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Vegetative Growth, Nutritional Status and Fruiting of "Wonderful" Pomegranate in Relation to Foliar Spraying with Growth Regulators, Amino Acids and Salicylic Acid

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Future Science Association

Available online free at
www.futurejournals.org

Print ISSN: 2572-3006

Online ISSN: 2572-3111

DOI:
10.37229/fsa.fjb.2023.05.25

Received: 21 March 2023
Accepted: 8 May 2023
Published: 25 May 2023

Abstract: A field experiment was carried out during two successive seasons (2019 and 2020) in new reclamation land under Minia Governorate conditions. The obtained data showed that spraying Wonderful pomegranate trees at any concentration used 250, 500, 750 ppm for mega flower, 100 ppm amino acids and 100 ppm for salicylic acid significantly enhanced all vegetative growth parameters (i.e. shoot lengths, number of leaves/shoot, number of new shoots/ tree and leaf area), leaves main pigments (chlorophylls and carotenoids), yield (kg/ tree), fruit number/tree and average fruit weight. The data showed that, all combined treatments between the three examined compounds (mega flower, amino acids and SA) was more effective than any of them alone. The trees received mega flower at 750 ppm combined with amino acids and SA each at 100ppm present the best results.

Key words: Wonderful pomegranate, amino acids, salicylic acid, mega flower, vegetative growth, yield.

INTRODUCTION

The pomegranate tree (*Punica granatum L.*) has the reputation of being highly adaptive to a wide range of climate, water and soil conditions **(Holland *et al.*, 2009)**. It grows successively in many different geographical regions including the Mediterranean basin, Asia and California. Many new orchards are now planted in the reclamation desert regions in Egypt.

Growth regulators such as NAA, NAD and β-nathoxthy acetic acid "β-NOA" (Mega flower compound), have been reported to influence growth, flowering, and productivity of fruit trees **(Bhujbal *et al.*, 2013 and Phawa *et al.*, 2017)**. Many reports have been published regarding these three growth regulator demonstrating its effects in fruit trees growth and productivity: NAA Molecular Formula is $C_{10}H_7CH_2CO_2H$ is a synthetic plant hormone widely used for growth, flowering and fruiting enhancement of different fruit trees **(Naduvilpurakkal *et al.*, 2014)**. NAA present in the environment undergoes oxidation reactions with hydroxyl radicals and sulfate radicals **(Navalon *et al.*, 1979)**. Naphthalene acetamid (NAD) is a synthetic auxin widely used in agriculture especially in promoted growth and fruiting. 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 its molecular Formula is $C_{12}H_{10}O_3$.

The present investigation aimed to study the effect of mega flower (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 vegetative growth, nutritional status and fruiting of "Wonderful" pomegranate grown in sandy soil under Minia Governorate conditions.

MATERIALS AND METHODS

This present investigation was conducted during two successive seasons 2019 and 2020 on forty-eight Wonderful pomegranate trees (*Punica granatum L.*) uniform in vigor fifteen years old and planted at 3×4 meters apart. The trees were grown in private orchard located beside the Assiut western desert road in the face of Minia city, Minia Governorate – Egypt. Whereas the soil texture is sandy and the water table depth is not less than two meters. The formation of the chosen trees is 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 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 experiment orchard soil and the underground well water used in irrigation

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 mega flower "MGF" (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 from amino acids and SA were used as a foliar spraying three times yearly, during 2019 and 2020 seasons. The present study included the following sixteen treatments from the three materials and their combination, as follows: untreated trees (Control); mega flower at 250 ppm; Mega flower at 500 ppm; mega flower at 750 ppm; Amino acids at 100 ppm;

Salicylic acid at 100 ppm; mega flower at 250 ppm + Amino acids at 100 ppm; mega flower at 500 ppm + Amino acids at 100 ppm; mega flower at 750 ppm + Amino acids at 100 ppm; mega flower at 250 ppm + SA at 100 ppm; mega flower at 500 ppm + SA at 100 ppm; mega flower at 750 ppm + SA at 100 ppm; Amino acids at 100 ppm + SA at 100 ppm; mega flower at 250 ppm + Amino acids at 100 ppm + SA at 100 ppm; mega flower at 500 ppm + Amino acids at 100 ppm + SA at 100 ppm; mega flower at 750 ppm + Amino acids at 100 ppm + SA at 100 ppm. Each treatment done three times annually during the growth season at: just after start of vegetative growth, full blooming and just after fruit setting. Each treatment was replicated three times, one tree per each. The treatments were arranged in a complete randomized block design (CRBD).

Parameters of vegetative growth

At the first week of July during the two experimental seasons, sixteen mature leaves from the middle part on the non-productive shoots in the four geographic directions were picked from each replicate according to Ibrahim (2010), Leaf area (cm^2) was estimated. Leaf area was determined by using an area meter (Area Meter Cl, 202). At the last week of July, during both experimental seasons, the average main shoot length (cm) was taken as a result of measuring the length of four shoots per tree from the four cardinal points (main geographic directions) of the tree. Then average shoot lengths were recorded. At the last week of July during both experimental seasons, the average leaves number/shoot were recorded as a result of counting the number of leaves located at the chosen eight shoots on each tree. Then the average leaves number per shoot was recorded.

Leaves main pigments

Samples of eight mature and fresh leaves, taken from the middle part on shoots, were chosen at the last week of July, during the two experimental seasons, cut into small pieces and 0. 5 g weight from each sample, the leaves pieces homogenized and extracted by 25% acetone in the presence of little amounts of Na_2CO_3 then filtered. The residue washed several times with 85% acetone until it became colorless. Then, the extract completed to 20 ml volume with acetone 85%. A little portion of this extract taken for the determination of main pigments; chlorophylls a & b and total chlorophyll by using calorimetrically determination (in mg/ 100 g F.W), however acetone (85 % V/V) was used as a blank. The optical density of was determined at the wave length of 662 and 664 nm to determine chlorophylls a and b respectively. While, total carotenoids were determined at the wave length 446 nm. Then, each pigment concentration was calculated by using the following equations according to **Walsh & Beaton (1986)** and **Ward & Johnston (1962)**.

$$\text{Chlorophyll a} = (9.784\ X\ E\ 662) - (0.99\ X\ E\ 644) = \text{mg/100g F.W.}$$

$$\text{Chlorophyll b} = (21.426\ \text{X E}\ 644) - (4.65\ \text{X E}\ 622) = \text{mg/100 g F.W.}$$

$$\text{Total Carotenoids} = (4.965\ \text{X E}\ 440) - 0.268(\text{Chlo. a} + \text{b}) = \text{mg/100 g F.W.}$$

Where E= Optical density at a given wavelength. Total chlorophyll was estimated by summation of chlorophyll a plus chlorophyll b (mg/ 100 g. F.W)

Leaves content of total chlorophyll (mg/100 g F.W.) were calculated mathematically by adding chlorophyll a + chlorophyll b.

Determination of N, P, K, Ca and Mg contents in leaves

16 leaves picked from the middle part of 8 main shoots from each tree, as described by **Martin-Préval *et al.*, (1984)**. These leaves were taken at the last week of June during the two experimental seasons. The blades were separated and discarded and the petioles only were saved for determining different nutrients. The petioles washed with distillated water, dried at air and oven dried at 50 C for overnight and grounded to fine powder. Then 0.5 g was digested by using H_2SO_4 and H_2O_2 until clear solution was obtained **(Martin-Préval *et al.*, 1984)**. The digested solution was transferred to 100 ml volumetric flask and completed by distilled water. Thereafter, contents of N, P, K and Mg for each sample were determined as follows:

Nitrogen was determined by the modified microkejldahl method **(Martin-Préval *et al.*, 1984)**. Phosphorus was determined by using colorimetric method **(Walsh and Beaton, 1986)**, by measuring the optical density of phosphor-molibdo-vanadate complex by using Spectro-photometrically at wave length 430 nm. Potassium determined by using flam-photometrically **(Martin-Préval *et al.*, 1984)**. Magnesium and Calcium were determined by using atomic absorption methods **(Buurman *et al.*, 1996)**.

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

Vegetative growth parameters

Data illustrated in (Table 2) showed the effect of spraying mega flower (NAA, NAD and β-NOA) at 250, 500 and 750 ppm, amino acids at 100 ppm and SA at 100 ppm on shoot lengths (cm), numbers of leaves per shoot, number of shoots per tree and leaf area (cm^2) of Wonderful pomegranate, during 2109 and 2020 seasons.

Data obtained during the two experimental seasons displayed that all mega flower treatments induced an increase of shoot length, number of leaves / shoot, number of new shoots / tree and leaf area over the control. This stimulation was related to the increase in mega flower concentrations from 250 ppm to 750 ppm. However, the combined applications of mega flower with amino acids or salicylic acid present superiority than using mega flower alone.

It is clear from the obtained data that treating Wonderful pomegranate with amino acids at 100 ppm or SA at 100 ppm significantly stimulated the shoot length, number of leaves/shoot, number of new shoots/tree and leaf area rather than untreated trees. However, the combined application of these two martials (amino acids + SA) present a superior effect than any of them alone, these data were true in both seasons.

Furthermore, spraying the combination of mega flower, amino acids and salicylic acid was more effective in enhancing shoot length, number of leaves / shoot and number of new shoots /tree rather than the other treatments including the control. In addition, spraying mega flower at 750 ppm + amino acids + SA each at 100 ppm present the best shoot lengths (135.8 cm and 150.9 cm), number of leaves / shoot (134.7 and 145.7), numbers of new shoots/tree (63.3 and 64.1 shoots) and leaf area (8.5 and 8.7cm^2), during the two experimental seasons, respectively. Contrary, untreated trees show the lowest shoot length (82.1 and 85.8 Cm), number of leaves/shoot (72.3 and 80.4), number of new shoots per tree and number of shoots/tree (39.3 and 38.2 shoot), leaf area (4.8 and 5.0 cm^2) during the two experimental seasons, respectively.

Treating "Wonderful" pomegranate with mega flower (NAA, NAD and β-NOA) at 750 ppm combined with amino acids and SA produced the maximum vegetative growth. This may be attributed to the main role of mega flower in increasing cell division and cell elongation at higher NAA concentrations and its possible reason for increased activation of vegetative growth aspects (i.e. shoot length, number of leaves/shoot, number of new shoots/tree and leaf area) **Goswami *et al.* (2013)**. These findings were similar to **Suman *et al.* (2017)** through its review article concerning the role of NAA on growth and fruiting of different fruit trees. Also, **Greenberg *et al.* (2006)** through their studies "Nova" mandarin trees and its response to foliar application with NAA at 150 ppm, the authors confirmed this positive effect on vegetative growth parameters. Contrary of our findings, **Choi and Minsson (2001)** stated that, spraying NAA cause a significant decrease in all vegetative parameters of "Fuji" apple trees. Amino acids as organic nitrogenous compounds are the main martial in the synthesis of proteins, which are formed by as process in which ribosomes catalyze the polymerization of amino acids **(Digrase *et al.*, 2016 and Wassel *et al.*, 2017b)**. Several authors have been proposed to explain the role of amino acids in plant. The most of them suggests several alternative routes of IAA and ethylene synthesis in plants, starting from amino acids. In this respect, **(Taiz & Zeiger 2002 and Wassel *et al.*, 2017a)** suggested that the regulatory effect of certain amino acids like glutamin, proline and Arginine in plant development appeared through their influence on the biosynthesis of gibberellins, tryptophan and methionine in building of IAA and ethylene, respectively.

However, the beneficial effect of salicylic acid on enhancing vegetative growth of "Wonderful" pomegranate, which observed in this study, attributed to its important role on enhancing the photosynthesis, uptake and transport of nutrients, upon the endogenous hormones specially the growth promoters, i.e. auxins, gibberellins and cytokinins **(Hayat & Ahmed, 2007; Mady, 2014 and Ibrahim 2019)**. These lead to promote cell division and cell elongation (Hayat *et al.*, 2005), as well as enhancing tolerance of plants to biotic and abiotic stresses, as well as lowering the level of oxidative stress in plant cell which acted as an improving the anti-oxidative capacity of the plant and helping to induce the synthesis of productive compounds such polyamines **(Raskin, 1992; Goswami *et al.*, 2013; Mohamed, 2017 and Ibrahim, 2019)**. Furthermore, these stimulatory effects on vegetative growth could be also attributed to the positive effect of salicylic acid upon the phyto-hormones especially the growth promoters which promote cell division and cell enlargement (Hayat *et al.*, 2005).

The obtained results are in harmony with those obtained on different pomegranate cultivars by: **Ghosh *et al.*** (**2009**) on "Ruby" pomegranate; **Tomar (2011)** on some percentage cultivars; **Khalil and Aly (2013)** on "Manfalouty" pomegranate; **Kumar *et al.* (2016)** on "Jodhpur Red" pomegranate; **Kishor *et al.* (2017)** on "Bhagwa" pomegranate trees; **Mohamed (2017)** on "Manfalouty" pomegranate and **Hussein and Hasan (2020)** on "wonderful" Pomegranate.

Table (2). Effect of spraying mega flower (M.F.), amino acids (A.A.) and salicylic acid (S.A.) on vegetative growth parameters (Shoot length, No. of leaves/shoot, No. of new shoots/tree and Leaf area) of Wonderful pomegranate trees, during 2019 and 2020 seasons

Treatments	Shoot length (cm)		No. of leaves/shoot		No. of new shoots/tree		Leaf area (cm^2)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	82.1	85.3	72.3	80.4	39.3	38.2	4/80	5.0
M.F 250 ppm	97.4	100.6	86.6	95.5	45.2	57.6	5.8	5.9
M.F 500 ppm	101.6	105.8	90.5	99.7	49.3	51.5	5.9	6.2
M.F 750 ppm	105.6	108.9	94.4	105.9	52.2	55.9	6.2	6.3
A.A. 100 ppm	94.5	98.7	82.5	91.6	42.2	43.7	5.5	5.8
S.A. 100 ppm	87.7	91.6	78.4	86.8	48.7	49.9	5.3	5.5
M.F 250 ppm + A.A 100 ppm	115.6	120.8	106.6	117.7	52.1	53.3	6.7	7.1
M.F 500 ppm+ A.A 100 ppm	121.8	130.5	113.8	123.5	54.4	56.2	7.2	7.4
M.F 750 ppm + A.A 100 ppm	127.8	138.8	119.7	130.4	57.7	58.3	7.5	7.8
M.F 250 ppm + S.A 100 ppm	109.9	112.4	98.8	109.6	50.1	51.3	6.3	6.6
M.F 500 ppm+ S.A 100 ppm	119.7	125.7	110.9	119.7	52.2	54.2	6.9	7.2
M.F 750 ppm + S.A 100 ppm	124.5	135.5	115.9	126.8	54.6	56.9	7.3	7.6
A.A 100ppm + S.A 100 ppm	113.8	117.8	102.6	111.6	49.7	51.5	6.6	6.8
M.F 250 ppm +AA 100 ppm+ SA 100 ppm	129.6	141.4	122.8	133.8	55.4	57.3	7.8	8.0
M.F 500 ppm + AA 100 ppm+ SA 100 ppm	133.7	147.7	130.7	141.9	58.8	60.3	8.2	8.8
M.F 750 ppm + AA 100 ppm+ SA 100 ppm	135.8	150.9	134.7	145.7	63.3	64.1	8.5	8.7
LSD at 5%	2.6	2.8	2.8	2.9	3.2	3.5	0.2	0.3

Leaves pigments

Changes in pigments contents of adult leaves of “Wonderful” pomegranate (chlorophyll a, chlorophyll b, total chlorophylls and total carotenoids “mg/100g F.W”) in relation to individual or combined applications of mega flower, amino acids and SA are presented in (Table 3). One can state that significant differences on chlorophyll a & b, total chlorophyll and total carotenoids in the leaves were observed among the three materials application. It is worth to mention that, increasing the concentration used of, mega flower from 250 ppm to 750 ppm, whether they used individually or in combinations, had a significant promotion on all leaves. These data were true during the two experimental seasons (2019 and 2020). However, non-significant differences were observed between the two highest concentrations (500 ppm and 750 ppm) in case of individually using of mega flower. Among the individually treatments with the two other compounds (amino acids and SA), during the two experimental seasons, it was capable to enhanced significantly the main pigments (chlorophylls and carotenoids), rather than untreated trees, except the cases of chlorophyll b during the two seasons and chlorophyll a during the first season which did not respond significantly to spraying amino acids. Among the three materials treatments, all combined applications of the three compounds shows more effectiveness on leaves pigments rather than using each compound alone. Furthermore, the combination mega flower + amino acids shows more effective in enhancing “Wonderful” pomegranate leaves pigments content rather than those of mega flower + SA. These data were true during the two experimental seasons. Changes in leaf pigments content of “Wonderful” pomegranate leaves show that, this positive effect significantly increase when the trees received the three materials in combination (mega flower + amino acids + SA). Then, the best results were obtained when the trees received the mega flower at 750 ppm + amino acids at 100 ppm + SA at 100 ppm (12.3 & 12.4 mg/100g F.W. for chlorophyll a, 4.7 & 5.0 mg/100g F.W for chlorophyll b, 17.0 & 17.4 mg/100g F.W for total chlorophyll and for 5.9 & 6.2 mg/100g F.W total carotenoids), during the two experimental seasons respectively. On the opposite side, lowest leaves pigments were obtained from untreated trees; (8.4 &8.2 mg/100g F.W. for chlorophyll a, 2.7 & 2.6 mg/100g F.W for chlorophyll b, 11.1 & 10.8 mg/100g F.W for total chlorophyll and 4.0 &4.2 for the total carotenoids), during the three experimental seasons respectively.

In agreement with our results concerning the role of mega flower (IAA, IAD and β-NOA), amino acids and salicylic acid in the leaf chlorophylls and carotenoids contents of some pomegranate cultivars was reported in different pomegranate cultivars by: **Kumar *et al.* (2016)** on “Jodhpur Red” pomegranate; **Kishor *et al.* (2017)** on “Bhagwa” pomegranate trees; **Mohamed (2017)** on “Manfalouty” pomegranate; **Hussein and Hasan (2020)** on “wonderful” Pomegranate and **Lorente-Mento *et al.* (2023)** on “Mollar de Elche” pomegranate. Furthermore, other authors noticed the same effect on other deciduous fruit trees such as: **Kassem *et al.* (2010)** on “Costata” persimmon; **Taghipour *et al.* (2011)** on “Gerdi” apricot; **Suman *et al.* (2017)** on different fruit trees and **Nia *et al.* (2022)** on grapevines. Several authors have been proposed to explain the role of amino acids in enhancing leaves pigments. The most of them suggests several alternative routes of IAA and ethylene synthesis in plants, starting from amino acids in addition nitrogen is the main principal compound in chlorophyll molecule structure. In this respect, **(Davies, 1982; Taiz & Zeiger, 2002 and Wassel *et al.*, 2017a)** suggested that the regulatory effect of certain amino acids in enhancing leaves chlorophylls development appeared through their influence on the biosynthesis of chlorophyll and carotenoids structure.

Previously, salicylic acid (SA) has been established as an important regulator of photosynthesis, water relations and metabolic aspects of fruit trees **(Hayat *et al.*, 2005)**. SA is known also to affect leaf and chloroplast structure **(Hayat and Ahmed, 2007)**, chlorophyll and carotenoid contents **(Fariduddin *et al.*, 2003; Ibrahim 2019 and Yazdanpanah *et al.*, 2021)**, and the activity of photosynthesis enzymes such as: ribulose-1,5-bisphosphate carboxylase/ oxygenase and carbonic anhydrase **(Slaymaker *et al.* (2002); Sarangthem & Singh (2003); Hayat *et al.* (2013) and Youssef *et al.* (2017)**. The results of these previous studies, which were mentioned in previous lines, can explained the positive effect of SA on leaf main pigments (chlorophylls and carotenoids) which was observed in the present study.

Table (3). Effect of spraying Mega flower (M.F.), amino acids (A.A.) and salicylic acid (S.A.) on main leaves pigments (Chlorophyll a, Chlorophyll b, Total chlorophyll and Total carotenoids) of Wonderful pomegranate trees, during 2019 and 2020 seasons

Treatments	Chlorophyll a (mg/100g F.W.)		Chlorophyll b (mg/100g F.W.)		Total chlorophyll (mg/100g F.W.)		Total carotenoids (mg/100g F.W.)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	8.4	8.2	2.7	2.6	11.1	10.8	3.9	4.1
M.F 250 ppm	9.3	8.8	3.3	3.5	12.6	12.3	4.4	4.7
M.F 500 ppm	9.9	9.9	3.7	4.0	13.6	13.9	4.9	5.1
M.F 750 ppm	10.5	10.7	3.9	4.0	14.4	14.7	5.2	5.3
A.A. 100 ppm	8.6	8.8	2.8	2.9	11.4	11.7	4.3	4.4
S.A. 100 ppm	9.2	9.4	3.0	3.3	12.2	12.7	4.2	4.4
M.F 250 ppm + A.A 100 ppm	10.6	10.9	4.0	4.2	14.6	15.1	4.6	4.6
M.F 500 ppm+ A.A 100 ppm	11.1	11.5	4.5	4.7	15.6	16.2	5.2	5.4
M.F 750 ppm + A.A 100 ppm	11.9	12.2	4.6	4.7	16.5	16.9	5.9	6.1
M.F 250 ppm + S.A 100 ppm	10.1	10.3	3.6	4.0	13.7	14.3	4.2	4.3
M.F 500 ppm+ S.A 100 ppm	10.6	10.9	3.9	4.1	14.5	15.0	4.7	4.8
M.F 750 ppm + S.A 100 ppm	10.9	11.3	4.2	4.5	15.1	15.8	5.1	5.3
A.A 100ppm + S.A 100 ppm	10.1	10.5	3.5	3.7	13.6	14.2	4.6	4.9
M.F 250 ppm +AA 100 ppm+ SA 100 ppm	11.4	11.5	4.4	4.4	15.8	15.9	5.2	5.6
M.F 500 ppm + AA 100 ppm+ SA 100 ppm	11.9	12.1	4.7	4.9	16.6	17.0	5.7	5.9
M.F 750 ppm + AA 100 ppm+ SA 100 ppm	12.3	12.4	4.7	5.0	17.0	17.4	5.9	6.2
LSD at 5%	0.5	0.5	0.3	0.47	0.5	0.6	0.3	0.3

Leaves mineral contents

Data illustrated in (Table 4) showed the effect of mega flower, amino acids and SA on leaves N, P, K, Ca and Mg contents of "Wonderful" pomegranate trees, during the two experimental seasons. Data in these table showed that the individual or combined applications of the three used materials (mega flower, amino acids and SA) significantly varied the leaves nitrogen%, potassium% calcium% and magnesium% contents of Wonderful pomegranate compared to those of untreated trees. Contrary of N, K, Ca and Mg contents all applied treatments failed to varied leaves phosphorus content significantly, neither in the first season nor in the second season. Moreover, such increment in leaves mineral contents was gradually increased parallel to increase the concentration of mega flower concentration. It is obvious that, all combined treatments of the three materials (mega flower, amino acids and SA) was superior than using each material alone, except the case of leaves phosphorus content since non-significant differences were observed.

It is worth to mention that the highest values of nitrogen (1.79% & 1.84%), potassium (1.73% & 1.81%), calcium (1.80% & 1.84% %) and Mg (0.79% & 0.83%) were obtained from the "Wonderful" pomegranate trees received mega flower at 750 ppm in combination with amino acids and SA, during the two experimental seasons respectively. Even, mega flower at 750 ppm + amino acids + SA present the highest leaf content from mineral elements. Raising mega flower concentration combined with amino acids and salicylic acid did not affect the leaf content N, P, K, Ca and Mg in the two experimental seasons. On the other hand, the lowest N, K, Ca and Mg percentages (1.47% & 1.49% for N, 1.44% & 1.42% for K, 1.64% & 1.59% for Ca and 0.65% & 0.66% for Mg) of Wonderful pomegranate were obtained from untreated trees. These findings were true during the two experimental seasons.

Our results concerning the role of mega flower (IAA, IAD and β-NOA), amino acids and SA on leaves mineral contents of some pomegranate cultivars are in agreement with those obtained **Ghosh *et al.* (2009)** on “Ruby” pomegranate; **Khalil and Aly (2013)** on “Manfalouty” pomegranate; **Goswami *et al.* (2013)** on "Sinduri” pomegranate; **Kumar *et al.* (2016)** on “Jodhpur Red” pomegranate; **Kishor *et al.* (2017)** on “Bhagwa” pomegranate trees; **Mohamed (2017)** on “Manfalouty” pomegranate and **Hussein and Hasan (2020)** on “wonderful” Pomegranate. Furthermore, authors mentioned the same effect on other deciduous fruit trees such as: **Kassem *et al.* (2010)** on “Costata” persimmon; **Taghipour *et al.* (2011)** on “Gerdi” apricot and **Nia *et al.* (2022)** on grapevines.

Table (4). Effect of spraying Mega flower (M.F.), amino acids (A.A.) and salicylic acid (S.A.) on leaves N, P, K, Ca and Mg contents (%) of Wonderful pomegranate trees, during 2019 and 2020 seasons

Treatments	N %		P %		K %		Ca %		Mg %	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control	1.47	1.49	0.28	0.29	1.44	1.42	1.64	1.59	0.65	0.66
M.F 250 ppm	1.60	1.65	0.28	0.29	1.58	1.64	1.68	1.72	0.73	0.71
M.F 500 ppm	1.63	1.69	0.30	0.30	1.63	1.65	1.69	1.73	0.73	0.73
M.F 750 ppm	1.69	1.72	0.28	0.29	1.64	1.70	1.71	1.73	0.74	0.74
A.A. 100 ppm	1.67	1.75	0.28	0.28	1.56	1.59	1.68	1.71	0.72	0.71
S.A. 100 ppm	1.57	1.65	0.28	0.28	1.51	1.51	1.67	1.70	0.72	0.71
M.F 250 ppm + A.A 100 ppm	1.70	1.76	0.30	0.31	1.68	1.73	1.74	1.75	0.75	0.77
M.F 500 ppm+ A.A 100 ppm	1.74	1.78	0.33	0.30	1.69	1.75	1.74	1.76	0.76	0.78
M.F 750 ppm + A.A 100 ppm	1.76	1.80	0.33	0.34	1.69	1.77	1.76	1.77	0.78	0.81
M.F 250 ppm + S.A 100 ppm	1.60	1.70	0.31	0.32	1.64	1.71	1.72	1.74	0.74	0.75
M.F 500 ppm + S.A 100 ppm	1.62	1.65	0.32	0.30	1.68	1.74	1.74	1.76	0.75	0.77
M.F 750 ppm + S.A 100 ppm	1.62	1.67	0.33	0.33	1.69	1.76	1.75	1.77	0.77	0.80
A.A 100ppm + S.A 100 ppm	1.68	1.75	0.31	0.32	1.66	1.72	1.73	1.75	0.74	0.76
M.F 250 ppm + AA 100 ppm+ SA 100 ppm	1.76	1.79	0.32	0.32	1.79	1.79	1.77	1.80	0.77	0.81
M.F 500 ppm + AA 100 ppm+ SA 100 ppm	1.77	1.83	0.33	0.33	1.71	1.81	1.78	1.83	0.78	0.81
M.F 750 ppm + AA 100 ppm+ SA 100 ppm	1.79	1.84	0.32	0.33	1.73	1.81	1.80	1.84	0.79	0.83
LSD at 5%	0.11	0.13	NS	NS	0.08	0.09	0.06	0.08	0.07	0.08

Fruit setting%, yield, fruit numbers/tree and fruit weight

Fruit setting %

Data regarding the effect of the three examined compounds (mega flower, amino acids and SA), each compound alone or in possible combinations on fruits set percentage of “Wonderful” pomegranate during 2019 and 2020 seasons are shows in Table (5). It is noticed from the obtained data that, all mega flower individually application was capable to significantly increase the percentage of fruit setting compared to untreated trees. During the first season, increasing mega flower concentrations from 250 ppm to 750 ppm individually caused a gradual and significant increase in fruit setting ratio. Contrary of first season, non-significant differences were obtained between mega flower concentrations during the second season. Also, using amino acids or SA individually was capable to enhancing significantly the fruit set % of Wonderful pomegranate trees. These data were true during the two experimental seasons.

It's worth to mentioned that, in both experimental seasons, all combined application of the three materials (mega flower, amino acids and SA) shows more effective on fruit setting than using each material individually. In addition, the trees received mega flower at highest concentration combined with amino acids at 100 ppm and SA at 100 ppm produced the highest fruit setting percentage (32.4% and 28.5%) during the two experimental seasons respectively. However, non-significant differences were observed between the two higher concentrations of mega flower neither individual nor combined application, during the two seasons. On the opposite side, untreated trees present the lowest fruit setting percentages (23.3% and 20.7%), during the experimental seasons, respectively.

Yield and its components

Data regarding the effect of mega flower, amino acids and SA on fruit number per tree, average fruit weight and yield (kg/tree), of Wonderful pomegranate trees grown in sandy soil under Minia Governorate conditions during 2019 and 2020 are illustrated in (Table 5). Results in the same table showed a surely important effect of the three examined materials on the number of fruits per tree, average fruit weight and yield (kg/tree), during the two experimental seasons.

The same Table showed that, either spraying mega flower individually or combined with amino acids and SA, the results showed that increasing the concentration of mega flower from 250 ppm to 750 ppm was parallel with increasing fruit numbers per tree and yield (kg/tree) of "Wonderful" pomegranate, during 2019 and 2020 seasons. On the other hand, no different had been noticed concerning the effect of SA and AA on the no. of fruits per tree in the first and second experimental seasons,

Based on Several hypotheses which proposed explain for the role of amino acids in improving fruit weight. It suggests several alternative routes of IAA and ethylene synthesis in plants, starting from amino acids. In this respect, **(Taiz & Zeiger, 2002 and Phawa *et al.*, 2017)** suggested that the regulatory effect of certain amino acids in plant cell development through their influence on the biosynthesis of gibberellins, tryptophan and methionine in building of IAA and ethylene, respectively. However, the impact of enhancing average fruit weight (g) as a result of spraying SA was associated with the improvement of leaf stimulatory effect on photosynthetic pigment biosynthesis as well as net photosynthetic rate **(Sadeghipour & Aghaei, 2012; Bhujbal *et al.*, 2013 and Phawa *et al.*, 2017)**.

The combined application of the three materials shows more effective in yield and its components of "Wonderful" pomegranate than the individual application of each material, except the case of fruit weigh which shows the highest fruit weight was obtained from the trees received SA at 100 ppm. Furthermore, the trees received mega flower at 750 ppm + amino acids 100 ppm + SA at 100 ppm produced the highest fruit setting% (32.4 & 28.5 %), fruit numbers per tree (65 & 67 fruit / tree) and yield (28.5 & 29.4 kg/tree). These data were true during the two experimental seasons respectively. On the other hand, untreated fruit produced the lowest fruit setting percentage (23.3% and 20.7%), fruit numbers per tree (39 and 37 fruit/tree) and lowest yield (15.6 and 15.1 kg/tree), during the two experimental seasons.

Table (5). Effect of spraying Mega flower (M.F.), amino acids (A.A.) and salicylic acid (S.A.) on fruit setting %, number of fruits / tree, average fruit weight (g) and yield (kg/tree) of Wonderful pomegranate trees, during 2019 and 2020 seasons

Treatments	Fruit setting %		No. of fruit per tree		Fruit weight (g)		Yield (kg/tree)	
	2019	2020	2019	2020	2019	2020	2019	2020
Control	23.3	20.7	39	37	401.1	407.7	15.6	15.1
M.F 250 ppm	26.6	27.2	46	47	480.7	489.5	22.1	23.0
M.F 500 ppm	29.9	27.5	48	51	475.4	481.8	22.8	24.6
M.F 750 ppm	30.6	27.5	50	51	472.2	476.7	23.6	24.3
A.A. 100 ppm	27.6	26.7	43	45	489.5	496.9	21.1	22.4
S.A. 100 ppm	28.6	28.4	43	44	495.6	500.1	21.3	22.0
M.F 250 ppm + A.A 100 ppm	31.9	28.1	56	57	452.1	457.3	25.3	26.1
M.F 500 ppm+ A.A 100 ppm	32.4	28.4	59	61	440.7	431.9	26.0	26.3
M.F 750 ppm + A.A 100 ppm	33.1	27.7	62	63	469.7	472.5	29.1	29.8
M.F 250 ppm + S.A 100 ppm	30.5	27.1	51	52	446.4	451.2	22.8	23.5
M.F 500 ppm + S.A 100 ppm	31.8	28.2	57	60	433.7	439.3	24.7	26.4
M.F 750 ppm + S.A 100 ppm	32.6	28.4	60	62	459.8	446.7	27.6	27.8
A.A 100ppm + S.A 100 ppm	30.9	27.3	53	54	425.2	429.2	22.5	23.2
M.F 250 ppm +AA 100 ppm+ SA 100 ppm	32.3	27.2	62	64	429.6	423.9	26.6	27.1
M.F 500 ppm + AA 100 ppm+ SA 100 ppm	32.3	26.9	63	65	437.7	433.5	27.6	28.2
M.F 750 ppm + AA 100 ppm+ SA 100 ppm	32.4	28.5	65	67	438.7	438.5	28.5	29.4
LSD at 5%	1.6	1.8	2.8	3.8	8.4	6.9	1.2	1.9

In agreement with our results concerning the role of mega flower (IAA, IAD and β-NOA), amino acids and salicylic acid on leaves mineral contents of some pomegranate cultivars was studied on different pomegranate cultivars by **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 **Beltagi *et al.* (2023)** on Manfalouty pomegranate. Similar results were observed by **Michell and Whitehead (1998)** on the other fruits when they studied the effect of β-Naphthoxy acetic acid on fruits. Also, **Ibrahim (2019)** mentioned the same results when he studied the effect of spraying salicylic acid on “Sultani” fig trees. **Asia *et al.* (2010)** on Conference and Blanquilla pear cultivars. Furthermore, those 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 different fruit trees. Also, **Greenberg *et al.* (2006)** through their studies on “Nova” mandarin trees and its response to foliar application with NAA at 150 ppm, the authors confirmed this positive effect on flowering, fruit numbers/tree and yield as well as fruit dimensions. Contrary of our findings, **Choi and Minsson (2001)** stated that, spraying NAA cause a significant decrease in yield and fruit number / tree of “Fuji” apple trees.

Conclusion

As a conclusion one can state that under the experimental conditions Minia Governorate Egypt and resembling regions increasing the yield and improving its quality of Wonderful pomegranate cultivar, could be achieved by spraying the trees with mega flower at 750ppm, amino acids at 100 ppm and salicylic acid at 100 ppm.

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