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Water - Yield Relationship of Tomato under Tekirdag Conditions in Turkey

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Abstract: Irrigation water requirement, irrigation times and numbers, evapotranspiration (ET) and water-yield (Y) relationship of tomato (*Lycopersicon esculentum*, SC 2121 variety) were investigated. Treatments included irrigations at 14 (T14), 21 (T21) and 28 (T28) days intervals. Because there was no statistically significant difference in the yield between treatments, T28 treatment was suggested to practice. Seasonal ET of T28 was measured as 668 mm while the highest monthly ET was recorded in July as 223 mm. A total of 370 mm irrigation water was applied and 76010 kg ha^{-1} yield was obtained from this treatment. Using seasonal ET and average yields of the treatments, water-yield relationships were explained in the from Y = 98.455 ET + 10956 (Y: yield in kg ha^{-1} and ET: evapotranspiration in mm).

Key words: Tomato, irrigation, evapotranspiration, irrigation scheduling

Introduction

Tomato is one of the most common vegetables that is produced in the world with 2.5 million ha and in Turkey with 0.2 million ha area (Anonymous, 1993). Recently, industrial type of tomato production has been increased in the European part of Turkey. Numerous of published works are available in literature on the water use characteristics of tomato under different soil and climatic conditions (Burgmans *et al.*, 1998; Obreza *et al.*, 1996 and Alharbi *et al.*, 1994). Ramalan *et al.* (2000) stated that fruit weight was significantly affected by soil water suction. A quadratic relationship (R^2 = 0.8-0.99) between the seasonal water applied and yield was found by Imtiyaz *et al.* (2000). This relationship might be either linear or non-linear (Tulucu, 1985). Araki (1994) indicated that soil moisture management based on soil moisture potential is preferable to that based on leaf water potential in the forcing cultivation of tomato in greenhouses. However, no study was conducted on this subject in Thrace Region, European part of Turkey. Therefore the aim of this study was to determine irrigation water requirement, irrigation times and numbers, evapotranspiration (ET) and water-yield (Y) relationship of tomato (*L. esculantum*) under field conditions in Thrace Region of Turkey.

Materials and Methods

The field experiment was conducted on the farmer area at Topagac district of Tekirdag Province at Trakya part of Marmara Region in Turkey during the years 1994 and 1995. The experimental area, distanced 500 m from Marmara Sea and altituded 50 m, located at 40°57′ N latitude and 27°28′ E longitude.

The climate of Tekirdag is characterized by Mediterranean type with mild and rainy winters and hot and dry summers at the coast while continental type prevails inside. The averages of annual temperature, relative humidity, wind speed, sunshine duration and total annual precipitation are 13.7 °C, 75 %, 3.1 m/s, 6.5 h and 579.7 mm, respectively (Anonymous, 1984).

Soil chemical and some other important properties are presented in Table 1. Soil moisture characteristics such as field capacity, wilting point, bulk density and available water holding capacity at the experimental site are presented in Table 2. The area has not boron, salt, sodium and drainage problems. Irrigation water quality was C_2S_1 (electrical conductivity: 0.5 dS/m and sodium adsorption rate: 7.0 meq/l).

Field experiment was designed in a randomized complete block design, replicated three times. The experiments included three irrigation treatments at 14 (T14), 21 (T21) and 28 (T28) days intervals. The first irrigation was done when 60 % of available soil moisture was consumed within 0-90 cm root zone for all treatments. Soil moisture deficit was brought to field capacity for 90 cm soil layer (Howell, 1988). Soil moisture was determined by gravimetric method at 0-30 cm, 30-60 cm and 60-90 cm soil layers during the whole growing season. The amount of water applied to the plots were measured with a flowmeter. The plots were irrigated by furrow irrigation.

Each experimental plot occupied an area of 28.8 m^2 (4.8 x 6.0 m^2) and included 48 plants with 1.2 x 0.50 m^2 plant spacing. The gap between the plots was 2.5 m. The plots were located on furrow-irrigated land having a uniform slope of about 0.5 %. Seedlings of SC2121 tomato variety were used for planting (Ferhatoglu, 1986). Nitrogen and phosphorous were applied at the rate of 100 kg per hectare N and 50 kg per hectare P_2O_5, respectively, before sowing. Winter wheat had been grown in the experimental site before the experiment. The seedling plants were transplanted into the plots on 1st May 1994 and 5th May 1995. After physiological maturity, tomatoes were harvested from two rows per plot. The harvest was finalized on 31st August 1994 and 6th September 1995.

ET for ten-days period was calculated according to the water balance method (Heerman, 1985). While total water use efficiency (TWUE) was calculated from yields and total water use. Irrigation water use efficiency (IWUE) was calculated from yields and irrigation water used (Unger, 1982). Data were analyzed by analysis of variance and relationship between water use and yield were evaluated using regression analysis (Yurtsever, 1984).

Results and Discussion

Tomato yield: Statistical analysis (One-Way ANOVA Test) showed that there was no significant difference between the irrigation treatments of the trial years.

The highest yields of the experiments were obtained from T14 treatment in 1994 and from T21 treatment in 1995. These were followed by T21 and T28 in 1994 and T14 and T28 in 1995, respectively. According to the averages of two years yield, the order was T14, T21 and T28 from the highest to the lowest. However, there was no statistically significant difference between the treatments. Therefore T28 treatment is suggested to practice.

Amount of irrigation water (I): The amount of applied irrigation water was given in Table 3. In 1994 irrigation was initiated on the 1st June and a total of 606 mm in 6 times, 451 mm in 4 times and 394 mm in 3 times were applied to the treatments T14, T21 and T28, respectively. As for the year 1995 irrigation started on 7th day of June and a total of 440 mm, 370 mm and 346 mm irrigation water was applied to the treatments T14, T21 and T28 in 6, 4 and 3 applications, respectively. While the number of irrigations were the same for both years. The amount of total irrigation water applied in 1994 was much more than in 1995. This was because of the differences in precipitation during the growth period. It was recorded as 103.5 mm in 1994 against 214.9 mm in 1995.

Table 1: Some chemical properties of the soils of experiment sites

Year	Soil layer (cm)	Soil reaction pH	EC 10^3 25° C	Total salt (%)	Lime $CaCO_3$ (%)	Organic matter (%)	Available (kg ha^{-1})	
							P_2O_3	K_2O
1994	0 – 20	6.2	1.5	0.037	-	1.16	77	393
	20– 40	6.2	1.5	0.036	-	1.34	68	393
1995	0 – 20	6.4	1.4	0.032	1.11	1.06	23	407
	20– 40	6.5	1.3	0.032	0.96	1.44	41	542

Table 2: Soil moisture characteristics of the soils of experimental sites

Soil layer (cm)	Field capacity		Wilting point		Bulk density (G/cm^3)	Available water		Texture
	Pw	(mm)	Pw	(mm)		Pw	(mm)	
0 – 30	19.83	98.16	11.18	55.34	1.65	8.65	42.82	SCL
30 – 60	19.94	98.70	10.90	53.96	1.65	9.04	44.74	SCL
60 – 90	20.58	104.34	11.24	56.99	1.69	9.34	47.35	SCL
0 – 90		301.20		166.29			134.91	

Pw: Weight basis moisture percentage; water height as mm in the defined layer; SCL: sandy clay loam.

Table 3: The yield, irrigation water, seasonal ET and water use efficiencies of irrigation treatments in the trial years

Years	Treatments	Total yield (kg ha^{-1})	Number of irrigation (mm)	Irrigation water amount (mm)	Seasonal ET (mm)	TWUE (Kg ha^{-1} mm)	IWUE (Kg ha^{-1} mm)
1994	T14	94510	6	606	810	116.7	155.9
	T21	896000	4	451	677	132.3	198.9
	T28	86690	3	394	665	130.4	220.0
1995	T14	70910	6	440	722	98.2	161.2
	T21	73190	4	370	666	109.9	197.8
	T28	65330	3	346	670	97.5	188.8
Average	T14	82710	6	523	766	107.5	158.6
	T21	81400	4	411	672	212.1	198.3
	T28	76010	3	370	668	113.9	204.4

ET = Evapotranspiration, TWUE = Total water use efficiency, IWUE = Irrigation water use efficiency

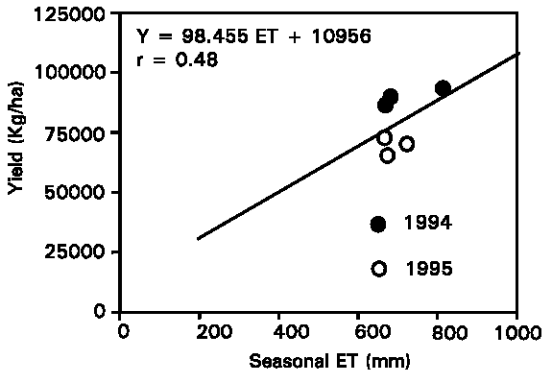

Fig. 1. Seasonal water use-production function of tomato.

The soil moisture level of the treatments in both trial years did not fall below the wilting point during the growth period from the seedling planting to the harvest. However, it partially fell below the wilting point in 1994 while it varied around the wilting point in 1995 during the harvest.

Considering the amount of applied irrigation water, T28 treatment with an average of 370 mm water application in 3 times seems to be more attractive than the other treatments because almost the same yield was achieved from the treatments.

Evapotranspiration (ET): Seasonal ET values of the treatment T14, T21 and T28 were 810 mm, 677 mm and 665 mm in 1994 and 722 mm, 666 mm and 670 mm in 1995, respectively (Table 3). The differences between the two years are attributed to the variation in climatic conditions of the years such as relative humidity, temperature and especially precipitation.

ET values of the treatments were consistent with each other in May since no irrigation was applied to the treatments in this month. However, when different irrigation treatments started in the early June, ET values also deviated depending on the treatments and took maximum value in July. ET of T28 treatment that was suggested for the practical purpose was 223 mm in this month, being 7.2 mm/day.

Previous investigation on tomato seasonal ET showed wide range of varieties depending on the climatic conditions. For example seasonal ET of tomato was found by Strydom (1968) as 584 mm, by Caliandro (1971) as 640-880, by Anonymous (1976) as 610 mm in Eskisehir, by Beyce *et al.* (1972) as 726 mm in Cukurova, by Ertas (1976) as 779 mm in Konya, by Demiroren (1983) as 807 mm in Tokat, by Gucer (1985) as 1220 mm in Ankara, by Sipahi (1987) as 1742 mm at the Harran plain and by Evren and Istanbulluoglu (1995) as 802 mm at the Igdir plain in Turkey.

Water use efficiency: IWUE values were higher than TWUE because ET was greater than the amount of irrigation water. When compared TWUE and IWUE of the trial years, they were found to be higher in 1994, implying that water was used more efficiently in this year and that less yield was achieved in 1995. Water use efficiencies of the treatments were also summarized in Table 3. The highest TWUE was obtained from T21 treatment followed by T28 and T14 while this order for IWUE was T28, T21 and T14, from the highest to the lowest, respectively.

Seasonal water use-production function of tomato: Using seasonal (ET) and average yields (Y) of the treatments, yield response of tomato to water was explained in the form Y = 98.455 ET + 10956 (r = 0.48) as shown in Fig. 1. Previous investigations also showed that this relationship might be either linear or non-linear (Tulucu, 1985). Here, a non significant relation was found between Y and T. The reason why there was not a significant difference between the treatments in the obtained yield was because of the climatic and soil factors.

Different amounts of irrigation water were applied to the treatments in the trial years, the averages varied between 370 and 523 mm and it was 370 mm for T28 treatment. The average ET varied between 668 and 766 mm. Using the average yields and ET values of the treatment, water-yield relationship was correlated linearly in the form Y = 98.455 ET + 10956. The seasonal ET of

T28 was 668 mm and it takes the maximum value in July with 223 mm, 7.2 mm/day.

The main conclusion from this study is that, considering the average yield of the two years and irrigation practices, T28 treatment with average yield of 76010 kg ha^{-1} was suggested. Irrigation schedule of the suggested treatment T28 is as fallows: first irrigation is 30-35 days following the seedling and just after the flowering, that is the first week of June, second and third irrigations are with 28 days intervals.

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