RESEARCH ARTICLE

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Effects of various soil structure and irrigation regimes on rio-red grapefruit yield and morpo-physiology

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Abstract
The research was carried out in 2011 using Rio-Red grapefruit trees in Research Station of Cukurova University, Agricultural Faculty, Citrus experiment Station, Adana Latitude, 5°2 ’ N Longitude, 6°50’ E, altitude 27 m).In the study, it was aimed to determine the effects of the amount of irrigation water applied at different levels to the trees growing in soils of different soil texture on fruit development and yield, tree trunk development, tree canopy volume development, leaf area index(LAI) and photosynthesis rate. The research area soils contain three different groups in terms of resistivity values and the trees are grown in soils electrical conductivity (ECa) with T1: 86-109, T2: 23-37 and T3: 62-72 ECavalues.In the experiment, three different irrigation levels I100, I70 and I50 water was applied. The average amount of irrigation water applied to grapefruit trees ranged from 332,48 mm (I100) to 178,92 mm (I50). Actual plant water consumption was between 810.5 mm (I100) and 694.4 mm (I50) according to the water budget method. Yields related to irrigation on trees in the plot varied between 883 (I70) and 828 (I50) kg per tree on average. It has been determined as 1050 kg on average from the fully irrigated I100. Photosynthesis values were measured as 2.64 umol/m2/s for I50, 3.48 umol/m2/s for I70 and 4.77 umol/m2/s for I100. Consequently, the effects of irrigation treatmentson fruit yield are not statistically significant, water reduction can be recommended for the region in order to save water for the farmers in this study.
Keywords: Fruit Size, DeficitIrrigation, Citrus Paradisi, Photosynthesis

INTRODUCTION

Studies conducted in the world and in our country; reveals that one of the plant groups with the highest amount of water consumption is citrus fruits.

Citrus fruits need precipitation or an adequate water source as irrigation water throughout the year, as they remain constantly green. The water requirement varies and the needed water is applied with various irrigation methods.The annual water requirement of citrus fruits varies between 900-1200 mm depending on the soil, climate and physiological condition of the trees (Doorenboss and Kassam, 1979). Considering the potential irrigated areas of Turkey and the water use of plants, only about 33% of the total irrigated areas could be irrigated with the potential of existing water resources. For this reason, it has become imperative to consider approaches such as limited irrigation management, which provides water increase in order to be able to irrigate more effectively and to irrigate more areas with our existing water resources allocated for agriculture (Ünlü et al, 2008). The potential benefits of the scarce irrigation technique have three major factors: reduction of production costs, higher water use efficiency and lower water costs. The effective use of deficit irrigation thinking depends on a good understanding of the importance of these three factors (Stegman et al., 1990; Kanber et al., 2007). In the deficit irrigation approach, the plant is faced with a lack of water in all or some periods of the growing season; Increases in irrigation water are provided without significant reductions in yield. For this reason, the approach mentioned is called by different names. These are Partial Irrigation; Regulated Deficit Irrigation; ET Deficit Irrigation and Limited Irrigation approaches (English et al., 1990; Kanber et al., 2007). Deficit irrigation practices, which were first introduced in Australia and New Zealand in the early 1970s, can save a significant amount of water without causing any loss in yield in plants with high water requirements (Chalmers et al., 1981). This study was carried out in 2011 using Rio Red grapefruit trees in Çukurova University Faculty of Agriculture Research and Application Farm. Electrical conductivity (ECa) maps of the soils of the trial area were drawn in order to make a detailed structure analysis. In the study, it was aimed to determine the effects of the amount of irrigation water applied at different levels to the trees growing in soils of different soil texture on fruit development and yield, tree trunk development, tree canopy volume development, leaf area index(LAI) development and photosynthesis rate.

MATERIALS AND METHODS

In the region that the research is carried out, is dominant by Mediterranean climate; Summers are hot and dry, winters are mild and rainy. The long-year climate data of the area where the experiment was carried out are from the records of Adana Meteorology Regional Directorate, which is affiliated to the General Directorate of Meteorology; The data related to the research years were obtained from the automatic climate observation station located in the experimental area. The research was carried out in the grapefruit orchard in Çukurova University Faculty of Agriculture Research and Application Farm in 2011. The trial garden is located in the Eastern Mediterranean Region, at 36°59'N, 35°18'E north and east latitudes and longitudes and at an altitude of 20 m from the sea. Grapefruit orchard was established in 1993 and its area is 39.1 decares and there are a total of 612 trees (16 tree decares^{-1}). Trees were planted at 8×8 m intervals.

In 2011, when the study was conducted, the lowest temperature was -3°C in February; the highest temperature was determined as 41°C in September. However, in the long-term (1930-2007) the lowest and highest relative humidity values were recorded in October with 58.1% and in April and July with 65.9%, respectively. In the trial year, these values were 49.4% in October; 72.3% in July; In its second year, it was measured as 55.9% in March and 77.7% in December. The average monthly rainfall in the region between 1932 and 2007 is 644.9 mm. Most of the precipitation occurs during the winter months. The highest precipitation amount in the study year was measured in December with 169.4 mm. There was no precipitation in July and August. The irrigation water source of the trial area is an open channel irrigation system and the irrigation water quality is C2S1. Irrigation water samples taken from the irrigation canal were analyzed using the methods detailed in USSL (1954) and the results are given in Table 1.

The applications in the study were created on the west side of the trial garden. Irrigation levels are arranged as described below.

Controlirrigation: It is the maximum amount of water supplied from the existing irrigation system in the trial area applied to the parcels. (I100, Control).

Deficit irrigation I: where 70% of the irrigation water given to I100 is applied (I70).

Deficit irrigation II: where 50% of the irrigation water given to I100 is applied (I50).

Trial were arranged in a randomized block design in the field. Each treatment was repeated 3 times. The replicates are arranged side-by-side in strip-like blocks. Throughout the study, irrigation applications could be carried out with an average dripper flow rate of 2.2 L/h. I100 is the level where the highest amount of water is applied.In this case, the irrigation interval in the study was determined to be 10-15 days, according to the water supply process, which is necessarily connected to the water source.

Considering the calculated water amounts, the application time (day, hour) was the applied total irrigation time, and the deficit applications were calculated by reducing the total time by 70% and 50%.

Measurement of Soil Resistivity

Electrical conductivity (ECa) maps of the soils of the trial garden were drawn in order to make a detailed structure analysis. For this purpose, the Wenner Mechanism, which measures the resistivity of the soil (ECa; resistivitymeter), developed by the ATP (Agro-TechniqueBornim, Germany) Institute was used. The mentioned ECa map was obtained

Table 1. Analysis Results of Irrigation Water Used in Experiment

irrigation water class	ECw (dS/m)	pH	Cations(me/L)				Ations(me/L)				SAR
			Na^+	K^+	Ca^{++}	Mg^{++}	CO^{-3}	HCO^{-3}	Cl^-	SO^{-4}	
C2S1	0,35	7,0	0,45	0,07	1,54	1,54	-	1,6	0,94	1,06	0,36

by using the said device separately for each tree.

The specified Wenner Arrangement is a geophysical method tool used to reveal the geological structure of the region to be investigated and, accordingly, the detailed structure distribution of the trial area (Özdemir, 2008).

In the method described, electricity is sent into the earth with two current electrodes and the potential distribution created by this current with two potential electrodes is determined through measurements made from the surface.

In the method, the Wenner Electrode Arrangement approach developed by the researcher, called the mechanism, is used. Vertical discontinuities determined sensitively by using the offset measurement technique. Information could be obtained from a depth equal to approximately one-third of the distance between the current electrodes. Since the impact (penetration) depth is low, it can detect shallow soil structures with high resolution.

The obtained map is arranged according to soil resistivity (ECa) values. The structure value of the soil at the point where each tree is taken into consideration is revealed.

Constituent classes are classified according to the ECa values read. It is accepted that as the ECa values increase, there is a finer soil texture, and as the ECa values decrease, there is a coarser soil texture.

Trunk Diameter (circumference) Measurements and Fruit Development

In the trial, on 26.06.2011; Before the start of irrigation, the trunk circumference of the trees was measured 10 cm above the grafting point and before the start of irrigation on 11.06.2012.

In order to determine fruit development, 10 fruits showing equal development and homogeneously distributed around the crown were marked in the plots of the trial treatments (30 fruits in total for each treatment. The circumferences of the marked fruits were measured once a month on days 221, 262, 292, 314 and 345 of the year from mid-August to mid-December in the first year of the experiment.

Canopy Volume

Canopy volumes of trial trees were measured. For this purpose, trees from which trunk circumference was measured were used in plots related to each treatment. Measurements in the working year were on 05.03.2012, YGS: 64; made on the day. The approach given by Westwood (1978) was used to calculate the tree canopy volume. Measurements were made at noon, when the sun's rays were perpendicular. First of all(firstly), the shade diameter of the tree canopy was measured in the north-south and east-west directions. The average canopy diameter obtained from these measurements was compared with the canopy height of the tree. Crown heights were determined by mira readings. Tree canopy volume, if these two values are equal to each other, equation 1a: if not, it was estimated using equation 1b.

$$V = \frac{4}{3}\left(h \times r^3\right) r \leq h \qquad (1a)$$

$$V = \frac{4}{3}h\left(a \times b\right)^2 r > h \qquad (1b)$$

In the formulas, h is the tree crown height, m; r, crown mean radius, m; a and b are the short and long radius of the tree canopy, respectively, m.

The measurements made regarding the tree canopy were punctuated against time, and the temporal dimension change/development of cover development was obtained. In addition, after each irrigation, the width of the wetness occurring within the crown projection of the tree and around the lateral of the drop was measured. In the measurements, the wetness formed at a depth of 5 cm from the soil surface was taken into account.

Photosynthesis Measurements

Portable photosynthesis meter system CI-340 model was used to measure the amount of photosynthesis. In order to monitor the internal water status of the plants under different applications, photosynthesis measurements were carried out with a portable photosynthesis meter (CI-340 Handheld Photosynthesissystem) at noon (11:00 - 13:00) on three plants from each plot, which are completely sun-facing and newly developed leaves (Figure 1).

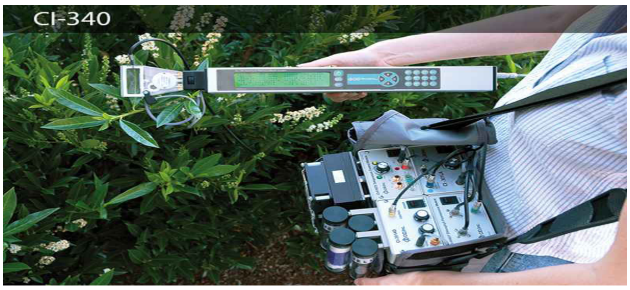

Figure 1.CI-340 HandheldPhotosynthesissystem

Statistical analysis

The experiment was organized as 3 x 3, nine row, three replicates, respectively, in a 'Randomized Block Design'. The means and calculated standard deviations were stated.

Least significant difference (LSD) test was used for mean comparison and the F test was significant at $P < 0.05$. The 'Correlation coefficients' were also calculated between all measured parameters. Data used in the ANOVA by the SAS v9 statisticalanalysessoftwareandSigmaPlot® v11 (Systat Software, San Jose, CA, USA).

RESULTS AND DISCUSSION

Irrigation and Water Consumption

Trial irrigation applications in the study were 11 times; for the first irrigations on 30.06.2011; started; and it was terminated on 31.10.2011. Thus, the length of the irrigation season for the grapefruit plant varied between 123 days depending on the climate, plant growth and soil conditions. In the study, 332.48 mm irrigation water was given to I100, 240.35 mm to I70, and 178.92 mm to I50. The ET values calculated with the water budget approach has changed between 810.5mm for I100 and 694.4mm for I50.

Resistivity Change in Trial Field Soils

The colors in the general resistivity change map of the field reflects different soil texture groups. For example, dark colors represent fine textured soils and light colors represent coarse textured or gravel areas. It is understood from the map that there are 10 different texture groups in the experimental garden(Figure 2).

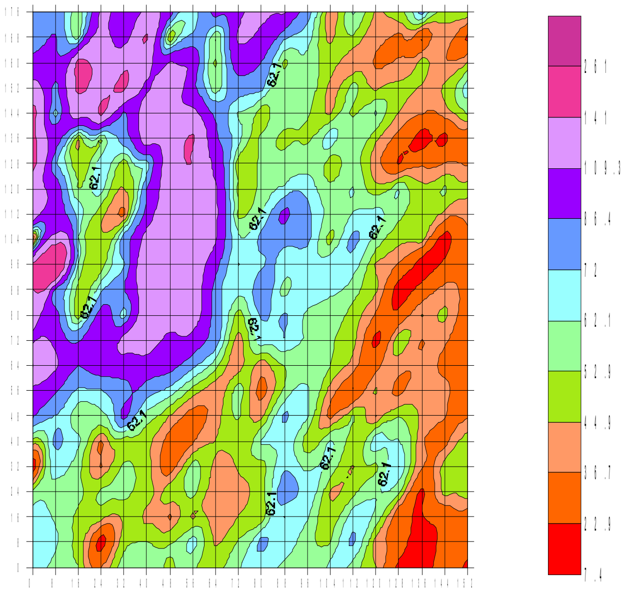

Figure 2. General ECa map of trial garden soils.

As seen from the map, the pink colors represent the heavy tecture class; dark red color represents coarse textured or gravel areas. In this case, it is seen that the trees grown on soils of different texture classes; It can be stated that the situation summarized above should be taken into account in estimating water and fertilizer requirements and monitoring their developments.

Figure 3.shows the soil resistivity values for each tree in the field. In particular, it has been determined that the trees, which are shown in light-colored or even white colors on the eastern sides of the garden, which was established on the lands of the river bed, are mostly on the conglomerate and gravel areas. In this section, the soil depth is quite shallow, around 1.0 m.

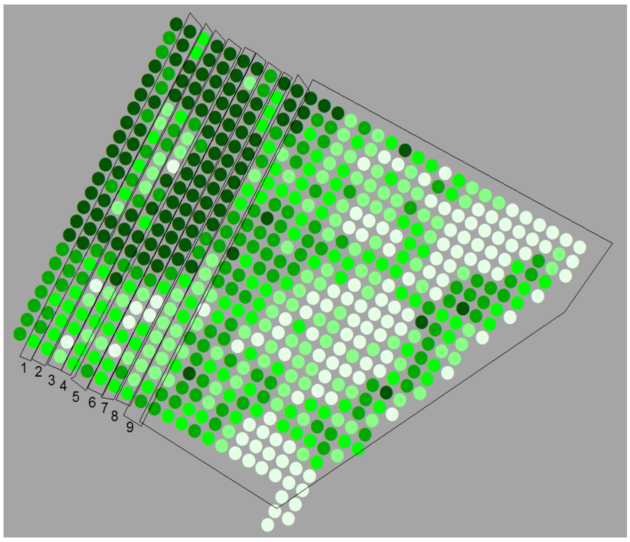

Figure 3. Resistivity values of trees in the experimental garden according to their location

Trunk Development in Trial Trees

Trunk circumferences were measured on 27.06.2011 at the beginning of the study in order to understand whether all trees in the trial plots were homogeneous in terms of development and the effect of the applied water restriction on the tree circumference and diameter. The homogeneity of the experimental trees in terms of development is a very important factor in understanding the effects of applied irrigation regimes on yield and other considerations and in comparing the regimes with each other. Therefore, the measurement results were evaluated statistically.

Kanber.etal.(1999) and Abdel-Messih and Nokrashy (1977) found that grapefruit trunk development changes at the beginning and end of the season. They determined that the tree trunk circumference increased with irrigation. Kırda et al (2007), determined that the circumference of the mandarin main stem increased between 1.53 and 3.33 cm according to the various irrigation regimes. Perez et al. (2014) in star ruby variety grapefruit trees, the water restriction applied at different stages of development, the tree trunk growth rate and they stated that it decreased in the cell division phase, but at the harvest it was the same as the control treatment. On the contrary, Gonzalez-Altozano and Castel (2000), conducted a study on mandarin and stated that water restriction applied in the same period caused an increase in trunk growth.

Many researchers have found a correlation between tree environment and irrigation, as in this study. According to these researchers; They determined that measuring trunk circumference can be used to compare the response of trees in the same garden to different irrigation practices (Wiegand and Swanson, 1982; Dasberg et al, 1981).

Fruit development

In the study, 10 fruits were selected from the trees in 3 different soils (soils with different resistivity values; ECa: 86.4-109.3 for T1; ECa:22.9-36.7 for T2 and ECa:62.1-72.0 for T3) for each irrigation regime circumferences were measured. Measurements were made at five different times between 08 August and 11 December 2011. The last reading values were considered as the harvest values.

The measurement results which are an indicator of fruit development, were evaluated statistically and graphically. Thus, at the end of the first year of the experiment, the effects of the applied irrigation programs on tree growth according to the soil characteristics of the area where the tree is located; The contribution of different irrigation treatmentsto fruit development in the same season has been tried to be examined. Fruits are smaller in other deficitirrigation than in fully watered regimes. For example, fruits in the I-70 were 5% smaller than the I-100, and the fruits in the I-50 were 15% smaller. From this, it could be said that regardless of soil conditions, fruit size is directly affected by irrigation programs and the amount of water given.The average fruit circumference values of the irrigation treatmentsfor the trial year are given in Figure 5. Compared to the fully watered regimes, the fruits are smaller in other deficit irrigation. For example, the goldenball fruits in the I50 were 6% smaller than the I100, and the fruits in the I70 remained 4% smaller than the I100. From this, it could be said that fruit size is directly affected by irrigation programs and the amount of water given. In the study, a tree was determined in each replication for each irrigation and the circumferences of 10 fruits on this tree were measured at different times. Measurements were made at five different times between 8 August and 11 December 2011.

The temporal variation of fruit development is given in Figure 4. Thus, the contribution of irrigation programs applied in the trial year to fruit development was tried to be examined.

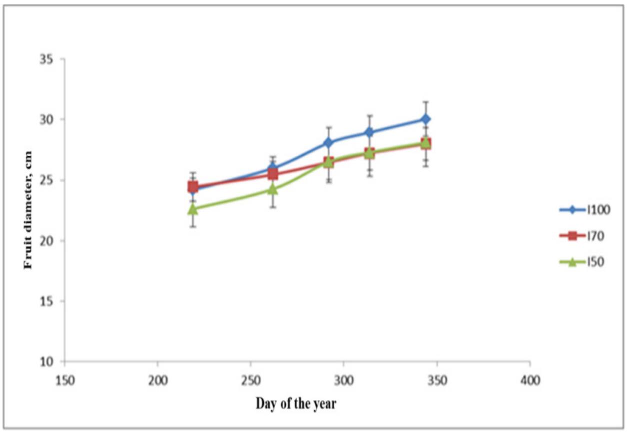

Figure4. The temporal variation of fruit development

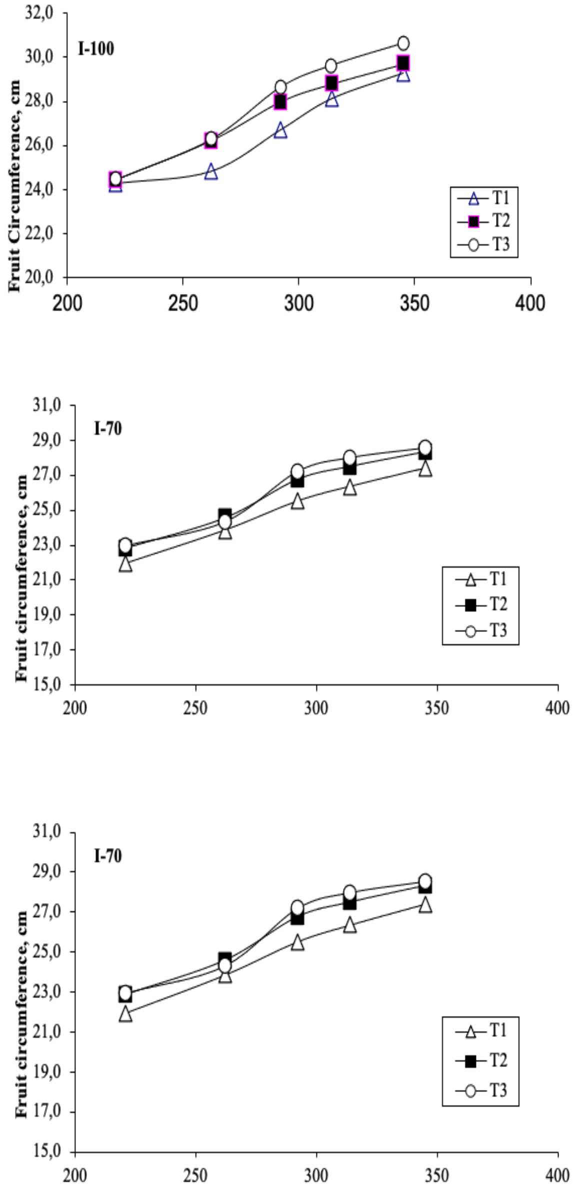

Figure 5. Temporal changes in the development of fruits in different soil and irrigation programs.

The temporal changes in the development of fruits on the trees considered in the study in different soil and irrigation programs are shown schematically in Figure 5.

As mentioned, T1 indicates heavy textured, T2 light textured and T3 medium textured soils. In Table 3, fruit development in irrigation treatmentsshowed differences according to soil textures.

For example, in the treatmentof I100, it was determined that the fruits developed better in medium and light textured soils than in heavy textured soils. A similar situation is observed for I70. As the soil texture gets heavier, fruit development worsens. On the other hand, on the I50 treatment, where the water shortage is more severe, a contrasting situation has emerged compared to other treatment. n the I50 line, this time, the fruits on the trees grown on heavy textured soils showed a better development. In this regard, fruits developed more in soils with T1 symbol than other T2 and T3 soils. It can be thought that the described situation arises as a result of the deterioration of aeration in heavy textured soils in areas where excess water is applied and the negative effect of fruit development due to the decrease in water intake as a result.

As can be seen from Table 2, the photosynthesis change and the transpiration change are similar to each other in the grapefruit tree. The highest transpiration rate was obtained from the I100 treatmentwhere full irrigation was attempted. This was followed by the water-restricted I70 treatment. The least transpiration rate was measured on the I50 with the highest water restriction. Transpiration values measured according to irrigation treatmentsin the grapefruit tree ranged from 0.57 (I100) to 0.28 mmol/m2/s (I50). From this, it can be explained that transpiration rate in grapefruit trees, like photosynthesis rate, varies depending on the amount of irrigation water applied.As can be seen from Table 2, the statistically significant net photosynthesis values were measured as 2.64 umol/m^2/s for I50, 3.48 umol/m^2/s for I70 and 4.77 umol/m^2/s for I100. The highest net photosynthesis value was obtained in I100, which was tried to be fully irrigated. This was followed by the I70, and the smallest value was found on the I50, where the water was significantly reduced. From this, it can be said that the rate of photosynthesis is directly related to the water level in the plant root zone under the same climate, soil and cultural application conditions and varies significantly depending on irrigation applications. In particular, it could be said that the rate of photosynthesis changes depending on the amount of irrigation water used in the grapefruit trees. Panigrahi et. al., (2014) found that photosynthesis, stomatal conductivity and transpiration decrease with decreasing irrigation water amount, similar to the study conducted in Kinnow mandarin variety.In another way, it can be expressed that the mandarin plants could sustain their photosynthesis rate with 50% reduction of water supply, which is called as the photosynthetic acclimatisation nature of citrus (Tomar and Singh, 1986; Vu and Yelenosky, 1988; Zhihui et al., 1990). The gs and Tr values followed the same trend of Pn in different irrigation treatments.

Table 2. Photosynthetic active radiation ranged between 820 and 1296 at leaf surface during gas exchange measurements where leaf surface temperature in °C varied from 21.4 to 24.9.

		photosynthetic rate, µmol $m^{-2}s^{-1}$	transpiration rate, mmol$m^{-2}s^{-1}$	Stomatal conductance, mmol $m^{-2}s^{-1}$	WUE
Irrigation treatment					
I50		2.64 c	0.28 c	28.22 c	9.56 a
I70		3.48 b	0.43 b	33.56 b	8.11 b
I100		4.77 a	0.57 a	39.22 a	8.39 b
Soil structure					
ECa: 22.9-36.7		3.60 b	0.43 b	33.67 b	8.56
ECa: 62.1-72.0		3.25 c	0.38 c	31.78 c	8.84
ECa: 86-109.3		4.06 a	0.47 a	35.56 a	8.67
irragation	soil				
I50	ECa:22.9-36.7	2.68	0.28fg	28.00 f	9.71 ab
	ECa:62.1-72.0	2.38	0.24 g	25.67 g	9.90 a
	ECa: 86-109.3	2.87	0.32ef	31.00 e	9.07abc
I70	ECa:22.9-36.7	3.47	0.44 d	33.33 cd	7.81 e
	ECa:62.1-72.0	3.02	0.36 e	32.67 de	8.41cde
	ECa: 86-109.3	3.97	0.49 c	34.67 c	8.10 de
I100	ECa:22.9-36.7	4.65	0.57 ab	39.67 a	8.15cde
	ECa:62.1-72.0	4.34	0.53bc	37.00 b	8.19cde
	ECa: 86-109.3	5.33	0.60 a	41.00 a	8.83bcd
Prob> F					
irragation		<.0001*	<.0001*	<.0001*	<.0001*
soil		<.0001*	<.0001*	<.0001*	0.2207
irragation*soil		0.1675	0.0326*	0.0030*	0.0065*

Table 3. Statistical evaluation of the effect of irrigation water applied at different levels on trees grown in soils with different soil textures on fruit development, fruit yield, tree trunk development, canopy volume development and leaf area index (LAI).

		Fruitperimeter (cm)	Trunkdiameter (cm)	Canopyvolüme (m³)	LAI	Yield (kg/tree)
Irrigation treatment						
I50		26.33	67.22	48.07 b	7.06	828b
I70		25.74	71.11	52.70 ab	6.35	883b
I100		27.44	73.39	63.21 a	7.01	1050a
Soil structure						
ECa: 22.9-36.7		26.69	67.66	52.41	7.00 a	877b
ECa: 62.1-72.0		26.56	72.38	55.06	7.52 a	1155a
ECa: 86-109.3		26.25	71.69	56.51	5.89 b	727b
irragation	soil					
I50	ECa:22.9-36.7	26.65	61.57	36.57	7.80	633c
	ECa:62.1-72.0	25.55	68.90	53.41	7.81	1000b
	ECa: 86-109.3	26.78	71.20	54.22	5.56	850bc
I70	ECa:22.9-36.7	26.00	72.70	61.55	6.19	1083b
	ECa:62.1-72.0	26.19	69.37	43.24	7.11	700c
	ECa: 86-109.3	25.02	71.27	53.32	5.74	866b
I100	ECa:22.9-36.7	27.43	68.70	59.10	7.03	1766a
	ECa:62.1-72.0	27.94	78.87	68.55	7.64	916b
	ECa: 86-109.3	26.94	72.60	61.98	6.36	466c
Prob> F						
irragation		0.0698	0.5076	0.0218*	0.2397	116*
soil		0.8060	0.6317	0.7143	0.0063*	217*
irragation*soil		0.6324	0.7913	0.0741	0.5461	369*

As seen in Table 3, there is no statistically significant difference between tree trunk circumference measurements at the beginning of the experiment. Trees are very homogeneous among themselves. At the end of the statistical analysis, no statistically significant difference was found between the irrigation levels.

In this case, it can be said that the differences between the regimes may have occurred by chance.

In the analyzes (canopy volume and main trunk circumference and height measurements), it was understood that the trees included in the experiment developed quite homogeneously and there was no statistical difference in terms of growth. It was determined that the irrigation levels were statistically significant in Canopy volume and yield, soil structure was statistically significant in LAI and yield, and interaction was statistically significant only in yield.

Experimental garden soils contain three different groups in terms of resistivity values (ECa); It has been determined that trees develop in soils with these soil structures. Accordingly, the tested trees were T1: 86-109; It is grown in soils with ECa values of T2: 23-37 and T3: 62-72. According to the ECa values mentioned, T1 soils are heavy; T2 soils represent light and T3 soils represent medium structures groups(Table 3).

In the study, the yields for irrigating the trees in the plot taken for the experiment varied between 883 (I70) and 828 (I50) kg per average tree. An average of 1050 kg was obtained from the fully irrigated I-100 treatment. The figures given are quite high. It can be said that this situation is due to the fact that the multi-year average has been overestimated during the year. Table 3.

CONCLUSION

This study was carried out in 2011 using Rio Red grapefruit trees in Çukurova University Faculty of Agriculture Research and Application Farm. Electrical conductivity (ECa) maps of the soils of the trial garden were formed in order to make a detailed structure analysis. In the study, it was aimed to determine the effects of the amount of irrigation water applied at different levels on the fruit growth and yield, tree trunk development, tree canopy volume development, leaf area index development and photosynthesis rate on trees growing in soils of different body classes. The highest net photosynthesis value was obtained in I100, which was tried to be fully irrigated. This was followed by I70, and the smallest value was found on

I50, where the water was significantly reduced. From this, it could be said that the rate of photosynthesis is directly related to the water level in the plant root zone under the same climate, soil and cultural application conditions and varies significantly depending on irrigation applications. In particular, it can be said that the rate of photosynthesis changes depending on the amount of irrigation water used in grapefruit trees. It was understood that the fruits of the other treatments with water restriction were smaller compared to the fully irrigated treatmentin the change of fruit size with the amount of irrigation water. From this, it can be said that regardless of soil conditions, fruit size is directly affected by irrigation programs and the amount of water given. Within the scope of this study, since the effects of irrigation treatmentson fruit yield are not statistically significant, water reduction can be recommended for the region in order to save water for the farmers.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest

The authors declared that for this research article, they have no actual, potential or perceived conflict of interest.

Author contribution

The contribution of the correspondingauthor to the study is 70%, that of the other author is 30%.

All the authors read and approved the final manuscript. All the authors verify that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Ethics committee approval is not required.

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Data availability

All data associated with this research were indicated and used in the manuscript submitted.

Consent for publication

All aouthors consented to the publication of this manuscript.

REFERENCES

Abdel-Messih, M.N., El-Nokrashy, M. A. E. G. (1977) Effect of Different Soil Moisture Levels on Growth, Yield and Quality of Washington Navel Orange. Egypt Agric. Res. Rev. 55(3): 47-57.Agricultural Water Management96:565–573.

Chalmers, D.J., Mitchell P.D, Van Heek, L. (1981). Control of Peach Tree Growth and Productivity by Regulated Water Supply, Tree Density and Summer Pruning. J.Am. Soc. Hor. Sci.106:307–312.

Dasberg, S., Bielorai, H., Erner, Y. (1981).Partial Wetting of The Root Zone and Nitrogen Effect on Growht and Quality of Shamouti Orange. ActaHortic. 119: 103-105. https://doi.org/10.17660/ActaHortic.1981.119.9

Doorenbos, J., Kassam A.H. (1979). Yield Response to Water.FAO United Nations, Irr. and Drain. Paper, No. 33,Rome, 193 S.

Engısh, M.J., Musick, J.T., Murty, V.V.(1990). Deficit Irrigation. Management of Farm Irrigation Systems, Edit. G.J. Hoffman., T.A. Howell., K.H. Solomon."Chap. 17. An ASAE Monograph,St. Joseph, MI, 631-663 S.

González,A.P., and Castel, J.R. (2000). Regulated Deficit İrrigation in Clementina De Nules' Citrus Trees. II.Vegetative Growth. Journal of Horticultural Science & Biotechnology75:388–392. https://doi.org/10.1080/14620316.2000.11511256

Kanber, R., Köksal, H., Yazar, A., Özekici, B., Önder, S. (1999). Effects of Different Irrigation Programs on Fruit, Trunk Growth Rates, Quality and Yield of Grapefruit Trees. Tr. J. of Agriculture and Forestry, 23, 401-411.

Kanber,R.,Ünlü,M., Tekin, S., Koç, L., Kapur, B. (2007). Akdeniz İklim Koşullarında Kimi Tarla Bitkilerinin Su KullanımRandımanlarının İrdelenmesi Türkiye VII. Tarla Bitkileri Kongresi, 25-27 Haziran2007, Erzurum (Poster Bildiri).(in Turkish)

Kırda, C., Topaloğlu, F., Topçu, S., Kaman, H.(2007). Mandarin Yield Response to Partial Root Drying and Conventional Deficit Irrigation. Turkish Journal of Agriculture For. 31. 1-10 .

Özdemir, A. (2008). Çokelektrotlu Jeofizik Rezistivite Ölçümlerinin Yeraltısuyu ve Jeotermal Arama Alanlarındaki Uygulamalarının Değerlendirilmesi. (in Turkish)

Panigrahi, P., Sharma, R. K. Hasan, M. and Parihar, S. S. (2014). Deficit irrigation scheduling and yield prediction of Kinnow mandarin (*Citrus reticulate* Blanco) in a semiarid region. Agricultural Water Management, 140: 48-60. https://doi.org/10.1016/j.agwat.2014.03.018

Perez-Perez, J.G., Robles, J.M., Botia, P. (2014). Effects of Deficit İrragation İn Different Fruit Growft Stages on"StarRuby"Grapefruit Trees İn Semi-Aridconditions. Agricultural Water Management 133. 44-54. https://doi.org/10.1016/j.agwat.2013.11.002

Stegman, E.C., B.G. Schatz, J.C. Gardner.(1990). Yield Sensitivities of Short Season Soybeans to Irrigation Management. Irrigation Sci. 11(2):111-119.

Tomar, N.S., Singh, R., 1986. Effect of various moisture regimes on photosynthesis and photorespiration in plant lemon. Indian J. Hort. 43 (1 & 2), 46–50.

Ünlü, M., Kanber , R., Kapur , B., Koç, D.L., Tekin, S. (2008).Tarımsal Sulamada Su Artırımı: Kısıntılı Sulama Yaklaşımı 5. DünyaSu Forumu Bölgesel Hazırlık Süreci DSİ Yurtiçi Bölgesel Su Toplantıları Sulama – Drenaj Konferansı Bildiri Kitabı 81-95. (in Turkish)

USSL,(1954). Diagnosis and Improvement of Saline and Alkali Soils,Agriculture Handbook, No:60, 160s., USA.

Vu, J.V., Yelenosky, G., 1988. Water deficit and associated changes in some photosynthetic parameters in leaves of 'Valencia' orange (Citrus sinensis L. Osbeck). Plant Physiol. 88, 375–378. https://doi.org/10.1104/pp.88.2.375

Westwood, M.N.(1978). Fruit and Nut Species. In: Temperate-Zone Pomology, M.N. Westwood (Ed) Chapter.3, W.H. Freeman and Co., San Francisco CA, Pp. 41-76.

Wiegand, C. L., Swanson, W. A.(1982).Citrus Response to Irrigation. III Tree Trunk and Canopy Growth. J. Rio Grande WalleyHortic. Soc. 35: 97-107.

Zhihui, C., Liangcheng, Z., Guanglin, W.U., Shonglong, Z., 1990. Photosynthetic acclimation to water stress in citrus. In: Proc. Int. Citrus Symp., 5-8 November, 1990, Guangzhou, China, pp. 413–418.