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RESEARCH ARTICLE

IMPACT OF SUSTAINED DEFFICIT IRRIGATION AND FOLIAR SPRAY OF ASCORBIC ACID ON PRODUCTIVITY AND PEEL DISORDERS OF WONDERFUL POMEGRANATE TREES

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Abstract

The investigation was carried out during 2017and 2018 seasons on Wonderful pomegranate trees grown at private orchard located on "Cairo-Alexandria Desert" road about 50 Km from Cairo, Egypt. Trees planted at 3x5 meters apart in sandy soil and watered from wells using drip irrigation system. The trial was a factorial experiment, hence sustained deficit irrigation100%, 80% and 60% from crop evapotranspiration (ETc) throughout season, the occupied main plot, whereas foliar sprays of ascorbic acid treatments at 0, 500, 750 and 1000 ppm /tree located in the subplots were carried out two times, the first foliar spray was done at full bloom and the second one was performed four weeks later. The results showed that leaf characteristics (leaf area and total chlorophyll), number of fruits per tree, yield and fruit quality traits (weigh, length, diameter, weight of fruit grains, flesh percentage, weight of 100 grains and juice volume) recorded the highest values with higher both irrigation level and sprays of ascorbic acid treatments. On the contrary fruits cracked percentage and fruits sunburned percentage, peel thickness, total sugar, TSS, TSS/acidity, ascorbic acid and water used efficiency showed an adverse correlation with irrigation level. Also, spraying by ascorbic acid is reducing number of fruit cracked, number of sunburned fruits and acidity. On other hand, peel thickness, total sugar, TSS, TSS/acidity and ascorbic acid concentration were increasing. Therefore, sustained deficit irrigation is considered to be an effective strategy for arid and semi-arid regions, moreover ascorbic acid may be used to prevent or mitigate oxidative damage caused by sustained deficit irrigation.

Introduction:-

Pomegranate (*Punica granatum* L.) is belonging to the family Punicaceae and it is one of the oldest known edible fruit. It is considered as an important fruit crop of arid and semi-arid regions. It is recommended for a resource limited farmers. Wonderful pomegranate cultivar is considered one of the most important pomegranate cultivars grown successfully on new reclaimed soils.

Water scarcity is become the one of the main factors limiting agricultural development in Egypt. And agriculture activity will suffer from water shortage currently and in the future irrigation. In addition, irrigation water is limited in most new reclaimed regions. Water scarcity has become a challenge for agricultural production. In this case,

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deficit irrigation is an ideal water saving technique when applied on many fruit orchards. Deficit irrigation has been widely investigated as a valuable strategy under water scarcity (Pereira et al., 2002), reducing agricultural water use (Fereres and Soriano, 2007), for dry region (English, 1990 and Fereres et al., 2003). Deficit irrigation mean the water is applied at rate less than the need of crop evapotranspiration (ETc). The adoption of deficit irrigation by farmers is one of the options that can help to save irrigation water under desert conditions. In irrigated fruit trees, deficit irrigation strategy has been proposed to save water without major effects on yield (Chalmers et al., 1981). Deficit irrigation caused a significant decrease in crop yield compared to full irrigation (Tavousi et al., 2015). Intrigliolo et al. (2012) showed that deficit irrigated treatments allowed increasing water use efficiency. Ghanbarpour et al. (2018) indicated that fruit cracking in the pomegranate cultivar dependent on irrigation. Fruit cracking is a serious problem in pomegranate orchard as it causes about 50% of fruit marketing value (El-Masry, 1995). Vegetative growth and fruits quality were significantly affected by levels of soil moisture of field capacity (Abdel-Sattar and Mohamed, 2017). Water deficit stress induces numerous biochemical and physiological responses in plants (Pattangual and Madore, 1999). Zahedi and Moghadam (2011) reported that antioxidant enzymes activity was increased when plants were exposed to water deficit. Under conditions of water deficit, reactive oxygen species (ROS), such as superoxide anion radicals, hydrogen peroxide and hydroxyl radicals, are generated (Zhu, 2000). Plant cells contain an array of protection mechanisms and repair systems that can minimize the occurrence of oxidative damage caused by reactive oxygen species (Abdel Latef, 2010). To prevent or mitigate oxidative damage from ROS, plant cells possess a enzymatic antioxidant system that includes tocopherols and ascorbic acid.

Antioxidants such as ascorbic acids are safe to human and environment (Elade, 1992). It has also been reported that application of exogenous ascorbic can reduce oxidative stresses (Shalata and Neumann, 2001). It is considered as an antioxidant and association with other components of the antioxidant system. It protects plants against oxidative damage (Smirnoff, 1996). Ascorbic has been shown to play multiple roles in plant growth, such as in cell division, cell wall expansion and other developmental processes (Lee and Kader, 2000 &Pignocchi and Foyer, 2003). Moreover, ascorbic acid functions as enzymatic cofactor, and it plays important roles in many physiological processes, including photosynthesis, photo-protection, stress resistance, biosynthesis of hormones and cell wall constituents (Davey et al., 2000 & Conklin and Barth, 2004). Ascorbic acid has auxinic action. It has a synergistic effect on improving growth, flowering, yield and fruit quality of fruit crops (Barth et al., 2006). 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 ascorbic acid improved growth, yield fruit quality of Wonderful pomegranate trees.

The aim of this study is to investigate the effect of foliar ascorbic acid under sustained deficit irrigation on vegetative growth, yield and fruit quality as well as water used efficiency of Wonderful pomegranate trees.

Material and Methods:-

This investigation was carried out during two successive seasons 2017 and 2018 at orchard located on "Cairo-Alexandria desert" road about 50 km 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).

This experiment was considered a Factorial design, the sustained deficit irrigation (SDI) (60%, 80% and 100% of ETc) being the first factor and ascorbic acid (AsA) foliar sprays (0, 500, 750 and 1000 ppm) the second factor, with three replicates for each treatment and each replicate was represented by two plants.

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

Irrigation treatments were applied from 1st February and continued until 20th September, then stopped until harvest date 5th October, after that completed irrigation until the end of October for both seasons, and was programmed twice per week during the afternoon based on calculation crop evapotranspiration (ETc) which was done by using the following method:

Water requirement for irrigation was calculated as potential crop evapotranspiration (ETc), based on climatic data obtained from Central Lab. for Agricultral Climate, using CROPWAT computer program. The reference evapotranspiration ETo, was calculated by Penman–Monteith equation (Allen et al., 1998). Then the crop evapotranspiration (ETc) was calculated by using the following formula according to Doorembos and Pruitt (1977).

$$ETc = ETo \times Kc \qquad (mm.day-1) \qquad (1)$$

Where:

ETo = Reference crop evapotranspiration ($mm.day^{-1}$) , Kc= Crop coefficient according to (Intrigliolo et al., 2011).

Then irrigation requirements (IR) were calculated by using the following equation

$$IR = ETc \times Kr \times Pw \times Ea \times Ec \quad (2)$$

Where: Kr = Reduction coefficient, Pw: Rate wit soil = 0.40 under drip irrigation system, Ea: Irrigation application = 0.85, Ec: Conveyance efficiency = 0.90

$$Kr = 2C/100 \qquad (3)$$

$$C = ¾ \times \pi \times a \times b^2 (4)$$

When (a) is of canopy height (m), and (b) is half of canopy spread (m) according to Westwood (1993)

The four treatments regarding ascorbic acid spraying were: control tap water, , ascorbic acid as foliar sprays at 500 ppm, ascorbic acid as foliar sprays at 750 ppm, ascorbic acid as foliar sprays at 1000 ppm. Were carried out two times, the first foliar spray was done at full bloom and the second one was performed four weeks later, in both seasons. 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 per tree) at the previously mentioned dates. This study is considered a factorial experiment hence a split plot is devoted to the sustained deficit Irrigation as main plot whereas ascorbic acid foliar occupied sub-plot. The element of each factor was replicated three times.

Seventy two healthy trees, nearly uniform in shape, size, and productivity received the same horticulture practices were subjected to the tested sustained deficit irrigation and ascorbic acid treatments and 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.

Number 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 and sunburned fruits

Number of cracked and sunburned fruits per tree was counted and recorded.

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).

Water use efficiency (kg/m^3)

Water use efficiency (WUE) was defined as kilograms of fruits per one cubic meter of water consumed. It was calculated during two seasons, according to (Yaron et al., 1973) as follow:

$$WUE = \frac{Y}{cu} \qquad (Kg.m^{-3}.tree^{-1}) \qquad (5)$$

Where: WUE = Water use efficiency ($kg.m^{-3}.tree^{-1}$), Y = Seasonal yield, ($kg.tree^{-1}$), CU = Water consumptive use, ($m^3.tree^{-1}$)

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 illustrate that significant differences were noticed between the tested irrigation levels. However, under sustained deficit irrigation treatments level 100% irrigation resulted the highest increment in the leaf area value followed descending by 80% and 60% irrigation treatment in both two seasons, respectively.

Moreover, spraying treatments of ascorbic acid increased leaf area as compared with the control in both seasons of study; the highest leaf area was recorded with ascorbic acid foliar spray at 1000 ppm treatment followed ascorbic acid at 750 ppm treatment and ascorbic acid at 500 ppm and control (tap water), respectively.

However, the interaction between the two tested factors showed that irrigation at 100%support with ascorbic acid foliar spray at 1000 ppm recorded the highest value on the leaf area value (5.56 and 5.45 cm^2) followed descending by ascorbic acid foliar spray at 750 ppm (5.28 and 5.05cm^2) ascorbic acid foliar spray at 500 ppm treatment (4.76 and 4.58 cm^2) and control (tap water) (4.23 and 3.93 cm^2) in both two seasons, respectively. The same trend noticed with other levels irrigation 80% or 60%. In the other side, irrigation treatment at 100% combined with spraying ascorbic acid at 1000 ppm proved to be the best interaction in this regard.

Leaf total chlorophyll content

Table, 3 shows that 100% level of irrigation gave the highest value of total chlorophyll followed by 80% in descending order. Meanwhile, the lowest total chlorophyll value was recorded with 60% irrigation in both seasons.

In addition, the highest total chlorophyll value was recorded with 1000 ppm ascorbic acid while control treatment recorded the lowest values in this respect. Moreover, no significant differences were noticed between ascorbic acid treatments at 750 and 500 ppm.

Irrigation levels with spray treatments showed that irrigation at 80% with ascorbic acid foliar spray at 1000 ppm gave high value in total chlorophyll (57.36, and 58.16) followed descending by ascorbic acid foliar spray at 750 ppm (54.47, and 55.20) ascorbic acid foliar spray at 500 ppm treatment (53.33and 52.93) and control (tap water) (47.66 and 47.67) in both two seasons, respectively in this regard. The same trend noticed with other levels irrigation 100% or 60%.

The combined effects of irrigation levels with spray treatments showed that 100% irrigation level with ascorbic acid at 1000 ppm was the most effective treatment in increasing total chlorophyll, finally irrigation level at 60% combined with control treatment resulted in less effective in total chlorophyll.

Table 3:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on leaf characteristics of Wonderful pomegranate trees (2017 & 2018 seasons).

	Leaf area (cm^2)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	4.23 h	4.76 f	5.28 d	5.56 a	4.95 A	3.93 e	4.58 d	5.05 c	5.45 a	4.75A
Irrigation 80%	4.19 hi	4.71fg	5.22 de	5.49 b	4.90 B	3.92 e	4.56 d	5.02 c	5.41ab	4.72 B
Irrigation 60%	4.15 i	4.66 g	5.16 e	5.42 c	4.84 C	3.91 e	4.54 d	4.99 c	5.37 b	4.70 C
Mean	4.19 D	4.71 C	5.22 B	5.49 A		3.92 D	4.56 C	5.02 B	5.41 A	
	Total chlorophyll									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	47.91c	53.63b	54.82b	57.77 a	53.54A	47.92 e	53.23d	55.55abcd	58.56a	53.82A
Irrigation 80%	47.66c	53.33b	54.47b	57.36 a	53.21B	47.67 e	52.94d	55.20abc	58.17ab	53.49B
Irrigation 60%	47.42c	53.03b	54.12b	56.96 a	52.89C	47.41 e	52.63d	54.85 cd	57.76abc	53.16C
Mean	47.6C	53.33B	54.47B	57.36A		47.67D	52.93C	55.20 B	58.16 A	

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

The obtained results regarding the effect of sustained deficit irrigation on leaf characters go in line with the findings of Khattab et al. (2011) and Haneef et al. (2014) on pomegranate trees. They indicated that high irrigation level was increased leaf area. Abo-Taleb et al. (1998) mentioned that chlorophyll (a & b) of pomegranate trees decreased under severe water stress.

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 may serve as a potential growth regulator to enhance stress resistance in several species (Shalata and Peter, 2001 and Khan, 2006). Foliar application of ascorbic acid increased 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 El-Sayed et al. (2014) mentioned that ascorbic acid treatments enhanced leaf area and total chlorophyll of Manzanillo olive trees. Atef (2018) showed that foliar sprays with ascorbic acid enhanced growth parameters of "Wonderful" pomegranate trees.

No. of fruits/tree and yield kg/tree

No. of fruits/ tree

Table, 4 indicates that irrigation level at 100% recorded the highest number of fruits per tree followed irrigation level at 80% and irrigation level at 60%, respectively in both seasons.

Furthermore ascorbic acid 1000 ppm treatment gave the highest increment in number of fruits per tree followed by ascorbic acid at 750 ppm, ascorbic acid at 500 ppm and control treatment.

Meanwhile, the interaction between irrigation and spraying treatments revealed that the highest number of fruits per tree value was recorded with irrigation level at 100% combined with spraying ascorbic acid at 1000 ppm. On the contrary, the combination between 60% irrigation level and tab water foliar spray gave the least positive effect on increment on the number of fruits per tree. Irrigation level at 60% with spray treatments ascorbic acid at 1000 ppm proved to be effective interaction in increasing number of fruits per tree (69.83and 67.83) followed descending by ascorbic acid foliar spray at 750 ppm (65.0 and 57.66) ascorbic acid foliar spray at 500 ppm treatment (57.5 and 52.16) and control (tap water) (52.0 and 46.33) in both two seasons, respectively in this respect. The same trend noticed with other levels irrigation 100% or 80%.

Table 4:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on No. of fruits/tree and Yield (kg)/tree of Wonderful pomegranate trees (2017 & 2018 seasons).

	No. of fruits/tree									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	56.0 hi	62.5 f	71.0 c	76.83 a	66.58 A	50.33 I	57.16 f	63.66 d	74.83 a	61.50A
Irrigation 80%	54.0 ij	60.0 g	68.0 d	73.33 b	63.83 B	48.34 j	54.67 g	60.67 e	71.33 b	58.75 B
Irrigation 60%	52.0 j	57.5 h	65.0 e	69.83cd	61.08 C	46.33 k	52.16 h	57.66 f	67.83 c	56.00 C
Mean	54.0 D	60.0 C	68.0 B	73.33 A		48.33 D	54.67 C	60.67 B	71.34 A	
	Yield (kg)/tree									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	18.32 fg	22.50bc	24.67 b	27.5 a	23.25 A	18.00 d	21.50 c	25.32 b	28.51 a	23.33A
Irrigation 80%	16.33 h	20.00def	21.67 cd	24.0 b	20.50 B	16.00 e	19.00 d	22.33 c	25.00 b	20.58 B
Irrigation 60%	14.31 i	17.50 gh	18.66efg	20.5 de	17.75 C	14.00 f	16.50 e	19.31 d	21.50 c	17.83 C
Mean	16.33D	20.00 C	21.67 B	24.0 A		16.00 D	19.00 C	22.32 B	25.00 A	

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

Yield (Kg) / tree

It is clear from Table, 4 that significant differences on tree yield were resulted negatively by reducing irrigation rate. However, irrigation level at 100% produced the highest yield as compared with those given by a reduction 60% in both seasons. On the other hand, a reduction 80% gave an intermediate effect in this respect in both seasons.

Furthermore, Table, 4 shows that spraying ascorbic acid at 1000 ppm gave the highest increment in yield (24 and 25 kg/tree) followed by ascorbic acid at 750 ppm (21.67 and 22.32 kg/tree) , ascorbic acid at 500 ppm (20 and 19 kg/tree) and control treatment (16.33 and 16.0 kg/tree) respectively in the two seasons.

In addition, irrigation at 100% combined with ascorbic acid foliar spray at 1000 ppm proved to be the most effective treatment in improving yield (kg)/tree (27.5, and 28.51 kg/tree) followed descending by ascorbic acid foliar spray at 750 ppm (24.67 and 25.32 kg/tree) ascorbic acid foliar spray at 500 ppm treatment (22.5 and 21.5 kg/tree) and control (tap water) (18.32 and 18.0 kg/tree) in both two seasons, respectively in this regard. The same trend noticed with other levels irrigation 80% or 60%.

The obtained results regarding the effect of sustained deficit irrigation on yield go in line with the findings of Khattab et al. (2011) mentioned that high irrigation level increased yield of pomegranate trees. Abd-Ella (2011) found that high irrigation level enhanced yield of pomegranate trees. Abdel-Sattar and Mohamed (2017) pointed that the treatment of 100% field capacity gave the highest yield value of pomegranate trees. Haneef et al. (2014) showed that irrigation level (100%) registered maximum number of fruits and yield of 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. The obtained results regarding the effect of ascorbic acid on yield go in line with the findings of Fayed (2010) on pomegranate treesand Abd-El-Rhman et al. (2017) on "Manfaloty" pomegranate trees and Atef (2018) on "Wonderful" pomegranate trees.

Fruits cracked and fruit sunburned percentages

Fruit cracked percentage.

Table, 5 illustrates that under sustained deficit irrigation, reduction irrigation at 60% recorded the lowest fruit cracked percentage compared with those given full irrigation level in both seasons. On the other hand, reduction 80% irrigation level of gave an intermediate effect in this respect.

Moreover, ascorbic acid treatments reduced fruit cracked percentage as compared with the control in both seasons. 1000 ppm of ascorbic acid treatment recorded the lowest values of fruit cracked percentage tree against for the control treatment in two seasons.

The interaction between the two tested factors indicated that sustained deficit irrigation combined with ascorbic acid spraying treatments succeeded in reducing fruit cracked percentage in both seasons. Shortly, reduction of irrigation 60 % treatment combined with 1000 ppm ascorbic acid treatment reduced of fruit cracked percentage in this concern.

AS while, 1000 ppm of ascorbic acid treatment with any of irrigation levels (100% , 80% and 60%) recorded the lowest values of fruit cracked percentage against for the control treatment control with any of irrigation levels (100% , 80% and 60%) in two seasons.

Table 5:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on fruits cracked percentage and fruits sunburned percentage of Wonderful pomegranate trees (2017 & 2018 seasons).

	Fruits cracked percentage									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	34.73 a	24.82d	19.23 g	14.85 j	23.41A	32.42 a	27.10 d	21.36g	12.89 j	23.45 A
Irrigation 80%	33.33 b	23.33e	17.63 i	13.15 k	21.86 B	31.02 b	25.60 e	19.76h	11.19 k	21.89 B
Irrigation 60%	31.93c	21.82 f	16.03 i	11.45 l	20.31 C	29.62 c	24.10 f	18.16 i	9.49 l	20.35 C
Mean	33.33 A	23.32B	17.63 C	13.15D		31.20A	25.60B	19.76C	11.19D	
	Fruit sunburned percentage									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	16.20 a	13.70 c	11.38de	9.40 f	12.67A	15.87a	14.89 b	13.13 c	11.50 d	13.85 A
Irrigation 80%	14.80b	12.20 d	9.78 f	7.70 g	11.12B	14.47b	13.39 c	11.53 d	9.80 e	12.30 B
Irrigation 60%	13.40 c	10.70 e	8.18 g	6.01 h	9.57 C	13.07c	11.89 d	9.93 d	8.10 f	10.75 C
Mean	14.80A	12.20 B	9.78 C	7.70 D		14.47A	13.39 B	11.53 C	9.80 D	

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

Fruits sunburned percentage.

Table, 5 shows regulated deficit irrigation treatments. Irrigation level at 60% reduced of fruits sunburned percentage as compared with the irrigation level at 80% and irrigation level at 100% treatments in the both seasons of this study.

Moreover, Ascorbic acid treatments scored comparatively lower values of sunburned percentage than did control treatments. In this respect, 1000 ppm ascorbic acid treatment recorded the lowest values of sunburned percentage against for the control treatment in two seasons.

The interaction between the two tested factors showed irrigation level at 60% combined with ascorbic acid at 1000 ppm high reductive effect on sunburned percentage and surpassed other combinations in reducing sunburned percentage in both seasons.

High level of ascorbic acid at 1000 ppm combined with any of irrigation levels (100%, 80% and 60%) reductive effect on sunburned percentage as compared with the control treatment combined with same irrigation levels previously in both seasons of study.

The obtained results regarding the effect of sustained deficit irrigation on cracked and sunburned fruits go in line with the findings of Khattab et al. (2011). They indicated that high irrigation level increased fruit cracking but low irrigation level gave the lowest fruit cracking of pomegranate trees. Ghanbarpour et al. (2018) indicated that fruit cracking in the pomegranate cultivar dependent on irrigation. In addition, deficit irrigation caused a significant decrease in crop yield compared to full irrigation of pomegranate trees (Tavousi et al., 2015).

The positive effect of ascorbic acid in reducing cracked and sunburned fruits may be attributed that ascorbic acid has catch all free radicals produced during plant metabolism (Nichloas, 1996). Ascorbic acidincreased IAA content, which stimulates cell division as well as cell enlargement and this in turn in improved plant growth (Hassanein et al., 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, ascorbic acid reduces sunburn damage in fuji apples (Andrews et al., 1999). The obtained results regarding the effect of ascorbic acid on fruit cracking and sunburned fruits 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, it was reduced fruit splitting of Manfalouty pomegranate (Ahmed et al., 2014), and Abd-El-Rhman et al., (2017) pointed out that foliar spray ascorbic acid reduced fruit cracked percentage of Manfalouty pomegranate trees.

Fruit physical and chemical properties

Fruit weight (g)

Data presented in Table, 6 indicated that the highest increment in fruit weight values were recorded with 100% irrigation followed by reduction irrigation at 80% and 60%, respectively.

Furthermore, the highest increments fruit weight values were recorded with ascorbic acid at 1000 ppm followed by ascorbic acid at 750 ppm compared to control treatment in both seasons.

The interaction effect of irrigation and spray treatment proved that the highest fruit weight values were scored with irrigation level at 100% plus ascorbic acid at1000 ppm, while the lowest values were recorded with irrigation level at 60% with control treatment.

Table 6:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on fruit weight (g) and fruit length (cm)of Wonderful pomegranate trees (2017 & 2018 seasons).

	Fruit weight (g)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	312.20g	334.87d	346.87ab	353.53 a	336.87A	306.20 e	328.87c	341.87c	351.53a	332.12A
Irrigation 80%	301.00h	323.67 f	335.67cd	342.33 bc	325.67B	295.00 f	317.67d	330.66c	340.33b	320.92B
Irrigation 60%	289.80i	312.47g	324.47ef	331.13de	314.47C	283.80g	306.47e	319.47d	329.13c	309.72C
Mean	301.00D	323.67C	335.67 B	342.33 A		295.00D	317.67C	330.68B	340.33A	
	Fruit length (cm)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	8.40 d	8.63 c	8.77 b	8.89 a	8.67 A	8.41 d	8.64 c	8.79 b	8.90 a	8.68 A
Irrigation 80%	7.88 g	8.11 g	8.24 e	8.37 d	8.15 B	7.89 h	8.12 g	8.27 f	8.38 e	8.16 B
Irrigation 60%	7.36 j	7.59 i	7.72 h	7.85 g	7.63 C	7.37 l	7.60 k	7.75 j	7.86 i	7.64 C
Mean	7.88 D	8.11 C	8.24 B	8.38 A		7.89 D	8.12 C	8.27 B	8.38 A	

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

Fruit length (cm)

Table, 6 demonstrates that increasing irrigation level from 60% and 80% to 100 % cause a steady increase in fruit length in both seasons.

Furthermore, it is clear that 1000 ppm ascorbic acid treatment recorded the highest fruit length followed by 750 ppm ascorbic acid, 500 ppm ascorbic acid and control treatments, respectively.

Moreover, the interaction between irrigation levels and spraying ascorbic acid treatments showed that irrigation level at 100% supplemented with ascorbic acid at 1000 ppm spraying treatment scored the highest values of fruit length while the lowest value was recorded with the combination of irrigation level at 60% and control treatment. Other interaction scored in between rather in this respect.

Fruit diameter (cm)
Table, 7 illustrates that 100% irrigation gave the highest fruit diameter followed discerningly by 80% irrigation level. Meanwhile, irrigation at 60% recorded the lowest fruit diameter.

Furthermore, it is evident that the highest fruit diameter was recorded with ascorbic acid at 1000 ppm followed by ascorbic acid at 750 ppm as compared to control treatment.

In addition, irrigation at 100% combined with ascorbic acid at 1000 ppm spraying treatment proved to be the most effective treatment in improving fruit diameter. On the contrary, reduction irrigation at 60% of (ETc) combined with spray treatment control gave comparatively the lowest values in this respect.

Weight of fruit grains (g)
Table, 7 shows that 100% level of irrigation gave the highest weight of fruit grains followed by descending that irrigation level at 80%. Moreover, reducing that irrigation level at 60% has recorded the lowest of weight of fruit grains.

Furthermore spraying treatment ascorbic acid at 1000 ppm treatment induced the highest weight of fruit grains followed by ascorbic acid at 750 ppm, ascorbic acid at 500 ppm treatments and control treatment in descending order.

In addition, irrigation at 100% combined with ascorbic acid at 1000 ppm spraying treatment proved to be the most effective treatment in improving weight of fruit grains. On the contrary, 50% irrigation combined with tab water spray treatment gave comparatively the lowest values in this respect.

Table 7:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on fruit diameter (cm) and weight of fruit grains (g) of Wonderful pomegranate trees (2017 & 2018 seasons).

	Fruit diameter (cm)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	8.92 f	9.04 d	9.08 c	9.28 a	9.08 A	8.84 D	8.98 C	9.10 B	9.27 A	9.05 A
Irrigation 80%	8.77 h	8.89 g	8.93 f	9.13 b	8.93 B	8.69 F	8.83DE	8.95 c	9.12 B	8.90 B
Irrigation 60%	8.62 j	8.74 i	8.78 h	8.98 e	8.78 C	8.54 G	8.68 f	8.80 e	8.97 C	8.75 C
Mean	8.77 D	8.89 C	8.93 B	9.14 A		8.69 D	8.83 C	8.95 B	9.12 A	
	Weight of fruit grains (g)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	142.0 h	150.67 e	163.34 c	177.33 a	158.33A	141.0 f	155.0 d	164.0c	176.67 a	159.17A
Irrigation 80%	135.0 j	143.68g	156.33d	170.34b	151.33B	134.0g	148.0 e	157.0d	169.67b	152.18B
Irrigation 60%	128.0 k	136.66 i	149.34 f	163.34 c	144.33C	127.0h	141.0 f	150.0e	162.67 c	145.16C
Mean	135.0 D	143.67C	156.33B	170.33A		136.0D	148.0C	157.0B	169.67A	

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

Flesh (%)
Data presented in Table, 8 shows that the highest increment in flesh percentage values were recorded with 100% irrigation followed by irrigation at 80% and 60%, respectively.

Furthermore, the highest increments flesh percentage values were recorded with ascorbic acid at1000 ppm followed by ascorbic acid at 750 ppm, ascorbic acid at 500 ppm and control treatments, respectively in the two seasons.

The interaction effect of irrigation and spray treatment proved that the highest flesh percentage values were scored with irrigation level at 100% plus ascorbic acid at1000 ppm, however, the lowest values were recorded with irrigation level at 60% with control treatment.

Table 8:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on flesh (%) and weight of 100 grains (g) of Wonderful pomegranate trees (2017 & 2018 seasons).

	Flesh (%)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	44.64ef	45.51de	47.69 c	50.87a	47.18A	45.22 i	47.70de	48.60cd	50.97 a	48.12A
Irrigation 80%	43.52gh	44.39fg	46.57 d	49.75b	46.06B	44.10 j	46.58fg	47.48ef	49.85 b	47.00 B
Irrigation 60%	42.40 i	43.27 hi	45.45ef	48.63c	44.94C	42.98k	45.46hi	46.36gh	48.73 c	45.88C
Mean	43.52 D	44.39 C	46.57B	49.75A		44.10D	46.58C	47.48 B	49.85A	
	Weight of 100 grains (g)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	36.00 e	39.00 h	40.33 b	43.00 a	39.58 A	37.00 d	40.00 c	42.66 b	44.33 a	41.00 A
Irrigation 80%	31.00 c	34.00 f	35.33 e	38.00 d	34.58 B	32.00 f	35.00 e	37.66 d	39.33 c	36.00 B
Irrigation 60%	26.00 j	29.00 i	30.33 h	33.00 g	29.58 C	27.00 h	30.00 g	32.66 f	34.33 e	31.00 C
Mean	31.00 D	34.00 C	35.33 B	38.00 A		32.00 D	35.00 C	37.67 B	39.34 A	

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

Weight of 100 grains (g)
Table, 8 indicates that increasing irrigation level and ascorbic acid spraying rate treatments results in increasing weight of 100 grains in the both seasons.

Furthermore, irrigation level at 100% plus ascorbic acid at 1000 ppm spraying treatment proved to be the most effective combination in this respect in two seasons.

Juice volume / fruit (cm ^{3})
Table, 9 shows that juice volume per fruit was significantly affected by irrigation levels and spraying treatments. Irrigation level of 100% gave the highest juice volume per fruit followed by irrigation at 80% and 60% in both seasons.

Concerning ascorbic acid spraying treatments the highest juice volume per fruit was recorded with ascorbic acid at 1000 ppm followed by ascorbic acid at 750 ppm, ascorbic acid at 500 ppm and control treatments, respectively.

Irrigation level at 100% with ascorbic acid at 1000 ppm spraying treatment proved to be the most effective interaction in increasing juice volume per fruit. On the contrary, irrigation level at 50% combined with tab water spraying treatment gave comparatively the lowest value in this concern.

Table 9:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on Juice volume/fruit (cm^3) and Peel thickness (cm) of Wonderful pomegranate trees (2017 & 2018 seasons).

	Juice volume/fruit (cm^3)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	160.0 j	192.0 g	229.0 d	253.0 a	208.50A	161.0 j	195.0 g	223.67d	252.67 a	208.08A
Irrigation 80%	153.0 k	185.0 h	222.0 e	246.0 b	201.51B	154.0 k	188.0 h	216.67e	245.66b	201.08B
Irrigation 60%	146.0 l	178.0 i	215.0 f	239.0 c	194.50C	147.0 l	181.0 i	209.66e	238.67 c	194.08C
Mean	153.0D	185.0 C	222.0 B	246.0A		154.0D	188.0 C	216.67B	245.67A	
	Peel thickness (cm)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	0.26 f	0.30 e	0.33 d	0.36 c	0.31 C	0.27 h	0.32 f	0.34 de	0.37 c	0.32 C
Irrigation 80%	0.29 e	0.33 d	0.36 c	0.39 b	0.34 B	0.30 g	0.35 d	0.37 c	0.40 b	0.35 B
Irrigation 60%	0.32 d	0.36 c	0.39 b	0.42 a	0.38 A	0.33 ef	0.40 b	0.38 c	0.43 a	0.38 A
Mean	0.29 D	0.33 C	0.36 B	0.39 A		0.30 D	0.35 C	0.37 B	0.40 A	

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

Peel thickness (cm)

Data presented in Table, 9 shows that the highest increment in peel thickness values were recorded with irrigation level at 60% followed by irrigation level at 80% and irrigation level at 100%, respectively.

Furthermore, the highest increments peel thickness values were recorded with ascorbic acid at 1000 ppm followed by ascorbic acid at 750 ppm as compared to control treatments in both seasons.

The interaction effect of irrigation and spray treatment proved that the highest peel thickness values were scored with irrigation at 60% plus ascorbic acid at 1000 ppm, whilst the lowest values were recorded with irrigation at 100% with control treatment.

Fruit total sugars content

Table, 10 illustrate that irrigation level at 60% resulted the highest total sugar value followed descending by 80% and 100% irrigation in the two seasons, respectively. However, significant differences were noticed between the tested sustained deficit irrigation levels.

Moreover, the highest total sugar was recorded with ascorbic acid at1000 ppm followed by ascorbic acid at 750 ppm, ascorbic acid at 500 ppm and control spraying treatments, respectively.

Concerning the interaction between the tested irrigation levels, and spraying treatments, 60% irrigation level combined with ascorbic acid at 1000 ppm spraying treatment proved to be the best interaction in this regard.

Fruit T.S.S. (%)

Table, 10 shows that TSS significantly affected by irrigation and spraying treatments. Irrigation level of 60% gave the highest TSS followed by irrigation level at 80% and 100%.

Concerning spraying treatments the highest TSS was recorded with ascorbic acid at1000 ppm treatment, while control treatment recorded the lowest values in this respect.

Irrigation level at 60% with ascorbic acid foliar application at 1000 ppm proved to be the most effective interaction in increasing TSS. On the contrary, irrigation at 100% combined with control spraying treatment gave comparatively the lowest value in this concern.

Table 10:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on total sugar (%) and T.S.S. (%) of Wonderful pomegranate trees (2017 & 2018 seasons).

	Total sugar (%)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	11.00 h	12.03 e	12.40 d	12.69 c	12.94 C	11.44 d	11.93 e	12.34 c	12.57 c	12.98 C
Irrigation 80%	11.01 g	12.25de	12.78 c	13.11 b	12.30 B	11.45 f	12.28 d	12.72 c	12.99 b	12.36 B
Irrigation 60%	11.36 f	12.71 c	13.17 b	13.53 a	12.69 A	11.80 e	12.63 c	13.01 b	13.41 a	12.73 A
Mean	11.01 D	12.33 C	12.79 B	13.12 A		11.65 D	12.28 C	12.72 B	12.99 A	
	T.S.S. (%)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	13.98 h	15.52 d	15.14 e	15.79 c	14.94 C	13.89 g	14.76 e	15.12 d	15.62 c	14.85 C
Irrigation 80%	14.33 g	15.21 e	14.68 f	16.21 b	15.31 B	14.24 f	15.11 d	15.51 c	16.04 b	15.22 B
Irrigation 60%	14.68 f	15.56 d	15.90 c	16.62 a	15.69 A	14.59 e	15.46 c	15.89 b	16.46 a	15.60 A
Mean	14.33 D	15.21 C	15.52 B	16.21 A		14.24 D	15.11 C	15.51 B	16.04 A	

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

Fruit total acidity content (%)

Table, 11 shows that 60% irrigation gave the highest acidity value followed by, irrigation level at 80% in descending order. Meanwhile, the lowest fruit acidity value was recorded with irrigation level at 100% in both seasons.

In addition, the highest acidity value was recorded with control followed by ascorbic acid at 500 ppm, ascorbic acid at 750 ppm and ascorbic acid at 1000 ppm, respectively.

Meanwhile, the interaction between irrigation levels and spraying treatments shows that the combination between irrigation level at 60% and ascorbic acid at 1000 ppm gave the lowest value in this concern.

Irrigation level at 60% with spray treatments control (tap water) proved to be effective interaction in increasing acidity followed descending by ascorbic acid foliar spray at 500 ppm, ascorbic acid foliar spray at 750 ppm treatment and spray treatment ascorbic acid at 1000 ppm in both two seasons, respectively in this respect. The same trend noticed with other levels irrigation 80% or 100%.

Fruit T.S.S. /acid ratio

Table, 11 illustrates that significant differences were noticed between the tested regulated deficit irrigation levels. However, full irrigation treatment resulted in the lowest TSS/acidity value, while the ratio was increased by reducing irrigation levels at 80 % and 60% in both seasons.

Moreover, the highest TSS/acidity was recorded with ascorbic acid at 1000 ppm followed by ascorbic acid at 750, ascorbic acid at 500 ppm and control spraying treatments, respectively.

Concerning the interaction between the tested irrigation levels, and spraying treatments, 60% irrigation combined with ascorbic acid at 1000 ppm spraying treatment proved to be the best interaction in this regard.

Table11:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on acidity (%)and T.S.S./acid ratio of Wonderful pomegranate trees (2017 & 2018 seasons).

	Acidity (%)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500	750	1000	Mean	0 ppm	500	750	1000	Mean

		ppm	ppm	ppm			ppm	ppm	ppm	
Irrigation100%	1.57 c	1.28 f	1.20 g	1.01 i	1.26 C	1.63 c	1.41 f	1.24 h	1.08 j	1.34 C
Irrigation 80%	1.64 b	1.36 e	1.29 f	1.10 h	1.34 B	1.70 b	1.49 e	1.32 g	1.17 i	1.42 B
Irrigation 60%	1.72 a	1.44 d	1.36 e	1.19 g	1.42 A	1.77 a	1.56 d	1.40 f	1.26 h	1.50 A
Mean	1.64 A	1.36 B	1.28 C	1.10 D		1.70 A	1.49 B	1.32 C	1.17 D	
	T.S.S./acid ratio									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	8.35 l	10.74 i	11.77 f	14.20 c	11.26C	8.11 k	9.89 i	11.38 f	13.39 c	10.69C
Irrigation 80%	8.65 k	11.06h	12.12 e	14.58b	11.60B	8.41 jk	10.21h	11.73 e	13.78b	11.03B
Irrigation 60%	8.95 j	11.37g	12.47d	14.97 a	11.94A	8.71 j	10.53g	12.08d	14.16 a	11.37A
Mean	8.65 D	11.06C	12.12B	14.58A		8.41 d	10.21 c	11.73b	13.78 a	

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

Fruit ascorbic acid content

Table, 12 shows that irrigation level at 60% give the highest ascorbic acid value followed by irrigation at 80%. Meanwhile, the lowest ascorbic acid value was recorded with 100% irrigation level. In the first season no significantly between 100 % and 80% irrigation levels.

In addition, the highest ascorbic acid value was recorded with foliar application of ascorbic acid at1000 ppm followed by ascorbic acid at 750, ascorbic acid at 500 ppm, and control treatment which recorded the lowest values in this respect.

The combined effects of irrigation levels with spraying treatments showed that irrigation level at 60% with ascorbic acid at 1000 ppm treatment were the most effective treatment in increasing ascorbic acid content of juice. Finally, the corresponding ones of 100% irrigation level combined with tab water foliar spray gave the less content of ascorbic acid in juice.

The enhancement effect of irrigation on fruit quality may be attributed that irrigation affected of the most physiological parameters and photosynthesis of olive trees (Masmoudi-Charfi et al., 2010) this led to effect in vegetative growth, yield and productive performance. The obtained results regarding the effect of deficit irrigation on fruit quality go in line with the findings of Abd-Ella (2011) found that the highest irrigation level enhanced fruit quality (fruit weight, diameter, length, TSS and V.C. of pomegranate fruits). Haneef et al. (2014) mentioned that application of irrigation level (100%) registered maximum fruit weight, juice content, TSS : acid ratio of pomegranate fruits. Moreover, higher level of water stress (ETc 50) increased the TSS and decreased the vitamin C in comparison with water irrigation ETc 75 and full irrigation strategies of pomegranate (Parvizi and Sepaskhah 2015). Abdel-Sattar and Mohamed (2017) showed that TSS, TSS/ acidity, and vitamin C were the maximum values at 50% field capacity, while the acidity value was the highest in the treatment of 100% field capacity and yield the highest values of with the treatment of 100% field capacity of pomegranate trees.

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. Also, enhanced fruit quality of pomegranate trees (Fayed 2010 & Ahmed et al., 2014).

Table12:- Effect of sustained deficit irrigation and foliar application of ascorbic acid on ascorbic acid (mg/100 ml juice) and Water used efficiency ($Kg.m^{-3}.tree^{-1}$) of Wonderful pomegranate trees (2017 & 2018 seasons).

	Ascorbic acid (mg/100 ml juice)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	13.64k	14.54h	15.01fg	16.13 c	14.83B	13.84d	14.70g	15.50e	16.03cd	15.02C
Irrigation 80%	13.94 j	14.85g	15.36 e	16.51b	15.16B	14.14h	15.01 f	15.85d	16.42b	15.3B
Irrigation 60%	14.24 i	15.17ef	15.71d	16.89 a	15.50A	14.44g	15.33e	16.20c	16.80 a	15.69A
Mean	13.94D	14.85C	15.36B	16.51A		14.14D	15.01C	15.8B	16.42A	
	Water used efficiency ($Kg.m^{-3}.tree^{-1}$)									
	2017					2018				
	Ascorbic acid					Ascorbic acid				
Treatments	0 ppm	500 ppm	750 ppm	1000 ppm	Mean	0 ppm	500 ppm	750 ppm	1000 ppm	Mean
Irrigation100%	0.09 g	0.11 ef	0.12 de	014 cd	0.11 C	0.09 h	0.11 fg	0.13de	0.14 c	0.12 C
Irrigation 80%	0.10 fg	0.12 de	0.13 cd	0.15 bc	0.13 B	0.10gh	0.12 ef	0.14 c	0.16 b	0.13 B
Irrigation 60%	0.11 e	0.14 bc	0.15 b	0.17 a	0.15 A	0.12 ef	0.14cd	0.16 b	0.18 a	0.15 A
Mean	0.10 D	0.13 C	0.14 B	0.15 A		0.10 D	0.12 C	0.14 B	0.16 A	

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

Water use efficiency (kg/m^3)

Table, 12 demonstrates that irrigation at 60% produced higher positive effect on water used efficiency followed by irrigation 80% and finally by the corresponding ones received irrigation at 100%.

Furthermore, significant differences were found between spraying treatments in the two seasons, the highest increments flesh percentage values were recorded with ascorbic acid at1000 ppm followed by ascorbic acid at 750 ppm, ascorbic acid at 500 ppm and control treatments in the two seasons.

Finally, the interaction between the two tested factors showed that treatment 100% irrigation combined with ascorbic acid 1000 ppm spraying treatment proved to be the best interaction in this regard.

The obtained results regarding the effect of deficit irrigation on fruit quality go in line with the findings of Khattab et al. (2011) indicated that low irrigation level of 13 m^3 /tree/year recorded the highest water use efficiency of pomegranate trees. Intrigliolo et al. (2012) showed that deficit irrigation caused increasing water use efficiency of pomegranate trees.

The obtained results regarding the effect of deficit irrigation on fruit quality go in line with the findings of Bakry et al. (2013) they mentioned that increasing foliar application levels of ascorbic acid significantly increased water use efficiency. And the interaction between the water irrigation requirements of (80% irrigation) and (300 mg/L) foliar application level of ascorbic acid gave the highest values of water use efficiency of wheat.

Conclusion:-

Sustained deficit irrigation is pronounce positive effect water used efficiency to saving water and protecting of water resources in the future, it is preferable to use the strategy of sustained irrigation deficit water in arid and semiarid areas. We can be reducing negative impacts sustained irrigation deficit by using spraying by ascorbic acid.

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