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RESPONSE OF PERSIMMON TREES ON CLAY LOAMY SOILS TO DIFFERENT IRRIGATION LEVELS

BY

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ABSTRACT

The G_1 (wet) regime gave the highest consumptive use followed by G_2 (medium), then G_3 (dry). Hachyia and Costata were as follows: wet (1554.6 and 1528), medium (1405.5 and 1385.1) and dry (989.8 and 985.3 mm) respectively. Water consumption increased as soil moisture maintained high by frequent irrigation . Monthly water use was low after dormancy, then increased to reach a maximum during July and August. The rates declines to reach minimum during October. Seasonal crop coefficient (Kc) was 0.72 . Comparing actual ET with calculated ET under using the Doorenbos - Pruitt equation could be recommended to estimate the crop evapotranspiration (ETc) from the agroclimatological data. Estimated ETc of Persimmon trees were 1320 mm, while the overall average of the actual consumptive use, measured by the soil moisture depletion, both by Hachyia and Costata was 1374 and 1370 mm. respectively . Water use efficiency (WUE) both by Hachyia and Costata cvs was highest with G_2 (2.12 and 1.26), then with G_3 (1.96 and 1.25) then with G_1 (1.91 and 1.19) kg fruits / m^3 irrigation water respectively. Fruit yield was 12.405, 12.205 and 8.112 ton/fed. With G_1, G_2 and G_3 respectively with Hachyia and 7.610, 7.248 and 5.160 ton/fed. Respectively with Costata with the former irrigation rates, respectively. Hachyia cv. could give higher yield and water use efficiency under different irrigation water regimes.

INTRODUCTION

Persimmon trees is one of important deciduous fruits, botanically belonging to the family *Ebonaceae* and the genus *Diospyros.* Persimmon trees grow well with good production under the native temperate and subtropical areas where soils are well drained with suitable cultural practices especially both fertilization and irrigation.

Irrigation of the cultivated fruit trees is problem of fruit production in arid and semi arid regions. However yield and fruit quality of fruit trees depend entirely on frequency of irrigation. Each fruit variety and cultivar needs certain quantity of irrigation water which must be added in certain times during the growing season.

Water requirement differs considerably with season, soil type and tree variety. When a tree suffers from lack of water, its yield decreases even though it may recover after irrigation. On the other hand, increasing the number of irrigations (or water quantity) may result in injuring the crop and the soil besides being a waste as water and labor.

Before irrigation reduction can be adopted as a management strategy, it is important to understand its effect on commercial fruit production. Minimizing water use not only reduces production costs (especially where fertigation is practiced) but also helps to meet the environmental regulations in many (Drake, *et al.*, 1981 and Hanks, 1983). Irrigation at 80 % field capacity gave highest growth parameters (Storchus and Kosykh, 1993). Moreover, Chalmers (1990) working on pear and Peach showed that, deficit irrigation at 25 % evapotranspiration gave less shoot development than full irrigation at 100 % evapotranspiration. Decreased water supply caused a decrease in N-content in plants was reported by Draz, (1986) on bitter almond and Mohamed, (1993) on banana. Also, decreased irrigation caused a decrease in plant P-content was reported by Swellem, (1986) on "Valencia" orange and Safaa, (1994) on persimmon. Decreased irrigation led to a decrease in K in citrus plants El-Kassas, (1972) and Youssef, (1990).

Water for agriculture in Egypt is becoming a major constraint therefore maximizing its use can be carried out through the use of modern irrigation systems (Brown, 1999).

Cathoun (1975) found that soil water stress caused by increasing its moisture tension from zero to 0.33 bar released more than 75 % of soil water in light textured soil but less than 50 % in heavy textured ones. El-Gindy *et al.* (1991) on cucumber and squash grown on calcareous soils showed that, high moisture in soil induced when soil moisture tension decreases the yield and water use efficiency increase. Abd El-Messeih and El-Gindy (2004) on apricot concluded that, irrigation scheduling by the soil matric suction near field capacity has saved irrigation water, increased vegetative growth, fruit yield and water use efficiency under drip irrigation.

Wright and Stark (1990) observed that, plant growth and development was retarded when water supply was restricted. Semash and Panasenko (1984), Ali *et al.* (1998) and Salem *et al.* (1999), Fathi (1999 a and b) and Ismail *et al.* (2007) on pear and Ali, (2006) on peach obtained increased growth with irrigation at 80 %. (Kandil and El-Feky, 2006) reported that water soil potential at 100-200 m bar (12.94 m^3/tree/year) was the best level for "Canino" apricot trees.

There is a lack information about the response of persimmon trees to water deficit. The present study was carried out to study the effect of different irrigation regime growth and leaf composition for two persimmon cultivars (Costata and Hachyia) grown under conditions of Qalyoubia Governorate.

MATERIALS AND METHODS

The present investigation was undertaken during the two successive seasons of 2007 and 2008 in the Experimental Farm at El-Kanater Horticultural Research Station, Kalubia Governorate on fruitful trees of two Japanese persimmon (*Diospyros kaki* L.) ("Hachyia" and "Costata" cultivars.).

Eighteen healthy and uniform trees from each cultivar were carefully selected to represent three replicates for each treatment. Each replicate was represented by two trees. Trees were about 15-year-old budded on *Diospyros virginiana* rootstock. Hachyia cv. trees were at 5 x 5 m apart while Costata cv. ones were at 3 x 4 m apart in a clay loamy soil with flood irrigation. Analysis of the soil are shown in Table 1 Meteorological data for the Agricultural Research Station are shown in Table 2.

Methods used in this study one described by Piper (1950), Allam (1951) and Jensen (1968). Trees were subjected to standard fertilization, pruning and control programs usually done at the region.

The experimental design was a randomized complete block . Irrigation treatments used in this study were as follows:

1- Irrigation water when 25 % of available soil moisture is depleted (wet.) (G_1).
2- Irrigation water when 50 % of available soil moisture is depleted (medium) (G_2).
3- Irrigation water when 75 % of available soil moisture is depleted (dry) (G_3).

Irrigation started after trees received the winter irrigation on March i.e., starting from bud swelling stage . Irrigation was done when moisture reached the relevant level (5 days after irrigation) to determine available soil water retained in the soil . Soil moisture was determined grave metrically on oven dry basis of soil samples taken to a depth of 15 cm. up to 60 cm. water consumption use was computed as the differences of soil moisture content in soil samples taken prior to 48 h. after irrigation.

Table (1): Physical properties of soil of the experiment.

Parameter							Value
Particle size distribution (%):							
Clay %							31.4
Silt %							33.5
Fine sand %							34.0
Coarse sand %							1.1
Texture class							Clay loam
Water parameters and bulk density							
Depth	Field capacity (FC)		Wilting Point (WP)		Available water (AW)		Bulk density (BD) Mg/m^3
	% by weight	cm	% by weight	cm	% by weight	cm	
0-15	35.8	6.50	18.8	3.41	17.0	3.10	1.21
15-30	33.4	5.91	17.3	3.10	16.1	2.81	1.18
30-45	31.9	5.98	15.1	2.83	16.8	3.15	1.25
45-60	31.7	7.23	16.8	3.83	14.9	3.4	1.52
Total		25.62		13.17		12.46	

FC: moisture at 33 kPa moisture tension. WP: moisture at 1.5 MPa moisture tension.
AW = FC-WP

Table (2): Meteorological data in 2007 and 2008 seasons.

Season	2007					
Month	T.max.	T.min.	W.S	R.H.	S.S	S.R
March	24.6	13.2	4.4	59	8.6	441
April	27.8	16.1	5.2	57	9.6	519
May	33.4	20.7	5.0	51	10.8	585
June	36.3	22.1	4.8	45	12.0	627
July	37.2	24.4	3.3	54	11.7	613
August	36.0	25.8	2.8	61	11.1	577
September	33.1	23.4	3.2	62	10.3	512
October	31.3	21.2	4.6	58	9.2	417
	2008					
March	27.4	13.1	4.7	47	8.6	441
April	30.4	15.7	5.2	44	9.6	519
May	32.6	18.9	4.4	48	10.8	585
June	36.3	22.5	4.1	54	12.0	627
July	35.9	23.2	3.7	63	11.7	613
August	36.8	23.6	3.7	61	11.1	577
September	35.7	22.3	3.0	60	10.3	512
October	30.0	18.4	2.6	59	9.2	417

where: **T.max., T.min.**= maximum and minimum temperatures °C; **W.S** = wind speed (m/ sec); **R.H.**= relative humidity (%); **S.S**= actual sun shine (hour); **S.R**= solar radiation (cal/ cm^2/ day).
[Data were obtained from the agrometeorological Unit at SWERI, ARC]

1. **Calculation of water consumptive use (CU):**

Water consumpitive use was calculated for each irrigation using the following formula (Vites, 1965).

$CU = D.Bd. [Q_2 - Q_1] / 100$

Where:

CU = Consumptive use (mm.)

D = The depth (in mm) of the irrigated soil under consideration.

Bd = Bulk density (Mg/m^3) of the soil in the relevant soil depth.

Q_2 = Percentage of moisture in soil (w/w) following maximum irrigation (within the relevant soil depth).

Q_1 = Percentage of soil moisture (w/w) before next irrigation (within the relevant depth).

2. Calculation of crop coefficient and evapotranspiration:

2.1. Reference evapotranspiration (ETo):

Reference evapotranspiration (ETo) was calculated using the meteorological data by four formulas as cited by Doorenbos and Pruitt, (1977) and Allen *et al.* (1998) as follows:-

a - Formula 1: the Modified Penman equation:

ETp =C[w. Rn + (1-w). F(u). (ea-ed)].

Where:

ETp = Potential evapotranspiration (mm / day).

C = Adjustment factor.

W = Temperature-related weighing factor.

Rn = Net radiation in equivalent evaporation (mm / day).

Fu = Wind-related function.

ea-ed = Difference between the saturated vapor pressure at mean air temperature and mean actual vapor pressure of the air (both in mbars).

b – Formula 2:3 the Doorenbos- Pruitt equation:

Doorenbos – Pruitt (1977) adapted the radiation formula of Makkink 1957 to predict potential evapotranspiration as follows:

ETp = bw Rs/L- 0.3

Where:

ETp = Daily potential evapotranspiration (mm/day).

b = Adjustment factor based on wind and mean relative humidity.

W = Weighting factor based on temperature and elevation above sea level.

Rs = Daily total incoming solar radiation for the period of consideration (cal/cm^2/ day).

L = Latent heat of vaporization of water (cal/ cm^2/ day)

Factors (b) and (w) could be obtained from the tables cited by (Doorenbos and Pruitt 1977).

c- Formula 3: the Penman- Monteith equation:

For estimating potential evapotranspiration of Penman Monteith, it was applied by using CROP WAT model (Smith 1991) as follows:-

$ETo = ET_{rad} + ET_{aero}$

Where:

ETo= Reference evapotranspiration of standard crop canopy (mm/day).

ET_{rad} = Radiation term (mm/day).

ETaero = Aerodynamic term (mm / day).

2.2. Crop Coefficient (Kc):

The recommended values of Kc, according to Doorenbos and Kasam (1986) were used to estimate the ET for the potatoes crop under conditions of the area where the experiment was done. The formula is as follows:

Kc = Etc / ETo

Where:

Kc = Crop coefficient.

ETc = The measured (actual) evapotranspition of a considered period (mm/day)

Eto = reference evapotranspiration (mm/day) referring to the same period, calculated as average value of four formulas.

3. Water use efficiency (WUE):

Water use efficiency (WUE) is used to describe the relationship between production and the amount of water used. It was determined according to the following equation (Vites 1965):

WUE = Yie (kg/f) / Total amount of water delivered to the crop (m^3/f)

4. Vegetative growth measurements: .

Some growth parameters were studied. Through determining both the average shoot length, diameter, number of leaves per shoot, leaf area and percentage of leaf dry weight.

5. Fruiting parameters:

Average yield per tree for each treatment was determined at harvesting time during the two seasons of study.

5.1. Fruit quality:

Samples of twenty fruits from each replicate at harvest were randomly collected and the following characters were determined as follows:

5.1.1. Physical properties:

Fruit weight, fruit size, length, diameter and firmness. Firmness was determined using Magness and Taylor (1925), preassure tester with 7/18 inch plunger.

5.1.2 Chemical properties:

Total soluble solids in fruit juice was determined using hand refractometer. Fruit juice acidity according was measured according to A.O.A.C. (1985) and Vogel (1968). Total sugars were determined colourmetrically according to Dubaist *et al.* (1956).

6. Leaf nutrient composition:

Leaf samples were collected then washed with tap water followed by distilled water to remove any residues that might affect the results (Labanauskas 1966), Fresh weight was determind and oven dried at 70 °C till a constant weight then weighed and ground for analysis. Total nitrogen was determined by the micro-kjeldahl method Pregl (1945). Total phosphorus was determined in concentrated acid digest and measured using a spectrophotometer at 882 μv according to the method described by Murphy and Reily (1962). Total potassium content was determined in the acid digest using the Atomic Absorption Spectrophotometer Method for plant analysis are cited in Jackson and Ulrish (1959) and Chapman and Pratt (1961).

All the obtained data in the two seasons of study were statistically analyzed according to Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

1. Water Relations

1.1. Water consumptive use:

1.1.1. Seasonal Rates (mm):

Seasonal rates of water consumptive use (cu) by trees under different soil moisture stress treatments are presented in Fig.1. The values of water use by Hachyia cv. Show that the highest irrigation (i.e. the wet G_1 regime) gave the highest cu of 1554.6 mm followed by the medium G_2 regime, which gave 1379.8 mm then by the dry regime G_3 989.8 mm. Water use by the Costata cv. trees showed the followings: G_1 (wet) 1528, G_2 (medium) 1357.0 and G_3 (dry) 985.3 mm. Increased cu with increased moisture is a direct consequence of increased input of irrigation water which accompanied increased wetness of the moisture regime. The values showed that seasonal water use by trees are higher in the second than in the first season. Such results are mainly due to differences in climatic factors and tree age.

Pruitt, 1960 and Chang, (1971) concluded that the rate of evapotranspiration depends on the evaporate power of air and there was a very close correlation of water consumptive use and climate. The pattern of consumptive use was $G_1 > G_2 > G_3$ is a manifestation of greater water availability of soil moisture to plants. High evaporation would occur from a relatively wet rather than a relatively dry soil surface. Higher CU with the wet regime can be attributed to greater availability of soil water to persimmon trees in addition to the higher evaporation rate from wet soil surface, Doorenbos and Pruitt (1984) concluded that, after irrigation the soil water content decreases primarily by evapotranspiration. As the soil dries, the rate of water transmitted through the soil is reduced. When the rate of flow falls below the rate needed to meet ET of crop, it will fall below its predicted level. Unger and Stewart (1983) pointed out that, soil water evaporation occurs in three stages. In the first, water loss is rapid and steady, and depends on the net effects of water transmission to the surface and on environmental conditions. In the second stage, the loss rate decreases rapidly as the soil water supply is depleted, and soil factors control the rate of water movement to the surface and above ground. In the third stage, evaporation is extremely slow and is controlled by absorptive factors at the liquid-solid interface. Abd Alla *et al.* (1990a) found that, the highest CU occurred when irrigation was done upon reaching a moisture of 70 to 80 % of the field capacity.

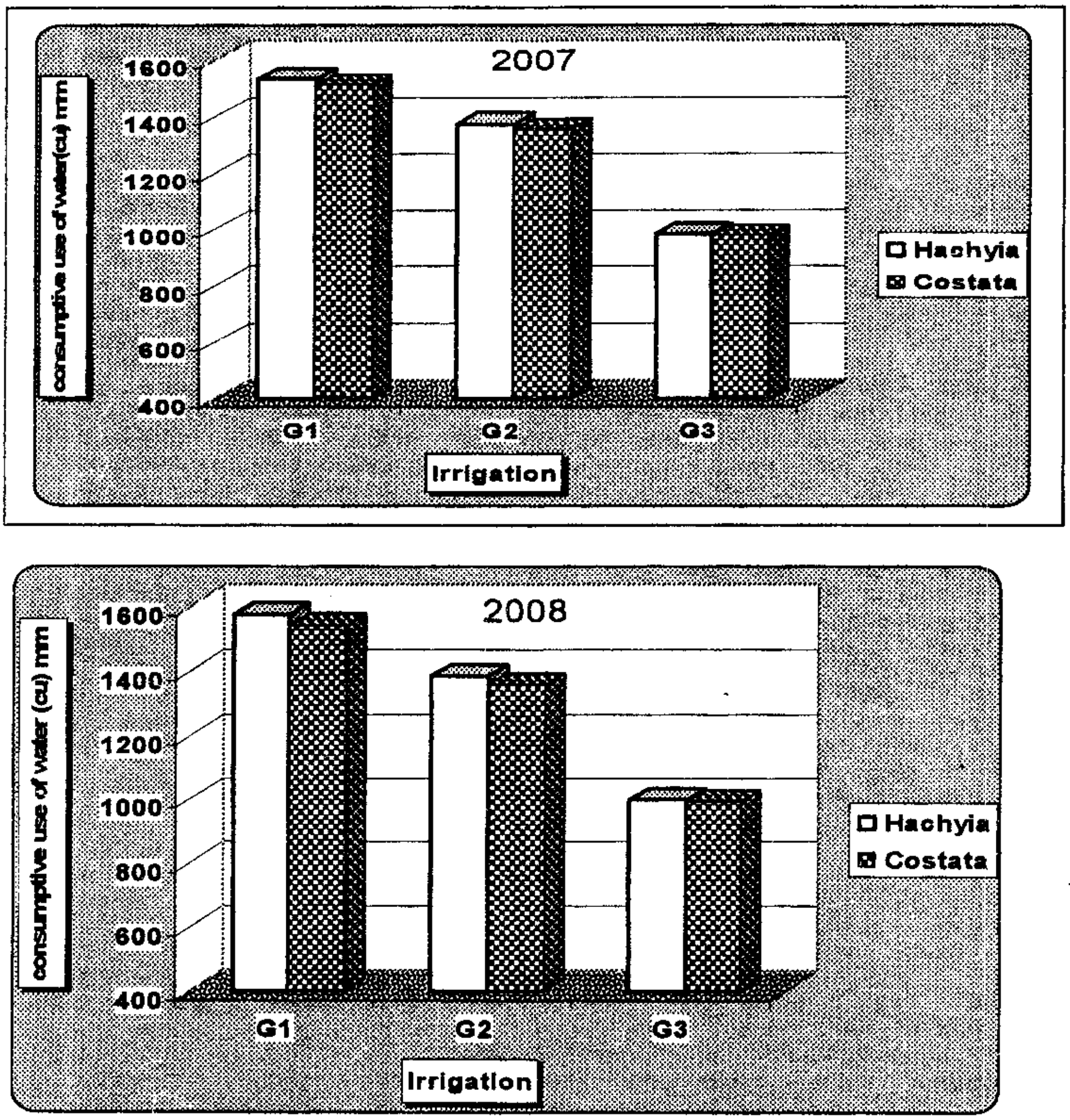


Figure (1): Effect of irrigation treatments (G) on consumptive use of water CU) mm of persimmon trees.

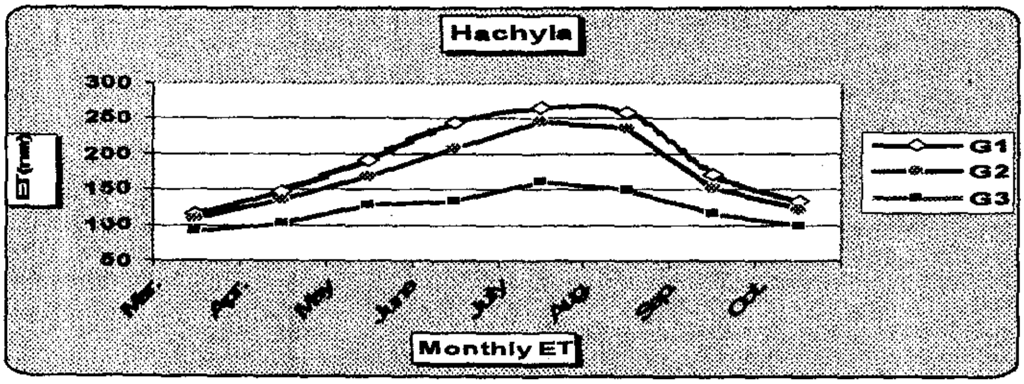
G1 Irrigation when 25% available soil moisture is depleted (wet).
G2 Irrigation when 50% available soil moisture is depleted (medium).
G3 Irrigation when 75% available soil moisture is depleted (dry).

1.1.2. Monthly consumptive use:

Monthly CU (Fig. 2) was low at the beginning of the growth season (after dormancy). This is related to less transpiring surface (leaves) during the period of blooming. Potential evapotranspiration was low through this period Table 3, then increased gradually as the green cover increased with increases in air temperature and solar radiation. The highest occurred during June and July reflecting: a) expansion of the leaf system, b) growth of fruit on a volume basis, c) high solar radiation and air temperature. Thereafter, evaportanspiration rate thereafter decline to reach its minimum value during October as the trees were approaching dormant period. Such results can be attributed to high evaporation than transpiration early in the season (blooming period) as plants intercept little of net radiation. Later, as the green cover expanded, transpiration was greater than evaporation. Thus, the increase in evapotranspiration from the beginning of the growth season till fruit maturity can be explained on the basis of the cover. It can be concluded that soil moisture stress has a direct effect on monthly evapotranspiration of trees. As soil moisture stress increased by prolonged irrigation intervals, monthly water use decreased. The drier the soil, the lesser is the water consumption by persimmon trees. Weagand (1962) pointed out that, the drying rate of a bare soil is positively related to the water content and relatively related to time, and that a drying front advances into the soil linearly. Ibrahim (1981) concluded that the increase in evapotanspiration by maintaining soil moisture at a high level is attributed to excess available water in the root zone .

Table (3) Actual ET.mm/Monthly by irrigation medium (G2).

	Actual ET.mm/Monthly								
	season	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
Hachyia	2007	109.74	166.20	175.15	191.10	226.92	220.10	153.00	131.44
	2008	110.98	167.40	177.63	193.20	229.71	221.65	154.50	131.75
	Mean	**110.36**	**166.80**	**176.39**	**192.15**	**228.32**	**220.88**	**153.75**	**131.60**
Costato	2007	108.50	164.40	170.81	188.10	217.80	212.40	160.80	132.68
	2008	110.36	165.90	160.02	194.70	219.30	215.40	162.30	130.51
	Mean	**109.43**	**165.15**	**165.42**	**191.40**	**218.55**	**213.90**	**161.55**	**131.60**
	Mean of two seasons								
	2007	109.12	165.30	172.98	189.60	222.36	216.25	156.90	132.06
	2008	110.67	166.65	168.83	193.95	224.51	218.53	158.40	131.13
	Mean	**109.90**	**165.98**	**170.90**	**191.78**	**223.43**	**217.39**	**157.65**	**131.60**



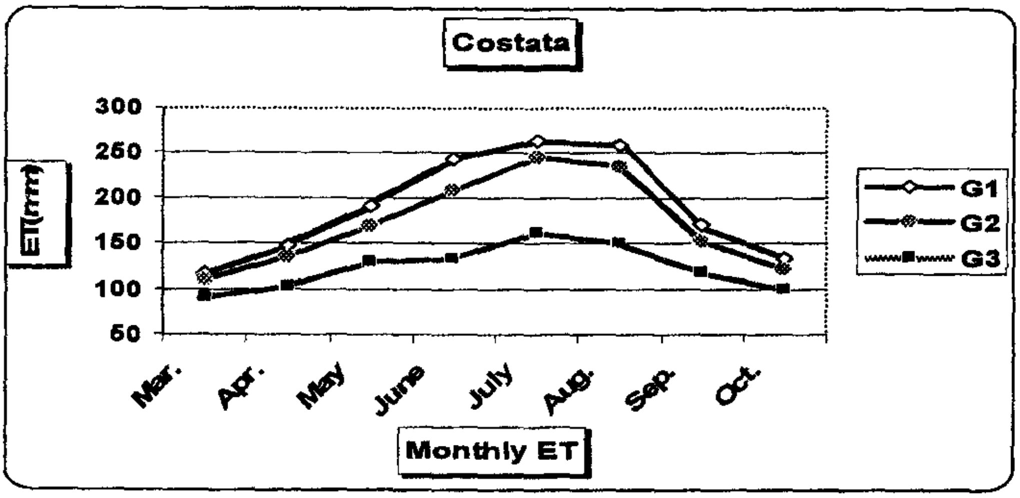


Figure (2): Monthly ET.(mm) for persimmon trees under different water stress treatments.

G1 Irrigation when 25% available soil moisture is depleted (wet) .

G2 Irrigation when 50% available soil moisture is depleted (medium) .

G3 Irrigation when 75% available soil moisture is depleted (dry) .

1.2.Water Uptake:

Water uptake by persimmon tree roots under different soil moisture stress is illustrated in Fig. 3. Results indicate that, persimmon roots extract 75% of their moisture needs from the first 30cm of soil profile . The rest is extracted from the second 30cm . These current results show that, most roots are usually concentrated in the upper soil layer. Illustrating the importance of irrigating frequency to compensate the moisture consumed from the first 30 cm. Prolonged irrigation intervals may cause an injury to the root hairs of the trees.

Growth of deciduous trees would be reduced. Increasing soil moisture stress may result in decreasing the amount of water absorbed from the lower soil depths. This can be attributed to, water deficit restricting the growth of root hairs of trees. Uriu and Magness (1967) concluded that, growth of apple roots decreased as soil water suction reached 0.4 - 0.5 bar. Johnson *et al.* (1992) pointed out that, soil moisture determination indicate that, water use by the control occurred mainly in the upper soil profile.

1.3. Crop coefficient (Kc) and assessment of ET:

Three different equations were used to assess the extent of closeness of each estimate with the actual values obtained by direct measurement (values shown by the G_2 treatment which is the medium treatment). These equations are (1) the modified Penman equation, (2) the Penman - Monteith equation using the CROPWAT model and (3) the Doorenobs – Pruitt (1977) equation.

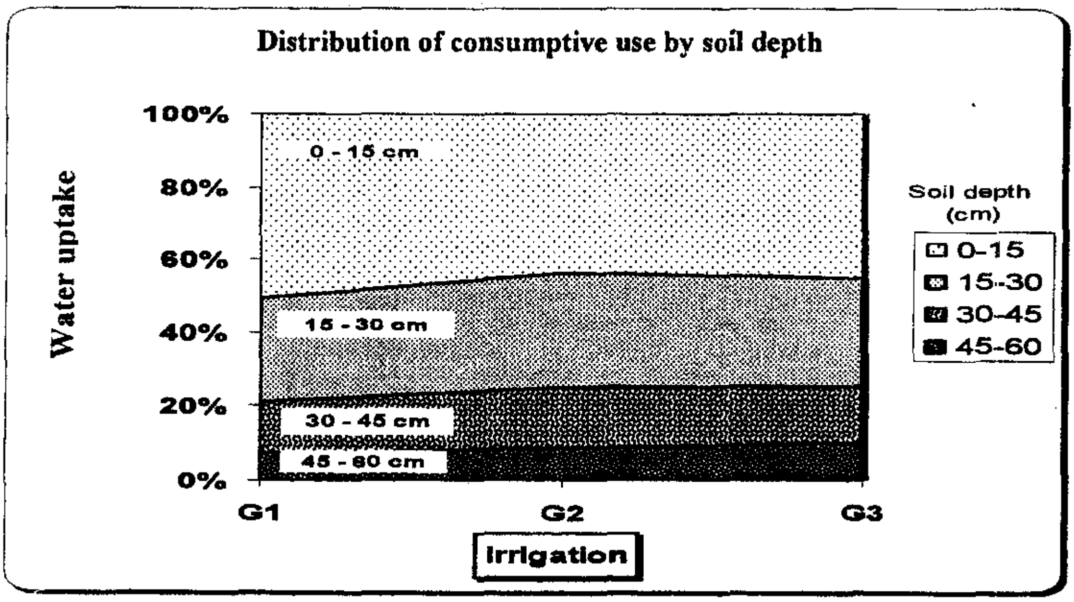


Figure (3): Effect of irrigation treatments (G) on consumptive use of water (CU) mm (depths) of persimmon trees.

G1 Irrigation when 25% available soil moisture is depleted (wet)

G2 Irrigation when 50% available soil moisture is depleted (medium)

G3 Irrigation when 75% available soil moisture is depleted (dry)

1.3.1. Crop coefficient "Kc"

Most crops do not require much water during the season as would be needed to meet the potential evapotranspiration, even though adequate soil moisture can be provided (Jensen, 1968). Thus, the term crop coefficient is used to differentiate water requirements of crops. For the determination of crop coefficient, both actual and potential evalpotraspiration are measured concurrently. Results of the current study (Table 4) show that crop coefficient was low at the beginning of the blooming period, (due to relatively large diffusive resistance of the soil). Thereafter, crop coefficient increased as the green cover increased due to the increase in growth and

Table (4): Crop coefficient (Kc), ETcrop for Modified Penman, Penman Monteith and Doorenbos- Pruitt formulae and actual ET for persimmon trees in 2007 and 2008 seasons.

Season	Kc	2007									
		Modified Penman		Penman Monteith		Doorenbos& Pruitt		Actual ET (V_1)		Actual ET (V_2)	
Month		mm/ day	mm/ month	mm/ day	mm/ month	mm/ day	mm/ month	mm/ day	mm/ month	mm/ day	mm/ month
March	0.40	5.52	171.12	5.13	159.03	3.86	119.66	3.54	109.74	3.50	108.50
April	0.65	6.68	200.40	6.57	197.10	5.00	150.00	5.54	166.20	5.48	164.40
May	0.75	7.85	243.35	8.50	263.50	6.14	190.34	5.65	175.15	5.51	170.81
June	0.85	8.62	258.60	9.85	295.50	6.80	204.00	6.37	191.10	6.27	188.10
July	1.00	7.79	241.49	8.30	257.30	6.42	199.02	7.32	226.92	7.26	225.06
August	0.80	6.99	216.69	7.14	221.34	5.80	179.80	7.10	220.10	7.08	219.48
September	0.70	6.20	186.00	6.30	189.00	5.02	150.60	5.10	153.00	5.36	160.80
October	0.60	5.84	181.04	6.17	191.27	4.09	126.79	4.24	131.44	4.28	132.68
Seasonal (mm)	0.72	6.94	1699	7.25	1774	5.39	1320	5.61	1374	5.59	1370
	2008										
March	0.40	6.31	195.61	6.47	200.57	4.09	126.79	3.58	110.98	3.56	110.36
April	0.65	7.42	222.60	8.03	240.90	5.23	156.90	5.58	167.40	5.53	165.90
May	0.75	7.57	234.67	8.22	254.82	5.99	185.69	5.73	177.63	5.16	159.96
June	0.85	8.22	246.60	8.73	261.90	6.67	200.10	6.44	193.20	6.49	194.70
July	1.00	7.79	241.49	7.88	244.28	6.39	198.09	7.41	229.71	7.31	226.61
August	0.80	7.68	238.08	7.81	242.11	6.06	187.86	7.15	221.65	7.18	222.58
September	0.70	6.67	200.10	6.65	199.50	5.21	156.30	5.15	154.50	5.41	162.30
October	0.60	5.12	158.72	4.87	150.97	3.82	118.42	4.25	131.75	4.21	130.51
Seasonal (mm)	0.72	7.10	1738	7.33	1795	5.43	1330	5.66	1387	5.61	1373

V1= Hachyia V2= Costata

expansion of leaves. This means that the diffusive resistance decreased as a result of the increase in leaf area. The factors affecting crop coefficient (Kc)are mainly climatic conditions, crop characteristics, sowing date, rate of crop development and length of growing season. The mean value of Kc was 0.72 increased with time and was highest in June and July (0.85 and 1.0 respectively). This demonstrates that such period the peak of water demand. The crop coefficient decreased again during the late season to reach minimum when plants were reaching dormancy. Seasonal crop coefficient of persimmon trees was (0.72).

1.3.2. Comparing actual ET with calculated ET

Evapotranspiration of crop was (ET crop value) crop values calculated using the three different equations or formulas (of modified Penman, Penman - Monteith and Doorenbos - Pruitt) and compared with the actual ET as obtained by actual measurement i.e. the consumptive use (Table 5). In season 2007, seasonal ET crop values were 1699, 1774 and 1320 mm for the modified Penman, Penman - Monteith and Doorenbos – Prui equations respectively. In season 2008, seasonal ET crop values were 1738, 1795 and 1330 mm for the same respective equations.

Results indicate differences among calculations. The modified Penman equation was the second highest estimate preceded by the Penman - Monteith equation. The Penman - Monteith one gave the highest ET crop value, while the Doorenbos - Pruitt equation gave the lowest one. Comparison with ET as calculated by actual determination, shows that the Doorenbos - Pruitt equation was the nearest to actual ET.

1.3.3.Comparison between the calculated ET crop and the actual ET:

Value of ratios of ET (i.e crop ET/ actual ET) are shown in Table 5 Actual ET was obtained from the G_2 irrigation treatment. Ratios of 1.25, 1.29 and 0.96 were recorded for Hachyia cv. by modified Penman, Penman-Monteith and Doorenbos-Pruitt equations respectively. In Costata the corresponding ratios were 1.26, 1.30 and 0.97 for the same respective formulae. The Doorenbos-Pruitt formula was the closest compared with the other equations because the ET crop calculated by this formula differed very slightly from the actual ET value. The ET crop calculated due to modified Penman was the second closest to actual ET while the value of the Penman-Monteith formula differed widely from actual ET.

Table (5): Ratios of ET crop values calculated by different ET formula to the actual ET of persimmon trees in 2007 and 2008 seasons.

Formulae	2007		2008		Average	
	ET crop	Ratio	ET crop	Ratio	ET crop	Ratio
Modified Penman	1699	1.24	1738	1.25	1719	1.25
Penman Monteith	1774	1.29	1795	1.29	1785	1.29
Doorenbos- Pruitt	1320	0.96	1330	0.96	1325	0.96
Actual ET (V_1)	1374	...	1387	...	1381	...
Modified Penman	1699	1.24	1738	1.27	1719	1.26
Penman Monteith	1774	1.29	1795	1.31	1785	1.30
Doorenbos- Pruitt	1320	0.96	1330	0.97	1325	0.97
Actual ET (V_2)	1370	...	1373	...	1372	...

V_1 = Hachyia V_2 = Costata

1-4.Water use efficiency WUE

Water use efficiency (WUE) is represented here as the amount of yield produced by one cubic meter of irrigation water used by crop. In such regions, water supplies is more limited and water cost is high. The management objectives may shift to optimizing production per unit of applied water. Water use efficiency is defined as the quotient of crop yield produced per unit area over the volume of water required in evapotranspiration to produce the crop. Water use efficiency by the persimmon trees expressed as kg. fruit yield/ fed./ unit of water (m^3)

consumed in complete evapotranspiration is presented in (Fig. 4). Values (kg/m^3) were higher in the G_2 treatments with both Hachyia and Costata trees mean values were: 2.12 for the first and 1.26 for the second kg/m^3.

This shows that irrigating persimmon trees either frequently or by prolonged intervals result in a decrease in water use efficiency. For maximizing WUE irrigation should be practiced at moderate soil moisture stress i.e. up on 50% depletion in available water. Ritchie (1974) pointed out that, water conservation benefits can be obtained by allowing plants to experience moderate water stress. When roots are subjected to soil moisture stress, extraction of soil water from greater depths would occur therefore, water stored in the profile is used more efficiently.

2. Growth parameters:

Results (Table 6) show that, growth parameters decreased with irrigation rate reduction. Shoot length for G_1, G_2 and G_3 treatments averaged 72.58 to 55.97 and to 40.34 cm. in season 1; and from 77.34 to 67.75 and to 56.37 cm. in season 2 . Average shoots length (cm) of Hachyia cv. (69.42 in season1 and 85.9 in season 2) were longer than Costata cv. (averages of 43.17 and 48.4 cm.) Leaf area decreased with decreased irrigation. Averages for G_1, G_2, and G_3 were 78.73 to 71.8 and to 61.27 cm^2 respectively in season 1 and 79.23 to 69.5 and to 61.12 cm^2 respectively in season 2. Although, leaves of the Hachyia cv. could expand larger than those of the Costata cv. ones, the differences were little. The same trend was observed with number of leaves/shoot (24.92, 22.67 and 18.00 for G_1, G_2,and G_3 respectively) as well as shoot diameter (0.86, 0.67 and 0.62 cm respectively). The, number of leaves/shoot and shoot diameter of Hachyia were more than those of Costata.

3. Yield and Related measurements:

3.1. Fruit characteristics and fruit quality:

Fruit weight, size and dimensions (length and diameter) as well as number of fruits/tree and fruit firmness are presented in Table 7 and 8 . There is a reduction parallel to irrigation reduction. Fruit firmness increased by irrigation decrease. Averages for G_1, G_2 and G_3 were from 10.96 to 14.68 and to 15.51 lb/inch^2 respectively. Smaller fruits have higher firmness. Fruits of the Hachyia cv. have quality attributes better than fruits of the Costata cv.

Fruit juice sugar, TSS, acidity and TSS/acid ratio (Table 9) showed no definite trend with irrigation. Hachyia fruits have less sugar TSS and acidity than Costata fruits. The value of TSS/acid ratio showed a increase with irrigation reduction. Average values for G_1, G_2 and G_3 were 53.58 to 58.36 and to 60.26 respectively.

Leaf dry weight percent showed a slight decrease. Average values for G_1, G_2 and G_3 were 59.45, 58.82, and 53.22 in season 1; and 57.45, 56.82, and 51.22 % in season 2.

Marangoni and Rossi-Pisa (1986) found that, fruit weight percent was lower in irrigated plots of apple trees. Crisosto *et al.* (1994) found that, the deficit irrigation increased TSS concentration Ramos *et al.* (1994) in their study of the effect of water stress on pears found that, weight and size of fruit decreased with water stress whereas TSS and acidity increased.

3.2. Yield components:

Fruit yield per tree and per feddan deceased slightly with the decrease in irrigation from G_1 to G_2 Table 8. Average yields decreased from 49.69 to 47.83 kg/tree and from 6.720 to 6.552 ton/feddan as irrigation decreased from G_1 to G_2 . On the other hand, fruit yield decrease considerably from 47.83 to 34.95 kg/tree and from 9.978 to 9.360 ton/ feddan when irrigation rate decreased from G_2 to G_3 .

The Hachyia cv. gave higher averages of yield (67.9 and 66.02 kg/tree for seasons 1 and 2 respectively, 11.100 and 10.714 ton/ feddan respectively) than the Costata cv. (20.41 and 17.17 kg/tree as well as 7.024 and 6.245 ton/feddan) the Hachyia cv would thus be of higher fruit yield even under wet or dry conditions.

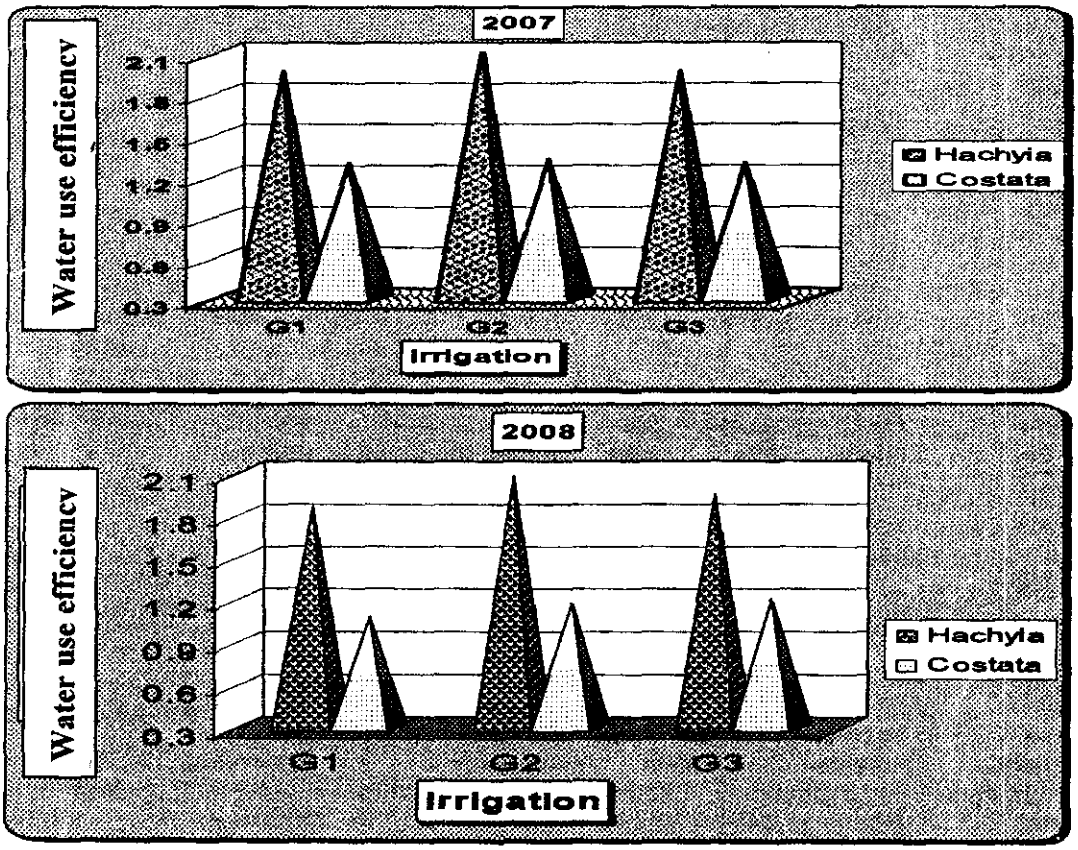


Figure (4): Effect of irrigation treatments (G) on water efficiency (WUE) kg/m^3 of persimmon trees.

G1 Irrigation when 25% available soil moisture is depleted (wet).

G2 Irrigation when 50% available soil moisture is depleted (medium).

G3 Irrigation when 75% available soil moisture is depleted (dry)

Adequate water supply for trees is an important factor for maximizing its production. Kramer (1977) stated that, water stress reduced photosynthesis by closure of stomata which decrease the supply of CO_2. Water stress reduces the capacity of the protoplasm to carry on photosynthesis, Cepicka and Novotny (1991) reported that, irrigation increases fruit yield trees. Benporatll and Greenblat (1994) found that, increased yield of apple trees was indicated by irrigation at the high level of water.

Marangoni and Rossi-pisa (1986) found that, apple fruit weight was lower than on irrigated plots. Johnson *et al.* (1992) found that, the growth was poorest in the dry treatment on peach trees. Lampine *et al.* (1995) showed an optimal level of tree water stress was required to give high fruit production in prune.

4. Leaf mineral contents:

Leaf nitrogen content decreased with decreased irrigation. Average values for G_1, G_2 and G_3 were (2.07, 1.87 and 1.57 %) respectively. (Table 10). Leaf phosphorus content increased by decreased irrigation, and values were (0.24, 0.24 and 0.25 %) for G_1, G_2, and G_3 respectively. leaf potassium increased with increased irrigation from G_1 to G_2; then a deceases occurred at G_3. Average values for G_1, G_2 and G_3 were 1.17, 1.27 and 1.22% in season 1; and 1.20, 1.53 and 1.35 in season 2. Hachyia persimmon leaves could gain much dry matter (59.79 and 57.79 %) but less nitrogen (1.82 and 1.62 %) and potassium (1.17 and 1.17 %) than Costata cv. Phosphorus leaf content was rather similar in both persimmon cvs. These results agree with those of Draz (1986), Oiszewski *et al.* (1995).

Table (6): Effect of irriation treatments (G) on shoot length (cm), number of leaves/shoot, shoot diameter (cm) and leaf area (cm^2) .

Treatments	Hachyia		Costata		Average A	
	2007	2008	2007	2008	2007	2008
Shoot length (cm)						
G 1	90.83	97.77	54.33	56.90	72.58	77.34
G 2	66.76	89.17	45.17	46.33	55.97	67.75
G 3	50.67	70.77	30.00	41.97	40.34	56.37
Average B	69.42	85.90	43.17	48.40		
LSD at 5%				A =	8.38	7.34
				B =	8.38	7.34
				AB =	11.84	10.37
Number of leaves/shoot						
G 1	31.5	32.43	18.33	20.23	24.92	26.33
G 2	28.33	28.13	17	16.8	22.67	22.47
G 3	22.67	22.33	13.33	14.77	18.00	18.55
Average B	27.50	27.63	16.22	17.27		
LSD at 5%				A =	4.88	4.67
				B =	4.88	4.67
				AB =	6.91	6.6
Shoot Diameter (cm)						
G 1	0.897	0.99	0.83	0.853	0.86	0.92
G 2	0.68	0.983	0.663	0.757	0.67	0.87
G 3	0.593	0.89	0.653	0.68	0.62	0.79
Average B	0.72	0.95	0.72	0.76		
LSD at 5%				A =	0.091	0.182
				B =	0.091	0.182
				AB =	0.129	0.257
Leaf area (cm^2)						
G 1	79.23	83.67	78.23	79.23	78.73	79.23
G 2	72.23	74.60	71.37	64.4	71.80	69.50
G 3	63.37	63.57	59.17	58.67	61.27	61.12
Average B	71.61	72.47	69.59	67.43		
LSD at 5%				A =	6.22	6.75
				B =	6.22	6.75
				AB =	8.8	9.55

G1 Irrigation when 25% available soil moisture is depleted (wet) .
G2 Irrigation when 50% available soil moisture is depleted (medium) .
G3 Irrigation when 75% available soil moisture is depleted (dry) .
A=Irrigation B=Species AB=Irrigation * Species

Table (7): Effect of irriation treatments (G) on fruit diameter, fruit length (cm) number of fruits/tree and fruit firmness (lb/inch2). (cm^2).

Treatments	Hachyia		Costata		Average A	
	2007	2008	2007	2008	2007	2008
Fruit diameter (cm)						
G 1	6.03	6.33	5.53	5.83	5.78	6.08
G 2	5.46	6.27	5.43	5.37	5.45	5.82
G 3	5.23	5.73	5.12	5.07	5.18	5.40
Average B	5.57	6.11	5.36	5.42		
LSD at 5%				A =	0.373	0.343
				B =	0.373	0.343
				AB =	0.527	0.485
Fruit length (cm)						
G 1	6.03	6.37	5.57	6.00	5.80	6.19
G 2	5.75	6.37	5.54	5.47	5.65	5.92
G 3	5.47	5.83	5.25	5.1	5.36	5.47
Average B	5.75	6.19	5.45	5.52		
LSD at 5%				A =	0.273	0.282
				B =	0.273	0.282
				AB =	0.386	0.399
Number of fruits/tree						
G 1	607.4	582.6	252.3	217.80	429.85	400.20
G 2	606.3	575	250.2	251.50	428.25	413.25
G 3	516.5	514.7	228.4	199.2	372.45	356.95
Average B	576.73	557.43	243.63	222.83		
LSD at 5%				A =	56.78	52.5
				B =	56.78	52.5
				AB =	80.3	74.25
Fruit firmness ($lb/inch^2$)						
G 1	7.8	10.64	8.29	11.28	8.05	10.96
G 2	8.79	16.03	10.43	13.33	9.61	14.68
G 3	9.74	16.4	14.93	14.61	12.34	15.51
Average B	8.78	14.36	11.22	13.07		
LSD at 5%				A =	2.42	3.24
				B =	2.42	3.24
				AB =	3.42	4.58

G1 Irrigation when 25% available soil moisture is depleted (wet).
G2 Irrigation when 50% available soil moisture is depleted (medium).
G3 Irrigation when 75% available soil moisture is depleted (dry).
A=Irrigation B=Species AB=Irrigation * Species

Table (8): Effect of irriation treatments (G) on fruit size (cm^3), Fruit weight (g), fruit yield/tree (kg) and fruit yield/feddan (ton)

Treatments	Hachyia		Costata		Average A	
	2007	2008	2007	2008	2007	2008
Fruit size (cm^3)						
G 1	124.8	120	93.7	90.00	109.25	105.00
G 2	122.5	120	85	83.30	103.75	101.65
G 3	105	105.6	70.7	75.6	87.85	90.60
Average B	117.43	115.20	83.13	82.97		
LSD at 5%				A =	9.49	12.72
				B =	9.49	12.72
				AB =	13.42	17.99
Fruit weight (g)						
G 1	124.3	123.8	93.8	90.97	109.05	107.39
G 2	122.6	123.4	85.27	78.70	103.94	101.05
G 3	104.3	106.9	70.2	71.7	87.25	89.30
Average B	117.07	118.03	83.09	80.46		
LSD at 5%				A =	11.09	12.56
				B =	11.09	12.56
				AB =	15.68	17.77
Fruit yield/tree (kg)						
G 1	75.50	72.13	23.87	19.81	49.69	45.97
G 2	74.33	70.95	21.33	17.43	47.83	44.19
G 3	53.87	54.97	16.03	14.28	34.95	34.63
Average B	67.90	66.02	20.41	17.17		
LSD at 5%				A =	9.76	5.89
				B =	9.76	5.89
				AB =	13.8	8.33
Fruit yield/feddan (ton)						
G 1	12.690	12.120	8.285	6.934	10.488	9.527
G 2	12.490	11.920	7.466	6.800	9.978	9.360
G 3	8.120	8.103	5.320	5.000	6.720	6.552
Average B	11.100	10.714	7.024	6.245		
LSD at 5%				A =	0.299	0.337
				B =	0.299	0.338
				AB =	0.423	0.478

G1 Irrigation when 25% available soil moisture is depleted (wet).
G2 Irrigation when 50% available soil moisture is depleted (medium).
G3 Irrigation when 75% available soil moisture is depleted (dry).
A=Irrigation B=Species AB=Irrigation * Species

Table (9): Effect of irriation treatments (G) on TSS (%), acidity (%) TSS/acid and leaves dry weight (%).

Treatments	Hachyia		Costata		Average A	
	2007	**2008**	**2007**	**2008**	**2007**	**2008**
			TSS (%)			
G 1	20.33	17.67	20.33	20.00	20.33	18.84
G 2	18.67	18.67	20.00	19.67	19.34	19.17
G 3	18.50	18.33	19.33	19.00	18.92	18.67
Average B	19.17	18.22	19.89	19.56		
LSD at 5%				**A =**	4.14	1.78
				B =	4.14	1.78
				AB =	5.85	2.52
			Acidity (%)			
G 1	0.346	0.358	0.335	0.346	0.34	0.35
G 2	0.369	0.380	0.313	0.291	0.34	0.34
G 3	0.268	0.246	0.358	0.413	0.31	0.33
Average B	0.33	0.33	0.34	0.35		
LSD at 5%				**A =**	0.041	0.043
				B =	0.041	0.043
				AB =	0.058	0.060
			TSS /acid ratio			
G 1	57.80	60.69	49.36	50.09	53.58	55.39
G 2	67.59	63.94	49.13	50.60	58.36	57.27
G 3	46.00	54.59	74.51	69.03	60.26	61.81
Average B	57.13	59.74	57.67	56.57		
LSD at 5%				**A =**	12.62	7.1
				B =	12.62	7.1
				AB =	17.85	10.04
			Leaves dry weight (%)			
G 1	59.13	57.13	59.77	57.77	59.45	57.45
G 2	60.70	58.70	56.93	54.93	58.82	56.82
G 3	59.53	57.53	46.90	44.90	53.22	51.22
Average B	59.79	57.79	54.53	52.53		
LSD at 5%				**A =**	6.25	5.97
				B =	6.25	5.97
				AB =	8.83	8.45

G1 Irrigation when 25% available soil moisture is depleted (wet).
G2 Irrigation when 50% available soil moisture is depleted (medium).
G3 Irrigation when 75% available soil moisture is depleted (dry).
A=Irrigation B=Species AB=Irrigation * Species

Table (10): Effect of irriation treatments (G) on Sugar (%), Nitrogen (%) Phosphorus (%) and Potassium (%).

Treatments	Hachyia		Costata		Average A	
	2007	2008	2007	2008	2007	2008
Sugar (%)						
G 1	16.26	17.06	18.25	17.25	17.26	17.16
G 2	15.42	16.42	17.81	16.81	16.62	16.62
G 3	15.84	16.84	18.15	17.15	17.00	17.00
Average B	15.84	16.77	18.07	17.07		
LSD at 5%				A =	0.592	0.543
				B =	0.592	0.543
				AB =	0.838	0.768
Nitrogen (%)						
G 1	1.90	1.70	2.23	2.03	2.07	1.87
G 2	1.93	1.73	1.80	1.60	1.87	1.67
G 3	1.63	1.43	1.50	1.30	1.57	1.37
Average B	1.82	1.62	1.84	1.64		
LSD at 5%				A =	0.251	0.247
				B =	0.251	0.247
				AB =	0.355	0.35
Phosphorus (%)						
G 1	0.235	0.223	0.237	0.223	0.24	0.22
G 2	0.242	0.230	0.237	0.223	0.24	0.23
G 3	0.247	0.233	0.247	0.233	0.25	0.23
Average B	0.24	0.23	0.24	0.23		
LSD at 5%				A =	0.013	0.014
				B =	0.013	0.014
				AB =	0.018	0.019
Potassium (%)						
G 1	1.180	1.190	1.160	1.200	1.17	1.20
G 2	1.130	1.130	1.417	1.930	1.27	1.53
G 3	1.190	1.190	1.257	1.503	1.22	1.35
Average B	1.17	1.17	1.28	1.54		
LSD at 5%				A =	0.058	0.108
				B =	0.058	0.108
				AB =	0.081	0.152

G1 Irrigation when 25% available soil moisture is depleted (wet) .
G2 Irrigation when 50% available soil moisture is depleted (medium) .
G3 Irrigation when 75% available soil moisture is depleted (dry) .
A=Irrigation B=Species AB=Irrigation * Species

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إستجابة اشجار الكاكي في الاراضي الطينية الطميية لمستويات ري مختلفة

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الإستهلاك المائي (مم) للري الرطب G_1 أعطي ارتفاع في الاستهلاك المائي متبوعا بالرى المتوسط G_2 ثم انخفض الاستهلاك المائي مع الري الجاف G_3 وكانت النتائج المتحصل عليها في صنفي الكاكي هاشيا والكوستاتا (مم) كالأتي الري الرطب ١٥٥٤,٦– ١٥٢٨الري المتوسط ١٤٠٥,٥– ١٣٨٥,١ والري الجاف ٩٨٩,٨–٩٨٥,٣ علي التوالي. وقد وجد أن الاستهلاك المائي الشهري بدأ منخفضا بعد فترة السكون ثم يزيد تدريجيا ليصل إلى أعلي معدل له خلال شهري يوليو وأغسطس ثم يبدأ يتناقص ليصل الي ادني مستوي له خلال شهر أكتوبر . وكان معامل المحصول ٠,٧٢ خلال الموسم (G_2). وبالمقارنة بين الاستهلاك المائي المحسوب والاستهلاك المائي الفعلي وجد أن استخدام معادلة دورن بوث – برايت هي أفضل معادلة لحساب قيم البخر نتح المرجعي تحت ظروف منطقة الدراسة ويمكن بواسطتها تقدير الاستهلاك المائي و بهذه المعادلة فان الاستهلاك المائي الموسمي ١٣٢٠ مم بينما كان المتوسط العام للاستهلاك المائي الفعلي المقاس بطريقة نقص الرطوبة الأرضية ١٣٧٤–١٣٧٠ مم لكلا من أشجار الكاكي هاشيا وكوستاتا علي التوالي. وبالنسبة لكفاءة استخدام المياه (كجم ثمار/م^3 مياه) كان هناك ارتفاع في كفاءة استخدام المياه في الري المتوسط متبوعا بالري الجاف ثم الري الرطب حيث أعطي الري المتوسط (٢,١٢–١,٢٦) والري الجاف (١,٩٦–١,٢٥) والري الرطب (١,٩١–١,١٩) كجم/م٣ لكلا من الهاشيا والكوستاتا علي التوالي.

وكان محصول الثمار ١٢,٤٠٥، ١٢,٢٠٥ و٨,١١٢ طنّ / فدان لصنف هاشيا و٧,٦١٠ و٧,٢٤٨ و ٥,١٦٠ طنّ / فدان لصنف كوستاتا لكلا من الريّ الرطب والمتوسط والجاف على التوالي. لوحظ أن صنف الهاشيا أعطى اعلي محصول وكفاءة استخدام المياه تحت مستويات الري المختلفة.