Scientific Research and Essays Vol. 6(4), pp. 738-747, 18 February, 2011
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE10.526
ISSN 1992-2248 ©2011 Academic Journals

Full Length Research Paper

Evapotranspiration, irrigation water applied,and vegetative growth relations of young apricot trees under different irrigation regimes

Sebahattin Kaya[1]*, Salih Evren[2], Erdal Dasci[2], M. Cemal Adiguzel[2] and Hasbi Yilmaz[3]

[1]Department of Agricultural Structures and Irrigation, Faculty of Agriculture, Bingol University, 12000, Bingol, Turkey.
[2]Soil and Water Resources Research Institute, 25700, Aziziye, Erzurum, Turkey.
[3]Ataturk Central Horticultural Research Institute, 77102, Yalova, Turkey.

Accepted 2 September, 2010

This study was carried out between 2004 and 2008 to investigate effects of different irrigation regimes on crop water use and vegetative growth of drip-irrigated young apricot trees. Six different irrigation treatments were used: five of which (S1, S2, S3, S4, and S5) were based on adjustment coefficients of Class A pan evaporation (0.50, 0.75, 1.00, 1.25, and 1.50). The other treatment (S6) was regulated deficit irrigation treatment that was irrigated by applying 100% of Class A pan evaporation until harvest, but not irrigated after harvest in all the years of study. The greatest irrigation water and evapotranspiration values were observed in the S5 treatment while the smallest values were observed in the S6 treatment. A linear relationship was found between irrigation water applied and evapotranspiration in the experimental years (R^2 = 1.00). Both the crown diameter and trunk diameter values showed statistically significant differences among treatments in the experimental years. The S5 and S4 treatments showed the highest crown and trunk diameter values, while the lowest crown and trunk diameter values were found for the S1 in 2004, 2005 and 2006, and for the S6 treatment in 2007 and 2008. Furthermore, it was found that there was a positive polynomial relationship between both the crown diameter and trunk diameter and evapotranspiration (R^2 = 0.89 and 0.96). When considering irrigation treatments and vegetative growth parameters as a whole, the best developments were obtained at S5 and S4. However, taken into consideration relationships between tree development and evapotranspiration, the S4 treatment has been more productive.

Key words: Apricot, drip-irrigation, class A pan, vegetative growth, regulated deficit irrigation, evapotranspiration.

INTRODUCTION

Apricot is mostly grown in Mediterranean countries, Russia, USA, Iran and Pakistan. Total world production of fresh apricot is between 2.2 and 2.7 million tons/year. Turkey is the leading producing country both for fresh and dried apricot. Total fresh and dried apricot production of Turkey in 2001 was 500 and 120 thousand metric tons, respectively, composing a 15-20% fresh and 65-80% dried apricot production of the world (Asma and Öztürk, 2005). The Igdir region, in which there are low seasonal rainfall amounts and scarce water resources, has great agricultural potential because it is a microclimate area. The apricot is the most important stone fruit grown in the region with 1525 ha dedicated to its cultivation, representing 74% of the total orchard area in the region (Anonymous, 1998). Salak apricot (*Prunus armeniaca* L cv. Salak) is the most often grown cultivar in the region and is specific to the region.

One of the major problems in irrigating crops is finding practical measures for determining the frequency and amount of water application. Such measures may also help evaluate crop response to a seasonal irrigation regime and thus improve the irrigation program for subsequent seasons (Kanber et al., 1999). On the other hand, the world faces very serious global warming, which will produce a general warming and significantly increase the evaporative

*Correponding author. E-mail: sebahattinkaya@yahoo.com. Tel: (90) 426 213 25 50. Fax: (90) 426 225 10 17.

demand and the irrigation requirement for crops. For this reason, irrigation efficiency is becoming increasingly important in arid and semi-arid regions with limited water resources. Therefore, it is necessary to adopt specialized and efficient methods of irrigation, such as drip irrigation, in order to achieve the twin objectives of higher productivity and optimum use of water (Gercek et al., 2009). Furthermore, the use of irrigation methods or systems that require low labor and energy inputs has become more popular in recent years. These conditions are readily satisfied by means of drip (micro) irrigation systems. More importantly, economic and environmental reasons, such as increasing irrigation costs and decreasing sources of irrigation, have encouraged farmers to use the drip irrigation method, especially for valuable crops (Cetin et al., 2002). As well as drip irrigation, Regulated Deficit Irrigation (RDI) provides many advantages, such as saving water with a minimum impact on yield and fruit quality, and decreasing water lost from the soil surface. This is accomplished by imposing water deficits during phenological stages when trees are relatively tolerant to water stres (non-critical periods) (Ruiz-Sanchez et al., 2000).

The water stress results in less evapotranspiration by closure of the stomata, reduced assimilation of carbon and decreased biomass production. Hence, the effect of irrigation has been studied in various fruit species in relation to growth, fruit quality and yield (Proebsting et al., 1981; Caspari et al., 1994; Mpelasoka et al., 2001). According to Li et al. (1989) and Girona et al. (1997), timing of water deficits has important effects on productivity of fruit trees, since it has observed that are not always detrimental. Determining optimal depletion levels for fruit tree irrigation requires information on the effects of declining water supply on tree processes. Long- term experiments with fruit trees tend to suggest that soil water threshold levels for fruit trees should not be very different from these determined for herbaceous crops (Demirtas et al., 2008). The total growth rate of a tree is a function of the growth of various tree organs during each season. The number of fruits and their final size are dependent on the growth of other organs such as the root, shoots, and trunk. It is, therefore, important to study the growth patterns and growth rates of the various tree organs and to investigate the effect of water potential at different stages. According to various researchers (Hilgeman, 1963, 1977; Levy et al., 1978; Dasberg et al., 1981 and Wiegand and Swanson, 1982), for measure-ments of wood growth, either the trunk or main branches may be used to compare the response of trees to different irrigation treatments at the same location. Also, the same researchers have found that measurement of the growth of the trunk may be used to compare the response of trees to different irrigation treatments in the same orchard(Kanber et al., 1999).

There are very few studies on the response of apricot to irrigation in global scale and Turkey which has the highest apricot production and many apricot cultivars in the world. More importantly, investigation carried out on irrigation of Salak apricot trees is nonexistence in Turkey. Therefore, it is important to investigate the efficient optimisation of the irrigation of Salak apricots. This study focused on the effects of various irrigation regimes on crop water use and the vegetative growth of Salak apricot trees.

MATERIALS AND METHODS

This study was conducted from 2004 to 2008 at the Soil and Water Resources Research Station, Igdır, Turkey. The Igdır Plain is located in the Eastern Anatolia region (44º 49' - 45º 31' E; 39º 38' - 40º 03' N; altitude 850 m). The region has a semi-arid climate, with an average annual temperature of 12.1ºC, an average relative humidity of 55%, The sun shines an average 6.41 h day^{-1} and the average annual rainfall is about 247.8 mm (Anonymous, 2009). The soil at the experimental site is clay loam with 34% clay, 40% silt, and 26% sand. Average field capacity, 31.4%; permanent wilting point, 17.1%; dry bulk density, 1.27 g cm^{-3}; pH 8.04 at 0-120 cm soil depth. There is no shallow water table, salinity, and alkalinity. Precipitation values, measured in growing seasons from 2004 to 2008 were 209, 181, 217, 223, and 108 mm, respectively. Water suitable for irrigation (pH 8.23; EC 0.275 dS m^{-1}) was obtained from a deep well in the experimental area.

The studied plant materials were Salak apricot cultivar trees (*P. armeniaca* L.Salak) grafted on Zerdali rootstocks. Salak apricot trees have very large volume of crown and are specific to Igdır region. The trees were planted in 2001, spaced 8 x 8 m apart. The trees were subjected to six drop irrigation treatments: five of which (S1, S2, S3, S4 and S5) were based on adjustment coefficients of Class A pan evaporation (0.50, 0.75, 1.00, 1.25, and 1.50). The other treatment (S6) was regulated deficit irrigation treatment that was irrigated by applying 100% of Class A pan evaporation until harvest, but not irrigated after harvest in all the years of study. The experimental design was a completely randomized block design with three replicates. Each block consisted of 36 trees and the total number of trees was 108 on the trial plot.Each plot contained one plant row with 6 trees, taking middle three trees for experimental measurements and considering the others as non-experimental guard trees.

Trees received the same fertilization treatments by using fertigation techniques. The amount of fertilizer was 0.44 kg urea (from April to July four times in a year), and 0.11 kg PO_4H_3 (from April to mid-September) applied to each tree each year. A routine pesticide program was maintaned. No weeds were allowed to develop within the orchard, resulting in a clean orchard floor for the duration of the experiment. Trees were irrigated by using a double-drip irrigation lateral line for each row. The lateral lines had online compensating emitters and the discharge rates of the emitters were 6.8 L h^{-1} at the operating pressure of 1.5 atm. The emitter spacing was chosen as 0.50 m due to soil characteristics. About 35% of the soil's surface was wetted.

The amount of first irrigation water for all the plots was based on the moisture deficit that would be needed to bring a 0 -120 cm layer of soil to field capacity and it was applied by means of the system when available water at a 120 cm depth soil profile was at 50%.

Experimental treatments were initiated one week after the first irrigation application which was in the last week of May or the first week of June, and were continued by mid September. However, the trees undergoing S6 irrigation treatment were not irrigated after

Table 1. Irrigation water amounts applied to treatments and values of evapotranspiration determined.

Treatments	Amount of water applied (I) (mm)					Evapotranspiration (ET) (mm)				
	2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
S1	274	303	356	342	453	547	501	613	647	645
S2	392	431	504	477	612	674	630	765	771	777
S3	502	548	638	603	771	780	752	879	923	948
S4	629	696	817	745	930	903	892	1067	1045	1083
S5	755	836	959	875	1089	1028	1014	1199	1159	1262
S6	208	214	276	272	303	494	428	529	573	484

harvest in the experimental years. The amount of irrigation water to be applied during a particular week was calculated from the daily evaporation values measured in the class A pan during the preceding week. Irrigation amounts were adjusted according to canopy size (Ruiz-Sanchez et al., 2000). The class A pan was set up according to criterions offered by Doorenbos and Pruitt (1977). Soil water contents were determined monthly by gravimetric sampling method at 30 cm increments down to 120 cm in the profile. Furthermore, the soil water contents were checked using a neutron probe (Campbell Hydroprobe Model 503-DR) that had previously been calibrated for the site. Rainfall was measured both by a manual rain gauge and an automatic rain gauge connected to a data logger. The amount of irrigation water applied to each plot was measured by a water meter. Determination of soil water content and evapotranspiration (ET) calculations were made from the beginning of flowering until leaves began to fall off the trees. ET was calculated for each treatment via a water balance equation water content (Doorenbos and Kassam, 1988). Since there was no runoff during irrigation and the watertable was at a depth of more than 3 m, capillary flow to the root zone and runoff were assumed to be negligible in the calculation of ET. On the basis of a number of soil water content measurements, drainage below 120 cm was considered to be negligible. To determine the effects of the treatments on vegetative growth the following measurements were done on three trees per block in the experimental years. The trunk circumference was measured with a plastic tape at harvest, and the beginning of the winter period, 30 cm above the soil line. On the same trees, the canopy shaded area was estimated as the vertical projection of the tree canopy measured across and within rows before each irrigation application, and the beginning of the winter period.

In the present study, water use and vegetative growth values from 2004 to 2008 were evaluated. To take into account the water from rainfall and soil water as well as irrigation water, comparisons was made according to evapotranspiration rather than applied irrigation water. Because, in particular, the trees have received more water completely covered tree spacing since the end of growth season of 2006, differences of tree crown development in 2007 and 2008 not be evaluated. Statistical analyses were carried out in order to determine the effects of irrigation treatments on ET, and vegetative growth using TARIST version 1.0 software with the general linear mode (GLM) (Acikgoz et al., 2004). Duncan`s multiple test, an acceptable tool for the comparison of discrete data, was used to compare different irrigation programs. To determine the relationships between vegetative growth and evapotranspiration values, regression analysis were performed (Yurtsever, 1984).

RESULTS

Irrigation water applied and evapotranspiration

The seasonal amounts of irrigation water applied and the results of seasonal evapotranspiration obtained according to the treatments and experimental years are given in Table 1. The greatest irrigation water and evapotranspiration were observed in the S5 treatment while the smallest irrigation water and evapotranspiration were observed in the S6 treatment in the experimental years (from 2004 to 2008). In this study, a linear relationship was found between irrgation water applied and evapotranspiration in all the years of study. Regression analysis between seasonal applied irrigation and observed apricot crop ET values indicated a relationship of:

$$ET = 0.975\ I + 254.09$$

with R^2 values of 1.00 for the experimental years (Figure 1).

Crown growth and evapotranspiration

Cumulative crown diameter and trunk diamater values according to irrigation treatments are presented in Table 2. Cumulative crown diameter values showed statistically significant differences among treatments in the experimental years. The S5 treatment showed the highest crown diameters in 2004 and 2005. The S4 treatment showed the highest crown diameter and S4, and S5 treatments were in the same statistical group in 2006. The S1 treatment had the lowest crown diameter in the experimental years (from 2004 to 2006).

Cumulative crown diameter growth versus time for different treatments are presented in Figure 2. The cumulative crown diameter values showed increase in all the years of study. However, it was observed that there was a decreasing trend at growing amount of crown diameter year by year.

Accordingly , the crown diameter growth showed increasing trend depending on the amount of evapotranspiration which depends on the water amount applied in 2004 and 2005, while a decreasing trend was observed in 2006 as a natural result of tree growth. This relationships between cumulative crown diameters and seasonal evapo-transpirations in the experimental years are shown in Figure 3. Polynomial relationship observed between cumulative crown diameter and evapo-transpiration for all

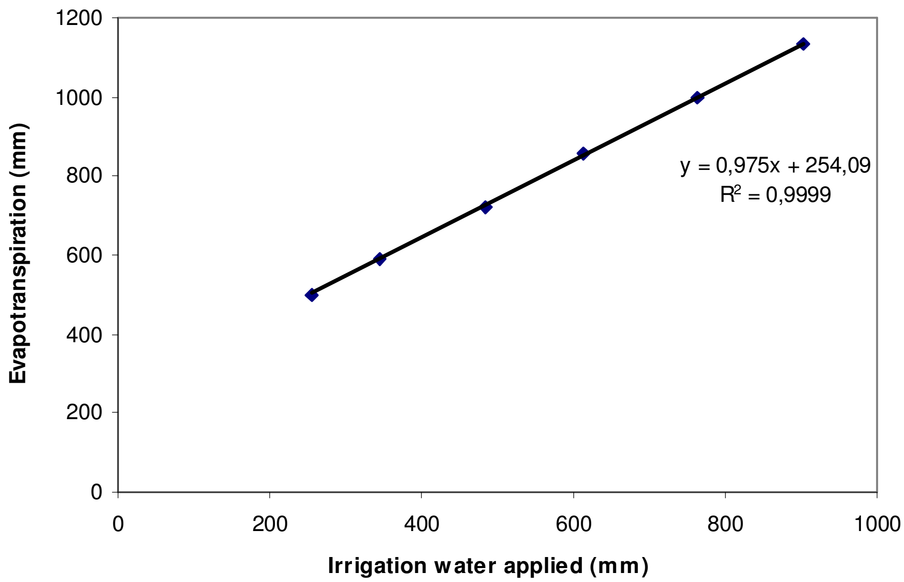

Figure 1. Relationship between irrigation (I) and evapotranspiration (ET) for 2004 - 2008.

Table 2. Effects of different treatments on vegetative growth parameters.

Treatments	Trunk diameters (cm)					Crown diameters (m)		
	2004	2005	2006	2007	2008	2004	2005	2006
S1	13.21c	15.98b	19.17b	21.26b	23.21b	5.11b	6.13d	6.94b
S2	14.65bc	17.74ab	21.19ab	23.57ab	25.58ab	5.31ab	6.64bc	7.44ab
S3	14.89abc	18.08ab	21.57ab	24.15ab	26.14ab	5.41ab	6.64bc	7.44ab
S4	15.88ab	19.33a	22.85a	25.50a	27.67a	5.67ab	6.98ab	7.98a
S5	16.45a	19.69a	23.26a	26.05a	28.67a	5.80a	7.08a	7.85a
S6	14.46bc	16.75b	19.17b	21.19b	22.49b	5.29ab	6.39cd	7.08b
Replication(R)	ns	ns	ns	ns	ns	ns	ns	ns
Treatments (T)	**	**	**	**	**	*	**	**
Years (Y)	14.92e**	17.93d	21.20c	23,62b	25.63a	5.43c**	6.64b	7.46a
YXT	**	**	**	**	**	ns	ns	ns
Error	**	**	**	**	**	**	**	**

* values followed with different letters in the same column are significantly differents according to Duncan test (* $p \leq 0.05$, ** $p \leq 0.01$, ns: non-significant).

irrigation treatments is as follows:

$$y = 0.3\ 10^{-6}x^2 + 0.9\ 10^{-3}x + 5.6414$$

with $R^2 = 0.89$ for the experimental years.

The relationship between average annual increment in crown diameter and average seasonal evapotrans-pirasyon according to irrigation treatments for the experimental years are presented in Figure 4. As shown in Figure 4, the annual increment in crown diameter showed decreasing trend depending on the amount of evapotranspiration in the experimental years. Polynomial relationship was observed between annual increment in crown diameter and evapotranspiration for all irrigation treatments:

$$y = -0.1\ 10^{-6}x^2 + 2.1\ 10^{-3}\ x + 0.3571$$

with $R^2 = 0.80$ for the 3 years.

Trunk growth and evapotranspiration

Cumulative trunk diameters were observed by measuring trunk circumference at end of each season (Figure 5). Cumulative trunk diameter values showed statistically significant differences among treatments in the

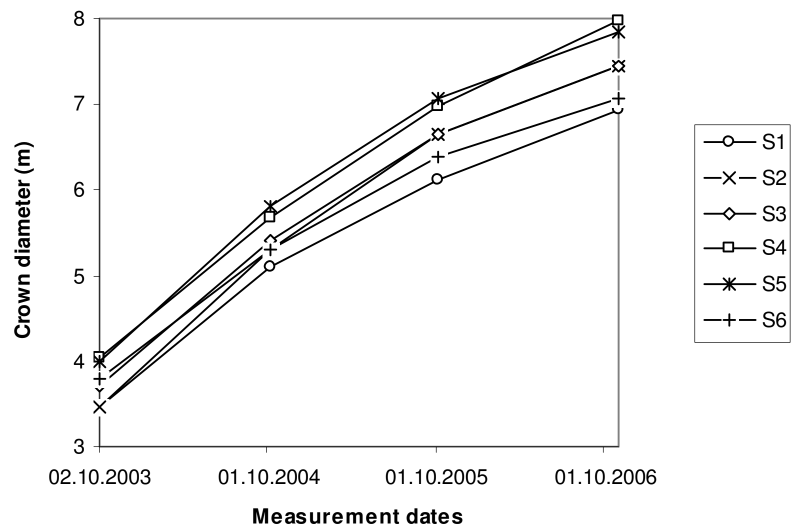

Figure 2. Cumulative crown diameter growth versus time for different treatments.

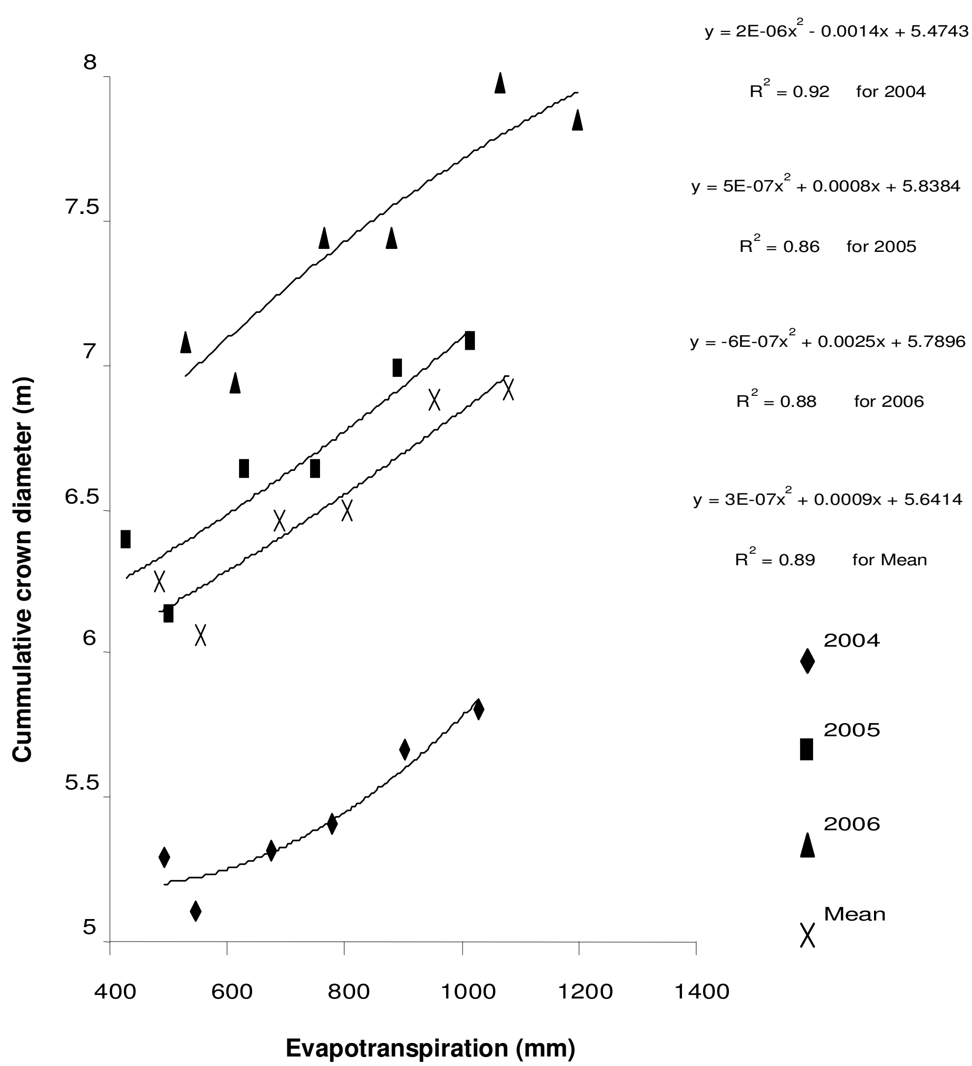

Figure 3. The relationships between cumulative crown diameters and seasonal evapotranspirations for all irrigation treatments.

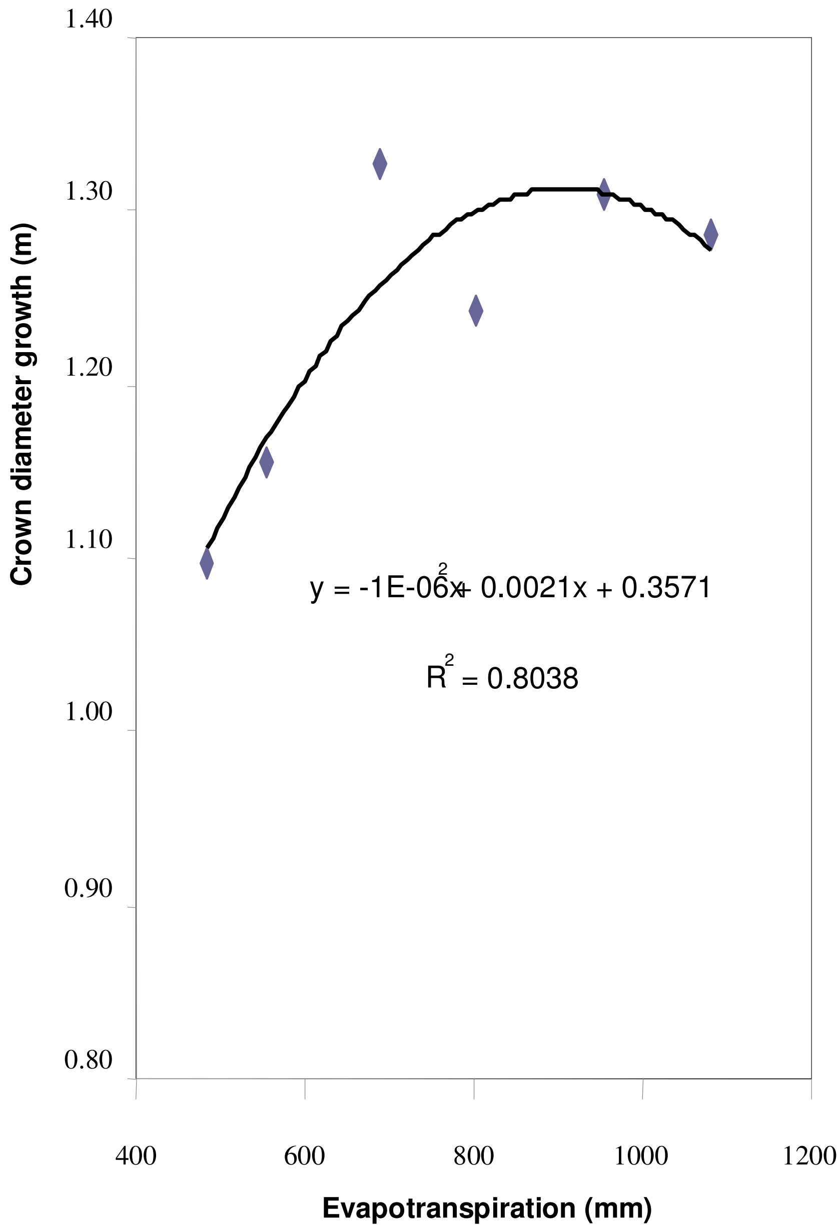

Figure 4. The relationship between annual crown diameter increment and seasonal evapotranspiration for all irrigation treatments for the experimental years.

experimental years. The S5 treatment showed the highest trunk diameters and S4, and S5 treatments were in the same statistical group in all the years of study except for the 2004, while the lowest values were found for S1 (in 2004, 2005, and 2006) and S6 treatments (in 2007 and 2008).

The curves showing the relationship between cumulative trunk diameter and evapotranspiration are presented in the Figure 6. Accordingly , the trunk diameter values showed increasing trend depending on the amount of evapotranspiration in 2004, and 2005, while a decreasing trend was observed in 2006, 2007,and 2008 as a natural result of the tree growth. Polynomial relationship observed between cumulative trunk diameter and evapotranspiration for all irrigation treatments is follows:

$$y = -0.1\ 10^{-5}x^2 + 9.4\ 10^{-3}x + 14.139$$

with R^2 = 0.96 for the experimental years.

The relationship between annual increment in trunk diameter and seasonal evapotranspirasyon for all irrigation

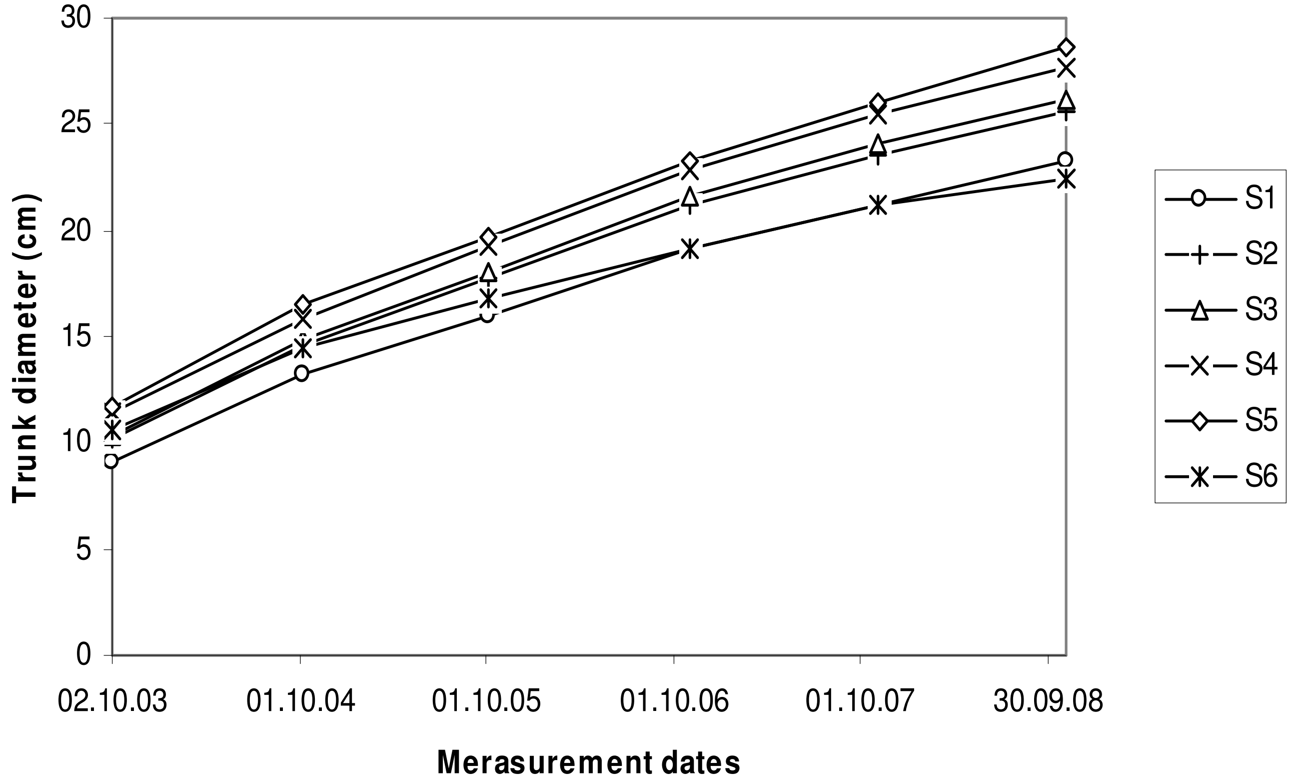

Figure 5. Cumulative trunk diameter growth versus time for different treatments.

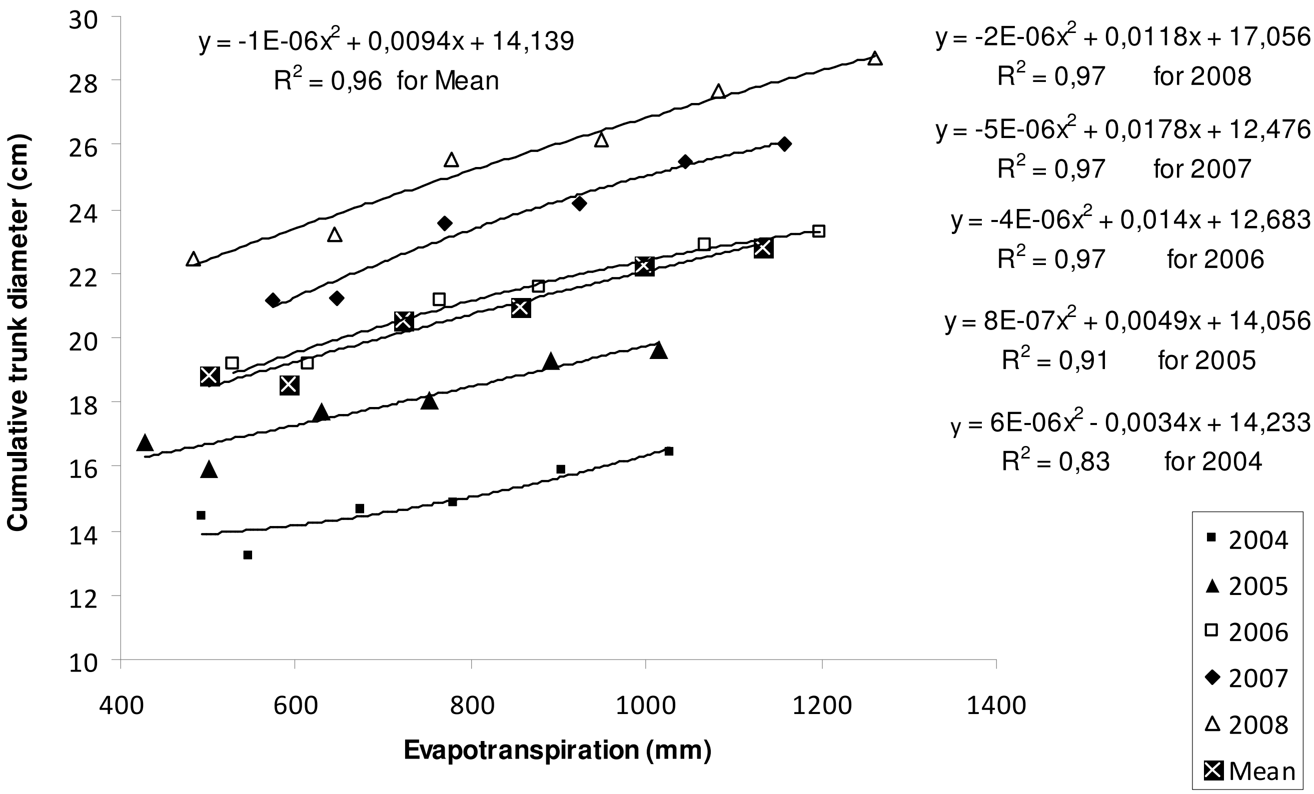

Figure 6. The relationships between cumulative trunk diameters and seasonal evapotranspirations for all irrigation treatments.

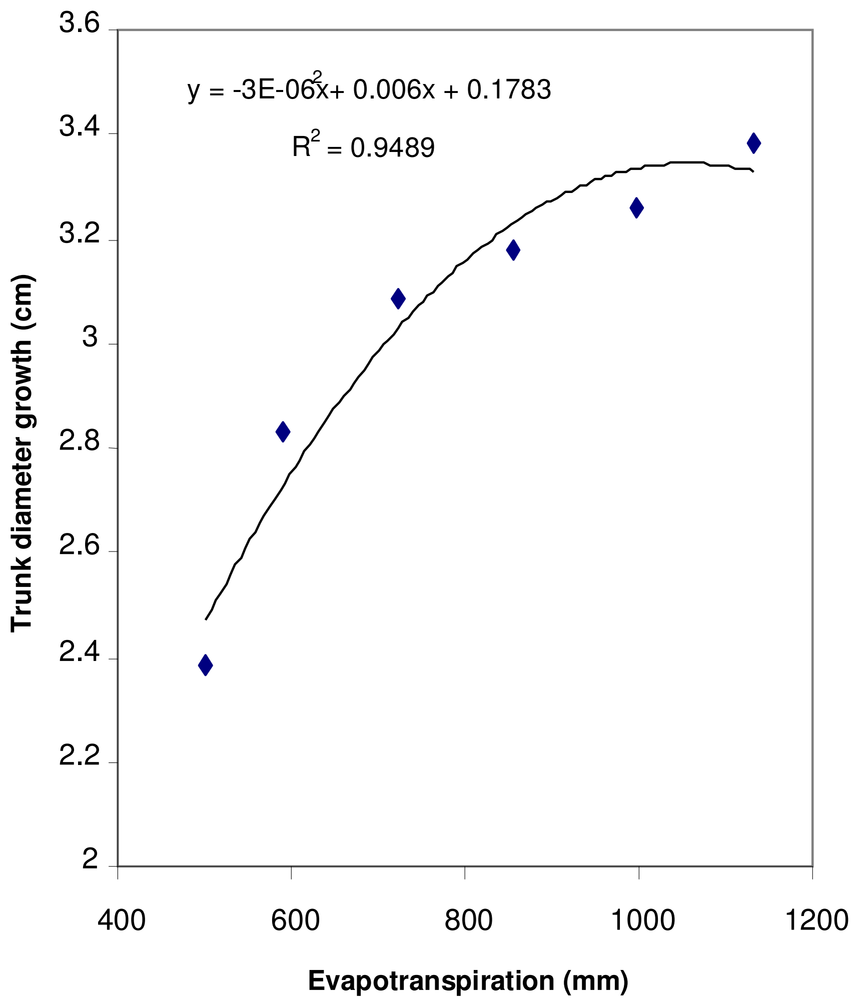

Figure 7. The relationship between annual increment in trunk diameter and seasonal evapotranspiration for all irrigation treatments for the experimental years.

treatments for the experimental years are presented in Figure 7. Polynomial relationship was observed between annual increment in crown diameter and evapotran spiration for all irrigation treatments:

$$y = -0.3\ 10^{-5}x^2 + 0.6\ 10^{-2}\ x + 0.1783$$

with R^2 value of 0.95 for five years.

DISCUSSION

Since irrigation water amounts were adjusted according to canopy size depending on the tree crown development, the values were observed to increase year by year throughout the study except for the 2007. The amounts of irrigation water applied for irrigation treatments in 2006 were higher than those of 2007 due to variations in evaporation during the growing period in this years. The seasonal quantity of irrigation water applied increased with an increase in the pan coefficient. So, evapotranspiration also increased as long as irrigation water increased.

Evapotranspiration values in 2004 were higher than those of 2005, since rainfall, and soil water content at the beginning of the season in 2004 were higher than those of 2005. Similarly, evapotranspiration value of the S6 treatment in 2007 was higher than that of 2008, because rainfall was higher in growing season of 2007 than that of 2008 (223 mm for 2007 and 108 mm for 2008). A similar finding was also reported by Yazgan et al. (2006). The S4 treatment showed more crown growth than the S5 treatment in 2006, which might have been affected by differences in winter pruning. The results of crown growth obtained in the present study agree with the suggestions reported by Goldhamer (1989), who have suggested that deficit irrigation strategies may be applied in apricot trees since water deficit will affect vegetative growth without detrimental effect on fruit growth and yield (Ruiz-Sanchez et al., 2000). In similar, Wiegand and Swanson, (1982) have stated that controlled water stress is used to limit canopy development (Kanber et al., 1999). While evapo-traspirasyon value corresponding to the maximum crown diameter growth was determined to be 1050 mm according to this polynomial relationship, this value is around 950 mm according to Figure 4, which is equivalent to average evapotranspiration value of the S4 treatment. This difference was due to determination coefficient of polynomial relations being not very high ($R^2 = 0.80$).

As is seen at Figure 5, the trunk development rate was higher in the initial years than that of the later years for all treatments. Unlike others, the S6 treatment showed a decline in trunk growth trend year by year, since the effect of deficit water applied during the previous year has also continued in later years. Similar findings were reported by Ruiz-Sanchez et al. (2000), who stated that trunk growth was reduced by continuous water deficit. These results are similar to results determined by Proebsting et al. (1981), who stated that growth of fruit and vegetative parts was reduced by severe stres condition in bearing sweet cherry and prune trees. Regression analysis showed that there were statistically significant polynomial relations between trunk diameter growth and evapo-transpiration in all the years of study (Figure 6). Also, Girona et al. (1993) determined that trunk circumference of almond trees varied depending on the amount of applied water. Similar results were obser-ved by various researchers such as Veimeyer (1975) and Micke et al. (1972) (Yazgan et al., 2006).

The trunk diameter growth showed decreasing trend depending on the amount of evapotranspiration in the experimental years. Also, Mokhtar and Samir (1999) reported that there was a positive relationship between water use and tree growth, yield and root length density and that more yield, higher root length and stronger trees were got from the treatments which have got more water use. According to these polynomial relations, evapotras-pirasyon value corresponding to the maximum trunk diameter growth was determined to be 1000 mm. This value is almost the same as the average evapotranspi-ration of the S4 treatment which is 998 mm. According to ANOVA, the S4 and S5 treatments showing the highest values of trunk development were at the same statistical group.

Conclusion

This study is initiated to determine effects of different irrigation treatments on water use and wood growth of apricot trees. It was determined that tree growth significantly increased depending on amount of water applied. Tree growth values in the treatments received more water were higher than those in the treatments received less water. The results revealed that the effects of the irrigation programs on the evapotranspiration and tree growth of apricot were significantly different. The rate of increase, both in crown diameter and trunk diameter was greater in the S5 treatment than in the other treatments. As an increasing tree growth trend depending on the amount of evapotranspiration or amount of water applied is seen in the initial years of the experiment, this trend has begun to decrease for all the irrigation treatments in the last years of the experiment for trees approaching to their maturity size.

The relationships between evapotranspiration and crown diameter, and trunk diameter were analyzed in order to predict tree growth from observations made during the season. Various prediction equations were derived through regression analysis. When considering irrigation treatments and vegetative growth parameters as a whole, the best developments were obtained at S5 and S4. However, taken into consideration relationships between tree development and evapotranspiration, the S4 treatment has been more productive. Increasing trend in the cumulative trunk diameter versus time was lower than increasing trend in the cumulative crown diameter for the S6 treatments, which means that continuous water deficit after harvest more affects to trunk growth than crown growth. Since the improvement of fruit quality is the main purpose of apricot production, water application levels should be tested with yield and quality. In this context, earlier results of this study showed us that S1 irrigation level was sufficient for the trees under the experimental conditions (Kaya et al., 2010).

ACKNOWLEDGEMENTS

This present study was summaried partially from the research project supported General Directoraty of Agricultural Research, Agriculture and Rural Services Ministry, Turkey.

REFERENCES

Acikgoz N, Ilker E, Gokcol A (2004). Evaluation of biological research on computer. Ege Üniv. TTUAM, 2: 236.
Anonymous (1998). The Igdır in 75th year of The Republic. Igdır Government,Igdır,Turkey.
Anonymous (2009). Statistical data.Turkish State Meteorological Service. (www.dmi.gov.tr).
Asma BM, Ozturk K (2005). Analysis of morphological, pomological and yield characteristics of some apricot germplasm in Turkey, Genetic Resources Crop Evol., 52: 305-313.
Caspari HW, Behboudian MH, Chalmers DJ (1994). Water use, growth, and fruit yield of 'Hosui' Asian pears under deficit irrigation. J. Am. Soc. Hortic. Sci., 119: 383-388.
Cetin O, Yıldırım O, Uygan D, Boyacı H (2002). Irrigation Scheduling of Drip-Irrigated Tomatoes Using Class A Pan Evaporation. Turk. J. Agric. For., 26: 171-178.

Dasberg S, Bielorai H, Erner Y (1981). Partial wetting of the root zone and nitrogen effect on growht and quality of shamouti orange. Acta Hortic., 119: 103-105.

Demirtas C, Erturk U, Yazgan S, Candogan BN, Soylu A (2008). Effects of different irrigation levels on the vegetative growth, flower bud formation and fruit quality of sweet cherry in western part of Turkey. J. Food, Agric. Environ., 6(2): 173-177.

Doorenbos J, Pruitt WO (1977). Guidelines for prediction of crop water requirements. FAO Irrig. and Drain. Paper No: 24, 2nd ed., Rome, Italy.

Doorenbos J, Kassam AH (1988). Yield response to water: irrigation and drainage. FAO Paper, 33: 193.

Gercek S, Boydak E, Okant M, Dikilitas M (2009). Water pillow irrigation compared to furrow irrigation for soybean production in a semi-arid area. Agric. Water Manage., 96(1): 87-92.

Girona J, Marsal M, Cohen M, Mata M, Miravete C (1993). Physiological, growth and yield responses of Almond (*Prunus dulcis* L) to different irrigation regimes. Acta Hortic., 335: 389-398.

Girona J, Marsal J, Mata M, Arbones A, Miravete C (1997). Evaluation of almond (*Prunus amygdalus* L.) seasonal sensitivity to water stress. Acta Hortic., 449: 489-496.

Goldhamer DA (1989). Drought irrigation strategies for decidious orchards. Univ. Of California, Div. Agric. And Nat. Resources. Public. no 21453, p. 15.

Hilgeman RH (1963).Trunk growth of valencia orange in relation to soil moisture and climate. Proc. Am. Soc. Hortic. Sci., 82: 193-198.

Hilgeman RH (1977). Response of Citrus to Water Stress In Arizona. Proc. Int. Soc. Citrus. (Orlando). 1: 70-74.

Kanber R, Köksal H, Yazar A, Ozekıcı B, Onder S (1999). Effects of different irrigation programs on fruit, trunk growth rates, quality and yield of grapefruit trees. Tr. J. Agric. For., 23: 401-411.

Kaya S, Evren S, Dasci E, Adiguzel MC, Yilmaz H (2010). Effects of different irrigation regimes on vegetative growth, fruit yield and quality of drip-rrigated apricot trees. Afr. J. Biotechnol., 9(36), (In press).

Levy Y, Shalhevet J, Bielorai H (1978). Long-term effects of different irrigation regimes on grapefruit tree development and Yield. J. Am. Soc. Hortic. Sci., 103: 680-683.

Li SH, Huguet JG, Schoch PG, Orlando P (1989).Responses of peach treegrowth and cropping to soil water deficit at various phenological states of fruit develpoment.J. Hortic. Sci., 64: 541-552.

Micke WC, Meith WC, Uriu K, Martin PE (1972). Early irrigation for almonds. California Agric., 9: 7.

Mpelasoka BS, Behboudian MH, Mills TM (2001). Effects of deficit irrigation on fruit maturity and quality of 'Braeburn' apple. Sci. Hortic., 90: 279-290.

Mokhtar MH, Samir AS (1999). Water use of apricot trees. Karayiannis I.(ed.). Proc. XI. Int. Symp. on Apricot Culture. Acta Hortic., 488: 547-550.

Proebsting EL, Middleton JE, Mahan MO (1981). Performance of bearing cherry and prune tress under very low irrigation rates. J. Am. Soc. Hortic. Sci., 106: 243-246.

Ruiz-Sanchez MC, Torrecillas A, Perez-Pastor A, Domingo R (2000). Regulated deficit irrigation in apricot trees. Ferreira MI and Jones HG (eds.). Proc. 3rd on Irrigation Hort. Crops. Acta Hortic., 537: 759-766.

Veimeyer FJ (1975).The growth of fruit trees in response to different soil moisture conditions, measured by width of annual ring and other means. Soil Sci.,119: 448-460.

Wiegand CL, Swanson WA (1982). Citrus response to irrigation. III Tree Trunk And Canopy Growth. J. Rio Grande Walley Hortic. Soc., 35: 97-107.

Yazgan S, Buyukcangaz H, Demirtas C, Candogan, BN (2006). Evapotranspiration for young cherry trees (Prunus avium) and growth responses to irrigation. Pakistan J. Biol. Sci., 9(1): 39-44.

Yurtsever N (1984). Experimental Statistic Methods. Soil and Fertilizer Research Institute. General Publications No: 121 Ankara, Turkey.