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EFFECT OF IRRIGATION LEVELS ON GROWTH AND FRUITING OF MANFALOUTY POMEGRANATE TREES

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ABSTRACT

This investigation was carried out in two successive seasons (2007 and 2008) on 20 year old pomegranate cv. Manfalouty (*Punica granatum* L.) trees grown at El-Kassasien Research Station, Ismailia Governorate in sandy soil under drip irrigation system. The experiment was designed to study the response of pomegranate trees to different irrigation levels and their effect on vegetative growth and fruit quality. The trees received the following five irrigation levels: 7, 9, 11, 13 or 15 m^3/tree/year. The results indicated that the highest irrigation level of 15m^3/tree/year enhanced vegetative growth by increasing shoots length, number of leaves per shoot and leaf area. Also, it increased the number of flowers per shoot, fruit set, fruit retention, fruit dimensions, fruit volume, fruit grains, yield and fruit cracking. Using irrigation level of 13 m^3/tree/year recorded the highest leaf mineral contents of N, P, K and Ca. Also, increased fruit juice, TSS/ acid ratio and water use efficiency (WUE) and gave the lowest fruit cracking. Meanwhile, using the lowest irrigation level of 7 m^3/tree/year decreased vegetative growth, yield and fruit weight, with increasing fruit cracking, fruit TSS, acidity, sugar, V.C. and anthocyanin content.

Key words: *fruiting, growth, irrigation, pomegranate tress.*

1. INTRODUCTION

Water is one of the most important components in the biological function (Salisbury and Ross, 1985). There is an increasing demand on water resources used for irrigation, and a need to maximize agriculture water utilization efficiency. Many approaches for measuring soil water status to guide irrigation are used to optimize yield of fruit trees (Devid *et al*., 1999). The amount and quality of available irrigation water of the arid and semi-arid regions of the world such as Egypt, are the main limiting factors for extension agriculture (Beaumont, 1993). Therefore plant growth and development are retarded when water supply was restricted (Wright and Stark, 1990).

Many investigations have focused on the effect of irrigation levels on vegetative growth, yield, fruit quality as well as fruit cracking of pomegranate fruit (Afria *et al*., 1998, Prasad *et al*., 2003 and Meti *et al*., 2008)

Pomegranate *cv*. Manfalouty is considered one of the most important pomegranate cultivars grown successfully in Egypt, and the biggest area is located in Assuit region (5809 feddans according to the Central Administration for Agriculture Economic Ministry of Agriculture, A. R. E., 2007) where they use flooding irrigation which wastes a big amount of water while drip irrigation saves up to 50 -66% of water and increases yield by 30- 40% compared to flooding irrigation (Behnia, 1999 and Chopade *et al*., 2001).

There is little information about water use of pomegranate trees in relation to growth and productivity. Therefore, this experiment was designed to determine water level in relation to pomegranate tree growth, fruit quality and yield.

2. MATERIALS AND METHODS

This investigation was carried out through 2007 and 2008 seasons on 20 year old pomegranate cv. Manfalouty (*Punica granatum,* L.). Trees under investigation were grown in a sandy soil under drip irrigation system. Trees were planted at five meters apart at El-Kassasien Research Station, Ismailia Governorate. Trees received the normal cultural practices according to the recommendations of Horticulture Research Institute (H.R.I.), Ministry of Agriculture, Egypt. The study involved five treatments; each treatment comprised three replicates (an individual tree/replicate) and were well managed. The main objective of the present investigation was to find out the irrigation levels that gave good growth and fruiting of pomegranate. The common irrigation rate that is used at this station is 11 m^3/tree/season (1848 m^3/feddan/year) according to the recommendations of the Ministry of Agriculture. Pomegranate is irrigated in Israel with 5000 m^3/ha/year about (2000 m^3/feddan/year) according to Blumenfeld (1995). Trees were given irrigation water levels as follows:

1) 7 m^3/tree/year (1176 m^3/feddan/year),
2) 9 m^3/tree/year (1512 m^3/feddan/year),
3) 11m^3/tree/year (1848 m^3/feddan/year),
4) 13 m^3/tree/year (2184 m^3/feddan/year)
5) 15 m^3/tree/year (2520 m^3/feddan/year).

Irrigation treatments varied with the change of the developmental stage of the plant.

The following parameters were measured at the end of the season.

-Length of the new developed shoot (cm), number of leaves per shoot and leaf area (cm^2).

-Leaf mineral content: ten leaves from the middle part of shoots were taken in July of both seasons to determine the total nitrogen by the modified micro-Kejldahl method (Naguib, 1969). Phosphorus content was coloremetically estimated according to Murphy and Riely (1962), potassium was determined using flame photometer (Brown and Lilleland, 1946) and calcium by an Atomic Absorption Spectrophotometer (Perkin Elmer-3300) according to Chapman and Pratt (1961).

-Flowering and fruiting attributes:

Number of flowers per shoot was counted at balloon stage. Fruit set (%) was calculated by the following equation:

Fruit set % = number of set fruit / total number of flowers X 100.

Fruit drop (%) was calculated by the following equation :

Fruit drop % = total number of fruit set - total number of fruits at harvest time / total number of fruit set X 100.

Fruit retention (%) was determined by counting the number of fruits at harvest time/ initial number of fruit set. Tree yield (kg) was estimated at harvest.

Nine fruits were taken at harvest from each treatment for determination of the following physical and chemical properties:

Fruit weight (gm), fruit size (cm^3), fruit dimensions (cm), grain weight (%), juice volume (%), peel weight (%), percentage of fruit cracking/tree at harvest time, juice total soluble solids (%), titrateable acidity (%) according to A.O.A.C., (1985), TSS/acid ratio, Vitamin C content (mg L-ascorbic acid /100 ml juice) according to A.O.A.C., (1985). Total sugar contents were determined calorimetrically according to Dubois *et al.*(1956). Total anthocyanin content in fruit juice was determined as described by Hsia *et al*.(1965).

Water use efficiency was calculated as obtained yield in each treatment divided by the amount of water (as described by Hussein, 2004).

Experiments conducted in this study followed the randomized complete blocks design. The obtained data were tabulated and statistically analyzed according to Snedecor and Cochran (1980). Differences between treatments were compared by Duncan's multiple range test according to Duncan (1955).

3. RESULTS AND DISCUSSION

3.1. Effect of irrigation levels on vegetative growth

Data in Table (1) show the effect of irrigation levels on shoot length, number of leaves per shoot and leaf area. Regarding shoot length, there were significant differences between all treatments, the highest shoot length (30.23 and 29.76 cm in the first and second seasons respectively) resulted from irrigation with 15 m^3/tree/year while the lowest significant one (20.77 and 18.92 cm) resulted from irrigation at 7 m^3/tree/year. In addition, the number of leaves/ shoot increased significantly by increasing irrigation. Irrigation at 15 m^3/tree/year gave the highest leaf number/ shoot, while the lowest number was recorded with irrigation at 7 m^3/tree/ year. Concerning leaf area, it is noticeable that reducing irrigation rate

Table (1): Effect of irrigation levels on shoot length (cm), number of leaves / shoot and leaf area (cm^2) of pomegranate c v. Manfalouty in the 2007 and 2008 seasons

Irrigation levels (m^3/tree/ year)	Shoot length (cm)	number of leaves / shoot	Leaf area (cm^2)
2007 Season			
7	20.77 e	20.00 e	4.91 e
9	22.70 d	21.03 d	5.36 d
11	25.07 c	22.80 c	5.77 c
13	28.83 b	24.47 b	6.68 b
15	30.23 a	25.83 a	7.13 a
2008 Season			
7	18.92 e	18.61 e	4.45 d
9	20.89 d	20.09 d	5.38 c
11	23.96 c	22.09 c	5.60 c
13	27.12 b	23.59 b	6.37 b
15	29.76 a	25.31 a	6.91 a

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability considerably reduced leaf area. The highest significant of leaf area was obtained by irrigation at 15 m^3/tree/ year while irrigation level at 7m^3/tree/ year gave the significantly lower values in both seasons.

Generally, increasing irrigation levels from 7 to 15m^3/tree/year enhanced vegetative growth of pomegranate by increasing shoot length, number of leaves per shoot and leaf area. It can be explained that water stress decreases the cytokinin transport from roots to shoots and increase the amount of leaf abscisic acid. These changes in hormone balance cause a reduction in cell growth and leaf expansion. These results are in line with those obtained by Hussein (2004) on pear, Kandil and El-Feky (2006) on apricot, as they stated that shoot growth and leaf area were markedly increased by increasing irrigation rates. Also, Abou El-Wafa (2002), on pomegranate, stated that the lowest number of leaves per shoot was correlated with drought.

3.2. Leaf mineral content (N, P, K, Ca)

Data in Table (2) show leaf content of N, P, K and Ca. The N content increased significantly by increasing irrigation level from 7 to 13 m^3/tree/season. Also, a slight reduction in N content was observed by increasing irrigation rate to 15 m^3/tree/ year in both seasons.

Table (2): Effect of irrigation levels on leaf mineral content (%) of pomegranate c v. Manfalouty in 2007 and 2008 seasons.

Irrigation levels (m^3/tree/ year)	N (%)	P (%)	K (%)	Ca (%)
2007 Season				
7	1.80 c	0.22 b	1.45 d	1.30 d
9	1.83 c	0.23 ab	1.52 c	1.37 cd
11	1.88 bc	0.25 ab	1.58 bc	1.45 bc
13	2.10 a	0.27 a	1.66 a	1.51 b
15	1.95 b	0.27 a	1.61 ab	1.63 a
2008 Season				
7	1.72 c	0.20 b	1.34 b	1.18 c
9	1.76 bc	0.22 ab	1.30 b	1.22 c
11	1.81 bc	0.23 ab	1.44 a	1.43 b
13	2.03 a	0.25 a	1.50 a	1.52 ab
15	1.90 ab	0.23 ab	1.44 a	1.60 a

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability

The highest significant leaf P content (0.27-0.25%) was recorded by irrigation at 13 m^3/tree/ year, while, irrigation at 7 m^3/tree/ year gave the significantly lower value (0.22 and 0.2% in the two seasons).

Regarding leaf K content, irrigation at 13 m^3/tree/ year produced the highest significant K-content (1.66- 1.50 %) in both seasons. On the other hand, irrigation at 7 m^3/tree/ year gave the lowest significant K content (1.45- 1.34%) in both seasons. The increase of leaf N, P and K content with increasing irrigation rate was previously reported by Hussein (2004) on pear, Chauhan *et al*. (2005) on apple, as they found that nitrogen, phosphorous and potassium contents were increased under the condition of high irrigation treatment.

Regarding Ca content, it was cleared that the highest irrigation level (15m^3/tree/ year) increased Ca content significantly compared with other irrigation levels. These results are in line with those reported by Ahmed (1994) on pomegranate, Chauhan *et al*. (2005) on apple as they indicated that leaf content of Ca was greater with the highest irrigation regimes than the lowest irrigation ones.

Reduction in leaf element contents with reducing irrigation amount is explained by a substantial decrease in transpiration rates and impaired active transport and membrane permeability, resulting in a reduced root absorbing power of nutrients.

3.3. Effect of irrigation levels on fruiting and yield

Results presented in Table (3) show the effect of irrigation levels on the number of flowers per shoot, fruit set, fruit retention and fruit drop. Considering flower number per shoot, there was a significant increase in the flower number/ shoot in both seasons associated with high rate of irrigation. Irrigation level at 15 m^3/tree/ year recorded the highest significant flower number/ shoot while the lowest significant flower number/ shoot was formed by irrigation at 7m^3/tree/ year.

Regarding fruit set (%), it is clear that there was a significant increase in the fruit set percentage in both seasons, associated with high rate of irrigation. Meanwhile, irrigation at 15 m^3/tree/ year recorded the highest fruit set percentage (33.40 and 30.10% in the 2007 and 2008 seasons, respectively) while the lowest fruit set percentage (23.27 and 21.18%) was produced by irrigation level at 7 m^3/tree/ year in both seasons.

The increase of flower number/shoot and fruit set was discussed by Lavee and Wodner (1992) on olive, as they mentioned that, dry soil conditions decreased the number of flowers. Moreover, Ruiz-Sanchez *et al*., (1999) on apricot and Hussein (2004) on pear mentioned that, increasing the amount of applied water increased flower number per shoot and fruit setting.

Table (3): Effect of irrigation levels on flower number/ shoot, fruit set (%), fruit retention (%) and fruit drop (%) of pomegranate *cv.*Manfalouty in the 2007 and 2008 seasons

Irrigation levels (m^3/tree/ year)	Flower number / shoot	Fruit set (%)	Fruit retention (%)	Fruit drop (%)
2007 Season				
7	2.70 d	23.27 e	82.85 d	17.15 a
9	3.20 c	26.96 d	85.23 c	14.77 b
11	3.33 c	28.98 c	86.31 c	13.69 b
13	3.70 b	31.52 b	88.26 b	11.74 c
15	4.10 a	33.40 a	91.25 a	8.75 d
2008 Season				
7	2.76 e	21.81 e	82.12 e	17.88 a
9	2.97 d	25.94 d	84.18 d	15.82 b
11	3.17 c	27.36 c	85.48 c	14.52 c
13	3.44 b	30.13 b	88.31 b	11.69 d
15	3.63 a	32.10 a	90.91 a	9.09 e

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability.

Concerning fruit retention, there was a significant difference between all treatments. Irrigation at 15 m^3/tree/year recorded the highest fruit retention percentage (91.25 and 90.91% in the 2007 and 2008 seasons, respectively) while the lowest fruit retention percentage (82.85 and 82.12%) was attained by irrigation at 7 m^3/tree/ year.

Considering fruit drop percentage, the highest significant fruit drop percentage took place with irrigation at 7 m^3/tree/ year while the lowest fruit drop was observed by irrigation level at 15 m^3/tree/ year.

Increasing fruit retention and reducing fruit drop with high irrigation rate are in harmony with results of Lavee and Wodner (1992) on olive, who reported that the fruit retention increased and fruit drop decreased as the irrigation rate increased. Also, Chauhan *et al*. (2005) on apple and Ruiz-Sanchez *et al*., (1999) on apricot found that, drought stress increased fruitlet drop.

3.4. Fruit physical properties at harvest time

Effect of irrigation levels on fruit dimensions and fruit size are illustrated in Table (4). Fruit length and diameter (cm) gradually increased in both seasons with increasing irrigation level. The biggest fruit length and diameter were produced from trees irrigated with 15 m^3/tree/year, while the smallest fruit length and diameter resulted from irrigation at 7 m^3/tree/ year. These results are in line with those of El-Khoreiby and Salem (1989) on guava, and Abd El-Moteleb (1998) on apple, as they concluded that the highest fruit size was recorded from moist treatment, and the lowest fruit dimensions were obtained due to drought treatment.

Table (4): Effect of irrigation levels on fruit length (cm), fruit diameter (cm) and fruit size (cm3) of pomegranate c v. Manfalouty fruits in the 2007 -2008 seasons.

Irrigation levels (m^3/tree/ year)	Fruit Length (cm)	Fruit diameter (cm)	Fruit volume (cm^3)
2007 Season			
7	7.91 d	7.14 d	264.0 e
9	8.26 c	7.57 c	285.3 d
11	8.94 b	8.27 b	337.0 c
13	9.47 a	8.53 ab	354.7 b
15	9.63 a	8.83 a	375.7 a
2008 Season			
7	7.64 e	6.85 e	248.7 e
9	8.07 d	7.09 d	274.7 d
11	8.56 c	7.62 c	318.4 c
13	9.17 b	8.12 b	336.0 b
15	9.47 a	8.56 a	355.0 a

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability

According to fruit size, it is evident that fruit size increased significantly as irrigation rate increased, reaching the greatest values (375.7 and 355.0 cm^3 in the 2007 and 2008 seasons, respectively) with irrigation at 15 m^3/tree/ year. These results are in harmony with those reported by Chauhan *et al*. (2005) on apple, Kandil and El-Feky (2006) on apricot as they illustrated that trees produced the biggest fruits when subject to the highest irrigation rate, and the smallest fruit resulted from lowest irrigation.

Data in Table (5) show the effect of irrigation levels on fruit grain, fruit juice and fruit peel percentage. Concerning fruit grain (%) it increased significantly with increasing irrigation level. Irrigation at 15 m^3/tree/ year gave the highest values of fruit grain (65.13 and 65.46 %), while the lowest values (49.60 and 57.45 %) were recorded by irrigation at 7 m^3/tree/ year in both seasons of study. These results agree with EI-Kassas (1983) and (1984) on pomegranate c v. Manfalouty who found that the grain weight (%) increased by increasing soil moisture level.

Table (5): Effect of irrigation levels on fruit grain (%), fruit juice (%) and fruit peel (%) of Manfalouty pomegranate fruits in 2007 and 2008 seasons

Irrigation levels (m^3/tree /year)	Fruit grain (%)	Fruit juice (%)	Fruit peel (%)
2007 Season			
7	49.60 e	33.50 e	50.40 a
9	55.13 d	36.30 d	44.87 b
11	58.77 c	40.60 c	41.23 c
13	62.53 b	44.29 a	37.47 d
15	65.13 a	42.99 b	34.87 e
2008 Season			
7	57.45 e	35.00 e	42.55 a
9	59.43 d	36.00 d	40.57 b
11	61.07 c	39.63 c	38.93 c
13	63.15 b	46.50 a	36.85 d
15	65.46 a	45.26 b	34.54 e

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability.

In both seasons, irrigation at 13 m^3/tree/ year gave the highest significant fruit juice percentage (44.29 and 46.50 %) followed by irrigation rates of 15, 11 and 9 m^3/tree/ year while 7 m^3/tree/ year gave the lowest value of fruit juice (33.50 and 35.00 %). In this sphere, EI-Kassas (1983) and (1984), Lawand and Patil (1996) on pomegranate and El-Gendy (2002) on grape mentioned that the percentage of juice increased by increasing soil moisture level.

In addition, fruit peel percentage decreased significantly with increasing irrigation levels. Whereas the highest fruit peel percentage (50.40 and 42.55 %in 2007 and 2008 respectively) was recorded by irrigation at 7 m^3/tree/ year and the lowest (34.87 and 34.54 %) was recorded with irrigation at 15 m^3/tree/ year in 2007 and 2008 season respectively. This result is in agreement with El-Khawaga *et al*. (2007) who found that increasing duration of water withholding from one to three weeks before maturation caused a gradual increase in fruit peel (%).

Table (6): Effect of irrigation levels on fruit weight (gm), yield (kg/tree), fruit cracking (%) and water use efficency (kg/m^3 water) of pomegranate c.v. Manfalouty in 2007 and 2008 seasons

Irrigation levels (m^3/tree/ year)	Fruit weight (gm)	Yield (kg/tree)	Fruit cracking (%)	WUE (kg/m^3 water)
2007 Season				
7	230.86 e	20.47 e	8.58 a	2.92 c
9	251.08 d	25.61 d	7.27 c	2.85 c
11	298.94 c	33.87 c	6.85 d	3.08 b
13	321.03 b	41.83 b	6.02 e	3.22a
15	331.19 a	44.81 a	7.93 b	2.98bc
2008 Season				
7	214.94 e	17.41 e	8.99 a	2.49 d
9	245.81 d	22.86 d	8.22 c	2.54 cd
11	287.12 c	29.20 c	6.72 d	2.65 bc
13	306.89 b	37.84 b	6.09 e	2.91 a
15	316.42 a	40.09 a	8.65 b	2.67 b

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability.

As regards fruit weight, yield, fruit cracking and WUE, the data in Table (6) indicate that, fruit weight significantly increased with increasing irrigation levels. Trees produced the heaviest fruits (331.19 and 316.42 gm in the 2007 and 2008 seasons, respectively) when subjected to the highest irrigation level (15 m^3/tree/ year) followed in descending order by those trees under irrigation at 13, 11, 9 then 7 m^3/tree/ year which produced the lowest fruit weight.

Considering yield, there was a significant increase in the tree yield as irrigation level increased reaching the greatest (44.81 and 40.09 Kg) with irrigation at 15 m^3/tree/ year compared with the other treatments. On the other hand lowest yield (20.47 and 17.41 Kg) was detected with the lowest irrigation level (7m^3/tree/ year).

These results agree with those mentioned by Hussein (2004) and Abd El-Samad *et al*. (2006) on pear; Kandil and El-Feky (2006) on apricot, as they concluded that the highest fruit weight and yield (kg/tree) were obtained on trees which received the highest irrigation rate.

Regarding fruit cracking (%), it was reduced significantly with increasing irrigation level from 7 to 9, 11 and 13 m^3/tree/ year, then it increased with irrigation at 15m^3/tree/ year. The lowest significant fruit cracking (6.02 and 6.09% in 2007 and 2008, respectively) was recorded by irrigation at 13 m^3/tree/ year. These results are in line with those reported by EI-Kassas (1983) and (1984), Prasad *et al* (2003) and El-Khawaga *et al*. (2007) on pomegranate, who stated that, by increasing soil moisture level, fruit cracking (%) was decreased.

Concerning WUE, the highest significant WUE (3.22 and 2.91 kg/ m^3 water) was found in trees grown under irrigation at 13 m^3/tree/year. The values decreased with either decreasing or increasing water quantity than 13m^3/tree/ year. Irrigation at 7 m^3/tree/ year gave the lowest WUE (2.92 and 2.49 kg/ m^3 water in 2007 and 2008 seasons respectively). Similar results showing that trees receiving more frequent irrigation had greater water use than trees receiving less frequent irrigation under similar climatic conditions were recorded by Smitle *et al*., (1994), Abd- El-Samad, (2001) on orange, and Abd-El-Samad (2005)on guava.

3.5. Fruit chemical properties at harvest time

Data in Table (7) show the effect of irrigation levels on fruit TSS, acidity and TSS/ acid ratio. Generally, TSS decreased by increasing irrigation level but no significant differences were found between all treatments except between irrigation at 7m^3/tree/ year and 15 m^3/tree/ year in the second season only. The same result was stated by EI-Kassas (1983), Lawand and Patil (1996) and Afria *et al*. (1998) on pomegranate, as they found that TSS decreased by increasing soil moisture level.

In addition, total acidity decreased significantly with increasing irrigation level. The highest significant fruit acidity (2.03 and 2.16 % in 2007 and 2008, respectively) was obtained by irrigation at 7 m^3/tree/ year. Meanwhile, the lowest fruit acidity (1.51 and 1.58 %) was recorded by irrigation at 15 m^3/tree/ year. These results are in agreement with Lawand and Patil (1996) on pomegranate, Abd El-Samad *et al*. (2006) on pear and Kandil and El-Feky (2006) on apricot, as they stated that, the highest fruit acidity was observed with the lowest irrigation rate.

Table (7): Effect of irrigation levels on TSS (%), total acidity (%) and TSS/ acid ratio of Manfalouty pomegranate fruits in 2007 and 2008 seasons

Irrigation levels (m^3/tree/ year)	TSS (%)	Total acidity (%)	TSS /acid ratio
2007 Season			
7	16.50 a	2.03 a	8.13 d
9	16.33 a	1.78 b	9.17 c
11	16.33 a	1.73 b	9.44 c
13	16.17 a	1.39 d	11.63 a
15	16.17 a	1.51 c	10.71 b
2008 Season			
7	16.17 a	2.16 a	7.49 d
9	16.17 a	1.96 b	8.25 c
11	16.00 ab	1.64 c	9.76 b
13	15.83 ab	1.43 e	11.07 a
15	15.67 b	1.58 d	9.92 b

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability

TSS/ acid ratio increased significantly with increasing irrigation level till 13 m^3/tree/ year. The highest TSS/acid ratio (11.63 and 11.07in 2007 and 2008, respectively) resulted from irrigation at 13 m^3/tree/ year, while the lowest values (8.13 and 7.49) were recorded with 7 m^3/tree/ year. Similar results were obtained by Smirnov *et al*.(1986) on grapevines and Verreynne *et al*. (2001) on clementine, as they reported that TSS/acid ratio was increased with increasing the level of irrigation.

Results in Table (8) show the effect of irrigation levels on total sugar, vitamin C and anthocyanin contents of pomegranate fruits. By increasing irrigation level the total sugar content decreased. Whereas irrigation at 7 m^3/tree/ year gave the highest total sugar (14.8 and 14.98%), irrigation at 15 m^3/tree/ year had the lowest total sugar (13.44 and 13.4%). These results are in line with those of Ibrahim (2005) on mango and El-Khawaga *et al*. (2007) on pomegranate, who concluded that, the highest total sugar content resulted from the lowest irrigation levels.

Table (8): Effect of irrigation levels on total sugar (%), vitamin C (mg. scorbic acid/ 100 ml juice) and total anthocyanin (%) of Manfalouty pomegranate fruits in 2007 and 2008 seasons

Irrigation levels (m^3/tree/ year)	Total sugars (%)	Vitamin (c) (mg. scorbic acid/ 100 ml juice)	Total anthocyanin content (%)
2007 Season			
7	14.80 a	17.13 a	5.82 a
9	14.35 b	16.52 b	5.16 b
11	14.00 bc	15.93 c	4.95 b
13	13.73 cd	15.31 d	4.48 c
15	13.44 d	14.80 e	4.01 d
2008 Season			
7	14.98 a	16.37 a	7.66 a
9	14.57 b	15.80 b	6.91 b
11	14.24 c	15.12 c	6.77 b
13	13.65 d	14.77 d	6.29 c
15	13.40 d	14.22 e	6.05 d

Means designated with the same letter in the same column are not significantly different at 0.05 level of probability

Concerning vitamin C (V.C), irrigation at 7 m^3/tree/ year gave the highest (V.C) content, while the lowest content, resulted from irrigation at 15 m^3/tree/ year. High vitamin C content may serve as a protective strategy against drought injury (Seung and Kader, 2000). This result was confirmed by EI-Kassas (1983) on pomegranate c v. Manfalouty, who stated that ascorbic acid decreased by increasing soil moisture. An opposite trend was noticed by El-Khoreiby and Salem (1989) on guava, who indicated that increasing soil moisture content increased V.C content.

In addition, the total anthocyanin content decreased by increasing irrigation levels. Irrigation at 7m^3/tree/ year gave the highest significant total anthocyanin content (5.82 and 7.66 % in 2007 and 2008, respectively) while irrigation at 15 / m^3/tree/season gave the lowest total anthocyanin content (4.01 and 6.05 % in both seasons). Water stress enhances secondary metabolism in particular anthocyanin biosynthesis as part of the stress response (Kevin *et al*., 2009). These results are in parallel to those reported by, Kilili *et al.*, (1996), Abd El-Moteleb (1998) on apple trees, and El-Gendy (2002) on grape, who showed that anthocyanin concentration was higher with drought treatment.

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تأثير مستويات الري على نمو واثمار اشجار الرمان المنفلوطي

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ملخص

أجريت هذة الدراسة خلال موسمى 2007- 2008 على أشجار الرمان المنفلوطي عمر20 عاما منزرعة في ارض رملية تحت نظام الري بالتنقيط بمحطة بحوث القصاصين بمحافظة الإسماعيلية . صممت التجربة بهدف دراسة استجابة أشجار الرمان المنفلوطى للمستويات المختلفة من الري ومدى تأثيرها على النمو الخضرى للأشجار وجودة الثمار. أجريت على الأشجار خمس معاملات من الري وهى 7 أو 9 أو 11 أو 13 أو 15 م^3/شجرة/سنة. أوضحت النتائج ان المعاملة باضافة 15م^3 /شجرة/سنة ادت الى زيادة النمو الخضري من خلال زيادة أطوال الأفرع وعدد الأوراق لكل فرع ومساحة الورقة وكذلك زيادة عدد الازهار للفرع ونسبة العقد ونسبة الثمار المتبقية وحجم الثمرة و نسبة الحب و المحصول ونسبة الثمار المتشققة. سجل إستخدام مستوى الرى 13 م^3 /شجرة/سنة أعلى محتوى للأوراق من عناصر النيتروجين والفوسفور والبوتاسيوم والكالسيوم وكذلك زيادة نسبة العصير بالثمار و نسبة المواد الصلبة الذائبة الكلية الى الحموضة وزيادة كفاءة استخدام ماء الري وأعطى أقل نسبة من تشقق الثمار. بينماأدت معاملة الري بإضافة 7م^3 /شجرة/سنة الى تقليل النمو الخضرى والمحصول ووزن الثمرة مع زيادة نسبة المواد الصلبة الذائبة الكلية و الحموضة و السكريات الكلية وفيتامين ج والانثوسيانين و كذلك نسبة تشقق الثمار.

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