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RESEARCH ARTICLE

EFFECT OF POTASSIUM AND HUMIC ACID ON PRODUCTIVITY AND FRUIT QUALITY OF WONDERFUL POMEGRANATE VARIETY

Amro S.M. Salama, Amin M. G. E. Shaddad and Samir M. Diab
Plant Production Department, Desert Research Center, Cairo, Egypt.

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Abstract

A two-year trial was conducted during 2017 and 2018 seasons on Wonderful pomegranate orchard about 7 years old grown in sandy soil under drip irrigation system from well at private orchard located on Cairo-Alexandria desert road (about 50km from Cairo), Egypt. Potassium fertilizer at 250 and 350g /tree/ year alone and/or humic acid at 20 and 30g/ tree/year, added as a soil application divided into two equal doses applied at two times a year in the first week of May and July in both seasons. Generally, all tested treatments enhanced leaf characteristics, yield and fruit quality traits as well as improved fruit marketable and minimized cracked fruit percentage and sunburned fruit percentage. Moreover, soil application of potassium at 350g /tree/ year combined with humic acid at 30g/tree/year, proved to be the most efficient treatment in this respect.

Introduction:-

Pomegranate (*Punica granatum* L) is belonging to the family Punicaceae and it is one of the oldest known edible fruit. Moreover, it widely cultivated as commercial orchards in Egypt. It has high adaptability to versatile conditions especially stress conditions (Haggag and El Shamy, 1987). Pomegranate is capable of growing under different agro-climatic conditions ranging from the tropical to sub-tropical (Jalikop, 2007). These differentiations make it as a favorable fruit for marginal land. It is recommended for as a resource limited farmers.

Pomegranates fruits ripen in late summer to early autumn. They are exposed throughout the summer to strong solar radiation and high temperatures where summer temperatures normally rise above 40 °C are much more vulnerable to sunburn damage and fruits cracking (Glenn et al., 2002 & Sheikh and Manjula, 2012). Cracked and sunburned fruits are considered the most important factors for the reduction of pomegranate production (Malhotra et al., 1983). Melgarejo et al. (2004) reported that cracking of the fruits of pomegranate is one of the serious problems because it causes loss of about 50 % of the fruit market value. Moreover, Sunburn damage led to losses 30 % of the harvested fruit. Racsko and Schrader (2012) found that sunburned fruit are more susceptible to cracking than non-sunburned fruit. El-Masry (1995) stated that there is no single factor that could be pointed to be the cause of fruit cracking. Furthermore, changes of peel properties and fruit volume are thought to be involved in fruit cracking. Pomegranate fruit cracking can occur as a result of the pressure of quickly expanding arils on the stretched peel (Yilmaz and Ozguven, 2006).

Recently, Wonderful pomegranate cultivar is widespread and grown in the newly reclaimed area (generally sandy soil that is poor in nutrient and holding water) under Egypt conditions. It still needs of a lot of studies towards adjusting the suitable horticultural practices that required for improving yield and fruit quality as well as reducing

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

fruit disorder such as cracked and sunburned fruits. It is well known that the growth and yield of fruit trees are affected by many factors such as tree nutritional status. Moreover, several essential elements are directly involved in plant growth and reproduction. Fertilization with these nutrients can affect fruit yield and quality (Dhillon et al., 2011). Fertilization with potassium and humic acid could be used to enhance tree productivity and reducing fruit disorders such as sunburned fruit and fruit cracking.

Potassium is a major essential nutrient it is being taken up by the crop plants in quite large quantities similar to or more than nitrogen. Moreover, potassium is not a constituent of any organic molecule or plant structure; it is involved in numerous biochemical and physiological processes and has a pivotal role plant growth, yield, quality, and stress (Cakmak, 2005). In plants, the potassium is related to the synthesis of proteins, carbohydrates, sugars, and starch storage that stimulated growth and improved utilization of water (Faquin, 1994). Moreover, potassium is the key in plant nutrient for promoting root growth, tree vigor, increasing yield, and improving fruit quality as well as enhancing plant resistance drought (Mengel and Kirkby, 1978). Wavhal et al. (1993) mentioned that fertilized pomegranate trees cv. Ganesh with 250g potassium improved vegetative growth, yield and fruit quality. In addition, Gill et al. (2013) showed that fertilized "Kandhari" pomegranate trees with potassium at 100g/tree increased tree height, leaf mineral contents, yield, and fruit quality. Moreover, Abd-Ella et al. (2010) reported that, fertilization of Arabi pomegranate with potassium improved yield, number of fruits, and fruit quality as well as enhanced marketable fruit. Hamouda et al. (2015) found that foliar application with potassium sulphate improved leaf minerals contents, yield and fruit quality moreover, it reduced fruit cracking of Manfalouty pomegranate trees.

Humic acid is a promising natural resource that can be used as an alternative to synthetic fertilizers. Moreover, it's reduces the requirement of other fertilizers to crop production. It exerts a direct effect, such as on enzymatic activities and membrane permeability and an indirect effect, mainly by changing soil structure, increasing soil aeration, and drainage (Biondi et al., 1994).Humic acid is on active constituent of organic fertilizers, and its application may be alternative to conventional soil fertilization (Karakurt et al., 2009). Humic acid enhances cell division and enlargement (Mehran et al., 2013). It has similar effect like cytokining and gibberellin on olive trees, and le-conte pear trees (Fawzi et. al., 2007). Moreover, humic acid have similar effect like IAA in plants (O'Donnell1973). Magda and Ayman (2012) found that, increasing humic acid doses from 32 to 48g/tree enhanced vegetative growth yield and fruiting parameters of Manfalouty pomegranate trees.

The aim of this work is to evaluate the effect of potassium and humic acid either alone or in combination on the growth, yield, fruit quality, sunburned fruit, fruit cracking and marketable fruits of Wonderful pomegranate variety.

Material and Methods:-

This investigation was carried out during two successive seasons 2017 and 2018 at farm located on Alexandria desert road about 50km from Cairo (latitude 30°9′ 2.92″ N, longitude 30°40′ 31.75″ E at an elevation of 200 m above sea level), Egypt. Wonderful pomegranate trees (*Punica granatum* L.) aged 7 years old grown in sandy soil, and spaced 3 x 5 m apart (280 trees / fed) 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

Forty two healthy trees, nearly uniform in shape, size, and productivity received the same horticulture practices, were subjected to seven treatments as: Control, soil application of potassium (K_2O) at 250g/tree/season, soil application of potassium (K_2O) at 350g/tree/season, soil application of humic acid at 20g/tree/season, soil application of humic acid at 30g/tree/season, soil application of potassium (K_2O) at 250g + humic acid at 20g/tree/season, soil application of potassium (K_2O) at 350g + humic acid at 30g/tree/season. Potassium applications were 250 and 350 g/tree, its equivalent to 520 and 729 g/tree from potassium sulfate (48% K_2SO_4) as a source of potassium, respectively. Potassium sulfate and humic acid were divided in two equal doses in the first week of May and July in both seasons and added as soil application in 15cm depth and 1m from the trunk at two does. The experiment was designed as randomized complete block design with three replicates for each treatment and each replicate was represented by two trees.
Response of Wonderful pomegranate trees to tested 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.

Leaf nitrogen, potassium and phosphorus content
Leaves samples were taken from non-fruiting shoots in both seasons, cleaned and dried at 70°C and digested according to Chapman and Pratt (1961). Nitrogen was determined by the micro-kjeldahl method Pregl (1945). Phosphorus percentage was determined calorimetrically using spectrophotometer 882 UV at the wave length of 660 nm according to Murphy and Riely (1962). Potassium was determined by flame-photometer according to Brown and Lilleland (1946).

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.

Fruit cracked, sunburn damage and fruit marketable
Number of cracked and sunburned fruits per tree was counted and recorded. The percentages of cracked, sunburned and Marketable fruits/tree were calculated.

Fruit physical and chemical properties
Ten fruits were taken at harvest 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), flesh (%), weight of 100 grains (g), juice volume (cm^3) per fruit, peel thickness. Furthermore, total sugar (%), total soluble solids (T.S.S.) was 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^2)
Table, 3 demonstrates that all tested treatments enhanced leaf surface area of wonderful pomegranate in 2017 and 2018 seasons as compared with control treatment. The highest leaf area was achieved by treatment of potassium fertilizer at 350g /tree / year combined with humic acid at 30g /tree / year (5.68 and 5.51 cm^2), against (4.26 and 3.75 cm^2) for the control treatment in both seasons, respectively. Other treatments produced a slight enhancing effect in this concern from the statistical standpoint.

Leaf total chlorophyll content

All tested treatments succeeded in increasing leaf total chlorophyll content as compared with the control in both seasons of study, (Table, 3). Generally, 350g potassium /tree / year combined with humic acid at 30g /tree / year treatment gave the highest leaves total chlorophyll content (61.10 and 58.60) against the control treatment (52.16 and 49.33) in both seasons, respectively.

Table 3:- Effect of potassium and humic acid soil applications on leaf characteristics of Wonderful pomegranate trees (2017 & 2018 seasons)**.**

Soil application treatments	Leaf area (cm^2)		Total chlorophyll	
	2017	2018	2017	2018
Control	4.26 G	3.75 G	52.16 D	49.33 D
250 g K /tree	4.98 D	4.89 D	56.43 C	54.23 C
350 g K /tree	5.21 C	5.05 C	58.13 B	56.60 B
20 g HA /tree	4.38 F	4.61 F	53.13 D	52.90 C
30 g HA /tree	4.54 E	4.75 E	55.50 C	53.76 C
250 g K + 20 g HA/tree	5.32 B	5.28 B	58.26 B	56.80 B
350 g K + 30 g HA/tree	5.68 A	5.51 A	61.10 A	58.60 A

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

The enhancement effect of potassium fertilizer on leaf characteristics may be attributed that potassium is related to the synthesis of carbohydrates, sugars and starch storage and this stimulated the growth and improved utilization of water (Faquin, 1994). Also, this enhancement in leaf chlorophyll content could be attributed to the increase of macronutrients uptake, especially K, N and Mg element, moreover, N and Mg nutrient are necessary for chlorophyll synthesis (Mengel and Kirkby, 1978). The obtained results of potassium fertilizer regarding their positive effect on leaf characteristics are in harmony with the findings of Wavhal et al. (1993) who mentioned that fertilized pomegranate trees cv. Ganesh with 250g potassium improved vegetative growth.

The improvement of humic acid on leaf characteristic may be attributed that application of humic acids exerts a direct effect on enzymatic activities, membrane permeability and an indirect effect mainly by changing the soil structure, increases soil aeration, and drainage (Biondi et al., 1994). Humic acid enhances cell division and enlargement (Mehran et al., 2013). Also, humic acid has similar effect like cytokining and gibberellin on olive trees, and pear trees (Fawzi et. al., 2007). Moreover, humic acids have similar effect like IAA in plants (O'Donnell,1973) that led to improve leaf area and chlorophyll content. Results of humic acid application on leaf parameters go in line with the findings of Magda and Ayman (2012) they mentioned that increasing humic acid doses from 32 to 48g /tree enhanced vegetative growth of Manfalouty pomegranate trees. Moreover, Fernández-Escobar et al. (1999) found that humic acid application improved leaf chlorophyll content in olive trees.

Leaf nitrogen, potassium and Phosphorus content

Leaf nitrogen content (%)

Table, 4 shows that all potassium fertilizers and humic acid applications alone and/or in combination gave the highest leaf nitrogen content of Wonderful pomegranate trees in both seasons. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment succeeded in increasing leaf nitrogen content in 2017 and 2018 seasons.

Leaf Phosphorus content (%)

Table, 4 illustrates that tested treatments exerted high leaf phosphorus content as compared with control in 2017 and 2018 seasons. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment surpassed other treatments in both seasons.

Leaf potassium content (%)

Table, 4 demonstrates that potassium fertilizers and humic acid applications gave high enhanced effect on leaf potassium content as compared with control treatment in both seasons. Furthermore, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment proved to be the superior treatment in this concern.

Table 4:- Effect of potassium and humic acid soil applications on mineral content of Wonderful pomegranate trees (2017 & 2018 seasons)**.**

Soil application treatments	Leaf N content (%)		Leaf P content (%)		Leaf K content (%)	
	2017	2018	2017	2018	2017	2018
Control	1.95 F	2.02 E	0.15 D	0.14 D	0.90 F	0.92 F
250 g K /tree	2.16 E	2.22 D	0.19 C	0.18 C	1.26 CD	1.30 CD
350 g K /tree	2.24 D	2.29 C	0.21 C	0.20 C	1.29 C	1.32 BC
20 g HA /tree	2.30 C	2.36 B	0.25 B	0.27 B	1.23 E	1.25 E
30 g HA /tree	2.36 AB	2.38 AB	0.33 A	0.31 A	1.25 E	1.27 DE
250 g K + 20 g HA/tree	2.34 BC	2.36 BC	0.26 B	0.28 B	1.34 B	1.35 B
350 g K + 30 g HA/tree	2.40 A	2.43 A	0.34 A	0.33 A	1.38 A	1.41 A

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

The enhancement effect of potassium fertilizer on leaf minerals content may be attributed that potassium promotes photosynthesis by improving leave chlorophyll content and the assimilated transport of the carbohydrates to the storage organs, and increased net photosynthetic rate, that led to enhance plant root uptake and improved leave mineral content (Fernández-Escobar et al.,1999). The obtained results of potassium fertilizer regarding their positive effect on leaf minerals content are in harmony with the findings of Dhakar et al. (2010). They reported that potassium application improved leaf nitrogen content on pomegranate. In addition, Mohamed et al. (2014) mentioned that potassium fertilizer enhanced Leaf phosphorus content on pomegranate. Generally, Taha et al. (2014) found that applied potassium enhanced leaf potassium content.

The improvement of humic acid on leaf minerals content may be attributed that application of humic acid stimulates the absorption of mineral elements through stimulating root growth and increases the rate of absorption of mineral ions on root surfaces as well as their penetration into the cells of the plant tissue (Biondi et al., 1994). Also, humic acid has similar effect like cytokinin and gibberellin on olive and pear trees (Fawzi et. al., 2007). Moreover, humic acid have similar effect like IAA in plants (O'Donnell, 1973). The obtained results of humic acid application on leaf minerals content are in harmony with the findings of Fernández-Escobar et al. (1999) found that humic acid application accumulates of K, B, Mg, Ca and Fe in olive leaves.

No. of fruits/tree and yield kg/tree

No. of fruits/ tree

It is clear from Table, 5 that all tested treatments trees produced higher number of fruits than those control in both seasons of study. Anyhow, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment scored 80.3 and 82.3 fruits/tree against 57.3 and 56.0 fruits /tree for control treatment in both seasons, respectively.

Table 5:- Effect of potassium and humic acid soil applications on number of fruits /tree and yield of Wonderful pomegranate trees (2017 & 2018 seasons).

Soil application treatments	No. of fruits/tree		Yield (Kg)/tree	
	2017	2018	2017	2018
Control	57.3 F	56.0 F	17.18 F	17.76 E
250 g K /tree	65.3 D	65.0 D	21.83 D	20.70 D
350 g K /tree	69.3 C	69.6 C	23.43 C	22.76 C
20 g HA /tree	61.6 E	61.3 E	19.00 F	18.26 E
30 g HA /tree	63.3 DE	63.0 DE	20.16 E	19.70 D
250 g K + 20 g HA/tree	75.6 B	78.0 B	26.50 B	25.86 B
350 g K + 30 g HA/tree	80.3 A	82.3 A	29.26 A	27.56 A

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

Yield (Kg)/ tree

Table, 5 illustrates that all tested treatments succeeded in improving tree yield as compared with the control in both seasons. Generally, 350g/tree potassium fertilizer combined with 30 g/tree humic acid treatment showed the highest tree production (29.26 & 27.56 Kg/tree) against (17.18 & 17.76 Kg /tree) for control trees in 2017 and 2018 seasons, respectively.

The enhancement of potassium fertilizer on number of fruits /tree and yield may be attributed that the physiological role of potassium in enhancing many metabolic processes such as carbohydrate formation, translocation and accumulation (Ganeshamurthy et al., 2011), which led to improve yield parameters. The obtained results regarding the effect of potassium fertilizer on number of fruits /tree and yield are in harmony with the findings of Mohamed et al. (2014) on pomegranate trees; Hamouda et al. (2015) on pomegranate trees. They mentioned that potassium fertilizer improved number of fruits per tree and yield of pomegranate.

The improvement of humic acid application on number of fruits/tree and yield may be attributed that humic acids have similar effect like auxins, (Tatini et al., 1991) and increasing nutrient uptake as well as increase in of leaf chlorophyll which leads to increase carbohydrates contents. These led to improve number of fruit/tree and yield. On the other hand, humic acid improved growth parameters and accumulation of all the macro and microelement in the fruit (Abdel Fatah et al., 2008). Those results were associated to enhancement yield. The obtained results regarding the effect of humic acid on number of fruits/tree and yield go in line with the findings of Olyaie Torshiz et al. (2017) on pomegranate.

Fruit cracked, sunburned fruit and marketable fruit

Fruit cracking (%)

Tabulated data illustrates that all tested treatments produced a pronounced negative effect on fruit cracking percentage of wonderful pomegranate trees as compared with the control in the first and second seasons. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment recorded the lowest values of fruit cracking (7.47 & 4.87 %) against (32.0 & 31.53 %) for the control treatment in 2017 and 2018 seasons, respectively.

Sunburned fruit (%)

Table, 6 shows that all tested treatments decrease sunburned fruit percentage of wonderful pomegranate trees as compared with the control in 2017 and 2018 seasons. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment exerted high reductive effect on sunburned fruit percentage as compared with other treatments in both seasons. The minimum sunburned value (7.47 and 5.39%) was observed by using 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment as compared with control treatment (14.89 and 14.09 %) for two seasons, respectively.

Marketable fruits/tree (%)

Table, 6 illustrates that all tested treatments increased the marketable fruits (%) as compared with the control in both seasons. The highest values (85.07 and 89.74 %) were obtained from 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment, while the control resulted in the lowest values (53.11 and 54.37 %) in both seasons, respectively.

Table 6:- Effect of potassium and humic acid soil applications on fruit cracking (%), sunburned fruit (%) and fruits marketable (%) of Wonderful pomegranate trees (2017 & 2018 seasons).

	Fruit cracking (%)		Sunburned fruit (%)		Fruits marketable (%)	
Soil application treatments	2017	2018	2017	2018	2017	2018
Control	32.00 A	31.53 A	14.89 A	14.09 A	53.11 D	54.37 E
250 g K /tree	21.97 B	21.53 BC	12.57 AB	13.29 A	65.46 C	65.18 D
350 g K /tree	17.30 C	15.83 D	10.96 BC	9.71 BC	71.74 B	74.46 C
20 g HA /tree	21.60 B	23.37 B	13.28 AB	12.17 AB	65.12 C	64.47 D
30 g HA /tree	16.90 C	18.60 CD	11.69 BC	10.19 B	71.41 B	71.21 C
250 g K + 20 g HA/tree	14.53 C	7.70 E	9.22 CD	7.59 CD	76.25 B	84.71 B
350 g K + 30 g HA/tree	7.47 D	4.87 E	7.47 D	5.39 D	85.07 A	89.74 A

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

The obtained results regarding the effect of potassium fertilizer on fruit cracked, sunburned fruit and enhancement of marketable fruits are in harmony of the findings of Hamouda et al. (2015) they reported that foliar application with potassium sulfate reduced fruit cracking of Manfalouty pomegranate trees.

The enhancement of humic acid on reducing fruit cracked ,fruit sunburned fruit and improvement of marketable fruits may be attributed that humic acids have similar like auxins, (Tatini et al., 1991). On the other hand, humic

acid improved growth parameters and accumulation of all the macro and microelement in fruit (Abdel Fatah et al., 2008). Results of leaf mineral analysis also support this idea, which led to reduced cracking and sunburned of fruits as well as enhancing of marketable fruit. The obtained results regarding the effect of humic acid on reduction in fruit cracking and sunburn damage as well as improvement of marketable fruit go in line with the findings of Olyaie Torshiz et al. (2017) on pomegranate. They reported that humic acid decreased fruit cracking.

Fruit physical and chemical properties

Fruit weight (g)

Table, 7 demonstrates that all tested treatments produced statistically higher positive effect on fruit weight as compared with control treatment. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment gave the highest fruit weight (353 and 351 g) against the control treatment (310 and 308 g) in both seasons, respectively.

Table 7:- Effect of potassium and humic acid soil applications on fruit weight, fruit length, fruit diameter and fruit grains weight of Wonderful pomegranate trees (2017 & 2018 seasons).

Soil application treatments	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Weight of fruit grains (g)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	310 E	308 F	7.95 E	8.29 E	8.79 E	8.94 D	140 F	138 G
250 g K /tree	324 D	323 D	8.23 D	8.38 D	8.86 D	9.02 B	153 DE	156 D
350 g K /tree	330 C	329 C	8.38 C	8.77 C	8.93 C	9.14 B	161 C	161 C
20 g HA /tee	322 D	321 E	8.28 D	8.37 D	8.90 CD	9.01 C	151 E	150 F
30 g HA /tree	325 D	325 D	8.37 C	8.37 D	8.96 BC	9.16 B	155 D	153 E
250 g K + 20 g HA/tree	342 B	340 B	8.86 B	8.90 B	9.01 B	9.23 A	171 B	173 B
350 g K + 30 g HA/tree	353 A	351 A	8.97 A	9.01 A	7.14 A	9.28 A	180 A	183 A

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

Fruit length (cm)

Statistical analysis illustrates that all tested treatments exerted a positive enhancing effect on fruit length of Wonderful pomegranate trees as compared with the control in both seasons. Shortly, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment showed highe values of fruit length throughout the two seasons of study. Other treatments scored an intermediate values in this concern.

Fruit diameter (cm)

Table, 7 indicates that the response of fruit diameter to all tested treatments scored statistically higher values of fruit diameter as compared with the control treatment in both seasons of study. Moreover, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment in the first seasons as well as 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment and 250g/tree potassium fertilizer combined with 20g/tree humic acid treatment in the second season produced the highest values of fruit diameter in both seasons. Other tested treatments occupied intermediate positions in this sphere.

Weight of fruit grains (g)

Table, 7 demonstrates that all tested treatments succeeded in improving weight of fruit grains of Wonderful pomegranate fruits in both seasons as compared with the control treatment. Moreover, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment gave the highest weight of fruit grains (180 & 183 g) against (140 & 138 g) for the control treatment in both seasons respectively. Other treatments produced an intermediate effect in this concern.

Flesh (%)

Table, 8 illustrates that in the all tested treatments produced high positive effect on flesh percentage as compared with the control treatment. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment gave a high positive effect on flesh percentage.

Weight of 100 grains (g)

Table, 8 indicates that all tested treatments scored statistically higher values of weight of 100 grains as compared with the control treatment in both seasons of this study. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment induced the highest weight of 100 grains (39 & 41 g) against (34 & 34 g) for the control treatment in both seasons respectively.

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

Soil application treatments	Flesh (%)		Weight of 100 grains (g)		Juice volume /fruit (cm^3)		Peel thickness (cm)	
	2017	2018	2017	2018	2017	2018	2017	2018
Control	45.15 E	44.80 F	34 E	34 E	151 G	158 G	0.30 F	0.31 F
250 g K /tree	47.12 D	48.19 D	35 DE	37 CD	205 D	200 D	0.35 D	0.35 DE
350 g K /tree	48.83 C	49.13 C	37 C	39 BC	217 C	212 C	0.37 C	0.38 C
20 g HA /tree	46.89 D	46.72 E	35 DE	37 D	171 F	167 F	0.34 E	0.34 E
30 g HA /tree	47.68 D	47.17 E	36 CD	38 CD	188 E	186 E	0.35 D	0.36 D
250 g K + 20 g HA/tree	49.99 B	50.92 B	38 B	40 AB	237 B	233 B	0.39 B	0.40 B
350 g K + 30 g HA/tree	51.08 A	52.32 A	39 A	41 A	267 A	262 A	0.40 A	0.42 A

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

Juice volume / fruit (cm^3)

Table, 8 indicates that all tested treatments produced a high positive effect on juice volume per fruit as compared with the control treatment in the two seasons of this study. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment induced the highest juice volume per fruit (267& 262 cm^3) against (151 & 158 cm^3) for the control treatment in both seasons respectively.

Peel thickness (cm)

Table, 8 indicates that all tested treatments produced high positive effect on peel thickness of Wonderful pomegranate fruits in both seasons of this study. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment gave a high positive effect on peel thickness as compared with the control treatment in this study.

Fruit total sugars content (%)

Table, 9 reveals that all tested treatments produced high positive effect on fruit total sugar content of Wonderful pomegranate fruits as compared with control treatment in both seasons of study. Moreover, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment produced a high positive effect on fruit total sugar content as compared with control treatment. Other tested treatments surpassed the control treatment in enhancing fruit total sugar content in both seasons.

Table 9:- Effect of potassium and humic acid soil applications on some fruit chemical properties of Wonderful pomegranate trees (2017 & 2018 seasons).

Soil application treatments	Total sugar (%)		T.S.S. (%)		Acidity (%)	
	2017	2018	2017	2018	2017	2018
Control	11.89 B	11.50 C	14.43 F	14.53 F	1.65 A	1.73 A
250 g K /tree	12.37 AB	12.38 B	15.04 E	15.28 DE	1.38 C	1.43 B
350 g K /tree	12.89 A	12.48 B	15.49 C	15.52 C	1.32 D	1.39 C
20 g HA /tree	12.36 AB	12.38 B	15.24 DE	15.21 E	1.44 B	1.45 B
30 g HA /tree	12.44 AB	12.45 B	15.37 CD	15.41 CD	1.38 C	1.40 C
250 g K + 20 g HA/tree	13.01 A	12.94 A	15.91 B	15.94 B	1.21 E	1.20 D
350 g K + 30 g HA/tree	13.14 A	13.10 A	17.26 A	17.33 A	1.10 F	1.08 E

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

Fruit T.S.S. (%)

Table, 9 indicates that all tested treatments exerted high positive effect of fruit T.S.S content than the control treatment in both seasons of study. Moreover, 350g/tree potassium fertilizer combined with 30g/tree humic acid

treatment proved to be the most efficient treatment in this concern scored (17.26 & 17.33 %) against control treatments (14.34 & 14.53 %) for control treatment in 2017 and 2018 seasons respectively. Other treatments showed an intermediate values in this respect particularly in both seasons.

Fruit total acidity content (%)

Table, 9 demonstrates that all tested treatments induced a pronounced reductive effect on fruit total acidity content as compared with the control. Briefly, 350g/tree of potassium fertilizer combined with 30g/tree humic acid treatment proved to be the most efficient treatment in reducing fruit total acidity content. Other tested treatments showed an intermediate values from the statistical standpoint.

Fruit T.S.S. /acid ratio

Statistical analysis indicates that all tested treatments scored significantly higher values of fruit T.S.S / Acid ratio as compared with the control treatment in both seasons of study. Moreover, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment proved to be the most efficient treatment in scoring the highest values (15.48 &16.04) against (8.75 & 8.40) for the control treatment in the first and second seasons, respectively, (Table, 10).

Table 10:- Effect of potassium and humic acid soil applications on T.S.S./acid ratio and fruit ascorbic acid content of Wonderful pomegranate trees (2017 & 2018 seasons).

Soil application treatments	T.S.S./acid ratio		Ascorbic acid (mg/100 ml juice)	
	2017	2018	2017	2018
Control	8.75 F	8.40 E	14.06 G	14.14 F
250 g K /tree	10.78 DE	10.65 D	14.73 E	14.67 E
350 g K /tree	11.63 C	11.16 C	15.27 C	15.31 C
20 g HA /tree	10.62 E	10.46 D	14.41 F	14.47 E
30 g HA /tree	11.11 D	11.00 C	14.84 D	14.95 D
250 g K + 20 g HA/tree	13.01 B	13.28 B	15.73 B	15.84 B
350 g K + 30 g HA/tree	15.48 A	16.04 A	16.62 A	16.35 A

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

Fruit ascorbic acid content

Table, 10 indicates that all tested treatments scored significantly high values of fruit ascorbic acid content as compared with control treatment in both seasons of study. Generally, 350g/tree potassium fertilizer combined with 30g/tree humic acid treatment proved to be the most efficient treatment of fruit ascorbic acid content (16.62 and 16.35 mg/100 ml juice) against (14.06 and 14.14 mg/100 ml juice) from the control treatment in first and second seasons, respectably.

The enhancement of potassium fertilizer on pomegranate fruit quality may be attributed that the physiological role of potassium in enhancing many metabolic processes such as carbohydrate formation, translocation and accumulation (Ganeshamurthy et al., 2011). Moreover, it plays an important role in, enzyme activation, protein synthesis, photosynthesis, and cell extension (Erner et al., 2001). That led to improved fruit quality. The obtained results regarding the effect of potassium fertilizer on fruit quality go in line with the findings of Gill et al. (2013) and Hamouda et al. (2015) on pomegranate. They mentioned that potassium fertilization improved fruit quality of pomegranate fruits.

The improvement of humic acid on fruit quality may be attributed that humic acids enhance cell division and enlargement Mehran et al. (2013). It has similar effect like cytokining and gibberellin on olive and pear trees (Fawzi et. al., 2007). Moreover, humic acid have similar effect like IAA in plants (O'Donnell., 1973). Humic acid increased nutrient uptake as well as increased leaf chlorophyll which led to increased carbohydrates contents and caused enhancement of fruit quality. The obtained results regarding the effect of humic acid on fruit quality go in line with the findings of Magda and Ayman (2012) they found that humic acid enhanced fruits quality of Manfalouty pomegranate trees. The same results were noticed when humic acid applied on apricot fruits, it enhanced T.S.S and decreased acidy (Fathy et al., 2010).

Conclusion:-

Thereupon it is preferable to added soil application of potassium at 350g /tree/ year combined with humic acid at 30g/tree/year, added as a soil application divided into two equal doses applied at two times a year in the first week of May and July in both seasons. It enhanced growth, yield and fruit quality as well as minimized fruit cracking and sunburned fruit percentages.

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