31.8	28.8	29.2
M.F 500 ppm	0.43	0.42	39.0	38.3	61.0	62.0	31.9	32.6	29.1	29.4
29.4M.F 750 ppm	0.40	0.40	38.0	37.1	62.0	63.0	32.6	33.3	29.4	29.7
A.A.29 100 ppm	0.49	0.48	41.0	40.1	59.0	60.0	30.4	31.0	28.6	28.9
S.A. 100 ppm	0.48	0.46	42.0	41.3	58.0	59.0	29.6	30.3	28.4	28.7
M.F 250 ppm + A.A 100 ppm	0.44	0.45	36.0	35.0	64.0	65.0	34.3	35.0	29.7	30.0
M.F 500 ppm + A.A 100 ppm	0.42	0.42	35.3	34.3	64.7	65.7	35.0	35.9	29.7	29.8
M.F 750 ppm + A.A 100 ppm	0.40	0.39	34.3	33.3	56.7	66.6	35.9	37.3	29.7	29.4
M.F 250 ppm + S.A 100 ppm	0.49	0.47	37.7	36.7	62.3	63.3	32.9	33.8	29.4	29.6
M.F 500 ppm + S.A 100 ppm	0.46	0.45	35.6	34.7	64.3	65.3	34.7	35.5	29.7	29.8
M.F 750 ppm + S.A 100 ppm	0.44	0.43	35.0	34.0	65.0	66.0	35.3	36.4	29.7	29.6
A.A 100ppm + S.A 100 ppm	0.49	0.48	37.3	36.3	62.6	63.7	33.3	33.8	29.3	29.9
M.F 250 ppm + AA 100 ppm+ SA 100 ppm	0.39	0.38	33.6	32.7	66.3	67.3	36.6	38.1	29.8	29.3
M.F 500 ppm + AA 100 ppm+ SA 100 ppm	0.35	0.34	33.0	32.0	67.0	68.0	37.3	38.7	29.4	29.3
M.F 750 ppm + AA 100 ppm+ SA 100 ppm	0.33	0.33	32.3	31.3	67.7	68.6	38.0	39.5	29.6	29.2
LSD at 5%	**0.04**	**0.03**	**0.87**	**0.76**	**0.87**	**0.76**	**0.45**	**0.46**	**0.42**	**0.39**

Edible/non-edible portion, Cracked fruits % and Sunburned fruits %

Data presented in (Table 4) showed the effect of single and combined application of Mega flowers (at 250, 500 and 750 ppm), amino acids (at 100 ppm) and SA (at 100 ppm) on the edible / non-edible portion of Wonderful pomegranate fruits, during 2019 and 2020 seasons. It is worth to mention that, treating Wonderful pomegranate trees with Mega flowers significantly was accompanied with increasing the edible portion of Wonderful pomegranate fruits, rather than the control (untreated trees). Concerning the individual application of Mega flowers, this increment was significant and parallel to increasing the concentration used. While, increasing Mega flowers concentration from 500 to 750 ppm had a negligible and non-significant effect on edible portion ratio. Also, there was a significant increment on the edible / non-edible portion as a result of treating the trees with amino acids or/and SA each at 100 ppm. These results were true during the two experimental seasons.

Furthermore, results in the same Table showed that, all combined applications of the three examined materials (MF, AA and SA) were superior than using any of them alone during the two experimental seasons. Results in the same table indicated that trees received Mega flowers at 750 ppm combined with amino acids at 100 ppm and SA at 100 ppm produced the highest edible/non-edible portion (2.10 and 2.20), during the first and second experimental seasons. The vice versa was noticed concerning edible / non-edible portion in the control (1.27 and 1.31), during both experimental seasons respectively.

Concerning, the effect of the three examined materials (MF, AA and SA) on cracked and sunburned fruits percentages, spraying the three examined materials (individually or in combinations) had a significant effect on these undesirable two characters. It is worth to mentioned that, increasing the concentration of Mega flowers from 250 to 750 ppm (whether individually or combined with amino acids and/or SA) was accompanied with remarkable and significant decrease in cracked and sunburned fruit percentages (Table 4). In addition, all combined applications of the three examined compounds were more effective on decreasing these two undesirable characters in comparison to the control during the two experimental seasons. Moreover, treated the Wonderful pomegranate trees with amino acids and SA, individually or in combinations, caused a significant decreased in cracked and sunburned fruits%, during 2019 and 2020 seasons. The trees received Mega flowers at 750 ppm + amino acids at 100 ppm + SA at 100 ppm present the lowest percentage of cracked fruits% (5.1% & 4.7%) and sunburned fruits % (2.3% & 2.0%), during the two experimental seasons, respectively. The highest cracked fruits % (16.3% & 15.7%) and sunburned fruits % (8.3% & 9.1%), were presented in the control.

Table (4). Effect of spraying Mega flowers (MF), amino acids (AA) and salicylic acid (SA) on edibles / non-edibles portion, cracked% and sunburned% of Wonderful pomegranate trees, during 2019 and 2020 seasons

Treatments	Edibles / non-Edibles		Cracked fruit %		Sun burned Fruit %	
	2019	2020	2019	2020	2019	2020
Control	1.27	1.31	16.3	15.7	8.3	9.1
M.F 250 ppm	1.50	1.56	14.5	13.5	6.0	5.5
M.F 500 ppm	1.56	1.63	13.3	12.7	5.3	5.1
M.F 750 ppm	1.63	1.70	11.7	10.3	4.7	3.7
A.A. 100 ppm	1.44	1.50	12.1	12.3	6.3	6.1
S.A. 100 ppm	1.38	1.44	13.6	13.0	7.0	7.0
M.F 250 ppm + A.A 100 ppm	1.78	1.86	11.3	11.0	7.7	6.3
M.F 500 ppm+ A.A 100 ppm	1.83	1.91	10.6	11.1	5.3	4.3
M.F 750 ppm + A.A 100 ppm	1.91	2.00	10.6	8.7	4.5	4.7
M.F 250 ppm + S.A 100 ppm	1.65	1.73	7.3	7.1	6.9	7.1
M.F 500 ppm + S.A 100 ppm	1.81	1.89	12.5	12.5	6.0	6.0
M.F 750 ppm + S.A 100 ppm	1.86	1.94	11.1	10.3	5.5	5.3
A.A 100ppm + S.A 100 ppm	1.68	1.75	9.3	8.6	6.7	6.3
M.F 250 ppm +AA 100 ppm+ SA 100 ppm	1.97	2.06	5.7	6.1	4.1	4.3
M.F 500 ppm + AA 100 ppm+ SA 100 ppm	2.03	2.13	5.5	5.0	3.7	3.1
M.F 750 ppm + AA 100 ppm+ SA 100 ppm	2.10	2.20	5.1	4.7	2.3	2.0
LSD at 5%	**0.06**	**0.06**	**1.6**	**1.2**	**0.8**	**0.7**

It is well known that, the losses of pomegranate fruits due to cracking and sunburn are quite high. Fruit cracking problem may be due to improper water management and deficiency of some mineral nutrients **(Thakur *et al.*, 2018; Galindo *et al.*, 2014; Ibrahim *et al.*, 2019 and Omar, 2019)**. Furthermore, cracked and sunburned fruit percentages are two of the most important factors limiting marketable value of pomegranate fruits **(Wunsche *et al.*, 2001 and Omar, 2019)**. These two characters were significantly reduced as a result of treating the trees with the three examined materials (MF, AA and SA). In agreement with our results concerning the role of Mega flowers (IAA, IAD and β-NOA), amino acids and salicylic acid on fruit physical properties of some pomegranate cultivars was studied by: **Kishor *et al.* (2017)** on “Bhagwa” pomegranate trees; **Mohamed (2017)** on “Manfalouty” pomegranate; **Thakur *et al.*, (2018)** on physic-chemical parameters of pomegranate *cv*. Kandhari; **Garcia-Pastor *et al.* (2020)** on “Mollar de Elche” pomegranate; **Hussein and Hasan (2020)** on “wonderful” Pomegranate and **El-Beltagi *et al.* (2023)** on Manfalouty pomegranate. **Fruit chemical properties**

TSS% and Sugars content

Data illustrated in (Table 5) clearly showed that spraying Mega flowers individually or in combination with amino acids or/and SA significantly was responsible for improving the TSS%, reducing sugars % and total sugars % contents in the juice of “Wonderful” pomegranate fruits, these data were true during the two experimental seasons. In the same context, spraying amino acids and SA “individually or in combination” was capable to improve the total soluble solids and sugars contents of fruits. The promotion on TSS%, reducing sugars% and Total sugars % were associated with increasing the concentration of Mega flowers from 250 ppm to 750 ppm.

Spraying "Wonderful" pomegranate trees with Mega flowers individually at 750 ppm present high and significant TSS% (14.7 & 14.7 %), reducing sugars% (9.6% & 9.5 %) and total sugars% (11.2% & 11.4%) rather than using the low concentrations or control trees. Whereas, these results improved when the trees received Mega flowers at 750 ppm combined with 100 ppm amino acids or combined with SA. Furthermore, this improvement in fruit TSS% reducing sugars% and total sugars% was greatest when the trees received Mega flowers at 750 ppm combined with amino acids at 100 ppm and SA at 100 ppm (16.1% & 16.0% for TSS %, 10.9% & 10.8% reducing sugars and 11.8% & 11.9% total sugars), during the two experimental seasons, respectively.

Table (5). Effect of spraying Mega flowers (M.F.), amino acids (A.A.) and salicylic acid (S.A.) on TSS%, reducing sugars % and total sugars % of Wonderful pomegranate trees, during 2019 and 2020 seasons

Treatments	TSS %		Reducing sugars %		Total sugars %	
	2019	2020	2019	2020	2019	2020
Control	13.8	13.8	8.8	8.7	9.98	9.82
M.F 250 ppm	144	14.4	9.4	9.3	10.2	10.4
M.F 500 ppm	14.5	14.5	9.4	9.3	10.7	10.8
M.F 750 ppm	14.7	14.6	9.6	9.5	11.2	11.4
A.A. 100 ppm	14.0	14.1	9.3	9.1	10.41	10.5
S.A. 100 ppm	14.2	13.9	9.2	9.1	10.1	10.3
M.F 250 ppm + A.A 100 ppm	15.2	15.1	9.8	9.7	10.8	10.9
M.F 500 ppm+ A.A 100 ppm	15.5	15.3	10.0	9.9	11.2	11.4
M.F 750 ppm + A.A 100 ppm	15.6	15.6	10.4	10.1	11.6	11.9
M.F 250 ppm + S.A 100 ppm	14.9	14.8	9.6	9.6	10.6	10.7
M.F 500 ppm + S.A 100 ppm	15.3	15.2	9.9	9.8	10.9	11.1
M.F 750 ppm + S.A 100 ppm	15.5	15.4	10.1	10.0	11.3	11.5
A.A 100ppm + S.A 100 ppm	15.0	14.9	9.8	9.7	10.2	10.3
M.F 250 ppm +AA 100 ppm+ SA 100 ppm	15.7	15.7	10.2	10.3	11.3	11.3
M.F 500 ppm + AA 100 ppm+ SA 100 ppm	15.9	15.8	10.7	10.6	11.7	11.9
M.F 750 ppm + AA 100 ppm+ SA 100 ppm	16.1	16.0	10.9	10.6	11.8	11.9
LSD at 5%	**0.04**	**0.06**	**0.04**	**0.04**	**0.06**	**0.05**

Total acidity % and total soluble tannins %

It is clear from (Table 6) that spraying Mega flowers individually or in combination with amino acids or/and SA significantly was responsible for decreasing the total acidity% and total soluble tannins % in the fruit juice. Similar trend was observed during the two experimental seasons. It is worth to mention that, increasing Mega flowers concentrations from 250 ppm to 750 ppm individually or combined with the two other materials (amino acids or/and SA) was parallel with decreasing the total acidity and total soluble tannins, during the two experimental seasons. Results in the same table showed that, all combined treatments of the three materials (Mega flowers, amino acids and SA) were more effective on decreasing the total acidity % and total soluble tannins % rather than the individual application of each one.

The trees received Mega flowers at higher concentration (750 ppm) combined with 100 ppm amino acids and 100 ppm SA produced the lowest total acidity (2.69% & 2.51%) and lowest total soluble tannins (0.56% & 0.54%), during the two experimental seasons, respectively. In other words, untreated trees produced the lowest total acidity % and total tannins % in fruit juice (3.51% & 3.47% for total acidity and 1.15% & 1.23% for total soluble tannins). These data were true during the two experimental seasons respectively.

Total anthocyanins contents

Data illustrated in (Tables 6) concerning the effect of Mega flowers, amino acids and SA on juice total anthocyanin contents (mg/100 g F.W.) of "Wonderful" pomegranate displayed that, regardless the compound or the concentration used. Significant differences were observed in juice total anthocyanin contents during the two experimental seasons, except those of spraying the SA individually at 100 ppm.

Gradual and significant promotion in juice anthocyanin contents was observed as a result of increasing Mega flowers concentration from 250 ppm to 750 ppm. Regarding the combined application of the three materials, all combined application of the three materials shows more effectiveness on total anthocyanins contents, rather than the other treatments or untreated trees (Table 6). However, the trees received Mega flowers at 750 ppm combined with amino acids at 100 ppm and SA at 100 ppm produced the highest total anthocyanins contents in fruits juice (119 and 124 mg/100g F.W.), followed by those received Mega flowers at 500 ppm combined with amino acids at 100 ppm and SA at 100 ppm (115 and 119 mg/100g F.W.). Contrary, untreated trees produced the lowest anthocyanins content in fruit juice (70 and 68 mg/100g F.W.), during the two experimental seasons respectively.

Table (6). Effect of spraying Mega flowers (M.F.), amino acids (A.A.) and salicylic acid (S.A.) on Total acidity %, total soluble tannins % and total anthocyanins of Wonderful pomegranate trees, during 2019 and 2020 seasons

Treatments	Total acidity %		Total soluble tannins %		Total anthocyanins %	
	2019	2020	2019	2020	2019	2020
Control	3.51	3.47	1.15	1.23	70	68
M.F 250 ppm	3.31	3.19	0.94	0.97	81	83
M.F 500 ppm	3.28	3.16	0.90	0.93	94	96
M.F 750 ppm	3.25	3.12	0.87	0.91	99	101
A.A. 100 ppm	3.36	3.23	0.98	1.02	79	80
S.A. 100 ppm	3.40	3.29	1.03	1.09	69	67
M.F 250 ppm + A.A 100 ppm	3.15	3.02	0.78	0.82	88	91
M.F 500 ppm + A.A 100 ppm	3.07	2.96	0.70	0.77	97	98
M.F 750 ppm + A.A 100 ppm	2.98	2.88	0.63	0.69	106	108
M.F 250 ppm + S.A 100 ppm	3.20	3.09	0.83	0.89	79	84
M.F 500 ppm + S.A 100 ppm	3.11	3.01	0.74	0.80	86	85
M.F 750 ppm + S.A 100 ppm	3.04	2.91	0.67	0.73	90	93
A.A 100ppm + S.A 100 ppm	3.17	3.05	0.80	0.86	80	81
M.F 250 ppm +AA 100 ppm+ SA 100 ppm	2.87	2.75	0.61	0.65	105	109
M.F 500 ppm + AA 100 ppm + SA 100 ppm	2.76	2.64	0.58	0.60	115	119
M.F 750 ppm + AA 100 ppm + SA 100 ppm	2.69	2.51	0.56	0.54	119	124
LSD at 5%	**0.04**	**0.03**	**0.024**	**0.03**	**9.2**	**8.3**

Similar results, concerning the effect of growth regulators (NAA, NAD and β-NOA) on chemical properties of different pomegranate cultivars were obtained by **Ghosh *et al.* (2009); Taghipour *et al.* (2011); Tavakoli & Rahemi (2014); Khalifa *et al.* (2017); Mahmoud *et al.* (2018); Thakur *et al.* (2018); Harhash *et al.* (2019); Hussein & Hasan (2020) and Chaudhary & Singh (2021)**. The remarkable favorable effect of spraying Mega flowers (NAA, NAD and β-NOA) on fruit quality of "Wonderful" pomegranate could be explained by its high positive effect on photosynthsis activity, enhanced the mineral nutrients absorption and transport in plants, carbohydrates accumulation, enhancing several enzyme activations as well as improving effect of plant tolerances to abiotic stress, that may be lead to more carbohydrates productions and accumulations in fruits.

SA preharvest application provided protection against salinity in several fruits plants, may be due to increase activation of aldose reductase enzyme and APx enzyme as well as increase the accumulation of sugars, sugar alcohol or proline **(Tari *et al.*, 2004; Szepesi *et al.*, 2005 and Hayat & Ahmed 2007)**. It was found that SA applications caused a remarkable accumulation of both ABA and IAA, under salinity. Also, a high level of ABA was also maintained in seedlings, treated with SA hormones **(Szepesi *et al.*, 2005; Hayat & Ahmed, 2007; Hayat *et al.*, 2013 and Ibrahim, 2019)**. The SA-induced increase in ABA and IAA might contribute to the preadaptation of plants to stress, since ABA is known to have a favorable effect on proteins development of anti-stress reactions, such as proline accumulation. In this concern, the role of SA in uptake (which was already discussed in this investigation) can significantly improve the total soluble solids and sugars content in fruit juice. The previous lines may be explained the positive effects of the three examined materials (Mega flowers, amino acids and SA) on enhancing the TSS% and sugars% (reducing and total sugars) of Wonderful pomegranate fruits.

Conclusion

On the light of the previous results, one can state that spraying the three examined materials (Mega flowers, amino acids and SA) significantly improved the physic-chemical characteristics of fruit. It is worth to mention that, the combined application of the three materials (Mega flowers + amino acids + SA) showed remarkable and significant superiority over the individual application of each one alone. However, the trees received Mega flowers at 750 ppm + amino acid at 100 ppm + SA at 100 ppm produced the best fruit quality. Moreover, non-significant were observed between the two higher concentrations of Mega flowers in both experimental seasons. Then, under the experimental condition and resembling regions, this study can have recommended spraying received Mega flowers at 750 ppm + amino acid at 100 ppm + SA at 100 ppm**.**

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