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Effect of Humic Acid and Amino Acids on Pomegranate Trees under Deficit Irrigation. II: Fruit Quality

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Abstract: This experiment was carried out during 2007 and 2008 seasons on 20 years old pomegranate trees of Manfalouty cultivar. Trees under investigation were grown in a sandy soil at El-Kassasien Research Station, Ismailia Governorate. The trees received humic acid (32- 48gm / tree/season) or amino acids (8- 16 gm/ tree/ season) incorporated with irrigation levels 7 and 9m^3 /tree/year in comparison to farm control (11m^3). The results showed that, fruit length, fruit diameter, fruit weight, fruit grain percentage, fruit juice percentage and fruit peel percentage was improved with irrigation level 11m^3/tree/ year or 9m^3+48gm humic acid or 9m^3+16gm amino acids. Using higher concentration of humic (48gm/tree) or amino (16gm/tree) acid mixed with 7 or 9m^3/tree/year increased TSS, TSS acid ratio, total sugars, vitamin C and anthocyanin content of pomegranate fruits. The best treatment was 9m^3 incorporation with 48gm humic acid then 16gm amino acid.

Key words: Pomegranate · Irrigation · Humic acid · Amino acids · Fruit quality

INTRODUCTION

Pomegranate trees are considered as a crop tolerant to soil water deficit but require normal watering to produce good fruit crops; over watering results in soft, poorly-colored fruit. Plant growth and development retarded when water supply was restricted [1]. EI-Kassas [2] found that, the TSS, TSS/acid ratio and ascorbic acid decreased by increasing soil moisture level, while, total acidity, total sugar, grain and juice percentage of Manfalouty pomegranate fruit increased by increasing soil moisture level. Lawand and Patil [3] on pomegranate cv. Maskat found that, the highest fruit TSS and fruit acidity values were recorded with lowest water regime. Meanwhile, the lowest TSS and fruit acidity values were recorded at the highest water regime. Increasing duration of water withholding from one to two and three weeks before maturation caused a gradual increase in percentage of sugar content and fruit peel in pomegranate fruits [4]. Also, Ibrahim and Abd El-Samad [5] cleared that, the biggest fruit weight of pomegranate was observed on trees of higher irrigation treatments. Humic acid had a positive effect on yield and quality of florida prince peach fruits [6]. Mehran *et al.* [7] reported that humic acid and proline increased the yield, fruit length, diameter, width and weight of kiwifruit. Also, they cleared that the application of proline and humic acid improve all quantitative properties of fruits due to enhancing cell division and enlargement because of increasing the auxine and cytokinine like activities and also the concentration of the organic matters is important. Proline and tryptophan treatments enhanced yield and fruit quality of Manfalouty pomegranate cultivar [8]. Proline and other amino acids help in osmotic adjustment and crucial to sustain cellular functions under drought conditions [9]. Moreover, Aseri *et al*. [10] enhanced growth of pomegranate by using biofertilizers.

The aim of this investigation is to study the effect humic acid and amino acids on fruit quality of Manfalouty pomegranate cultivar grown under deficit irrigation conditions.

MATERIALS AND METHODS

This experiment was conducted during two successive seasons of 2007 and 2008 on 20 year old mature pomegranate trees (*Punica granatum* L.) Manfalouty cultivar. Trees under investigation were

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grown in a sandy soil at El- Kassasien Research Station, Ismailia Governorate. Trees distances were of 5 meters between trees and between lines and drip irrigation system was applied. Trees received the recommended horticulture management of the Horticultural Research Institute (H.R.I.). The experiment was designed to study the effect of adding humic acid or amino acids (as a soil water holding capacity) to the lower water levels (7 or 9m^3/tree/season) than the farm control (11m^3/tree/season) on fruit quality. Uniform thirty three trees were selected randomly for this experiment which included eleven treatments each treatment was replicated three times with one tree for each replicate. The randomized complete blocks design was used. The treatments were arranged as follows.

- 7m^3 water (tree/season)
- 7m^3 water plus 32g humic acid (tree/season)
- 7m^3 water plus 48g humic acid (tree/season)
- 7m^3 water plus 8g amino acids (tree/season)
- 7m^3 water plus 16g amino acids (tree/season)
- 9m^3 water (tree/season)
- 9m^3 water plus 32g humic acid (tree/season)
- 9m^3 water plus 48g humic acid (tree/season)
- 9m^3 water plus 8g amino acids (tree/season)
- 9m^3 water plus 16g amino acids (tree/season)
- 11m^3 water (tree/season) (control)

The dose of humic acid or amino acids for each treatment was divided into 16 equal doses and were added from February till September (two doses/ month).

Humic acid (85% potassium humates) or amino acids (commercial name pepton) were added to tree by dissolving the previously mentioned doses in one liter of water then added to the soil in the area of drippers and these doses applied through growing season every two weeks intervals from February till September.

Representative random samples of 9 fruits were taken of each tree (replicate) at harvest for determine the following physical and chemical properties.

Fruit physical properties: Fruit length (cm), fruit diameter (cm), fruit weight (g), fruit grain (%), fruit juice (%), fruit peel (%) were measured.

Fruit Chemical Properties: Juice total soluble solids (TSS) was determined by using hand Carl Zeis refractometer. Titrateable acidity was determined as percentage of anhydrous citric acid by direct titrating of 0.1 N sodium hydroxide using phenolphthalein 1% as an indicator [11]. TSS/ acid ratio was calculated by dividing the value of TSS over the value of titrateable acidity. Vitamin C content (mg L-ascorbic acid / 100ml juice) was determined by using direct titrating of 2,6- dichlorophenol indophenol [11]. Total sugars (%) were determined colorimetrically (phenol 80%) in fresh weight according to Dubois *et al*. [12]. Total anthocyanin (%) was determined by spectrophotometer as described by Hsia *et al*. [13]. The obtained data were tabulated and statistically analyzed according to Snedecor and Cochran [14]. Differences between means were compared by Duncan's multiple range test at 5% level of probability according to Duncan [15].

RESULTS AND DISCUSSION

Fruit Length: Fruit length increased significantly by increasing amount of water from 7 and 9 to 11m^3 (Table 1). Fruit length significantly increased by adding humic acid and amino acids to the lower water level as well as by increasing their concentrations.

Comparing the addition of humic acid with 7 and 9m^3 water, the highest significant value of fruit length resulted from using 9m^3+48g humic acid in the 1st and 2nd seasons. Comparison between adding amino acids to 7 and 9m^3 water levels data proved that, using 9m^3+16g amino acids has recorded the highest significant value of fruit length in first season while in the second season both treatments 9m^3+8g amino acids and 9m^3+16g amino acids was the best.

There were no significant differences between the lower concentrations of both humic and amino acids except with 9m^3 in the 1st season. Moreover, 7m^3+16g amino acids and 9m^3 water treatments did not show any significant differences in both seasons. Treatment 7m^3+48g humic acid gave the highest significant value of fruit length compared with the rest of the 7m^3 treatments except 7m^3+16g amino acids in both seasons. All 7m^3 water treatments recorded the shortest significant fruit length when compared with farm control 11m^3.

Fruit Diameter: Fruit diameter was significantly induced in both seasons by increasing amount of water from 7 and 9 to 11m^3 (Table,1).

Referring to 7m^3 water +humic acid treatments it is obvious that, fruit diameter significantly increased with increasing humic acid concentration.

Considering 9m^3 water with humic acid treatments, fruit diameter significantly increased with humic acid doses increased. While, 9m^3+ amino acids treatments, gave significant increment only in the first season.

Table 1: Effect of irrigation levels, humic acid and amino acids on fruit length, fruit diameter and fruit weight of pomegranate cv. Manfalouty in 2007 and 2008 seasons

Treatments		Fruit Length (cm)		Fruit diameter (cm)		Fruit weight (g)	
Irrigation Levels (m^3/tree/season)	Soil conditioner (g/tree/season)	2007	2008	2007	2008	2007	2008
$7m^3$	--------	7.91 g	7.64 f	7.14 g	6.85 f	230.86 h	214.94 i
$7m^3$	32g humic acid	8.14 f	7.89 e	7.37 f	7.10 def	246.49 g	226.07 g
$7m^3$	48g humic acid	8.40 cd	8.35 bc	7.67 cd	7.42 abc	262.92 d	237.78 f
$7m^3$	8g amino acids	8.07 f	7.88 e	7.27 f	7.00 ef	243.26 g	221.05 h
$7m^3$	16g amino acids	8.37 cde	8.14 cd	7.54 e	7.30 cde	254.79 e	235.40 f
$9m^3$	--------	8.26 e	8.07 de	7.57 de	7.09 def	251.08 f	245.81 e
$9m^3$	32g humic acid	8.47 c	8.48 b	7.74 c	7.34 bcd	264.86 d	261.44 c
$9m^3$	48g humic acid	8.70 b	8.81 a	7.94 b	7.67 a	279.16 b	276.69 b
$9m^3$	8g amino acids	8.34 de	8.39 b	7.67 cd	7.39 abcd	261.79 d	257.74 d
$9m^3$	16g amino acids	8.64 b	8.54 b	7.87 b	7.46 abc	274.84 c	263.76 c
$11m^3$ (control)	--------	8.94 a	8.56 b	8.27 a	7.62 ab	298.94 a	287.12 a

Number followed by the same letter (s) in the same column are not significantly different at 0.05 level of probability

The highest significant value of fruit diameter resulted from using $9m^3$+48g humic acid in the 1st and 2nd seasons compared to the addition of humic acid to both 7 and $9m^3$ water treatments.

Comparison between appending amino acids treatments to 7 or $9m^3$ water data revealed that, using $9m^3$+16g amino acids recorded the highest significant value of fruit diameter in first season while in the second one both doses of amino acids was the superior in this regard.

In case of $9m^3$ water treatments compared to farm control ($11m^3$) results indicated that, farm control showed the highest significant value of fruit diameter. No significant difference was detected between the lower doses also between the higher doses in the 1st season. While, $9m^3$+48g humic acid gave the longest insignificant fruit diameter compared to the other treatments. While, the lowest non-significant fruit diameter value was recorded with $9m^3$ only in the both seasons.

Fruit Weight: In response to treatments effects data in Table 1 showed that, fruit weight was significantly influenced by increasing amount of water from 7 and 9 to $11m^3$.

Considering to $7m^3$ water +humic acid treatments, it was obvious that with increasing humic acid doses fruit weight significantly increased from 246.49 to 262.92 and from 226.07 to 237.78g in both years respectively. Also, data revealed that, amino acids when added to the level $7m^3$ had the same effect.

Regarding $9m^3$ water level, when it was merged with humic acid treatments, by increasing humic acid doses fruit weight markedly increased. The same effect was noticed with $9m^3$+amino acids treatments.

Concerning humic acid mixed with $7m^3$ or $9m^3$, the heaviest significant fruit weight was recorded from using $9m^3$+48g humic acid in the 1st and 2nd seasons.

Comparison between appending amino acids treatments to 7 or $9m^3$ water, data revealed that, using $9m^3$+16g amino acids attained the highest significant fruit weight (274.84- 263.76g) during two seasons.

According to differences between $7m^3$ water treatments and $9m^3$ data revealed that, $7m^3$ water only recorded the least fruit weight. While, $9m^3$water exhibited significantly the heaviest fruit weight in the 2nd season compared with the other treatments.

Regarding the two tested additives, it proved a significant effect. Both of humic acid or amino acids in combination to the lowest irrigation water level $7m^3$ have recorded almost a similar effect. Generally, the additives have a significant effect on increasing fruit weight if compared with using water only. Increasing the water level from $7m^3$ to $9m^3$ has recorded a significant increase in fruit weight also, the additives induced a significant effect.

So to reduce the water use consumption, instead of using $11m^3$ (the farm control) we can use $9m^3$ with either humic acid or amino acids with the higher tested doses to attain a reasonable acceptable fruit weight.

Our results in this regard were confirming to those obtained by Fathi *et al*. [16] on peach, Eissa *et al*. [17] and Shaddad *et al*. [18] on apricot, Ismail *et al*. [19] on pear they clearly showed a gradual increase in polar and equatorial diameter and fruit weight parallel to increasing humic acid application from (0 to 50 to 75 cm/tree). Moreover, El-Shenawi *et al*. [20] on Grandnain banana reported that increasing amount of humic acid markedly increased finger weight and diameter.

Table 2: Effect of irrigation levels, humic acid and amino acids on fruit grain (%), fruit juice (%) and fruit peel (%) of pomegranate cv. Manfalouty in 2007 and 2008 seasons

Treatments		Fruit grain (%)		Fruit juice (%)		Fruit peel (%)	
Irrigation Levels (m^3/tree/season)	Soil conditioner (g/tree/season)	2007	2008	2007	2008	2007	2008
$7m^3$	--------	49.60 f	57.45 f	33.50 h	35.00 g	50.40 a	42.55 a
$7m^3$	32g humic acid	51.49 e	58.43 e	35.89 f	36.12 ef	48.51 b	41.57 b
$7m^3$	48g humic acid	53.67 d	61.12 ab	37.41 d	38.35 c	46.33 c	38.88 de
$7m^3$	8g amino acids	51.22 e	59.02 de	34.93 g	36.91 de	48.78 b	40.98 b
$7m^3$	16g amino acids	54.13 d	61.71 a	36.35 e	37.19 d	45.87 c	38.29 e
$9m^3$	--------	55.13 c	59.43 d	36.30 e	36.00 f	44.87 d	40.57 bc
$9m^3$	32g humic acid	56.69 b	60.29 c	37.23 d	38.88 bc	43.31 e	39.71 cd
$9m^3$	48g humic acid	58.37 a	61.46 a	39.15 b	40.27 a	41.63 f	38.54 e
$9m^3$	8g amino acids	56.49 b	60.67 bc	37.53 d	38.97 bc	50.40 a	42.55 a
$9m^3$	16g amino acids	58.41 a	61.62 a	38.64 c	39.30 b	48.51 b	41.57 b
$11m^3$ (control)	--------	58.77 a	61.07 ab	40.60 a	39.63 ab	46.33 c	38.88 de

Number followed by the same letter (s) in the same column are not significantly different at 0.05 level of probability

Fruit Grain: Fruit grain percentage was significantly affected by increasing amount of irrigation water from 7 and 9 to $11m^3$ in both seasons (Table 2).

Regarding $7m^3$ water integration with humic or amino acids treatments, data proved that, by increasing humic acid doses, fruit grain significantly increased in both seasons. Additionally, amino acids had the same effect.

Adding humic or amino acids with $9m^3$ water treatments, induced markedly fruit grain by increasing doses in both seasons.

Comparison among the merging of humic acid with 7 and $9m^3$ water, the highest significant fruit grain was detected by using $9m^3$+48g humic acid.

It can be summarized that, the highest fruit grain percentage went in parallel to the highest irrigation level ($11m^3$), $9m^3$+48g humic acid and $9m^3$+16g amino acids without any significant differences. So it is worthy to mention that, fruit grain percentage is a vital importance to have a fruit of a good quality, therefore we can save water use from $11m^3$ to $9m^3$+ 48g humic acid and have the same fruit grain percentage in the fruits.

Fruit Juice: By increasing amount of irrigation water from 7 and 9 to $11m^3$ fruit juice percentage significantly decreased (Table 2).

Regarding the effect of adding humic acid to 7 or $9m^3$ water, in this sphere the highest fruit juice percentage resulted from using $9m^3$+48g humic acid. About amino acids effect with 7 and $9m^3$ water, the highest significant fruit juice percentage was recorded by $9m^3$+16g amino acids in the 1st season and by both treatments $9m^3$ + 8g amino acids and $9m^3$+16g amino acids in the second season.

Comparing between $7m^3$ and $9m^3$ water treatments results proved that, in both seasons $7m^3$ treatments was recorded the lowest significant fruit juice percentage. $7m^3$+48g humic acid exhibited the highest significant fruit juice percentage. In the contrast, all $7m^3$ treatments recorded the lowest significant fruit juice percentage in both seasons when compared to farm control ($11m^3$).

The results indicated that, the farm control ($11m^3$) gave the highest significant fruit juice percentage in the 1st season. This treatment and $9m^3$+48g humic acid no significant differences was noticed in the 2nd season.

Fruit Peel: Fruit peel percentage was significantly reduced by increasing the irrigation water levels (Table 2). Fruit peel percentage for the farm control ($11m^3$) has recorded the lowest significant values compared to the two lower tested levels.

In regard to $7m^3$ water with humic acid treatments, the fruit peel percentage significantly decreased from 48.51 to 46.33% in the 1st season and from 41.57 to 38.88% in the 2nd season. Also, $7m^3$ water with amino acids treatments revealed the same trend in both seasons.

In the first season, all $7m^3$ treatments has recorded the highest significant fruit peel compared to $9m^3$ and no significant effect occurred between the lower and the higher concentration of both additives. In the second season, the treatments of $7m^3$+32g humic acid, $7m^3$+ 8g amino acids and $9m^3$ water did not significantly differ among each other. While the higher doses of humic acid or amino acids resulted in a lower significant fruit peel percentage than those results from $9m^3$ water.

The lowest significant fruit peel percentage was recorded by the farm control ($11m^3$) or $9m^3$+ 48g humic acid or $9m^3$+16g amino acids in both seasons, meaning

Table 3: Effect of irrigation levels, humic acid and amino acids on TSS, total acidity and TSS /acid ratio of of Manfalouty pomegranate fruits in 2007 and 2008 seasons.

Treatments		TSS (Brix°)		Total acidity (%)		TSS /acid ratio	
Irrigation Levels (m^3/tree/season)	Soil conditioner(g/tree/season)	2007	2008	2007	2008	2007	2008
$7m^3$	--------	16.50 ab	16.17 ab	2.03 a	2.16 a	8.13 h	7.49 i
$7m^3$	32g humic acid	16.83 a	16.50 a	1.83 b	1.83 c	9.19 e	9.01 f
$7m^3$	48g humic acid	16.50 ab	16.17 ab	1.72 cd	1.74 d	9.59 c	9.29 e
$7m^3$	8g amino acids	16.50 ab	16.17 ab	1.85 b	1.84 c	8.91 f	8.78 g
$7m^3$	16g amino acids	15.83 c	15.83 b	1.80 bc	1.93 b	8.79 g	8.20 h
$9m^3$	--------	16.33 b	16.17 ab	1.78 bc	1.96 b	9.17 e	8.25 h
$9m^3$	32g humic acid	16.83 a	16.50 a	1.65 de	1.73 d	10.20 b	9.53 d
$9m^3$	48g humic acid	16.17 bc	16.50 a	1.54 f	1.54 f	10.50 a	10.71 a
$9m^3$	8g amino acids	16.17 bc	16.17 ab	1.58 ef	1.65 e	10.23 b	9.80 c
$9m^3$	16g amino acids	16.50 ab	15.83 b	1.58 ef	1.54 f	10.44 a	10.27 b
$11m^3$ (control)	--------	16.33 b	16.00 b	1.73 cd	1.64 e	9.44 d	9.76 c

Number followed by the same letter (s) in the same column are not significantly different at 0.05 level of probability

that about $2m^3$ water/ tree/season could be saved by using $9m^3$ water with the higher dose of humic or amino acids instead of the farm control.

In this sphere, Abbas *et al*. [21] on grape found that applying humic acid to soil increased significantly juice volume.

Fruit Chemical Properties

Total Soluble Solids: Considering $7m^3$ water +humic acid treatments, differences between both doses of humic acid did not give any markedly changes in both seasons. Regarding amino acids treatments, TSS decreased significantly by increasing amino acid doses in the 1st season while this reduction was not significant in the second season (Table, 3).

Regarding $9m^3$ treatments, TSS decreased significantly by increasing humic acid doses in the 1st season while no significant differences was noticed among both doses of humic acid in the second season. Considering amino acids doses, no differences were observed.

Associating of humic acid with 7 and $9m^3$ water, in the first season, no significant changes between 32g humic acid with $7m^3$ or $9m^3$ also among 48g humic acid merging to $7m^3$or $9m^3$. In the second season, no significant differences appeared among all humic acid which merging for both irrigation levels ($7m^3$ and $9m^3$).

Comparison between adding amino acids treatments to 7 and $9m^3$ water, treatments of $7m^3$+ 8g amino acids, $9m^3$+ 8g amino acids and $9m^3$+16g amino acids were not affected in this regard in the first season. Also, no differences occurred among both doses of amino acids which appending with $7m^3$ and $9m^3$ in the 2nd season.

Total Acidity: Data in Table 3 showed that, total acidity was significantly reduced by increasing amount of water from 7 and 9 to $11m^3$.

Regarding $7m^3$ water subjoined with humic or amino acids treatments, data evidence that, total acidity significantly reduced by raising amount of humic acid. Also, the higher doses of amino acids reduced total acidity in 1st season.

Concerning $9m^3$ treatments, total acidity reduced significantly in both seasons by adding 48g humic acid to $9m^3$. Moreover, in the 1st season no significant differences were displayed with two amino acids treatments.

Comparing $7m^3$ treatments with $9m^3$ water, in the 1st season, $7m^3$ water only was exhibited the highest significant total acidity compared with other treatment. In the second season, there is a significant changes were showed among lower doses of humic and amino acids also, among $7m^3$+16g amino acids and $9m^3$. The farm control recorded the lowest significant total acidity in both seasons compared with all $7m^3$ treatments.

It can be concluded that, using higher concentration of humic or amino acids mixed with $9m^3$ gave the lowest significant total acidity.

TSS/Acid Ratio: TSS/ acid ratio significantly increased by increasing the irrigation water level (Table 3). TSS/ acid ratio for the control farm ($11m^3$) recorded the highest significant values compared to the two lower tested levels.

In regard to the lowest water level $7m^3$ with humic acid treatments, TSS/ acid ratio significantly increased from 9.19 to 9.59 in the 1st season and from 9.01 to 9.29 in the 2nd season. While, $7m^3$ water with amino acids

Table 4: Effect of irrigation levels, humic acid and amino acids on total sugars, vitamin C and total anthocyanin content of Manfalouty pomegranate fruits in 2007 and 2008 seasons

Treatments		Total sugars (%)		Vitamin (c) (mg. corbic acid/ 100 ml juice)		Total anthocyanin (%)	
Irrigation Levels(m^3/tree/season)	Soil conditioner(g/tree/season)	2007	2008	2007	2008	2007	2008
$7m^3$	--------	14.80 c	14.98 bc	17.13 d	16.37 d	5.82 cd	7.66 c
$7m^3$	32g humic acid	14.86 bc	15.01 b	17.98 ab	16.92 b	5.64 de	7.39 d
$7m^3$	48g humic acid	15.13 a	15.25 a	18.02 a	17.51 a	6.12 ab	8.64 a
$7m^3$	8g amino acids	14.92 abc	14.95 bc	17.51 c	16.65 c	5.38 ef	6.79 fg
$7m^3$	16g amino acids	15.04 ab	15.06 b	17.67 bc	16.75 bc	6.03 bc	8.19 b
$9m^3$	--------	14.35 d	14.57 d	16.52 f	15.80 f	5.16 fg	6.91 f
$9m^3$	32g humic acid	14.29 de	14.63 d	16.84 def	16.32 d	4.98 gh	6.67 g
$9m^3$	48g humic acid	14.47 d	14.86 c	16.84 def	16.35 d	6.37 a	8.56 a
$9m^3$	8g amino acids	14.10 ef	14.60 d	16.76 ef	16.06 e	4.78 h	6.58 g
$9m^3$	16g amino acids	14.32 de	14.70 d	16.98 de	16.27 d	6.23 ab	7.16 e
$11m^3$ (control)	--------	14.00 f	14.24 e	15.93 g	15.12 g	4.95 gh	6.77 fg

Number followed by the same letter (s) in the same column are not significantly different at 0.05 level of probability

treatments had the opposite tendency in both seasons. Whereas, with increasing amino acids doses TSS/ acid ratio decreased.

Using humic acid appending to $9m^3$water, TSS/ acid ratio significantly induced from 10.20 to 10.50 and 9.53 to 10.71 in both seasons respectively by increasing humic acid quantity. Also, the merging of amino acids to $9m^3$ level had a positive effect whereas, the highest significant TSS/ acid ratio was observed by using $9m^3$+16g amino acids in the both seasons **(Fig 8).**

The addition of humic acid to 7 or $9m^3$ water levels, resulted the highest significant TSS/ acid ratio by using $9m^3$+48g humic acid. Concerning the effect of adding amino acids to the lower levels of 7 or $9m^3$ water, the highest significant TSS/ acid ratio resulted from using $9m^3$+16g amino acids in both seasons.

In this line, Fathi *et al*. [16] on Desert Red peach, Ismail *et al*. [19] on Le-Conte pear and Abbas *et al*. [21] on grape, reported a gradual increase in TSS and TSS/ acid ratio with increasing humic acid quantity even under water stress. El-Shenawi *et al*. [20] on Grandnain banana reported that, fruit acidity were positively affected by humic applications, where increasing amount of humic acid markedly decreasing acidity.

Total Sugar Percentage: Total sugar was significantly reduced by increasing the irrigation water levels from 7 and 9 to $11m^3$ (Table 4).

Appending humic acid to $7m^3$ water increased total sugars (%) was significantly by increasing humic acid concentration. The same trend with noticed with $7m^3$ water with amino acids treatments in both seasons.

Using humic acid with $9m^3$ water have a positive effect on total sugar. Whereas, with increasing humic acid doses induced total sugar (%) in both season. Also, adding amino acids to $9m^3$ have the same effect.

The highest significant total sugar (%) was attained by using $7m^3$+48g humic acid. Also, adding amino acids to 7 and $9m^3$ water levels, increased total sugar (%) markedly especially by using $7m^3$+16g amino acids in both seasons.

In brief, the highest significant total sugar (%) was recorded by $7m^3$+48g humic acid in both seasons.

Vitamin C: Vitamin C content significantly decreased by increasing amount of water from 7 and 9 to $11m^3$ (Table, 4).

Considering $7m^3$ water associated with humic acid and amino acids treatment. Generally, vitamin C content induced by increasing humic acid quantity. Vitamin C content increased significantly in the second season only. According to amino acids treatments, vitamin C improved by increasing doses but no significant difference in both seasons.

Associating humic acid and amino acids with $9m^3$ water, generally, the differences among both concentration of humic acid did not exhibit any significant difference in both seasons. Also, the same trend was detected among both amino acids treatments in the 1st season only, while there were a significant increased by increasing amino acids doses in the second season.

It is obvious from the obtained data that vitamin C content in the fruits was correlated with using the lower levels of irrigation water. So even using the lowest level $7m^3$ alone or in corporation with the all tested additives

have recorded the highest vitamin C content in the fruits and the best content was recorded with the addition of both humic acid doses, followed by amino acids doses.

Total Anthocyanin: Data in Table 4 revealed that, total anthocyanin (%) was significantly reduced by increasing amount of water. Regarding $7m^3$ water subjoined with humic acid and amino acids treatments, total anthocyanin (%) significantly improved by increasing amount of humic acid. The higher doses of amino acids induced total anthocyanin (%) significantly in both seasons. According to $9m^3$ treatments, total anthocyanin (%) improved significantly in both seasons by adding 48g humic acid. Moreover, the same results were obtained with amino acids treatments whereas $9m^3$+ 16g amino acids in the 1st season gave the higher significant value.

Comparing the addition of humic acid with using 7 or $9m^3$ water, the highest significant value of total anthocyanin (%) was resulted from using 48g humic acid with both lower irrigation levels (7 and 9 m^3). Also, using $7m^3$ or $9m^3$ with the higher dose of amino acids has recorded the highest significant values in the first season. While, the higher dose of amino acids with the least irrigation level gave the highest significant value in the 2nd season.

It can be concluded that, decreasing the level of irrigation water in the orchards of pomegranate seemed important if we want to harvest fruits with a good color and of course a good nutritional value and high acceptability for export. As results indicated that, either using $9m^3$ or $7m^3$ instead of $11m^3$ is required to realize this goal. The additives were of good effects in this regard especially at higher doses and using them proved better than using the lower levels alone.

El-Shenawi *et al*. [20] reported that, Grandnain banana fruits were positively affected by humic applications. Increasing amount of humic acid markedly increased total sugars. Abbas *et al*. [21] on grape found that, applying humic acid increased anthocyanin significantly.

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