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Effects of Different Irrigation Levels on Fruit Yield and Quality of Valencia Late Orange Under Northern Cyprus Conditions

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ABSTRACT

This study was carried out to define different drip irrigation approaches on fruit yield and quality parameters of orange (*Citrus sinensis* cv. Valencia Late) trees during 2014-2016 at the private farm in Güzelyurt, Northern Cyprus. The amount of irrigation water was applied based on the total evaporation amount obtained from the Class A pan (K_{cp1}:1.25, K_{cp2}:1.00, K_{cp3}:0.75 and K_{cp4}:0.50) and experimental plots were irrigated when the total evaporation of Class A pan was about 35 ± 5 mm. It was determined that irrigation treatments affect yield, weight, length, width and juice of fruit, total soluble sugar, total acidity, pH and vitamin C content except for peel thickness. The average evapotranspiration values were 1343.5 mm for K_{cp1}, 1135.0 mm for K_{cp2}, 956.0 mm for K_{cp3}, and 787.3 mm for K_{cp4} irrigation treatments. According to the average data of 2 years, yearly yield for K_{cp1}, K_{cp2}, K_{cp3}, and K_{cp4} irrigation levels were 45.0, 47.1, 38.7, and 19.2 t ha^{-1}, respectively. It is determined that Valencia Late can be irrigated by means of the volume of irrigation equivalent to 75% of Class A Pan in Güzelyurt region in Turkish Republic of Northern Cyprus.

Keywords: Citrus, Drip irrigation, Water use, Yield, Total soluble sugar

1. Introduction

Nowadays, water shortage represents a real environmental concern. According to the climate change simulation forecasts, the problem of water shortage will be greater than before in the future in Mediterranean countries. After Sicily and Sardinia, Cyprus is the third largest island, with an area of 9,251 km^2, in the Mediterranean Sea. Cyprus, possesses a coastline of 1,364 km. It is located in the Eastern Mediterranean Basin at the crossroads of Asia, Africa, and Europe continent. Turkish Republic of Northern Cyprus (TRNC) is the northern part of the island with 3,355 km^2, approximately one third of the whole island (Gozen & Turkman 2008). Its economy is dominated by sectors like industry, tourism, public, education, and agriculture sectors. The backbone of the economy of TRNC is agricultural sector that plays a decisive role for the trade and industry development, and provides employment area and income for a significant part of labour force.

Turkish Republic of Northern Cyprus faces a severe water scarcity problem because of the climate conditions. Drought has affected negatively the agricultural production and the decreasing drop in precipitation during winter and increasing warm temperature in summer have caused deficiency in water resources. Especially, Morphou (Güzelyurt) area was famous with orange production but the increasing water scarcity problem and the increasing salt level in surface and underground water have dried trees over time. Citrus is the main crop that could be exported to other countries in TRNC. Citrus yields are affected by soil conditions, weather conditions, growing season, and water availability. Citrus are very sensitive to irrigation water deficit and deficit irrigation effects are several, which include leave loss, reduction in CO_2 assimilation, stomatal conductance, water potential and transpiration. Consequently, plant cell development decreases leading to plant growth inhibition and reproductive failure (Arbona et al. 2005).

Especially in arid and semi-arid regions, the amount of irrigation water plays numerous roles in the productive yield of oranges by affecting the yield, morphological and physiological chemical processes (Gozen & Ergil 2006). Treeby et al. (2007) reported that low irrigation water in the soil profile may denote a main restrictive reason for orange yield and quality in these regions and irrigation water deficiency losses crop loads of oranges. Perez-Perez et al. (2009) stated that if water stress is occurred at late growing periods, water deficiency in orange tree is related positively to titratable acids and total soluble solids and negatively to juice percentage, with no overall effect on maturation index in oranges.

Some researchers determined that the effects of irrigation water deficiency on orange yield and quality in the literature. Toledo et al. (1982) reported that the amount of irrigation water applied at 85% field capacity was the best results whereas the amount of irrigation water applied at 65% field capacity. Low field capacity lead to less water consumption, drought injury symptoms and excessive defoliation. Ghadekar et al. (1989) found that the irrigation water amounts were 651.9, 849.0 and 997.8 mm for young, middle age and mature trees, respectively. Eliadses (1998) stated that 780 mm of irrigation water was adequate for best yield and growth of 6-years-old Washington Navel orange and reducing irrigation water by 37% decreased yield by 10.7%, while further reduction to 26% reduced the yield by 5.8%. Garcia-Tejero et al. (2010), studied 4 approaches of different deficit irrigation levels based on a different water deficiency ratio in Spain. They reported that different deficit irrigation water amounts affect orange yield and quality. Shahabian et al. (2012), determined that the effects of three irrigation levels (75% and 50% of the full irrigation) on yield and quality orange and stated that water deficiency reduced yield by around 30% compared with full irrigation treatments, but deficit irrigation treatments caused no negative impact on quality. Consoli et al. (2014) concluded that the application of irrigation water to 75% of the plant needs did not cause significant harmful effects on orange tree and allowed water savings. Stagno et al. (2015) determined that the orange became low sensitive to moderate water stress (70% ETc) allowing nearly 80 mm of irrigation water saving in Sicily (Italy).

The irrigation and public water shortage problem on TRNC cannot be ignored, especially when future predictions of irrigation water needs show a gap of 32 million cubic meters (MCM) by 2035. To solve the problem of water scarcity in the TRNC, The Government of Republic of Turkey has experienced an under-sea Water Supply Project with a length of 80 km for the first time in the world. The project targets to transfer about 75 MCM of water annually (37.24 MCM for irrigation purpose and 37.76 MCM for domestic purposes) from Turkey to TRNC (Gozen & Turkman 2008; Gungor 2016). In order to deal with irrigation water shortage and to use water properly devoid of reducing agricultural productivity, it has become necessary to use water resources used in agriculture in the most efficient way and to increase water use and irrigation water productivity.

As seen from the researches, though there are some researches relating to irrigation of young and old orange trees, there is no research carried out the assessment of different irrigation levels on orange in TRNC. For that reason, this research was conducted to define the influence of deficit and excessive irrigation amounts on water use efficiency, yield and quality parameters of Valencia Late orange trees and to define the lowest irrigation threshold for orange trees and to predict the amount of irrigation water saving for the Mediterranean area and climate conditions.

2. Material and Methods

2.1. Research area and climatic parameters

The study was carried out on orange trees (*Citrus sinensis* cv. Valencia Late, twenty years old) located at the private farm (35°12'N, 33°0'E, 54 m above sea level) during the growing seasons between 2014-2016 years in Güzelyurt, TRNC. The climatic properties of the region are extreme Mediterranean type with very hot and dry summers and mild winters. Most of the rainfall is concentrated between December and February. The long term monthly mean temperature, relative humidity, rainfall, and wind speed averagely ranged from 15.2 to 32.4°C, from 62.2% to 72.6%, from 10.0 to 129.0 mm, and from 2.5 to 3.7 m s^{-1}, respectively. The annual average evaporation according to Class A Pan readings reaches up to 1807.0 mm $year^{-1}$. During the experimental years, climatic data obtained from Güzelyurt weather location were similar values. The climatic variables for long-term (1976-2013) means and experimental years in 2014-2015 and 2015-2016 are given in Table 1.

Table 1- Long-term monthly and growing season climatic data of the experimental area

Years	*Months*	*Temperature (^oC)*	*Rainfall (mm)*	*Evaporation (mm)*	*Wind ($m\ s^{-1}$)*	*Relative humidity (%)*
1976-2013	Jan.	15.2	126.0	42.0	3.5	68.4
	Feb.	16.1	105.0	52.0	3.5	67.2
	Mar.	18.4	78.0	86.0	3.4	67.5
	Apr.	22.5	54.0	143.0	3.6	68.1
	May	25.6	37.0	215.0	3.5	68.3
	June	28.8	17.0	268.0	3.6	69.1
	July	31.2	12.0	301.0	3.7	71.7
	Aug.	32.4	10.0	266.0	3.6	72.6
	Sep.	30.8	24.0	197.0	3.2	65.4
	Oct.	27.1	54.0	128.0	2.5	62.2
	Nov.	22.4	88.0	67.0	2.9	63.1
	Dec.	17.3	129.0	42.0	3.1	69.2
2014-2015	Apr.	17.4	6.8	167.5	2.7	68.4
	May	14.1	38.2	225.6	2.8	71.9
	June	16.8	11.3	298.6	3.2	61.7
	July	26.9	0.0	308.9	3.1	68.3
	Aug.	21.9	0.0	291.0	2.7	68.4
	Sep.	19.0	0.0	264.9	3.1	62.0
	Oct.	20.7	28.8	118.4	2.1	67.7
	Nov.	16.0	45.6	97.4	2.1	65.4
	Dec.	14.2	41.3	30.0	2.2	77.5
	Jan.	10.3	71.6	36.9	2.5	74.5
	Feb.	10.9	67.8	35.6	2.6	75.8
	Mar.	13.9	49.0	122.2	2.8	70.6
2015-2016	Apr.	15.5	23.3	137.8	2.7	65.0
	May	20.9	82.1	212.2	2.7	66.9
	June	23.5	0.0	292.7	3.1	67.8
	July	26.8	0.1	298.5	2.6	63.7
	Aug.	28.4	0.0	313.5	2.7	61.8
	Sep.	26.1	14.4	203.4	2.5	66.4
	Oct.	22.4	19.8	126.2	2.1	69.4
	Nov.	17.7	28.6	72.6	2.1	60.9
	Dec.	12.0	3.9	73.3	2.0	68.9
	Jan.	12.8	52.5	32.0	2.4	72.4
	Feb.	12.1	14.1	60.3	2.3	70.8
	Mar.	14.2	24.8	129.8	3.4	63.4

2.2. Properties of soil and irrigation water

The soil properties of the study area is clay (C) in texture, non-saline (0.42 dS m^{-1}), and rich in alkaline and calcium carbonate. The water content in 0-30, 30-60, 60-90 and 90-120 cm soil profile (cm cm^{-3}) at field capacity (FC, 1/3 atm. pressure) was 36.8, 36.1, 37.4, and 39.6 and at permanent wilting point of soil (PWP, 15 atm. pressure) was 19.1 19.4, 20.1, and 20.4, respectively. The bulk density, pH and $CaCO_3$ of experimental soil were 1.29, 1.25, 1.27 and 1.30 g cm^{-3}, 8.0, 8.3, 8.7, and 8.6 and 8.7%, 11.3%, 10.9%, and 13.0% in 0-30, 30-60, 60-90 and 90-120 cm soil profile, respectively. The electrical conductivity (EC) of irrigation water used in study was 1.66 dS m^{-1}. The electrical conductivity value does not threat for oranges and sodium absorption rate (SAR) was 5.2 (Ayers & Westcot 1985).

2.3. Experimental design

Randomized block (RB) with three replications was applied as an experimental design and each treatment has eighteen trees (Gomez & Gomez 1984). The plant material (*Citrus sinensis* cv. Valencia Late, grafted on Sour orange rootstock, 20 years old) are implanted at 6 m × 6 m in row spacing and in-row spacing. There were 12 plots in the study and each experimental plot consisted of 18 orange trees. Four orange trees in the middle of the each experimental plot were used for obtaining yield and quality data.

2.4. Irrigation system and treatments

Surface drip irrigation system was used and each orange tree row contained two drip irrigation laterals. The drip laterals were placed 0.50 m from afar the orange tree. The in-line drippers having discharge rate of 2 L h^{-1} on laterals were located 0.50 m apart. The irrigation water amount applied to each plot was controlled using a water counter. Each experimental plot has valves located on the main pipeline.

Soil water content in each experimental plots was observed gravimetrically before each irrigation treatments throughout the growing season. Irrigation applications were applied according to the data (E_{pan}, mm) achieved from a Class A Pan located in study area (Doorenbos & Pruitt 1977). When the cumulative amount of Class A pan evaporation was about 35 ± 5 mm, the experimental plots were irrigated. Irrigation levels were implemented, i.e. K_{cp1} = 1.25 E_{pan}, K_{cp2} = 1.00 E_{pan}, K_{cp3}=0.75 E_{pan}, and K_{cp4} = 0.50 E_{pan}. The amount of applied irrigation water (L) was determined according to the Kanber et al. (1996):

$$I = A \times E_{pan} \times K_{cp} \times P \tag{1}$$

Where I = total irrigation water amount (L); A = experimental plots (m^2); E_{pan}= the amount of Class A pan evaporation (mm); K_{cp} = crop-pan coefficient value (0.50, 0.75, 1.00 and 1.25); and P = wetted area (%, According to the Keller & Bliesner (1990) P was taken as 40%). The initial irrigation application was applied 1 April 2014 and 2015 when the orange trees were at the harvesting stage and study plots were irrigated when total Class A pan evaporation reached 35 ± 5 mm throughout the year.

2.5. Water use parameters

Evapotranspiration (ET) was determined using the soil-water balance method (Doorenbos & Pruitt 1977) for each growing period.

$$ET = I + P - D \pm \Delta W \tag{2}$$

Where ET = evapotranspiration (mm); I = total irrigation water applied in growing period (mm); P = total precipitation (mm); D = total deep percolation (mm); and ΔW = change in soil moisture. Total irrigation water (I) was measured using water counters, and P was measured at the weather station in the study area. Soil water measurement taken before some irrigation applications were compared to the amount of evaporation occurred. It was accepted that there was no deep percolation, since no soil moisture increase was observed in the lower soil profile during moisture control prior to irrigation.

Irrigation water use efficiency (IWUE, kg da^{-1} mm^{-1}) and water use efficiency (WUE, kg da^{-1} mm^{-1}) were explained as yield (Y, kg da^{-1}) divided by the evapotranspiration (ET, mm) and total irrigation water (I, mm) applied in the plots (Howell 2001).

$$WUE = (Y / ET) \times 100 \tag{3}$$

$$IWUE = (Y / I) \times 100 \tag{4}$$

2.6. Yield and fruit quality parameters

The Valencia Late fruits were harvested according to fruit maturity on March (March 14, 2015 and 2016) in experimental years. During the harvest, 4 trees at the edges of the experimental plots were left as a side effect and total yield (t ha^{-1}) was determined by harvesting all the fruits. Fruit weight (g), fruit length (mm), fruit width (mm), peel thickness (mm), total soluble solids (TSS, %), total acidity (TA, %), pH, vitamin C values were determined in the end of the study for each growing season. Variance analysis (ANOVA) was used to calculate the assessment of irrigation levels on parameters of Valencia Late. Duncan's multiple range tests was used to compare the averages (Gomez & Gomez 1984).

3. Results and Discussion

3.1. Water use parameters and yield

The values related to I, P, D, ΔW, ET, IWUE, and WUE were given in Table 2. The experimental plots were irrigated 58 and 56 times in 2014-2015 and 2015-2016, respectively. The total irrigation water applied to K_{cp1}, K_{cp2}, K_{cp3}, and K_{cp4} treatments were 1103.5, 903.8, 704.1, and 504.4 mm in 2014-2015, 976.2, 780.9, 585.7, and 390.5 mm in 2015-2016, respectively. Evapotranspiration ranged from 794.9 to 1347.8 mm in 2014-2015, and from 779.7 to 1299.1 mm in 2015-2016 growing season and ET rates were decreased with decreasing applied irrigation water and the peak ET rates in both of the years were obtained from K_{cp1} treatment.

Table 2- The parameters of water balance and water use efficiency in the experiment

Parameters	*2014-2015*				*2015-2016*			
	K_{cp1}	K_{cp2}	K_{cp3}	K_{cp4}	K_{cp1}	K_{cp2}	K_{cp3}	K_{cp4}
Irrigation events	58.0	58.0	58.0	58.0	56.0	56.0	56.0	56.0
Irrigation water (I, mm) [1]	1103.5	903.8	704.1	504.4	976.2	780.9	585.7	390.5
Rainfall (P, mm) [2]	360.4	360.4	360.4	360.4	263.6	263.6	263.6	263.6
Soil water depletion (ΔS, mm) [3]	-116.1	-111.6	-89.4	-69.9	59.3	72.9	87.6	125.6
ET (mm) [4]	1347.8	1152.6	975.1	794.9	1299.1	1117.4	936.9	779.7
Yield (t ha^{-1})	42.1a[x]	45.5a	37.7a	18.2b	47.9a	48.6a	39.6a	20.1b
Relative yield decrease	7.5	-	17.2	60.0	1.5	-	18.6	58.7
WUE (kg da^{-1} mm^{-1})	3.12	3.95	3.86	2.29	3.69	4.35	4.23	2.58
IWUE (kg da^{-1} mm^{-1})	3.82	5.04	5.35	3.61	4.91	6.22	6.77	5.15

x; The different letters indicate the important differences according to the Duncan test,[1] Irrigation periods are from 01 April 2014 to 31 March 2015 (first year) and 01 April 2015 to 25 March 2016 (second year), [2] Total rainfall received from 01 April 2014 to 31 March 2015 (first year) and 01 April 2015 to 25 March 2016 (second year) all the rainfall has been accepted to be effective, periodically, [3] Soil water depletion values are from 01 April 2014 to 31 March 2015 (first year) and 01 April 2015 to 25 March 2016 (second year), [4] Evapotranspiration values are from 01 April 2014 to 31 March 2015 (first year) and 01 April 2015 to 25 March 2016 (second year).

Water is important for orange trees (or for any citrus) because it is the transporter that transfers plant nutrients and other materials throughout the tree, it is an integral part of the biochemical reactions that take place within the plant, and it helps maintain plant temperature through transpiration. Ghadekar et al. (1989) were found irrigation water requirements as 651.9, 849.0 and 997.8 mm for young, middle and mature orange trees, respectively. Kanber et al. (1996) reported that irrigation water amounts were 1290 and 921 mm for sprinkler and drip irrigated orange trees, respectively. Treeby et al. (2007) determined that irrigation water amount was 1000 mm of Bellamy Navel orange in Australia. Eliadses (1998) reported that 780 mm of irrigation water was adequate for best yield and plant growth in the coastal region of Cyprus for Washington Navel orange trees and while Hussien et al. (2013) determined that 1024 mm irrigation water was adequate for Washington Navel orange. Additionally, Nizinski et al. (2017) reported that irrigation and evapotranspiration values of Valencia Late were 994.3 and 1271.5 mm under Egypt conditions.

The results obtained from the study indicated that different irrigation water amounts statistically ($P < 0.01$) effected orange yield in the study. Orange yields ranged from 18.2 t ha^{-1} to 45.5 t ha^{-1} and 20.1 t ha^{-1} to 48.6 t ha^{-1} for 2014-2015 and 2015-2016 growing season, respectively. In the study, maximum and minimum yield was obtained from K_{cp2} and K_{cp4} treatment. Orange yields were testified to ranged from 7.7 t ha^{-1} to 13.4 t ha^{-1} for drip and sprinkler irrigation system by Kanber et al. (1996), from 17.5 t ha^{-1} to 37.0 t ha^{-1} for deficit and full irrigation application conditions by Petillo & Castel (2004), from 29.1 t ha^{-1} to 35.2 t ha^{-1} for deficit and full irrigation conditions by Al-Rousan et al. (2012).

Data obtained study for both years on IWUE and WUE are shown in Table 2. In the study, IWUE and WUE were determined statistically not significant. The WUE values ranged from 2.29 to 3.95 kg da^{-1} mm^{-1} in 2014-2015 and from 2.58 to 4.35 kg da^{-1} mm^{-1} in 2015-2016. In both years, WUE values were lower than IWUE values. The IWUE values were between 3.61 and 5.35 kg $da^{-1}mm^{-1}$ in 2014-2015 and from 4.91 to 6.77 kg da^{-1} mm^{-1} in 2015-2016. Goodwin & Boland (2000) informed that excessive or deficit irrigation water level causes stomatal closure, stomatal closure leads to water stress in plants and thereby improving the WUE. Meshram et al. (2010) determined that the water shortage causes lower WUE values and therefore lower yields are obtained from water stressed plants. The results obtained this study are in consistent with literature studied by Kanber et al. (1996), Perez-Perez et al. (2009), Hussien et al. (2013), Zapata-Sierra & Manzano-Agugliaro (2017), and Silveira et al. (2018). Some differences can be attributed to the cultivar of orange used in the study and climatic conditions of the experimental area.

3.2. Irrigation water (I)-yield (Y) and evapotranspiration (ET)-yield relationship

The relationship between orange yield and water use was assessed for each growing season (Figure 1). It was found second degree-polynominal relationship between amount of I and Y and between ET and Y were established, as shown in Figure 1. Yield in Kcp_2 treatment is higher than excessive and deficit irrigation treatments. Water requirement varies considerably with climate, soil type and orange variety. When a tree suffers from lack of water, its yield decreases even 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 of water and labour (Hussien et al. 2013). Compared to K_{cp2} strategy, decreases in the orange yield were determined as 7.5%, 17.2%, and 60.0% for K_{cp1}, K_{cp3}, and K_{cp4} treatments for 2014-2015 growing season, and 1.5%, 18.6%, and 58.7% for K_{cp1}, K_{cp3}, and K_{cp4} treatments for 2015-2016 growing season, respectively. Zekri (2011) reported that a good irrigation management is required for maximum and quality yield in citrus. Citrus trees that are irrigated and nourished adequately grow stronger, tolerate biotic and abiotic stress parameters, and produce consistent yield and fruit quality. Conversely, excessive irrigation water or water shortage will leads to low yield and poor fruit quality. Similar relationships between yield and irrigation water for orange was recognized in other researches having a report a rather strong linear connection between the irrigation water applied and yield (Shalhevet & Levy 1990; Ali & Lovatt 1996; Goldhamer & Salinas 2000).

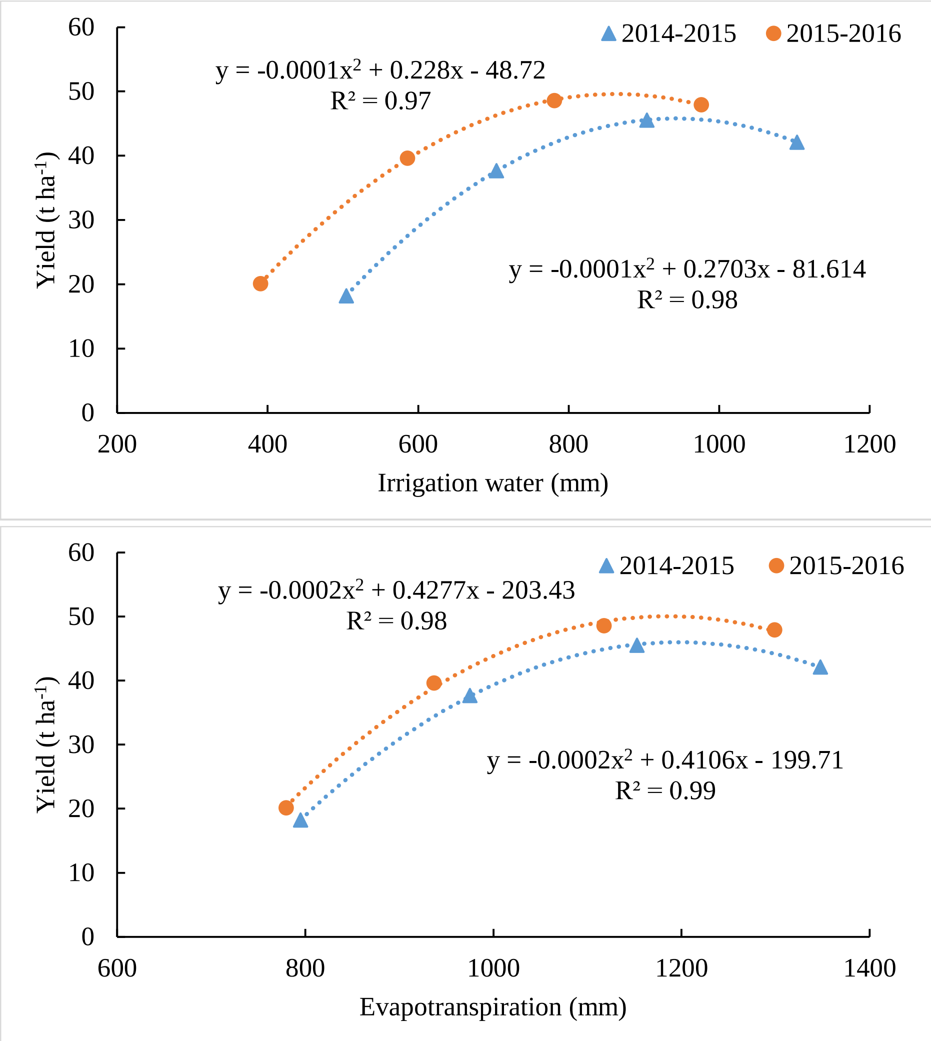

Figure 1- The relationship between orange yield and amount of irrigation water and evapotranspiration.

3.2. Fruit quality parameters

The effects of treatments on fruit weight, fruit length, fruit width, juice, TSS, pH, TA, vitamin C, except for peel thickness were statistically significant (Table 3). Except vitamin C, other parameters were higher in Kcp_1 treatments as compared to the other treatments in the study.

In both experimental years, it was found significant differences between water treatments in fruit weight, length, and width. These parameters significantly decreased with the decrease in water levels (Table 3). The fruit obtained from the K_{cp4} irrigation application were lesser than fruit obtained from the K_{cp3}, K_{cp2}, and K_{cp1} irrigation treatments, respectively. The highest fruit weight (173.4 and 173.9 g), fruit length (70.4 and 73.6 mm) and fruit width (70.2 and 69.8 mm) were obtained from K_{cp1} irrigation treatments in both years. The lowest fruit weight (89.2 and 111.3 g), fruit length (58.6 and 63.6 mm) and fruit width (56.7 and 59.7 mm) were obtained from K_{cp4} irrigation treatments in both years. Shalhevet & Levy (1990) and Castel & Buj (1990) concluded that fruit size is the main quality characteristic in citrus and this characteristic is greatly affected by water management. Treeby et al. (2007) stated that water stress reduced fruit size values in Navel orange. Nagaz et al. (2015) argued that irrigation water deficiency leads to a significant decrease in the fruit weight. Esmail et al. (2016) determined that the highest fruit weight and fruit length were obtained 240 g and 80.0 mm in full irrigation, respectively, while the lowest fruit weight and fruit length were obtained 120 g and 73.0 mm in deficit irrigation conditions for Valencia orange variety.

The irrigation levels (deficit or excessive) did not have a significant influence on peel thickness in two growing seasons (Table 3). The highest peel thickness (6.0 and 6.2 mm) was determined the least irrigation treatments (Kcp_4) in where the differences between irrigation treatments were insignificant in both seasons, whereas the lowest peel thickness (5.0 and 5.8 mm) was obtained from the highest irrigation treatment for both years. Hilgeman & Sharp (1970) El-Gazzar et al. (1986) and

Chartzoulakis et al. (1999) stated that low supply water increased peel thickness on Valencia, Washington and Bonanza orange trees. Similar effects were determined in this study for Valencia Late orange trees.

Table 3- The average values of some fruit quality components and Duncan test groups in different irrigation treatments

*Fruit weight (g)***	*Irrigation treatments*			
	K_{cp1}	K_{cp2}	K_{cp3}	K_{cp4}
2014-2015	173.4 a[x]	159.3 ab	137.0 b	89.2 c
2015-2016	173.9 a	152.7 ab	144.0 b	111.3 c
Fruit length (mm)**				
2014-2015	70.4 a	70.0 a	66.5 a	58.6 b
2015-2016	73.6 a	70.9 a	68.9 ab	63.6 b
Fruit width (mm)**				
2014-2015	70.2 a	68.0 a	65.1 a	56.7 b
2015-2016	69.8 a	65.6 b	65.5 b	59.7 c
Peel thickness (mm)[ns]				
2014-2015	5.0	5.3	5.4	6.0
2015-2016	5.8	6.0	6.1	6.2
Juice (%)**				
2014-2015	56.2 a	45.4 b	44.8 b	36.1 c
2015-2016	50.2 a	48.0 a	48.5 a	39.9 b
TSS (%)**				
2014-2015	10.2 c	12.0 b	12.3 b	13.2 a
2015-2016	10.3 c	13.2 b	13.8 b	15.5 a
pH**				
2014-2015	3.3 a	3.2 b	3.1 bc	3.0 c
2015-2016	3.4 a	3.3 b	3.2 bc	3.1 c
TA (%)**				
2014-2015	1.2 b	2.0 a	2.1 a	2.3 a
2015-2016	1.6 a	2.1 a	2.4 ab	2.6 b
Vitamin C (mg 100 mL^{-1})**				
2014-2015	37.2 b	50.8 ab	56.8 a	63.0 a
2015-2016	39.8 b	51.2 ab	57.4 a	64.2 a

ns and **; not significant and significant %1 level, respectively. [x]; Means different according to Duncan test at 5% confidence level are shown using different letters

The fruit juice, TSS, pH, TA and vitamin C were influenced by irrigation treatments (Table 3). The fruit juice was affected by different irrigation levels in experimental years, statistically. The fruit juice values decreased with decreasing level of irrigation in 2014-2015 and 2015-2016 study years. The average fruit juice of K_{cp1} (50.2%), K_{cp2} (48.0%), and K_{cp3} (48.5%) irrigation applications were in the same statistical group in 2015-2016 except for K_{cp4} treatments while K_{cp2} (45.4%), and K_{cp3} (44.8%) irrigation applications were in the similar statistical sets in 2014-2015. These results were similar Perez-Perez et al. (2009) and Gasque et al. (2016).

The influence of treatments on the TSS, TA, and pH were statistically significant in the study. Total soluble sugar values increased with decreasing level of irrigation in 2014-2015 and 2015-2016 study years. The average TSS values were changed between 10.2 and 13.2% in 2014-2015, and 10.3 and 15.5% in 2015-2016. The highest pH was determined 3.3 in 2014-2015 growing season and 3.4 in 2015-2016 growing season for K_{cp1}. Titratable acidity values increased with decreasing amount of water applied in both experimental years. Titratable acidity values varied from 1.2 to 2.3% and 1.6 to 2.6 for first and second year of experiment, respectively. K_{cp4} irrigation treatment gave the highest TA value while K_{cp1} treatment gave the lowest TA value in both experimental years. There is a conflict concerning water stress and TSS and TA level in the literature. Mohsen et al. (1989), El-Hanawy (2006) and Ghosh & Pal (2010) reported that TSS increased with increasing soil moisture level, while Ginestar & Castel (1996), Yakushiji et al. (1998), Gonzalez-Altozano & Castel (1999), Hockema & Etxeberria (2001); Ali & Gobran (2002), Romero et al. (2006), Perez-Perez et al. (2009), Garcia-Tejero et al. (2010), Ballester et al. (2011); Esmail et al. (2016) and Yang et al. (2018) reported that irrigation water deficiency causes an increase in TSS and TA level. The majority of published study results conform with those of the present research in that the basic influence of decreasing the amount of irrigation water is a enhance of the TSS and TA values.

Other significant results obtained from this study relate to the vitamin C content. Vitamin C values increased significantly decreasing irrigation water amounts. The vitamin C values for K_{cp1}, K_{cp2}, K_{cp3}, and K_{cp4} were 37.2, 50.8, 56.8, and 63.0 mg 100 mL^{-1} in 2014-2015 and 39.8, 51.2, 57.4, and 64.2 mg 100 mL^{-1} in 2015-2016, respectively. Seung and Adel concluded that high vitamin C content may function as a protective strategy against water stress and drought injury. Whereas, El-Zawily (2004), El-Hanawy (2006) reported that increasing irrigation water applied increased vitamin C of orange fruit juice. On the other hand, Perez-Perez et al. (2009), Yang et al. (2018) determined that the irrigation water deficiency enhanced vitamin C content in citrus fruit. In our study of Valencia Late orange fruit, reduced water amount was associated with higher vitamin C levels in fruit.

4. Conclusions

The influence of excessive and deficit irrigation treatments in Valencia Late orange grown in Güzelyurt region in TRNC on fruit yield and quality characteristics were studied in the research. The influence of irrigation levels on yield, fruit weight, fruit length, fruit width, juice, total soluble sugar, total acidity, pH and vitamin C content were statistically significant, nevertheless peel thickness was statistically insignificant under the experimental conditions. The maximum fruit yield was achieved from the K_{cp2} irrigation level, followed by K_{cp1} level. Fruit weight, fruit length, fruit width, and juice values increased as the amount of water deficit decreased. Conversely, TSS, TA, and vitamin C values decreased as the amount of water deficit decreased. This study showed that the yields obtained from K_{cp1} and K_{cp3} treatments did not decrease significantly compared to the K_{cp2} treatment with the highest yield. Regarding the combined effect of water use efficiency and yield reduction, the K_{cp3} treatments could be recommended in semiarid regions where the irrigation water resources are inadequate, as K_{cp3} treatments could protect about average 18% of water with only a 17.9% relative yield reduction in two experimental years. According to the all results obtained from the study, it can be stated that Valencia Late trees can be irrigated as much as the 75% of evaporation measured in Class A pan in Güzelyurt region of Turkish Republic of Northern Cyprus.

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