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Growth and Productivity of Pomegranate Trees Under Different Irrigation Levels. II: Fruit Quality

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Abstract: This experiment was carried out in two successive seasons 2007 and 2008 on 20 years old of Manfalouty pomegranate (*Punica granatum*. *L*) trees gown at El-Kassasien Research Station, Ismailia Governorate in sandy soil under drip irrigation system. The experiment involved the following five treatments: 7, 9, 11 (farm control), 13 or 15 m^3/tree/season. Fruit length, diameter and volume increased significantly with increasing irrigation level. Fruit weight increased by increasing the irrigation level from 13 to 15m^3/tree/season respectively and the opposite would be expected by both lower treatments 9 and 7m^3 whereas, fruit weight was lower than the farm control. Irrigation level at 13m^3 gave the higher significant fruit juice and fruit grain percentage compared to farm control. Peel thickness, fruit peel and fruit firmness decreased by increasing amount of water. By increasing irrigation levels TSS decreased as the least irrigation treatment 7m^3/tree/season gave the highest TSS. On the other side, the lowest TSS was achieved by highest irrigation rate 15m^3/tree/season. Fruit acidity decreased significantly by increasing irrigation treatments from 7m^3 to 13m^3/tree/season. Also, a slight raise in acidity was observed by increasing irrigation rate to 15m^3/tree/season as well as farm control (11m^3) displayed an intermediate values over both seasons. Irrigation treatments at 13m^3 showed the highest significant ratio between TSS and acidity, sequenced by 15 m^3 treatments. The moderate TSS/acid ratio was resulted from farm control (11m^3). Total sugars, V.C. and total anthocyanin gradually decreased by increasing irrigation levels where the least irrigation treatment (7m^3/tree/season) gave the highest values.

Key words: Pomegranate · Irrigation levels · Fruit weight · Fruit dimension · Fruit juice · TSS · Acidity · Sugars · V.C · Anthocyanin

INTRODUCTION

Pomegranates can tolerate long periods of drought once the plant is established. However, good water management is important in order to produce large, desirable fruit. Drought conditions will produce a small crop of poor quality fruit or no fruit at all. Pomegranate is widely distributed in the tropical and subtropical regions of the world, even if its importance in the world-wide trade is still very limited. Its high adaptability to versatile conditions especially to stress conditions make it a favourable fruit for marginal land [1, 2]. There are many local cultivars in Egypt such as Manfalouty, Wardy, Nab El-Gamal, El-Araby and recently foreign cultivar like wonderfull, which was entered in Egypt. Manfalouty is considered one of most important pomegranate cultivars grown successfully in Egypt. Pomegranates are fairly drought resistant but require normal watering to produce good fruit crops; over watering results in soft, poorly-colored fruit. EI-Kassas [3] 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 [4] 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 [5]. Also, Ibrahim and Abd El-Samad [6] cleared that, the biggest fruit weight of pomegranate was observed on trees of higher irrigation treatments.

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The present study was undertaken to determine the effect of different irrigation levels on fruit quality of Manfalouty pomegranate cultivar.

MATERIALS AND METHODS

This experiment was conducted during 2007 and 2008 seasons on 20 years old pomegranate cv. Manfalouty (*Punica granatum*. L) trees 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 recommendation of Horticultural Research Institute, Ministry of Agriculture, Egypt. Uniform fifteen trees were selected randomly where the experiment included five irrigation levels: 7 or 9 or 11 (farm control) or 13 and 15m^3/tree/season. Each treatment was replicated three times with one tree for each replicate and the randomized complete blocks design was used.

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 dimensions (cm) (fruit length and diameter were measured by using venire caliper 150 x 0.02mm), fruit volume (cm^3), fruit weight (g), fruit grain (%), fruit juice (%), fruit peel (%), peel thickness (cm) and fruit firmness (Magness-Taylor type pressure tester, has a standard 5/16 of inch pruner was used to determine fruit firmness which recorded in lb/inch^2).

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 [7]. 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 [7]. Total Sugars (%) were determined colorimetrically (phenol 80%) in fresh weight according to Dubois *et al*. [8]. Total anthocyanin (%) was determined by spectrophotometer as described by Hsia *et al*. [9]. The obtained data were tabulated and statistically analyzed according to Snedecor and Cochran [10]. Differences between means were compared by Duncan's multiple range test at 5% level of probability according to Duncan [11].

RESULTS AND DISCUSSION

Fruit Physical Properties

Fruit Dimensions: Fruit length and diameter increased significantly in both seasons with increasing irrigation level (Table 1). Whereas, the biggest significant fruit length and diameter were produced from trees irrigated with the highest level (15m^3/tree/season), meanwhile the smallest fruits were significantly resulted from the least irrigation level (7 m^3/tree/season). Irrigation level 11m^3/tree/season represented an intermediate between 7 and 15m^3. These results are in line with those obtained by El-Khoreiby and Salem [12] on guava, Abd El-Samad [13] on olive, Abd El-Moteleb [14] and Kandil and El-Feky [15] on apricot they declared that, as irrigation level increased both fruit length and diameter significantly increased.

Fruit Volume: Fruit volume increased significantly as irrigation rate increased (Table 1). The greatest significant fruit volume was recorded with trees irrigated by 15m^3/tree/year and decreased significantly with 13m^3 treatment. Farm control (11m^3) gave the middle fruit volume followed by 9m^3 meanwhile the smallest significant fruit volume was recorded by the least irrigation rate (7 m^3/tree/season) in both seasons. In the other word, the average fruit volume in both seasons increased by 42.52% with increasing irrigation rate from 7 to 15m^3/tree/season. These results are in harmony with those reported by Hussein [16] on pear, Ibrahim [17] on mango and Ali [18] on peach they found that, fruit size was gradually decreased parallel to the decrease of irrigation water.

Table 1: Effect of irrigation levels on fruit length, fruit diameter and fruit volume of pomegranate cv. Manfalouty in 2007 and 2008 seasons

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

Values followed by the same letter (s) in each column are not statistically differed at 5% level

Table 2: Effect of irrigation levels on fruit weight, fruit grain and fruit juice of pomegranate cv. Manfalouty fruits in 2007 and 2008 seasons

Irrigation levels (m^3/tree/season)	Fruit weight (g)	Fruit grain (%)	Fruit juice (%)
2007 season			
$7m^3$	230.86 e	49.60 e	33.50 e
$9m^3$	251.08 d	55.13 d	36.30 d
$11m^3$ (control)	298.94 c	58.77 c	40.60 c
$13m^3$	321.03 b	62.53 b	44.29 a
$15m^3$	331.19 a	65.13 a	42.99 b
2008 season			
$7m^3$	214.94 e	57.45 e	35.00 d
$9m^3$	245.81 d	59.43 d	36.00 d
$11m^3$ (control)	287.12 c	61.07 c	39.63 c
$13m^3$	306.89 b	63.15 b	46.50 a
$15m^3$	316.42 a	65.46 a	45.26 b

Values followed by the same letter (s) in each column are not statistically differed at 5% level

Table 3: Effect of irrigation levels on fruit peel, peel thickness and fruit firmness of pomegranate cv. Manfalouty fruits in 2007 and 2008 seasons

Irrigation levels (m^3/tree/season)	Fruit peel (%)	Peel thickness (cm)	Fruit firmenss ($lb/inch^2$)
2007 season			
$7m^3$	50.40 a	0.56 a	25.93 a
$9m^3$	44.87 b	0.54 a	25.59 a
$11m^3$ (control)	41.23 c	0.53 a	23.76 b
$13m^3$	37.47 d	0.49 b	22.88 bc
$15m^3$	34.87 e	0.45 b	22.66 c
2008 season			
$7m^3$	42.55 a	0.44 a	26.11 a
$9m^3$	40.57 b	0.41 ab	25.81 a
$11m^3$ (control)	38.93 c	0.39 ab	24.35 b
$13m^3$	36.85 d	0.37 b	23.44 c
$15m^3$	34.54 e	0.36 b	23.14 c

Values followed by the same letter (s) in each column are not statistically differed at 5% level

Fruit Weight (g): Fruit weight was influenced significantly by irrigation levels during both seasons of study (Table 2). Comparing the farm control ($11m^3$), fruit weight increased by increasing the irrigation level from 13 to $15m^3$ respectively. The opposite would be expected by both lower treatments 9 and $7m^3$ whereas, fruit weight was lower than the farm control in both seasons. These results are in agreement with Ibrahim and Abd El-Samad [6] and Abd El-Rhman [19] who cleared that, the biggest fruit weight of pomegranate was observed on trees of higher irrigation treatments.

Fruit Grain (%): Fruit grain percentage increased significantly with increasing irrigation level (Table 2). Both treatments 13 and $15m^3$ gave higher significant fruit grain in both seasons compared to farm control ($11m^3$) which gave the middle fruit grain percentage. The lower level of irrigation 9 then $7m^3$ decreased significant this trait. In this sphere EI-Kassas [3] and Abd El-Rhman [19] reported that, the fruit grain percentage of Manfalouty pomegranate increased by increasing soil moisture level.

Fruit Juice (%): Fruit juice percentage significantly increased with increasing irrigation levels (Table 2). There were significant differences occurred between irrigation water applied in both seasons except between both lower irrigation levels in the second season. Irrigation level at $13m^3$ gave the highest significant fruit juice percentage followed by 15, 11 and 9 meanwhile, 7 m^3/tree/season recorded the lowest significant value of fruit juice. Similar results were reported by EI-Kassas [3] and Lawand and Patil [4] and Abd El-Rhman [19] they found that, the percentage of pomegranate fruit juice increased by increasing soil moisture level.

Fruit Peel (%): The highest significant fruit peel in Table 3 was obtained by irrigation at $7m^3$/tree/season followed by $9m^3$/tree/ season then $11m^3$/tree/season. Meanwhile, with $13m^3$ treatment fruit peel was reduced finally, the lowest significant fruit peel was obtained with highest irrigation rate $15m^3$/tree/season. These results are in agreement with El-Khawaga *et al*. [5] who found that, increasing duration of water withholding from one to three weeks before maturation caused a gradual increase in percentage of fruit peel.

Peel Thickness (cm): As shown in Table 3 peel thickness increased due to decreasing amount of water in the first and second seasons. The highest peel thickness was obtained with the least irrigation treatments where the differences between them were insignificant in both seasons, whereas the lowest peel thickness was found with the highest irrigation treatments (13 and $15m^3$/tree/season). These results are in line with El-Gazzar *et al*. [20]; Chartzoulakis *et al*. [21] on orange and Halder *et al*. [22] on Pomelo citrus as they indicated that, tree grown under dried treatment yielded fruits with significantly thicker peel.

Fruit Firmness ($lb/inch^2$): Fruit firmness decreased by increasing amount of water and the farm control ($11m^3$) treatment gave moderate fruit firmness. No significant difference was occurs between both treatments 13 and $15m^3$ which had the lowest values. Trees that received the lowest irrigation rate $7m^3$ and 9 m^3 gave the highest fruit firmness in both seasons without any significant difference between each others. These results are in harmony with Ali [18] on peach, Kandil and El-Feky [15] on apricot and Mikhael and Mady [23] on apple.

Table 4: 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/season)	TSS (Brix°)	Total acidity (%)	TSS/acid ratio
2007 season			
$7m^3$	16.50 a	2.03 a	8.13 d
$9m^3$	16.33 a	1.78 b	9.17 c
$11m^3$ (control)	16.33 a	1.73 b	9.44 c
$13m^3$	16.17 a	1.39 d	11.63 a
$15m^3$	16.17 a	1.51 c	10.71 b
2008 season			
$7m^3$	16.17 a	2.16 a	7.49 d
$9m^3$	16.17 a	1.96 b	8.25 c
$11m^3$ (control)	16.00 ab	1.64 c	9.76 b
$13m^3$	15.83 ab	1.43 e	11.07 a
$15m^3$	15.67 b	1.58 d	9.92 b

Values followed by the same letter (s) in each column are not statistically differed at 5% level

Table 5: Effect of irrigation levels on total sugars, vitamin C and total anthocyanin of Manfalouty pomegranate fruits in 2007 and 2008 seasons

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

Values followed by the same letter (s) in each column are not statistically differed at 5% level

Fruit Chemical Properties

Total Soluble Solids Content (TSS): Total soluble solids content showed no significant differences under irrigation treatments throughout two seasons except between the lowest irrigation ($7m^3$/tree/season) and the highest irrigation ($15m^3$/tree/season) in the second season only (Table 4). But results of TSS showed that, by increasing irrigation rates TSS decreased. As the least irrigation treatment $7m^3$/tree/season gave the highest TSS. On the other side, the lowest TSS was achieved by highest irrigation rate $15m^3$ in both seasons. Similar result was showed by Ali *et al*. [24] on apple, Hussein [16] on pear and Abd El-Samad [25] on guava they concluded that, fruit produced on trees under irrigation at low rate contained more soluble solids than those under moderate or excess irrigation treatments.

Total Acidity (%): First and second seasons results as shown in Table 4 indicated that, total acidity (%) of fruits was decreased significantly by increasing irrigation treatments from $7m^3$ to $13m^3$/tree/season. Also, a slight raise in acidity was observed by increasing irrigation rate to $15m^3$/tree/season as well as farm control ($11m^3$) displayed an intermediate values over both seasons. It was also stated by Lawand and Patil [4] and Shailendra and Agrawal [26] on pomegranate that, the lowest fruit acidity was recorded by highest irrigation rate.

TSS/acid Ratio: Fruit quality is mainly affected by TSS of fruit juice as well as total acidity. Therefore, TSS/ acid ratio can truly express the fruit quality indices. Data in Table 4 appear that, irrigation treatments at $13m^3$ showed the highest significant ratio between TSS and acidity, sequenced by 15 m^3 treatments. The moderate TSS/acid ratio was resulted from farm control ($11m^3$). These results are in harmony with Abou-Aziz *et al*. [27] on Manfalouty pomegranate they found that, lower TSS/acid was observed under lowest irrigation treatment.

Total Sugars (%): By increasing irrigation level the total sugars (%) decreased (Table 5). In these sphere, the lowest irrigation level (7 m^3/tree/season) had the highest significant total sugars followed by the level $9m^3$ then farm control $11m^3$. Meanwhile, differences between 13 and $15m^3$/tree/season were less pronounced and not consistently significant in both seasons. These results are in line with Ibrahim [17] on mango and El-Khawaga *et al*. [5] on pomegranate, they pointed that trees exposed to reduced soil water availability had higher concentration of sugars.

Vitamin C Content (V.C): With increasing amount of irrigation water applied the V.C. content gradually decreased significantly (Table 5). The maximum V.C content was resulted from trees which irrigated with $7m^3$/tree/season then it decreased with $9m^3$/tree/season. The farm control $11m^3$ had the middle V.C content in both seasons. While, the V.C content decreased significantly when the amount of irrigation water increased than farm control to 13 or $15m^3$ respectively. High vitamin C content may serve as a protective strategy against drought injury [28]. This result was confirmed by EI-Kassas [3] on Manfalouty pomegranate that, ascorbic acid decreased by increasing soil moisture.

Total Anthocyanin (%): Total anthocyanin content decreased by increasing irrigation levels where the least irrigation treatment ($7m^3$) gave the highest significant total

anthocyanin content. Irrigation levels above farm control (13 and 15m^3) had the lowest total anthocyanin content in both seasons. However, water stress enhances secondary metabolism in particular anthocyanin biosynthesis as part of stress response [29]. These results are in parallel to those reported by El-Gendy [30] on grape who found that, the negative effect of applied water on skin color with special reference to anthocyanin content was parallel to the amount of irrigation water. The berries of cluster which received highest irrigation rate significantly contained the least content of anthocyanin. In this line, Abd El-Moteleb [14] on apple trees showed that, anthocyanin concentration was higher with drought treatment.

REFERENCES

1. Roy, S.K. and D.P. Waskar, 1997. Pomegranate. In: Postharvest physiology and storage of Tropical and subtropical fruits, S.K. Mitra, (ed). CAB International, Willingford.
2. Haggag, M.N. and H.A. El-Shamy, 1987. Response of fig and pomegranate fruits to NPK fertilization. Alex. J. Agric. Res., 32: 199-208.
3. El-Kassas, S.E., 1983. Effect of irrigation at certain soil moisture levels and nitrogen application on the yield and quality of Manfalouty pomegranate cultivar. Assiut J. Agric. Sci., 14: 167-179.
4. Lawand, B.T. and V.K. Patil, 1996. Effect of different water regimes on fruit quality of pomegranate (*Punica granatum* L.). Inter. J. Tropical Agric., 14: 153-158.
5. El-Khawaga, A.S., A.M. Abou-El-Khashab and M.A. El-Eraky, 2007. Impact of water withholding before ripening, zing and glutathione on fruit splitting and productivity of Manfalouty pomegranate trees. Minia J. Agric. Res. Develop., 27: 481-496.
6. Ibrahim, A.M. and G.A. Abd El-Samad, 2009. Effect of different irrigation regimes and partial substitution of N-mineral by organic manures on water use, growth and productivity of pomegranate trees. Euro. J. Sci. Res., 38(2): 199-218.
7. A.O.A.C., 1985. Official Methods of Analysis. 14th Ed. Washington DC, USA., pp: 382.
8. Dubois, M.., K. Gilles, J.K. Hamiton, P.A. Rebers and F. Smith, 1956. A calorimetric method for the determination of sugars and related substances. Anal. Chem., 28: 350-355.
9. Hsia, C.L., B.S. Luh and C.O. Chickester, 1965. Anthocyanin in fresh tone peaches. J. Food Sci., 30: 5-12.
10. Snedecor, G.W. and W.G. Cochran, 1980. Statistical methods. Oxford and J.B.H. Bub com. 7th Edition.
11. Duncan, D.B., 1955. Multiple range and multiple F test. Biometrics, 11: 1-24.
12. El-Khoreiby, A.M.K. and A.T. Salem, 1989. Effect of different irrigation regimes on growth, fruiting and fruit quality of seedy guava trees. Ann. Agric. Sci., Fac. Agric., Ain Shams Univ., 34: 313-321.
13. Abd El-Samad, G.A., 1995. Effect of Irrigation Regimes on Growth, Yield and Water Use of Olive Trees. Ph.D. Thesis, Fac. Agric. Hort. Dept., Fayoum, Cairo Univ., Egypt, pp: 218.
14. Abd El-Moteleb, M.M.M., 1998. Response of Apple Trees of Some Irrigation Treatments in New Reclaimed Soils. Ph.D. Thesis, Fac. Agric., Hort. Dept, Ain Shams Univ., Egypt, pp: 94.
15. Kandil, E.A. and U.S. El-Feky, 2006. Effect of soil matric potential on Canino apricot trees in sandy soil under drip irrigation. J. Agric. Sci. Mansoura Univ., 31(9): 5867-5880.
16. Hussein, S.M.M., 2004. Effect of Different Irrigation Levels on the Le-Cont Pear Trees. Ph.D. Thesis, Fac. Agric. Hort. Dept., Cairo Univ., Egypt, pp: 175.
17. Ibrahim, A.R., 2005. Studies on the Determination of Water Requirements of Mango Trees Under Giza Governorate Condition Using Agrometeorological Data. M.Sc. Thesis, Fac. Agric., Hort. Dept. Ain Shams Univ., Egypt, pp: 86.
18. Ali, M.M., 2006. Effect of different irrigation rates and emitter distance on vegetative growth, fruiting and water use efficiency (WUE) for Florida Prince peach cultivar trees. Egypt. J. Appl. Sci., 21: 184-204.
19. Abd El-Rahman, I.E., 2010. Physiological studies on cracking phenomena of pomegranate. J. Appl. Sci. Res., 6: 696-703.
20. El-Gazzar, A., A.A. Etman, A. Hussien and H.M. Sinbel, 1986. Effect of variation in soil water condition on fruit set, fruit drop, yield and fruit quality of Washington Navel orange trees. J. Agric. Res. Tanta Univ., 12: 487-500.
21. Chartzoulakis, D., N. Michelakis and E. Stefanoudaki, 1999. Water use, growth, yield and fruit quality of Bonanza orange under different soil water regimes. Adv. Hort. Sci., 13: 6-11.
22. Halder, N.K., M.K. Shaha., A.H.M. Fazlul Kabir, M.D. Jullur Rahman and M.D. Zahurul Islam, 2003. Effect of lime and irrigation on the yield performance of pomelo (*Citrus grandis*) in the Hilly region. Pakistan J. Biological Sci., 6: 246-248.

23. Mikhael, G.B. and A.A. Mady, 2007. Effect of some drip irrigation and mulching treatments on: II. Yield, fruit quality and water use efficiency of Anna apple trees grown in new reclaimed soils. Minufiya. J. Agric. Res., 32: 1175-1191.
24. Ali, M.A., M.M. Mahmoud and A.Y. Salib, 1998. Effect of soil moisture stress on apple trees. Egypt. J. Agric. Res., 76: 1565-1583.
25. Abd El-Samad, G.A., 2005. Water use, growth and productivity of some new guava strain as affected by different irrigation regimes. Egypt. J. Hort., 32: 41-56.
26. Shailendra, A. and N. Agrawal, 2005. Effect of trickle irrigation on growth, yield and quality of pomegranate (*Punica granatum*) cv. Ganesh in Chhattisgarh Region. Mysore J. Agric. Sci., 39: 175-181.
27. Abou-Aziz, A.B., S.E. Kassas, B.N. Boutros and A.M. El-Sese, 1995. Yield and fruit quality of Manfalouty pomegranate trees in response to soil moisture and irrigation regime. Assiut J. Agric. Sci., 26: 115-128.
28. Seung, K.L. and A.K. Adel, 2000. Preharvest and postharvest factors in?uencing vitamin C content of horticultural crops. Postharvest Bio. Tec., 20: 207-220.
29. Kevin, G., D. Kevin and W. Chris, 2009. Anthocyanins Biosynthesis, Functions and Applications. Springer Science, Business Media, pp: 330.
30. El-Gendy, R.S., 2002. Utilization of Evapotranspiration Data for Use in Irrigation for Thompson and Flame Seedless Grapevines. Ph.D. Thesis, Fac. Agric. Hort. Dept., Cairo Univ., Egypt, pp: 200.