Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/11762
DOI URL: http://dx.doi.org/10.21474/IJAR01/11762

ISSN NO. 2320-5407

RESEARCH ARTICLE

EFFECT OF SALICYLIC AND ASCORBIC ACIDS ON YIELD AND FRUIT QUALITY OF WONDERFUL POMEGRANATE TREES

Amro S.M. Salama, Osama H.M. El Gammal and Amin M. G. E. Shaddad
Plant Production Department, Desert Research Center, Cairo, Egypt.

Manuscript Info

Manuscript History
Received: 20 July 2020
Final Accepted: 24 August 2020
Published: September 2020

Key words:-
Wonderful Pomegranate Tree, Salicylic Acid, Ascorbic Acid, Yield, Fruit Quality, Cracked Fruits, Sunburn Damaged

Abstract

AN experiment trial was carried out during 2017 and 2018 seasons on Wonderful pomegranate trees about 7 years old grown in sandy soil under drip irrigation system from well at private orchard located on Cairo-Alexandria desert road (about 50 km from Cairo), Egypt. Treatments of salicylic acid (50,100 and 150 ppm), ascorbic acid (500, 750 and 1000 ppm) and tap water control were foliar sprayed twice a year i.e. at full bloom and four weeks later. Abstractly, salicylic and ascorbic acid treatments enhanced leaf characteristics, yield and fruit quality traits as well as minimized sunburned and cracked fruit percentages. Ascorbic acid treatment at 1000 ppm proved to be most efficient treatment in this respect.

Introduction:-

Pomegranate (*Punica granatum* L.) has high adaptability to versatile conditions especially stress conditions (Haggag and El- Shamy, 1987). Pomegranate fruit has medicinal properties especially in traditional systems from time immemorial (Roy and Waskar, 1997). It is a hardy fruit crop and it can be grown successfully even on marginal soils. It is recommended for resource limited farmers.

Fruit disorder is considered the most important factors believed to be responsible for the reduction of pomegranate production. Cracking or splitting is a serious problem in pomegranate orchard as it causes about 50% of fruit marketing value. It occurs more frequently in the dry atmosphere of the arid regions. Fruit cracking has no standard definition. In addition, there is no single factor that could be pointed out as fruit cracking. There are many horticultural practices could be used to enhance tree productivity and diminish fruit disorders (El-Masry, 1995). Chemicals could be used as one of these horticultural practices.

Antioxidants such as salicylic and ascorbic acids are safe to human and environment (Elade, 1992). They play a role in protecting the cells from senescence and preventing free radicals from the oxidation of lipids the components of the plasma membrane. They are also involved in minimizing the stresses through enhancing the antioxidant system.

Salicylic acid plays a vital role in plant growth, ion uptake and transport (Hayat et al. 2010). Salicylic acids play a role in plant water relations, photosynthesis, ethylene biosynthesis, stomatal movement and reversing the effect of ABA on leaf abscission (Arfan et al., 2007). It enhanced the activities of antioxidant enzymes to the drought and salinity stress in plants (Hayat et al., 2008). It is responsible for enhancing natural hormones that play a key part in regulating plant growth and development (Senarataa et al., 2004). In this respect, Ahmed et al. (2014) mentioned that foliar sprays with salicylic acid induced positive effects on yield and fruit quality and it reduced fruit splitting of

Corresponding Author:-Amro S.M. Salama
Address:-Plant Production Department, Desert Research Center, Cairo, Egypt.

Manfalouty pomegranate. Abdel Aziz et al. (2017) stated that foliar sprays of salicylic acid at 100 ppm improving growth, yield, fruit quality and reduced cracked fruits of Manfalouty pomegranate trees. On the other hand, Abada and Abd El- Hameed (2010) have worked on Flame seedless grapevines, Wassel et al. (2011) on Red Roomy grapevines. They mentioned that the application of salicylic acid enhanced yield and fruit quality.

Ascorbic acid is considered as a natural and organic antioxidant compound (Hafez et al., 2010). Ascorbate is a major metabolite in the plant. This antioxidant and its association with other components of the antioxidant system, protect the plant against oxidative damage resulting from aerobic metabolism, photosynthesis and range of pollutants (Abd-El Hamid, 2009 and Hassanein et al., 2009). It acts as a co-enzyme in an enzymatic cofactor and plant growth regulator (Gomez and Lajolo, 2008). Ascorbic acid has auxinic action. It has a synergistic effect on improving growth, flowering, yield and fruit quality of fruit crops (Ahmed et al., 1997 and Barth et al., 2006). It used instead of auxin and other chemicals for enhancing growth and fruiting of Washington navel orange trees (Ragab, 2002). Fayed (2010) found that the interaction of foliar application of compost tea with ascorbic and citric acids enhanced growth, yield and fruit quality of pomegranate trees. However, Ascorbic acid enhanced the yield and controlling the incidence of fruit disorders of apple trees (Ahmed et al., 1997). Abd-El-Rhman et al.(2017) reported that foliar spray ascorbic acid enhanced yield and fruit quality of Manfaloty pomegranate trees. Atef (2018) pointed out that foliar spray with a mixture of ascorbic acid improved growth, yield fruit quality of Wonderful pomegranate trees. Furthermore, El-Sayed et al. (2014) have worked on Manzanillo olive trees; Samra et al. (2012) on Balady mandarin trees and Mansour et al.(2010) on mango trees. They showed that application of ascorbic acid increased yield and fruit quality parameters of the aforementioned fruit species.

The purpose of this work is to study the effect of salicylic and ascorbic acids on leaf characteristics, yield, fruit quality, sunburned fruit and fruit cracking of Wonderful pomegranate trees.

Material and Methods:-

An experiment was carried out during two successive seasons 2017 and 2018 at a private farm located on Cairo-Alexandria desert road about 50 km fromCairo(latitude 30°9′ 2.92″ N, longitude 30°40′ 31.75″ E), Egypt. Wonderful pomegranate trees (Punica granatum) aged 7 years old grown in sandy soil and spaced 3 x 5 m apart under drip irrigation system from well. Physical and chemical analysis of the experimental soil shown in Table 1, meanwhile the chemical analysis of used water from irrigation is recorded in (Table 2).

Table 1:- Analysis of experimental soil in 2017 and 2018 seasons.I - Physical analysis.

Soil Depth (cm)	Particle size distribution				Texture Class	Bulk Density (g/cm)	Organic matter %	Moisture content (%)	
	Coarse sand	Fine sandy	Silt	Clay				Field Capacity	Wilting Point
0-30	0.00	97.50	1.50	1.00	Sand	1.52	0.20	9.21	4.44
30-60	0.00	98.00	1.40	0.60	Sand	1.56	0.19	8.88	4.49

II- chemical analysis.

Soil Depth cm	$CaCO_3$	pH Soil past	E.Ce (dSm^{-1})	Soluble cations (meq/l)				soluble anions (meq/l)			
				Ca^{++}	K^{+}	Na^{+}	Mg^{++}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	$CO_3^{=}$
0-30	4.1	7.1	1.8	3.1	1.5	11	1.8	9.5	5	1.1	-
30-60	4.2	7.1	1.4	2.8	1.4	10.2	1.3	8.5	4.5	1.2	-

Table 2:- Chemical analysis of water used for irrigation in 2017 and 2018 seasons.

pH	E.C. dSm^{-1}	O.M %	Soluble cations (meq/l)				soluble anions (meq/l)			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
7.00	0.6	0.8	1.8	1.2	0.6	0.9	0	1.8	2.6	0.1

The experiment consisted of forty two trees healthy, nearly uniform in shape and size and productivity and received the same horticulture practices, were subjected to seven treatments as: control tap water, Salicylic acid as foliar sprays at 50 ppm, Salicylic acid as foliar sprays at 100 ppm, Salicylic acid as foliar sprays at 150 ppm, Ascorbic acid as foliar sprays at 500 ppm, Ascorbic acid as foliar sprays at 750 ppm, Ascorbic acid as foliar sprays at 1000 ppm. Tween-20 was added at 0.1% as a surfactant to spray solution including the control "tap water". Spraying was

carried out using compression sprayers (5L solution/tree) at the previously mentioned dates. The experiment was designed as a randomized complete block design with three replicates for each treatment and each replicate was represented by two trees. Foliar spray of salicylic and ascorbic treatments were carried out at two times, the first foliar spray was done at full bloom and the second one was performed four weeks later, meanwhile, the control trees were sprayed with tap water at the previously mentioned times.

The response of Wonderful pomegranate trees to the tested salicylic and ascorbic treatments was evaluated through the following determinations.

Leaf characteristics
The area of leaves was determined by using portable area planimeter Mod Li3100 Ali (Li-Cor) while Leaf total chlorophyll content was determined by Minolta chlorophyll meter SPAD-502.

No. of fruits/tree and yield kg/tree
At harvest time, the number of fruits per each treated tree was counted and reported then yield (kg) per tree was weighed and recorded.

Cracked, sunburned fruits
Number of cracked and sunburned fruits per tree was counted and recorded. The percentages of cracked and sunburned fruits/tree were calculated.

Fruit physical and chemical properties
Physical properties
Ten fruits were taken at harvest time from each treated tree for determination of the following physical and chemical properties. Fruit weight (g), fruit length (cm), fruit diameter (cm), weight of fruit grains (g), weight of 100 grains (g), juice volume (cm^3) per fruit, peel thickness (cm).

Chemical properties
Total sugar (%), total soluble solids (T.S.S.) were determined by Hand refractometer, total acidity in fruit juice (expressed as citric acid per 100 ml juice), TSS/ Acid ratio and ascorbic acid (mg ascorbic acid/100 ml juice) according to A.O.A.C. (1995).

Statistical analysis
The obtained data in 2017 and 2018 seasons were statistically analyzed by MSTAT-C soft-ware and means were differentiated using Rang test at the 0.05 level (Duncan, 1955).

Results and Discussion:-

Leaf characteristics
Leaf area (cm^3)
Table, 3 demonstrates that salicylic and ascorbic treatments enhanced leaf surface area in both seasons as compared with control treatment. Generally, 1000 ppm ascorbic treatment proved to be the superior treatment in this respect.

Leaf total chlorophyll content
All salicylic and ascorbic treatments succeeded in increasing leaf total chlorophyll content as compared with the control treatment in both seasons of study (Table, 3). Moreover, 1000 ppm ascorbic proved to be the superior treatment in this respect.

Means within each column followed by the same letter (s) are not significantly different at 5% levelThe enhancement effect of salicylic acid on leaf characteristics of pomegranate trees may be attributed that salicylic is a growth regulator which participates in the regulation of physiological processes in plants. Salicylic acid has a role in protecting the cells from senescence and preventing free radicals from the oxidation of lipids the components of the plasma membrane. Salicylic acid showed a synergetic effect like auxin and gibberellins (Sanaa et al., 2006).

Table 3:-Effect of salicylic and ascorbic acids foliar sprays on leaf characteristics of Wonderful pomegranate trees (2017 & 2018 seasons).

	Leaf area (cm^2)	Total chlorophyll

Treatments	2017	2018	2017	2018
Control "Tap water"	4.19 G	3.92 G	47.66 D	47.66 D
Salicylic acid 50 ppm	4.51 F	4.42 F	50.76 C	52.20 C
Salicylic acid 100 ppm	4.95 D	4.83 D	53.80 B	54.10 BC
Salicylic acid 150 ppm	5.34 B	5.26 B	55.41 AB	56.56 AB
Ascorbic acid 500 ppm	4.71 E	4.56 E	53.33 B	52.93 C
Ascorbic acid 750 ppm	5.22 C	5.02 C	54.47 B	55.20 ABC
Ascorbic acid 1000 ppm	5.49 A	5.41 A	57.36 A	58.16 A

Means within each column followed by the same letter (s) are not significantly different at 5% level

Salicylic acids have direct effect on plant growth, ions uptake, stomatal movement and reversing the effect of ABA on leaf abscission, (Romani et al., 1989). It was found also to accelerate the photosynthetic rate, modify the activity of important enzymes, increase the leaf area and dry mass production and to exhibit a rapid rate of root differentiation, (Singh, 1993 and Hayat and Ahmed, 2007). The obtained results regarding the effect of salicylic acid on leaf characteristics go in line with the findings of Abdel Aziz et al. (2017) they mentioned that foliar sprays of salicylic acid at 100 ppm improving leaf area of Manfalouty pomegranate trees.

The enhancement effect of ascorbic acid on leaf characters may be attributed that ascorbic acid has positive action in catching all free radicals produced during plant metabolism (Alscher et al., 1997). Moreover, ascorbic acid has an auxinic action and synergistic effect on tree growth (Ragab, 2002). Ascorbic acid increased IAA content, which stimulates cell division as well as cell enlargement and this in turn in improved plant growth (Hassanein et al., 2009 and Abd-El Hamid, 2009). Ascorbic acid may serve as a potential growth regulator to enhance stress resistance in several species (Shalata and Peter, 2001 and Khan, 2006). Besides, foliar application of ascorbic acid had positive effect on growth parameter and increases in photosynthesis (Tarraf et al., 1999). The obtained results regarding the effect of ascorbic acid on leaf characteristics go in line with the findings of Fayed (2010) who mentioned that the interaction of foliar application ascorbic + citric acid enhanced leaf chlorophyll content of pomegranate trees. Moreover, El-Sayedet al. (2014) reported that ascorbic acid treatments enhanced leaf area and total chlorophyll of Manzanillo olive trees. Atef Abo-Ogiala (2018) stated that foliar sprays with ascorbic acid enhanced growth parameters of "Wonderful" pomegranate trees.

Number of fruits/tree and yield kg/tree

Number of fruits/ tree

It is clear from Table, 4 that salicylic and ascorbic sprayed trees produced a higher number of fruits than those sprayed with tap water control in both seasons of study. Anyhow, 1000 ppm ascorbic treatment shows superiority in this respect.

Table 4:- Effect of salicylic and ascorbic acids foliar sprays on number of fruits /tree and yield of Wonderful pomegranate trees (2017 & 2018 seasons).

	No. of fruits/tree		Yield (Kg)/tree	
Treatments	2017	2018	2017	2018
Control "Tap water"	54.0 G	48.3 G	16.3 D	16.0 E
Salicylic acid 50 ppm	57.6 F	51.6 F	18.0 D	17.0 E
Salicylic acid 100 ppm	63.6 D	57.6 D	21.0 BC	21.0 C
Salicylic acid 150 ppm	70.6 D	67.6 B	22.0 B	23.0 B
Ascorbic acid 500 ppm	60.0 E	54.6 E	20.0 C	19.0 D
Ascorbic acid 750 ppm	68.0 C	60.6 C	21.6 BC	22.3 BC
Ascorbic acid 1000 ppm	73.3 A	71.3 A	24.0 A	25.0 A

Means within each column followed by the same letter (s) are not significantly different at 5% level

Yield (Kg) / tree

Table 4 illustrates that salicylic and ascorbic treatments succeeded in improving tree yield as compared with the control in both seasons. Generally, 1000 ppm ascorbic sprayed trees showed to be the highest production trees (24 and 25 kg/tree) against (16.3 and 16.0 kg/tree) for tap water control sprayed trees in 2017 and 2018 seasons, respectively.

The improvement effect of salicylic acid on yield of pomegranate trees may be attributed that salicylic acid increased the photosynthetic rate, modify the activity of important enzymes, and it increased leaf area and dry mass production (Hayat and Ahmed, 2007). On the other hand, salicylic acid treatment increased leaf chlorophyll content (Hayat et al., 2010 and Abdel Aziz et al., 2017). These lead to more carbohydrate production reflected in increasing fruit set percentage and consequently improved yield. The obtained results regarding the effect salicylic acid on yield go in line with the findings of Hayat et al. (2014) and Abdel Aziz et al. (2017) they reported that foliar sprays of salicylic acid improving the yield of Manfalouty pomegranate trees.

The enhancement effect of ascorbic acid on yield may be attributed that ascorbic acid increased leaf chlorophyll content (Azzedine, et al., 2011). This led to an enhancement of photosynthesis process (Tarraf et al., 1999).which led to more carbohydrate production and that reflected in higher yield. Besides, ascorbic acid increased IAA content which stimulates cell division as well as cell enlargement (Hassanein et al. 2009 and Abd-El Hamid 2009). The obtained results regarding the effect of ascorbic acid on yield go in line with the findings of Fayed (2010) on pomegranate trees and Abd-El-Rhman et al. (2017) on "Manfaloty" pomegranate trees and Atef (2018) on "Wonderful" pomegranate trees.

Cracked and sunburned fruit

Number of cracked fruit/tree

Table, 5 shows that all tested treatments reduced the number of cracked fruits/tree as compared with the control treatment in both seasons of study. Generally, 1000 ppm ascorbic sprayed trees recorded the lowest values cracked fruits/tree in this respect.

Table 5:- Effect of salicylic and ascorbic acids foliar sprays on fruit cracking and sunburned fruit percentages of Wonderful pomegranate trees (2017 & 2018 seasons).

	No. of cracked fruits/tree		Fruit cracking (%)		No. of sunburned fruits/tree		Sunburned fruit (%)	
Treatments	2017	2018	2017	2018	2017	2018	2017	2018
Control "Tap water"	18 A	15 A	33.35 A	31.12 A	8.0 A	7.0 A	14.80 A	14.43 A
Salicylic acid 50 ppm	15 B	14 A	26.02 B	27.09 B	7.6 AB	7.0 A	13.31 AB	13.52 AB
Salicylic acid 100 ppm	12 BC	12 B	18.85 C	20.81 C	7.3 AB	7.3 A	11.51 BC	12.71 B
Salicylic acid 150 ppm	11.6 CD	11.6 B	16.57 CD	17.27 D	6.0 C	7.0 A	8.47 D	10.31 D
Ascorbic acid 500 ppm	14 BC	14 A	23.42 B	25.59 B	7.3 AB	7.3 A	12.21 B	13.40 AB
Ascorbic acid 750 ppm	12 CD	12 B	17.71 C	19.76 CD	6.6 BC	7.0 A	9.75 CD	11.51 C
Ascorbic acid 1000 ppm	9.6 D	8.0 C	13.16 D	11.22 D	5.6 C	7.0 A	7.72 D	9.78 D

Means within each column followed by the same letter (s) are not significantly different at 5% level

Fruit cracking (%)

Tabulated data illustrates that salicylic and ascorbic treatments reduced fruit cracking percentage of Wonderful pomegranate trees as compared with the control in the first and second seasons. In this respect, 1000 ppm ascorbic treatment recorded the lowest values of fruit cracking (13.16 and 11.22%) against (33.35 and 31.12%) for the control treatment in 2017 and 2018 seasons, respectively.

No. of sunburned fruits/tree

Table, 5 shows that all tested treatments reduced a number of sunburned fruits/tree as compared with the control treatment in the first season of study. Generally, 1000 ppm ascorbic treatment proved to be the most efficient treatment in reducing a number of sunburned fruits/tree in the first season. However, all salicylic, ascorbic and control treatments produced a similar effect on the number of sunburned fruits per tree in the second season.

Sunburned fruit (%)

Table 5 shows that salicylic and ascorbic treatments decreased sunburned fruit percentage as compared with the control in the 2017 and 2018 seasons. Generally, 1000 ppm ascorbic treatment exerted a high reductive effect on sunburned fruit percentage as compared with other treatments in both seasons.

The positive effect of salicylic acid in reduced cracked and sunburned fruits may be attributed that salicylic acid has an important role in protecting the cells from senescence and preventing free radicals from the oxidation of lipids the components of the plasma membrane. Salicylic acid is also involved in minimized of the stresses through enhancing

antioxidant system. It is responsible for enhancing natural hormones that play a key part in regulating plant growth and development as well as enhancing the biosynthesis of IAA and minimizing the unfavorable effects of different stresses on plant development (Senarataa et al, 2004). Salicylic acid has a significant role in plant water relations, photosynthesis, and growth in plants (Arfan et al., 2007). And this reflected on reducing cracked and sunburned fruits. The obtained results regarding the effect of salicylic acid on fruit disorders go in line with the findings of Ahmed et al. (2014) on pomegranate and Abdel Aziz et al. (2017) on pomegranate.

The positive effect of ascorbic acid in reducing cracked and sunburned fruits may be attributed that ascorbic acid has catched all free radicals produced during plant metabolism (Nichloas, 1996 and Alscher et al., 1997). Ascorbic acid increased IAA content, which stimulates cell division as well as cell enlargement and this in turn in improved plant growth (Hassanein et al., 2009 and Abd-El Hamid, 2009). Ascorbic acid may serve as a potential growth regulator to enhance stress resistance in several species (Khan, 2006). This led to reducing cracked fruit. Furthermore, Ma and cheng (2004) mentioned that fruit protected from photo oxidative damage by the central antioxidant system (the ascorbate – glutathione cycle). Ascorbic acid reduces sunburn damage in fuji apples (Andrews et al., 1999). The obtained results regarding the effect of ascorbic on fruit disorders go in line with the findings of Ahmed et al. (1997) showed that Ascorbic acid application was controlling the incidence of fruit disorders of apple trees. Abd-El-Rhman et al.(2017) pointed out that foliar spray with ascorbic acid reduced fruit cracked percentage of Manfalouty pomegranate trees.

Fruit physical and chemical properties

Fruit weight (g)

It is clear from Table, 6 that salicylic and ascorbic sprayed trees produced higher fruit weight than those sprayed with tap water control in both seasons of study. Anyhow, 1000 ppm ascorbic treatment shows superiority in this respect.

Table 6:- Effect of salicylic and ascorbic acids foliar sprays on some fruit physical properties of Wonderful pomegranate trees (2017 & 2018 seasons).

	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Weight of fruit grains (g)	
Treatments	2017	2018	2017	2018	2017	2018	2017	2018
Control "Tap water"	301.0 E	295.0 E	7.88 G	7.89 G	8.75 D	8.69 G	135.0 G	136.0 F
Salicylic acid 50 ppm	316.6 D	308.0 D	7.94 F	7.98 F	8.82 C	8.77 F	138.6 F	137.0 F
Salicylic acid 100 ppm	327.6 C	325.0 B	8.18 D	8.18 D	8.92 B	8.90 D	150.0 D	151.6 D
Salicylic acid 150 ppm	340.3 AB	338.0 A	8.31 B	8.32 B	9.10 A	9.01 B	165.3 C	160.0 B
Ascorbic acid 500 ppm	323.6 C	317.6 C	8.11 E	8.12 E	8.89 B	8.83 E	143.6 E	148.0 E
Ascorbic acid 750 ppm	335.6 B	330.6 B	8.24 C	8.27 C	8.95 B	8.95 C	156.3 C	157.0 C
Ascorbic acid 1000 ppm	342.3 A	340.3 A	8.37 A	8.38 A	9.14 A	9.12 A	170.3 A	169.6 A

Means within each column followed by the same letter (s) are not significantly different at 5% level

Fruit length (cm)

Table, 6 illustrates that the tested salicylic and ascorbic treatments exerted a positive enhancing effect on fruit length as compared with the control in both seasons. Shortly, 1000 ppm ascorbic treatment proved to be the most efficient treatments in this concern.

Fruit diameter (cm)

Table, 6 indicates that salicylic and ascorbic treatments produced higher fruit diameter than those sprayed with tap water control in both seasons of study. Moreover, 1000 ppm ascorbic treatment shows superiority in this respect. Other tested treatments occupied intermediate positions in this sphere.

Weight of fruit grains (g)

Table, 6 demonstrates that salicylic and ascorbic treatments succeeded in improving the weight of fruit grains in both seasons as compared with the control treatment. Generally, 1000 ppm ascorbic treatment gave the highest weight of fruit grains (170.3 and 169.6 g) against (135 and 136 g) for the control treatment in both seasons respectively.

Weight of 100 grains (g)
Table, 7 indicates that all tested treatments scored higher values of the weight of 100 grains as compared with the control treatment in both seasons of this study. Generally, 1000 ppm ascorbic treatment induced the highest weight of 100 grains (38.0 and 39.3 g) against (31 and 32 g) for the control treatment in both seasons respectively.

Table 7:- Effect of potassium and humic acid soil applications on some fruit physical properties and fruit total sugar content of Wonderful pomegranate trees (2017 & 2018 seasons).

	Weight of 100 arils (g)		Juice volume/fruit (cm^3)		Peel thickness (cm)		Total sugar (%)	
Treatments	2017	2018	2017	2018	2017	2018	2017	2018
Control "Tap water"	31.0 F	32.0 D	153 G	154 G	0.29 E	0.30 E	11.01 F	11.45 G
Salicylic acid 50 ppm	33.0 E	33.0 D	172 F	166 F	0.32 D	0.33 D	11.96 E	11.87 F
Salicylic acid 100 ppm	34.6 CD	36.0 C	205 D	201 D	0.35 C	0.35 BC	12.61 C	12.51 D
Salicylic acid 150 ppm	36.6 B	39.0 AB	232 B	234 B	0.37 B	0.39 A	12.89 B	12.86 B
Ascorbic acid 500 ppm	34.0 D	35.0 C	185 E	188 E	0.33 D	0.35 C	12.25 D	12.28 E
Ascorbic acid 750 ppm	35.3 C	37.6 B	222 C	216 C	0.36 BC	0.37 B	12.78BC	12.72 C
Ascorbic acid 1000 ppm	38.0 A	39.3 A	246 A	245 A	0.39 A	0.40 A	13.11 A	12.99 A

Means within each column followed by the same letter (s) are not significantly different at 5% level

Juice volume / fruit (cm^3)
Table 7 indicates that tested treatments produced a high positive effect on juice volume per fruit as compared with the control treatment both season. Generally, 1000 ppm ascorbic treatment shows superiority in this respect.

Peel thickness (cm)
Table 7 indicates that salicylic and ascorbic treatments produced a high positive effect on peel thickness in both seasons of this study. Generally, 1000 ppm ascorbic treatment gave a high positive effect on peel thickness as compared with the control treatment in this study.

Fruit total sugars content
Table 8 reveals that salicylic and ascorbic treatments produced a high positive effect on fruit total sugar content as compared with control treatment in both seasons of study. Generally, 1000 ppm ascorbic treatment shows superiority in this respect.

Fruit T.S.S. (%)
The tested concentration of salicylic and ascorbic exerted a high positive effect on fruit T.S.S. content than the control treatment in both seasons of study (Table 8). Moreover, 1000 ppm ascorbic treatment proved to be the most efficient treatments in this concern. Other treatments showed an intermediate value in this respect.

Table 8:- Effect of potassium and humic acid soil applications on some fruit chemical properties of Wonderful pomegranate trees (2017 & 2018 seasons).

	T.S.S. (%)		Acidity (%)		T.S.S./acid ratio		Ascorbic acid (mg/100 ml juice)	
Treatments	2017	2018	2017	2018	2017	2018	2017	2018
Control "Tap water"	14.33 G	14.24 G	1.64 A	1.70 A	8.65 G	8.41 G	13.94 G	14.14 G
Salicylic acid 50 ppm	14.86 F	14.85 F	1.47 B	1.58 B	10.08 F	9.37 F	14.41 F	14.79 F
Salicylic acid 100 ppm	15.41 D	15.35 D	1.34 C	1.41 D	11.40 D	10.91 D	15.07 D	15.31 D
Salicylic acid 150 ppm	15.87 B	15.75 B	1.21 E	1.25 F	12.99 B	12.66 B	15.72 B	16.09 B
Ascorbic acid 500 ppm	15.21 E	15.11 E	1.36 C	1.49 C	11.06 E	10.21 E	14.85 E	15.01 E
Ascorbic acid 750 ppm	15.52 C	15.51 C	1.28 D	1.32 E	12.12 C	11.73 C	15.36 C	15.85 C
Ascorbic acid 1000 ppm	16.21 A	16.04 A	1.10 F	1.17 G	14.58 A	13.78 A	16.51 A	16.42 A

Means within each column followed by the same letter (s) are not significantly different at 5% level

Fruit total acidity (%)
Tabulated data demonstrate that salicylic and ascorbic treatments induced a pronounced reductive effect on fruit total acidity content as compared with the control. Briefly, 1000 ppm ascorbic treatment proved to be the most efficient treatment in reducing fruit total acidity content.

Fruit T.S.S. /acid ratio
Statistical analysis indicates that salicylic and ascorbic treatments scored significantly high values of fruit TSS/acid ratio as compared with the control treatment in both seasons of study. Generally, 1000 ppm ascorbic treatment proved to be the most efficient treatment in scoring the highest values (14.58 and 13.78) against (8.65 and 8.41) for the control treatment in the first and second seasons, respectively (Table, 8).

Fruit ascorbic acid content
Tabulated data illustrate that salicylic and ascorbic treatments induced a high positive effect on fruit ascorbic acid content as compared with the control treatment. Moreover, 1000 ppm ascorbic treatment gave the highest values of fruit ascorbic acid content as compared with the control treatment throughout the two seasons of study.

The enhancement effect of salicylic acid foliar spray on fruit quality may be attributed to the salicylic acid plays a vital role in plant growth and ion uptake and transport (Hayat et al. 2010). Salicylic acid can also play a role in plant water relations, photosynthesis, ethylene biosynthesis, stomatal movement and reversing the effect of ABA on leaf abscission (Arfan et al., 2007). It enhanced the activities of antioxidant enzymes to the drought and salinity stress in plants (Hayat et al. 2008 and Yusuf et al. 2008). Salicylic acid showed a synergetic effect with auxin and gibberellins (Sanaa et al., 2006). Furthermore, salicylic acid increased leaf chlorophyll content (Abdel Aziz et al., 2017). These lead to more carbohydrate production and this reflected on fruit quality. The obtained results regarding the effect of salicylic acid on fruit quality go line with the findings of Abdel Aziz et al. (2017) on pomegranate fruits.

The enhancement effect of ascorbic acid on fruit quality may be attributed that firstly, ascorbic acid increased leaf area and leaf chlorophyll content (Azzedine, et al., 2011). That is lead to enhancement photosynthesis process (Tarrafet et al., 1999).which reflected in more carbohydrate production and consequently improved fruit quality. Secondly, ascorbic acid increased IAA content which stimulates cell division as well as cell enlargement (Hassanein et al. 2009 and Abd-El Hamid 2009). Furthermore, auxin was increased fruit quality (Ragab, 2002). Thirdly, ascorbic acid mitigates the adverse effect on plant growth by enhanced proline accumulation (Azzedine, et al., 1997). The proposed function of the accumulated proline is osmosis regulation which has an adaptive mechanism to environmental stress (Aspinall and Paleg 1981). So that the increase in proline leads to enhancement leaf chlorophyll content and that reflected in more carbohydrate production through photosynthesis process and consequently improved fruit quality. The obtained results regarding the effect of ascorbic on fruit quality go in line with the findings of Atef (2018) on pomegranate. He mentioned that foliar sprays of ascorbic improved fruit quality of pomegranate fruit.

Conclusion:-
Briefly, Spray Wonderful pomegranate trees with ascorbic at 1000 ppm twice a year i.e. at full bloom and four weeks later to enhanced tree growth, yield and fruit quality as well as it minimized both fruit cracking and sunburned fruit percentage.

Reference:-
1. A.O.A.C., 1995. Association of Official Agricultural Chemists, Official Methods of Analysis, 15th ed. A.O.A.C., Washington, DC.
2. Abada, M.A.M., Abd El- Hameed, H.M., 2010. The beneficial effects of spraying salicylic and citric acids on Flame seedless grapevines. The Sixth Inter. of Sustain Agric. And Develop. Fac. of Agric. Fayoum Univ. 27-29 December pp. 153- 164.
3. Abd-El-Hamid, E.K., 2009. Physiological effects of some phytoregulators on growth, productivity and yield of wheat plant cultivated in new reclaimed soil. PhD. Thesis, Girls College, Ain Shams Univ. Cairo, Egypt.
4. Abdel Aziz, F.H., El-Sayed, M.A. and Aly, H.A., 2017. Response of Manfalouty pomegranate trees to foliar application of salicylic acid. Assiut J. Agric. Sci., 48(2):59-74.

5. Abd-El-Rhman I. E., Attia,M. F., Eman S. El-Hady and Laila, F. H., 2017. Effect of foliar spraying of some antioxidants and micronutrients on yield, fruit quality and leaf mineral content of Manfalouty pomegranate trees (*Punica granatum* L.) grown in a calcareous soil. Middle East J. Appl. Sci., 7(4): 713-725.
6. Ahmed, F.F., Akl, A.M., Gobara, A.A.and Mansour, A.E., 1997. Yield and quality of Anna pple trees (Malusdomestica) in response to foliar application of ascorbine and citrine fertilizer. Egypt J. Hort., 25(2): 120-139.
7. Ahmed, F.F., Mohamed, M.M., Abou El- Khashab, A.M.A.andAeed, S.H.A., 2014. Controlling fruit splitting and improving productivity of Manfalouty pomegranate trees by using salicylic acid and some nutrients. World Rural Observations 6(1):87-93.
8. Alscher, R.G., Donahne, J.L.and Cromer, C.L., 1997. Reactive oxygen species and antioxidants: relationships in green cells. Physiol. Plant, 100:224–233.
9. Andrews, P.K., Johnson, J.R., Fahy, D.and Gish, N., 1999. Sunburn protection in apples with ascorbic acid. Le Fruit Belge, 481: 157–161.
10. Arfan, M., Athar, H.R. and Ashraf, M., 2007. Does exogenous application of salicylic acid through the rooting medium modulate growth and photosynthetic capacity in two differently adapted spring wheat cultivars under salt stress? J. Plan. Physiol. 6 (4): 685-694.
11. Atef, Abo-Ogiala, 2018. Managing crop production of pomegranate cv. Wonderful via foliar application of ascorbic acid, proline and glycinbetaine under environmental stresses. International Journal of Environment 7(3): 95-103.
12. Aspinall, D.andPaleg, L.G., 1981. Proline accumulation: physiological aspects. In: Paleg, L.G., Aspinall, D. (Eds.), The Physiology and Biochemistry of Drought Resistance in Plants. Academic Press, Sydney, pp. 205–241.
13. Azzedine, F., Gherroucha, H.andBaka, M., 2011. Improvement of salt tolerance in durum wheat by ascorbic acid application. J. Stress Physiol. Biochem. 7: 27-37.
14. Barth, C., Tullio, M.D. and Conklin, P.L., 2006. The role of ascorbic acid in the control of flowering time and the onset of senescence. J. Experimental Botany, 57(8): 1657-1665.
15. Duncan, D.B., 1955. Multiple range and multiple F test. Biometrics 11, 1–42.
16. Elade, Y., 1992. The use of antioxidants to control gray mould (*Botryticcibera*) and white mould (SclerotiniaAclerotiorum) in various crops, Plant Pathol., 141: 417-426.
17. El-Masry, S.E.M., 1995. Physiological Studies to Control Pomegranate Fruit Disorders. M.Sc. Thesis Faculty of Agric., Assiut Univ., Egypt.
18. El-Sayed, O.M., El-Gammal, O.H.M.andSalama, A.S.M., 2014. Effect of ascorbic acid, proline and jasmonic acid foliar spraying on fruit set and yield of Manzanillo olive trees under salt stress. ScientiaHorticulturae, 176:32–37.
19. Fayed, T.A., 2010. Effect of compost tea and some antioxidant application on leaf chemical constituents, yield and fruit quality of pomegranate. World J. Agric. Sci. 6 (4):402–411.
20. Gomez, M.L. and Lajolo, F.M., 2008. Ascorbic acid metabolism in fruits: activity of enzymes involved in synthesis and degradation during ripening in mango and guava. J. Sci. Food and Agric., 88: 756-762.
21. Hafez, O.M., Hamouda, H.A.andAbd-El - Mageed, M.A., 2010. Effect of Calcium and Some Antioxidants treatments on Storability of Le Conte Pear Fruits and its Volatile Components. Nature and Science, 8(5): 109-126.
22. Haggag, M.N. and El-Shamy, H.A., 1987. Response of fig and pomegranate fruits to NPK fertilization. Alex. J. Agric. Res. 32 (3):199–208.
23. Hassanein, R.A., Bassony, F.M., Barakat, D.M. and Khalil, R.R., 2009. Physiological effects of nicotinamide and ascorbic acid on Zea mays plant grown under salinity stress. 1- Changes in growth, some relevant metabolic activities and oxidative defence systems. Res J AgricBiol Sci., 5:72–81.
24. Hayat, S and Ahmad, A., 2007. Salicylic Acid: A Plant Hormone. Springer, Netherlands. 1–14. https://doi.org/10.1007/1-4020-5184-0
25. Hayat, S., Hasan, S.A., Fariduddin, Q.and Ahmad, A., 2008. Growth of tomato (*Lycopersiconesculentum*) in response to salicylic acid under water stress. J Plant Interact 3:297-304.
26. Hayat, Q., Hayat, S., Irfan, M.and Ahmad, A., 2010. Effect of exogenous salicylic acid under changing environment: A review. Environmental and Experimental Botany, 68: 14–25.
27. Khan, M., 2006. Effect of sea salt and l-ascorbic acid on the seed germination of halophytes. J. Arid Environ. 67:535–540.
28. Ma, F. and Cheng, L., 2004. Exposure of the shaded side of apple fruit to full sun leads to up-regulation of both the xanthophyll cycle and the ascorbate-glutathione cycle. Plant Sci., 166:1479-1486

29. Mansour, A.E.M., El-Shammaa, M.S., Shaaban, E.A.andMaksoud, M.A., 2010. Influence of some antioxidants on yield and fruit quality of four mango cultivars. Research Journal of Agriculture and Biological Sciences, 6(6):962-965.
30. Nicholas, S., 1996. The function and metabolism of ascorbic acid in plants, Annals of Botany, 78:661-669.
31. Ragab, M. M., 2002. Effect of spraying urea, ascorbic acid and NAA on fruiting of Washington Navel orange trees. M. Sc. Thesis. Fac. Agric. Minia. Univ. Egypt, Nutr. 16:163-166.
32. Romani, R. H., Hess, V. M.andLestic, C. A., 1989. Salicylic acid inhibition of ethylene production by apple discs and other plant tissues. J. Plant Growth Regulators, 8 : 62-69.
33. Roy, S.K. and Waskar, D.P., 1997. Pomegranate. In: Mitra, S.K. (Ed.), Postharvest Physiology and Storage of Tropical and Subtropical Fruits. CAB International, Wallingford.
34. Samra, N. R., EL–Kady, M. I., EL–Baz, E. E. T.andGhanem, M. S. H., 2012. Studies towards for effect of some antioxidants on yield and fruit quality of balady mandarin trees (*Citrus reticulata*blanco).J. Plant Production, Mansoura Univ., 3(1): 51-58.
35. Sanaa, A. M., Mostafa, M. A. and Shehata, S. A. M., 2006. Physiological studies on the effect of kinetin and salicylic acid on growth and yield of wheat plant. Annals Agric. Sci., Ain Shams Univ., Cairo, 51(1): 41-55.
36. Senarataa, T., Touchell, D., Bunn, E. and Dixon, K., 2004. Acetyle salicylic acid (Aspirin) and salicylic acid induce multiple stress tolerance in bean and tomato plants. Growth Refulator 30:157-161.
37. Shalata, A., Peter, M. N., 2001. Exogenous ascorbic acid (vitamin C) increases resistance to salt stress and reduces lipid peroxidation. J. Exp. Bot. 52:2207–2211.
38. Singh, S. P., 1993. Effect of non- auxinic chemicals on root formation in some ornamental plant cuttings. Adv. Hort., 3: 207-210.
39. Tarraf, S. A., Gamal El-Din, K.M. and Balbaa, L. K., 1999. The response of vegetative growth and essential oil of lemongrass (*Cymbopogon citrates*Hort) to foliar application of ascorbic acid, nicotinamid and some micronutrients. Arab Univ. of Agric. Sci., 7: 247-259.
40. Wassel, A. M. M., Ahmed, F. F., El- Mamlouk, E. A. H.andFekry, W. M. E., 2011. Relieving clusters looseness and shot berries in Red Roomy grapevines by using some antioxidants. Minia J. of Agric. Res J. develop., 3(2):205- 217.