Effect of irrigation applied at different soil moisture tensions on evapotranspiration and yield of cucumbers grown under glasshouse conditions during the spring and autumn

Tüzel I.H., Ul M.A., Tüzel Y.

in

Choukr-Allah R. (ed.).
Protected cultivation in the Mediterranean region

Paris : CIHEAM / IAV Hassan II
Cahiers Options Méditerranéennes; n. 31

1999
pages 229-234

EFFECT OF IRRIGATION ON EVAPOTRANSPIRATION AND YIELD OF CUCUMBER GROWN UNDER GLASSHOUSE CONDITIONS

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Abstract: The research was carried out to determine the effect of irrigations at soil moisture tensions 0.20 (A), 0.35 (B), 0.50 (C) and 0.65 (D) (-bars) in a glasshouse during spring and autumn on cucumber yield and evapotranspiration (ET). The results showed that ET varied between 208.6 (D) and 282.7 (A) mm in the spring and 189.2 (D) and 246.4 (A) mm in autumn. The highest monthly ET was obtained at A in both seasons and respectively in June (139.1 mm) and October (95.3 mm). Correlation between ET and pan evaporation were also determined. The cucumber yields ranged between 10.67 (D) - 13.30 (A) kg/m^2 in the spring and 8.14 (D) - 9.23 (B) kg/m^2 in autumn. Hence the effect of irrigation treatments on yield was statistically significant.

INTRODUCTION

Cucumber is the most common vegetable in protected cultivation in the Aegean Region (Anon., 1993). Due to the possibility of obtaining higher yields and quality through F_1 seeds, and to the ease in marketing at higher prices, the crop becomes more attractive for the growers. The regional yields, on the other hand, are quite lower than expected because of insufficient physical conditions of the greenhouses and improper practices of plant protection, irrigation, heating, etc.

It is well known that controlled irrigation applied during the growing period of cucumber increases yield and fruit quality. However, the use of drip irrigation provides water economy and gives higher yields per amount of water used (Mannini, 1988; Çevik et al., 1992).

Some of the trials designed to examine the effects of different drip irrigation schemes on yield were based on tensiometer values located at various depths (Judah and Rushdi, 1985; Çevik et al., 1992), on solar radiation data (Ritter et al., 1985) or indoor and outdoor evaporation values (Eliades, 1988; Mannini, 1988; Randall and Locasio, 1988).

The present investigation was performed with the aim of determining the effect of irrigation applied at different soil moisture tensions on evapotranspiration and cucumber yield grown in short season crop production.

MATERIALS AND METHODS

This study was conducted on cucumber (cv. Alara) in two growing seasons, spring and autumn, in 1993 in a glasshouse located at Ege University in Ýzmir, Turkey (38°28' N, 27°15' E). The climate is of the Mediterranean type, which is characterized by rainy and warm winters, and dry and hot summers.

The experimental soil was found to be sandy-loam at 60 cm in depth. There was a gravel and stony layer which restricted the root development below this level. Some properties of soil important in terms of irrigation are given in table 1.

Table 1 : Some properties of the soil

Soil layer	Sand (%)	Silt (%)	Clay (%)	pH	Organic Matter (%)	Field Cap. (% Pw)	Per.Wilt. Point (% Pw)	Bulk Density (g/cm^3)
0-30cm	71.2	24.3	4.5	6.94	7.62	34.1	20.4	1.05
30-60cm	62.9	28.3	8.8	6.73	4.65	26.9	15.2	1.32

Cucumber seedlings were planted at 80x50 cm distances and drip irrigation system was used. Data related to the applied cultural practices is given in table 2.

Table 2 : Sowing, planting and harvest dates

	Seed sowing	Planting	First Harvest	Last Harvest
Spring	24.02.1993	07.04.1993	03.05.1993	08.07.1993
Autumn	16.08.1993	01.09.1993	27.09.1993	06.01.1994

The amount of water per irrigation and the interval between irrigations were controlled by tensiometers to maintain the soil water potential higher than the following four levels: 0.20 (A), 0.35 (B), 0.50 (C), 0.65 (D) (-bars). For each level, the tensiometers were placed at 15 and 45 cm depths and 15 cm away from the drippers.

Irrigations were started when the soil moisture tensions reached the corresponding level at 15 cm depth and were stopped when water reached 45 cm, checked by the change in the readings of tensiometers placed at this depth (Michelakis and Chartzoulakis, 1985).

The levels of soil moisture tensions were observed daily from the two middle blocks. All four levels were arranged in random order and replicated 4 times. During the experiment, daily evaporation values were collected from class-A pans located at indoor and outdoor of the greenhouse.

Cucumber fruits were harvested twice weekly in autumn and thrice in the spring season. Totally, 29 harvests in spring and 30 in autumn were performed.

Routine cultural practices were carried on as recommended (Sevgican, 1989). The evaluation of plant performance was made on samples of 15 plants derived from the middle portion of each plot.

RESULTS AND DISCUSSION

During the growing seasons, experimental plots were irrigated at different intervals with different amounts of water. Table 3 shows the amount of irrigation water, number of irrigation and the first and last dates of irrigation.

The amount of irrigation water and number of irrigations varied according to the treatments and growing periods. The length of irrigation period also changed in spring and autumn. In both periods, -0.2 bar (A) was the most frequently irrigated treatment. Consequently, the shortest irrigation interval occurred in June during the spring and was 2 days, and in autumn it was determined in October as 3 days. Intervals other than the mentioned varied greatly in both seasons. Especially in autumn, the irrigation intervals in December were found to be 2 to 3 times longer than the October values. In the spring season during which the evapotranspiration of plants was higher, the irrigation intervals in treatments A, B, C and D were 2-3 days, 3-5 days, 4-6 days and 6-8 days, respectively. The intervals were 1 to 2 days longer during the autumn.

Table 3: Irrigation applications in growing seasons.

Season		A	B	C	D
	First irrigation date	15/4/1993	18/4/1993	20/4/1993	22/4/1993
	Last irrigation date	5/7/1993	4/7/1993	4/7/1993	3/7/1993
Spring	No of irrigation	30	20	13	11
	Tot.irrig.wat.(mm)	282.7	261.1	236.2	208.6
	First irrigation date	21/9/1993	23/9/1993	25/9/1993	26/9/1993
	Last irrigation date	3/1/1994	2/1/1994	4/1/1994	3/1/1994
Autumn	No of irrigation	24	18	12	9
	Tot.irrig.wat.(mm)	246.5	225.8	214.5	189.2

The total amounts of water applied in spring ranged between 208.6 (D) and 282.7 (A) mm whereas, 189.2 (D) and 246.5 (A) mm in autumn. Since the differences in the soil water level at planting and harvest were insignificant and runoff and the drainage loss accepted to be null, the calculation of seasonal evapotranspiration according to the treatments was done solely by the water applied. In other words, the amount of water applied in each treatment was accepted as the seasonal evapotranspiration. Monthly evapotranspiration values are given in figures 1 and 2.

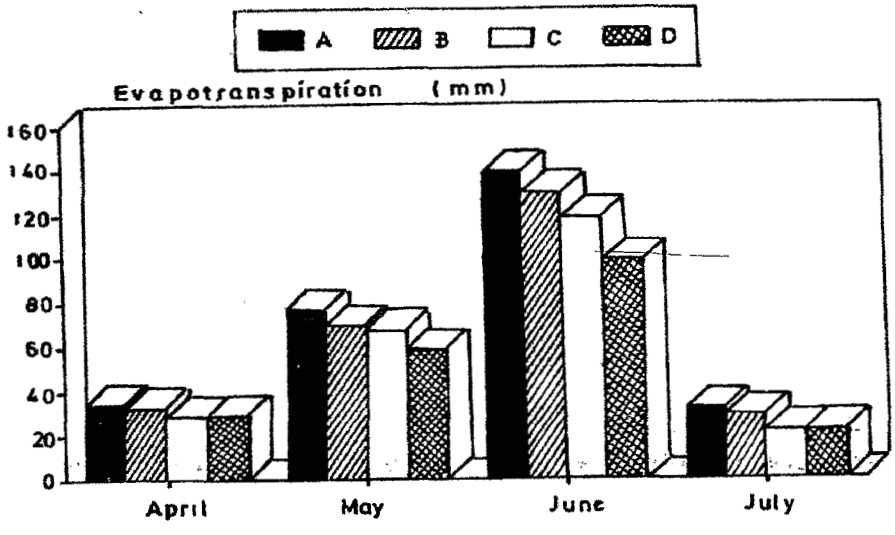

Figure 1. Monthly evaporation in spring

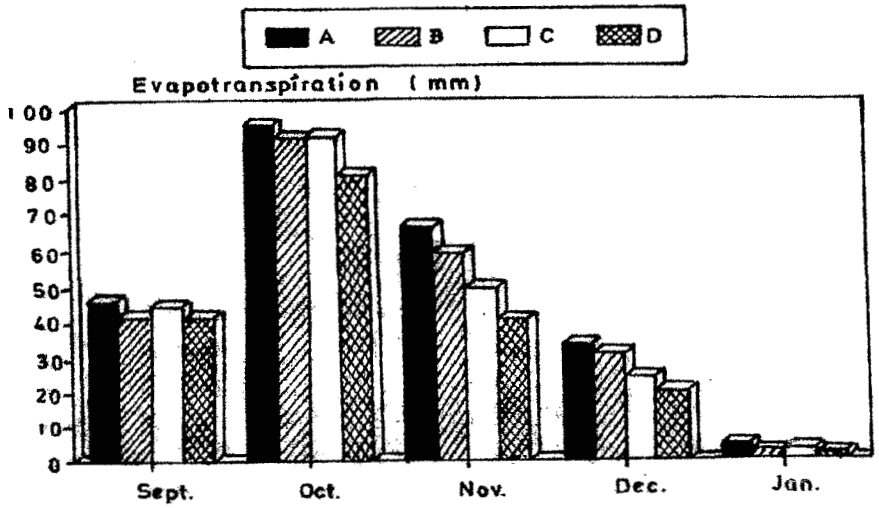

Figure 2. Monthly evaporation in autumn

Yields were found to differ according to the treatments and the seasons (figure 3). This can be the result of having no additional heating except for frost protection which may consequently affect the soil and air temperature within the greenhouse (Anon., 1983; Sevgican, 1989). In both seasons the highest yields were obtained in A and B whereas the lowest in D. The statistical evaluation of the results proved that irrigation performed at different soil moisture tensions had marked effects on yield , significant at 1 % level in the spring and 5 % in autumn. Mannini (1988), Eliades (1988) and Randall & Locasio (1988) report similar yield reductions parallel to the decreasing amounts of water applied in cucumber. In the spring season, the effect of treatment A on yield was 13 and 25 % more than the treatments C and D, respectively. In autumn, the increments were 6 and 13%.

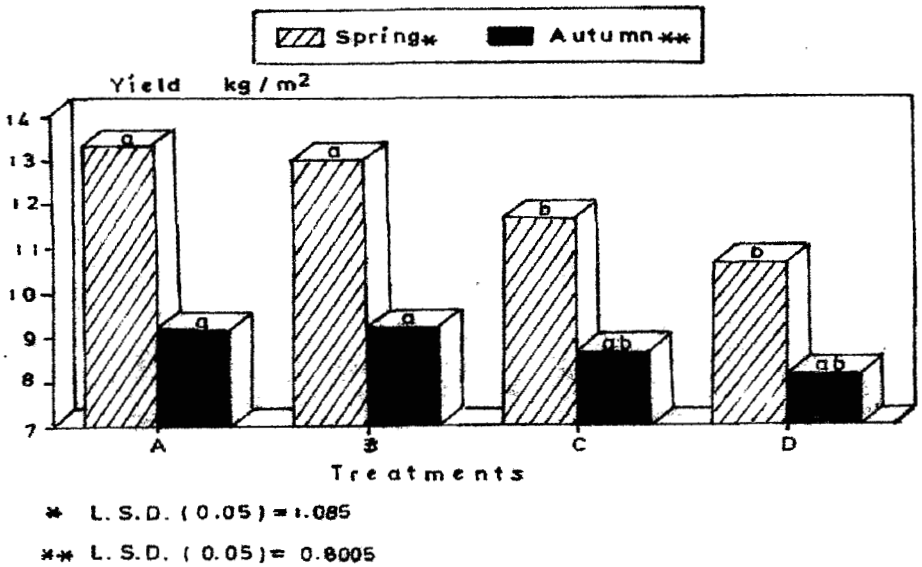

Figure 3. Effects of irrigation on yield at different soil moisture tensions.

These results can be attributed namely to the effect on the fruit number (table 4).

Table 4 : Fruit numbers (no/m^2) obtained from the treatments.

Season	A	B	C	D	LSD 0.05
Spring	102.7 a	97.9 ab	89.7 bc	79.7 c	12.00
Autumn	73.4 ab	74.8 a	71.6 ab	67.2 b	6.48

In the research, fruits harvested at each harvest through the season for each treatment was analyzed, as well. The results for treatment B are given as an example in figure 4.

As could be seen from the figure, the yield showed fluctuations through the season in both trails. In spring, the highest yield was obtained in June, whereas, in October during the autumn.

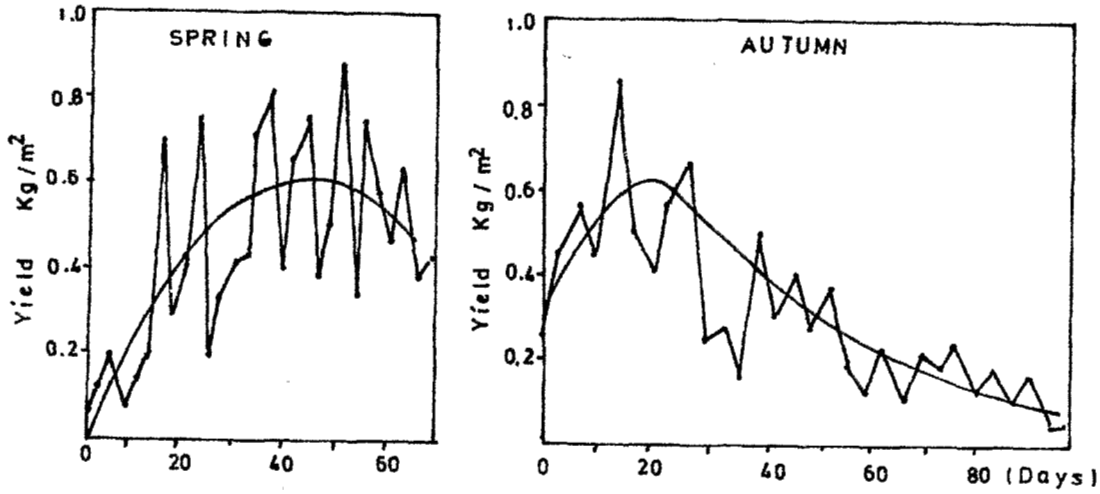

Figure 4. Yield values obtained in treatment B.through the harvest period

In the study, the relationship between evapotranspiration (ET) of treatments and evaporation (E_0) measured from class-A pans located indoors and outdoor of glasshouse was investigated. Since, the treatment B ranked in the first place in terms of yield, the variation of weekly ET/E_0 throughout of the growing season for treatment B is given figure 5 and 6. In the same figures, in outdoor evaporation rates are shown weekly as well. As could be seen from the figures, the changes in weekly ET/E_0 values in time were different in spring and autumn seasons. The weekly ratio of ET/E_0 for outdoor in spring was calculated as 0.3 at beginning of the growth periond, made a peak (0.6) during 8-10th weeks and decreased to 0.4 at the harvest. The ET/E_0 values were determined as 0.5, 0.9 and 0.7, respectively. During the autumn season, due to higher in and outdoor evaporation rates at the start of growth period, the ET/Eo values calculated for indoor and outdoor were lower than the values round for spring. The highest ratios were round during the period between 6 and 9th weeks. The decreases were more apparent for the indoor ratios.

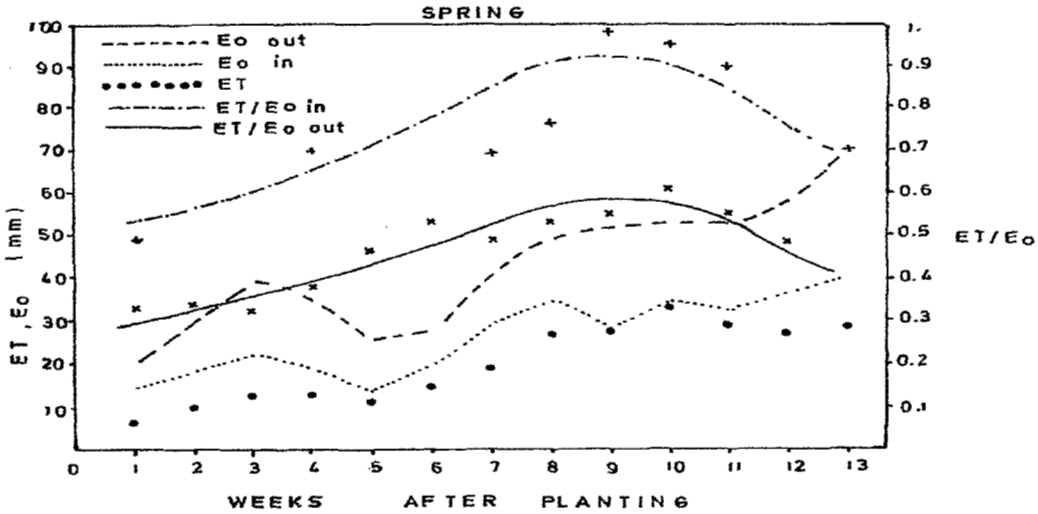

Figure 5. ET/E_0 ratios in treatment B in spring

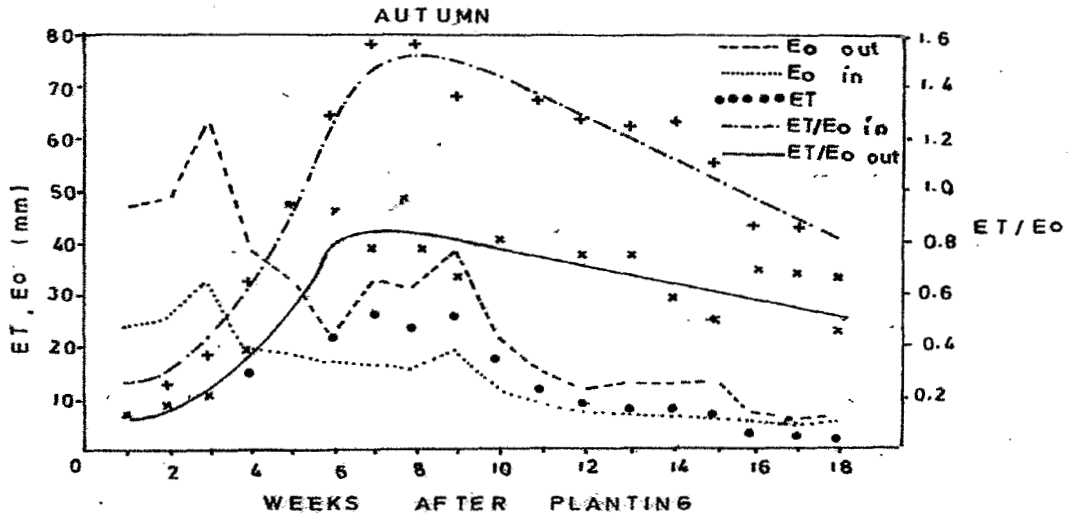

Figure 6. ET/E_O ratios in treatment B in autumn

In this study, aiming to determine the effects of irrigation applied at different soil moisture tensions on evapotranspiration and cucumber yield in autumn and spring greenhouse growing, it was concluded that the treatments A and B ranked in the first place. Consequently, it was decided that the tensiometer placed at a depth of 15 cm should not exceed -0.35 bar in determining the time of irrigation. The derived weekly ET/Eo curves for both growing seasons can yield to simple irrigation schedules, as well, for cucumber growers under similar conditions.

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