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Irrigation Scheduling for Green Pepper (*Capsicum annuum* L.) Grown in Field Conditions by Using Class - A Pan Evaporation Values

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Abstract: This study was conducted to determine the most suitable amount of applied water and the interval of irrigation water for green pepper plants by using the pan evaporation values in field conditions. Irrigation water was applied based on cumulative class-A pan evaporation within the irrigation intervals. Irrigation treatments consisted of two irrigation intervals based on pan evaporation (I1: 25±5 mm E_{pan}; I2: 50±5 mm E_{pan}) and three plant-pan coefficients (K_{cp}1: based on percent crop canopy closure; K_{cp}2: 0.75 and K_{cp}3: 1.10). According to the results, the average irrigation water values of treatments varied from 233 to 783 mm; the average evapotranspiration values of treatments ranged from 263 to 711 mm; and the green green pepper fruit yield ranged from 5.41 to 16.85 t ha^{-1}. Furthermore, K_{cp}3 treatment that irrigated with the highest amount of water gave the highest early fruit yield and the highest total fruit yield was obtained from I1K_{cp}3 treatment. Yield response factor (K_y) was determined as 0.91. E_t/E_{pan} ratios of the treatments varied from 0.34 to 1.76. In addition, it was determined that irrigation programs significantly affected the yield ($p<0.001$). Moreover, significant positive linear correlation ($p<0.01$) between irrigation water amount and plant vegetative growth traits and between plant water consumption and the fruit yield were determined. Thus, irrigation interval at 50±5 mm E_{pan} and K_{cp}3 plant-pan coefficient could be recommended for green pepper irrigation to save labor cost and time.

Key words: Water use efficiency · green pepper evapotranspiration · irrigation scheduling

INTRODUCTION

The typical purpose of irrigation is to favorably maintain the water status of plants. It, therefore, seems normal that irrigation should be accurately scheduled by using some measures of plant water status [1]. It is also important to know the water susceptibility of plants for suitable irrigation management [2].

Adequate amount of water must be applied at the right time in order to get higher crop yield in irrigated lands. Therefore, it is vital to determine the water consumption of plants and periods that plants are susceptible for water beside the irrigation intervals in order to increase crop yield in a limited area. Water requirement of plants from seed sowing to the harvest varies depending on plant species and plant growth stages. Excessive irrigation just after transplanting may cause coarse, tall, but weak growth, small inflorescences or flower shedding and small fruits in plants.

The world production of fresh fruit green pepper is about 24 million tons from 1.66 million ha and its production in Turkey is about 1.79 million tons from 88.000 ha area [3]. Green peppers develop relatively shallow root systems, to a depth of about 60 cm. They require about 25-50 mm of rainfall or irrigation per week for optimum production. Drought stress during early growth stages migth most probably reduce plant size and cause blossom shed and reduced fruitset [4]. Therefore, irrigation and water management become very critical for green pepper. Green pepper plants have shallow root systems; they, therefore, cannot tolerate to drought. The need for water is especially high during the flowering and fruit setting. Fields should be irrigated if there are signs of wilting at midday. Green pepper plants are also sensitive to water logging. Flooded fields should be drained within 48 h. Otherwise, the green pepper plants may soon die. Furrow or drip irrigation is recommended. Sprinkler irrigation should be avoided as wet leaves and fruit promote disease development [5].

Pan evaporation is a method widely used to schedule irrigation because of it's easy application and inexpensive to use [6, 7]. With available pan coefficient in hand, pan

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evaporation method can be used in the arrangement of irrigation programs. Therefore, evapotranspiration of growing plants can be estimated by using pre-determined coefficients and pan evaporation method [8].

The aim of this study was to determine the most suitable irrigation schedule for green pepper plants grown in the field conditions by using class-A pan evaporation and related plant-pan coefficients.

MATERIALS AND METHODS

This study was carried out in a farmer's field located in Central Van, in 2001 (between 35° 55' and 39° 24'N latitude and 42° 05' and 44° 22'E longitude and 1725 m altitude). The continental temperate climate rules over the region; while the highest average temperature is in July (22.1°C), the lowest is in January (-3.7°C); average wind speed is 2.3 m s^{-1}; precipitation is insufficient in summers when plant water use is greatest.

The soil at the study site is loamy and almost flat. Some soil characteristics related with irrigation are seen in Table 1. One month-old seedlings of green pepper cultivar Demre, which is one of the most important cultivars produced in Turkey with long and thin fruit, were transplanted in 80x30 cm spacing on May 27th, 2001 and adeqautely watered. The distance between the plots, which consisted of four rowed 24 plants in 5.76 m^2 was 100 cm. Diamonium phosphate (125 g DAP) was applied to each plot before transplanting the seedlings and 50 g urea as a nitrogen source per plot was given both at initial flowering (July 7th) and at initial fruit maturation stages (August 6th). During the growing season, plant protection measures and hoeing were practiced to the plots. Plants were hoed in order to both break the soil crust and fight against the weeds.

Irrigation water (2 l s^{-1}) was supplied from a well by a pump. Furrows in each plot were irrigated by a hose (4 cm in diameter) with a flow meter on it. Water is in C_3S_1 class (sodium risk is low; EC is medium) and it can be used for irrigation.

Treatments consist of two different irrigation intervals based on pan evaporation (I1: 25±5 mm E_{pan}; I2: 50±5 mm E_{pan}) and three different plant-pan coefficients ($K_{cp}1$: based on percent crop canopy closure; $K_{cp}2$: 0.75 and $K_{cp}3$: 1.10). Treatments were arranged in a Completely Randomized Block Design with three replications. Irrigation was done in short blunt furrows. Plots were irrigated up to field capacity one week after the transplanting. Then, scheduled irrigation was initiated when cumulative pan evaporation, values reached 25±5 mm or 50±5 mm. Evaporation between the irrigation intervals was measured with a Class-A pan located nearby to the plots.

In calculation of irrigation water amount, class-A pan evaporation whose fundamentals are given in the articles of Doorenbos and Pruitt [8]; Kanber [9] were used (Eq. 1):

$$I_r = E_{pan} * K_{cp} \quad (1)$$

Where I_r is the amount of applied irrigation water (mm), E_{pan} is the evaporation at Class-A pan (25±5 mm or 50±5 mm) and K_{cp} is the plant-pan coefficient. Eq. (2) was used in the determination of $K_{cp}1$ according to plant coverage.

$$K_{cp}1 = (W_p/W_b)\times 100 \quad (2)$$

Where W_p is the width of plant canopy (cm) and W_b is the bed spacing (cm).

E_t was calculated for each treatment by a water balance method (Equation 3) [10].

$$E_t = I_r+P+C_r-D_p-R_f+\Delta s \quad (3)$$

Where; E_t: evapotranspiration (mm), I_r: irrigation water (mm) calculated in Equation 1 for each treatment, p: precipitation (mm), C_r: capillary rise (mm), D_p: loss by deep percolation (mm), R_f: surface run-off (mm), Δs: change in profile soil water content (mm).

Precipitation (P) was measured daily at a nearby weather station. C_r was considered as zero because there was no high underground water problem in the area. If available water in the root zone (90 cm) and total amount of applied water by irrigation were above the field capacity, it would be assumed that mentioned water leaked and called as the deep percolation value [11].

Table 1: Soil characteristics of trial plots

Depth (cm)	γ (g cm^{-3})	FC (P_w)	WP (P_w)	Saturation (%)	pH	EC (dS m^{-1})	Salt (%)	Lime (%)	P (kg ha^{-1})	K (kg ha^{-1})	Organic matter (%)	Structure
0-30	1.42	14.93	7.95	41.0	7.94	2.91	0.08	4.69	3.89	36.3	0.95	Loamy
30-60	1.50	14.11	7.59	39.0	8.01	3.06	0.08	6.86	3.89	31.6	0.83	Loamy
60-90	1.44	18.23	9.94	41.6	8.06	2.33	0.06	10.56	0.46	29.9	0.70	Loamy

γ: Unit weight of soil; FC: Field Capacity; WP: Wilting Point

Soil water measurements were taken throughout the crop growth season. Profile soil water contents up to the 90 cm depth in 30 cm increments were measured gravimetrically (oven dry basis) at transplanting, before each irrigations and final harvest.

Irrigation Water Use Efficiency (IWUE) and water use efficiency (WUE) was calculated with Eqs. (4 & 5) [12, 13].

$$IWUE = (E_y/I_r)\times100 \qquad (4)$$

$$WUE = (E_y/E_t)\times100 \qquad (5)$$

where; IWUE: irrigation water use efficiency (t ha^{-1} mm), E_y: marketable yield (t ha^{-1}), WUE: water use efficiency (t ha^{-1} mm).

Moreover, Equation 6 was used to determine the contribution of different irrigation levels on plant water consumption [12, 13].

$$I_{rc} = (I_r/E_t) * 100 \qquad (6)$$

Where I_{rc} is the irrigation water compensation for plant water consumption (E_t) (%).

In order to determine yield-response factor (K_y), Eq. (7) was used advised by Stewart *et al.* [14] and Doorenbos and Kassam [15]. Therefore, using Eq. 7, relative yield decrease related to per unit water deficit, can be predicted.

$$K_y = (1\text{-}Y/Y_m)/(1\text{-}E_t/E_{tm}) \qquad (7)$$

Where, Y: yield (t ha^{-1}), Y_m: maximum yield (t ha^{-1}), E_t: plant water consumption, (mm), E_{tm} : maximum plant water consumption, (mm), K_y: yield-response factor. Yield-response factor (K_y), is a relative value which indicates the yield sensitivity under per unit water deficit.

Marketable green pepper were hand harvested by once a week and then weighted. Furthermore, the number, diameter and length of fruit were also determined by counting or measuring. The first four harvests were considered as the early yield. The height, coverage and stem diameter of plants were also measured and the number of lateral branches was counted.

Analysis of variance was performed on the yield data obtained from the treatments. The level of the significant difference (LSD at p<0.01) was used in the ANOVA to test the effect of treatments on different response variables [16].

RESULTS AND DISCUSSION

Applied irrigation water amount (I_r) and plant water consumption (E_t): A total 45 mm of water applied to all treatments prior to the scheduled irrigations. Soil water deficit in all plots was replenished to the field capacity in 0-90 cm soil depth and then scheduled irrigation based on 25 and 50 mm of cumulative evaporation were initiated. During the growing season in which 671 mm of evaporation occurred, treatments with 25±5 and 50±5 mm evaporation intervals were irrigated 26 and 13 times, respectively.

While $K_{cp}1$ treatments applied the lowest amount of water (233 mm), $K_{cp}3$ treatments applied the highest amount of water (783 mm). E_t increased with the amount of applied irrigation water. While the $I1K_{cp}1$ treatment had the lowest E_t (263 mm), the $I1K_{cp}3$ treatment had the highest E_t (796 mm). Although they were watered with the same amount of water, in the frequently watered treatments, plant consumed much more water than in less frequently irrigated plants. There was a little rainfall (11 mm) during the experiment (Table 2).

FAO [3] informed that total water requirements (E_t) was 600 to 900 mm and up to 1250 mm for long growing and harvesting periods and several pickings.

Fruit yield data: The first fruit was harvested 56 days after transplanting of seedlings and there were 8 harvests during the growing season which lasted 113 days. $K_{cp}3$ treatments irrigated the most abundantly and having the highest water consumption gave the highest early yields in both irrigation intervals. The early yield increased as the amount of applied water increased in both irrigation intervals. This finding proposes and shows that green pepper is a highly susceptible plant to water deficit and water scarcity in early growing period decreases the early green pepper yield. The average total yields increased with greater amounts of water applied for all treatments. The highest average total yields were also obtained from the $K_{cp}3$ treatments in both irrigation intervals, while $K_{cp}1$ treatments received with the least amount of water gave the lowest yields. Throughout the harvest period, although higher yields were usually followed by relatively lower yields, there was a relative increase in yield (Table 2).

Water-yield relationships: It was determined that irrigation treatments had significant effects on the green pepper fruit yield (Table 3). While there was considerable effect of K_{cp} on yield (p<0.001), I and I * K_{cp} interaction on yield were not significant. Treatments irrigated based on the $K_{cp}3$ coefficient resulted in more yield than other treatments. The more water applied to the treatments the more green pepper yield was obtained.

Moreover, significant correlations were obtained (p<0.01) between yield and I_r or between yield and E_t and

Table 2: Yield components and irrigation values

Yield components and irrigation values	Treatments					
	$I1K_{cp}1$	$I1K_{cp}2$	$I1K_{cp}3$	$I2K_{cp}1$	$I2K_{cp}2$	$I2K_{cp}3$
Early yield, t ha^{-1}	1.02	1.39	1.91	0.84	1.86	1.90
Mean fruit yield, t ha^{-1}	5.57	11.67	16.18	5.41	13.78	16.85
Fruit number	590.00	998.00	1286.00	466.00	1094.00	1294.00
Fruit diameter, mm	12.06	14.09	13.98	11.91	14.02	13.86
Fruit length, cm	11.21	12.80	13.31	11.21	13.95	14.34
Mean fruit weight, g	5.44	6.73	7.25	6.68	7.25	7.50
Plant height, cm	34.58	42.67	44.88	37.83	48.00	48.90
Plant coverage %	37.40	53.40	54.10	38.50	58.10	62.40
Numbers of lateral branches	5.00	5.28	5.67	5.00	5.44	5.84
Stem diameter (cm)	9.67	12.45	13.00	10.72	13.39	13.59
I_r, mm	233.00	548.00	783.00	246.00	548.00	783.00
E_t mm	263.00	581.00	796.00	268.00	565.00	711.00
IWUE, kg m^{-3}	2.40	2.10	2.10	2.20	2.50	2.20
WUE, kg m^{-3}	2.10	2.00	2.00	2.00	2.40	2.40
Irc %	88.60	94.50	98.40	91.80	97.00	100.00
Relative pepper yield %	33.10	69.30	96.00	32.10	81.80	100.00
Relative E_t %	33.00	72.90	100.00	33.60	70.90	89.20

Table 3: Mean pepper yields and fruit number of treatments compared with Duncan statistical method

Treatments	Yield		Fruit number	
	Mean (g)	Significant ranges	Mean	Significant ranges
I1	6415.9	9a	958	9a
I2	6917.6	9a	951	9a
$K_{cp}1$ ***	3162.5	6c	528	6c
$K_{cp}2$ ***	7327.5	6b	1046	6b
$K_{cp}3$ ***	9510.2	6a	1290	6a

*** LSD.001 = 1932.53 (Yield); *** LSD.001 = 192 (fruit number)

shown in Fig. 1a. As I_r, therefore E_t, increased, yield also increased. E_t was a little bit more effective on yield (R^2 : 0.97 **) than I_r (R^2: 0.95 **) (Table 4). These all indicate that green pepper plants are very sensitive to water deficiency. Furthermore, it was understood by visual inspection and eating that the fruit obtained from the treatments with higher K_{cp} had better quality than others. The less water applied to the treatments the more misshapen and dull colored pepper fruit was obtained. Some other studies have also shown the physiological response of green pepper plants to water stress data on the relationship between water use and yield of green pepper [17, 18].

The relationships between relative yield decrease and relative evapotranspiration deficit for the total growing period is given in Fig. 1b. Yield response factor (K_y) was determined as 0.91 and 1.00 for all growing period and the period after flowering, respectively. Thus, up to 1.00 unit decrease in yield for each unit water deficit is expected for green pepper grown outdoor. Therefore, for high yield and quality, the crop needs a controlled supply of water throughout the growing period. FAO [3] and Sagardoy *et al.* [19] informed that the yield-response factor (K_y) was 1.1 for pepper.

In order to obtain high yield in green pepper, an adequate water supply and relatively moist soils are required during the total growing period. Reduction in water supply during the growing period in general has an adverse effect on yield and the greatest reduction in yield occurs when there is a continuous water shortage until the time of first harvest. The period at the beginning of the flowering period is the most sensitive to water shortage and soil water depletion in the root zone during this period should not exceed the 25 percent. Controlled irrigation is essential for high yield because green pepper is sensitive to both over and under irrigation [3].

Table 4: Correlation equations and coefficients (R) among mean fruit weight, fruit length, fruit diameter, fruit number, irrigation water, evapotranspiration and yield

Yield components	Yield	Irrigation water	Evapotranspiration	Fruit Number	Cover percentage	Plant
branch number (PLBN)	(Y)	(I_r)	(E_t)	(FN)	(CP)	lateral
Fruit number	Y = 0.0143 FN-2.06	FN = 1.413 I_r+214.55	FN = 1.5437 E_t+135.8			
(FN)	R^2 = 0.99 **	R^2 = 0.96 **	R^2 = 0.96 **			
Fruit diameter	Y = 4.41 FD-47.17	FD = 0.00371 I_r+11.37	FD = 0.0042 E_t+11.09			
(FD)	R^2 = 0.82 **	R^2 = 0.76 **	R^2 = 0.82 **			
Fruit length	Y = 3.59 FL-34.38	FL = 0.00491 I_r+10.23	FL = 0.0052 E_t+10.03			
(FL)	R^2 = 0.91 **	R^2 = 0.80 **	R^2 = 0.75 **			
Mean fruit weight	Y = 5.662 MFW-26.97	MFW = 0.0025 I_r+5.51	MFW = 0.0026 E_t+5.41			
(MFW)	R^2 = 0.69 **	R^2 = 0.66 **	R^2 = 0.62 **			
Plant height	Y = 0.828 PH-23.86	PH = 0.0202 I_r+32.21	PH = 0.022 E_t+31.39	FN = 55.35 PH-1415		
(PH)	R^2 = 0.86 **	R^2 = 0.76 **	R^2 = 0.71 **	R^2 = 0.80 **		
Cover percentage	Y = 0.464 CP-11.94	CP = 0.0384 I_r+30.59	CP = 0.041 E_t+28.89	FN = 31.81 CP-656.9		
(CP)	R^2 = 0.90 **	R^2 = 0.82 **	R^2 = 0.78 **	R^2 = 0.88 **		
Plant lateral branch	Y = 14.23 PLBN-64.87	PLBN = 0.0014 I_r+4.7	PLBN = 0.0014 E_t+4.6	FN = 971.2 PLBN-4262.3	CP = 11.81 PLBN-14.71	
number (PLBN)	R^2 = 0.95 **	R^2 = 0.95 **	R^2 = 0.87 **	R^2 = 0.91 **	R^2 = 0.62 **	
Plant stem	Y = 3.01 PSD-24.94	PSD = 0.0059 I_r+9.05	PSD = 0.0064 E_t+8.75	FN = 202.8 PSD-1506.9	CP = 6.35 PSD-26.4	PLBN = 0.19 PSD-3.03
diameter (PSD)	R^2 = 0.89 **	R^2 = 0.82 **	R^2 = 0.80 **	R^2 = 0.84 **	R^2 = 0.95 **	R^2 = 0.79 **

** p<0.0 1

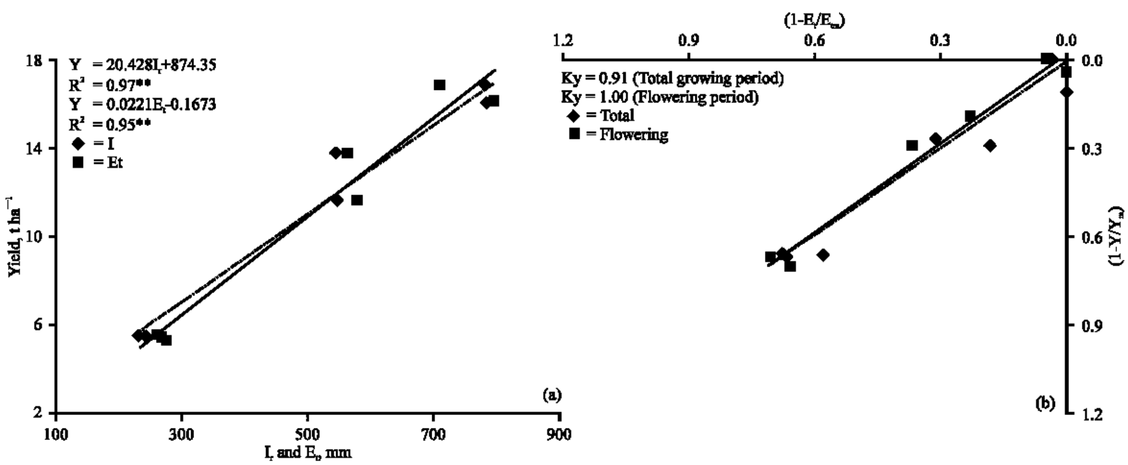

Fig. 1: Correlation among yield, I_r and E_t (a)-The relationships between relative yield decrease and relative evapotranspiration deficit for the total growing period (b)

Some fruit and plant growth traits: Some fruit and plant growth traits of irrigation treatments are presented in Table 2. Correlation equations and coefficients (R) among mean fruit weight, fruit length, fruit diameter, fruit number, irrigation water, E_t and yield are presented in Table 5.

Fruit number (FN): There was an increase in fruit number by I_r and E_t. There were significant positive linear correlations (p<0.01) between fruit number and both I_r and E_t. Increase in fruit number was one of the most significant (p<0.01) factor affecting the yield (Table 4)). Moreover, fruit number was significantly (p<0.001) affected by K_{cp}. While $K_{cp}3$ treatments produced the highest fruit number, $K_{cp}1$ treatments produced the lowest fruit number (Table 3). Thus, frequently and much more watered treatments increased the fruit number; consequently, the fruit yield. However, irrigation intervals had no significant effect on fruit number.

Herrera *et al.* [20] find the similar results and indicated that irrigation intervals did not effect the fruit number. Chartzoulakis and Drosos [21] determined that both the fruit number per plant and fruit size were affected by the amount of water applied. Water shortage just prior and during early flowering period reduces the number of fruit. The effect of water deficit on yield during this period is greater under conditions of high temperature and low humidity [19].

Fruit Length (FL): Fruit length of the treatments had positively correlated with irrigation water, E_t and the fruit yield. There was a similar case as in fruit number. Increase in FL increased fruit yield (R^2: 0.91**) more than increase in fruit diameter. Wierenga [18] determined the fruit length values ranges between 11.8 to 14.1 cm and he stated that lack of water also reduced the length and the weight of the green pepper fruit. In our study similar results were obtained.

Fruit Diameter (FD): Fruit enlarged mostly with the increasing amount of irrigation water and E_t. There were significant correlations between FD and yield and between FD and both irrigation water and E_t ($p<0.01$). Increase in fruit diameter was also one of the most significant ($p<0.01$) factor affecting the yield.

Mean Fruit Weight (MFW): There were significant positive correlations ($p<0.01$) between mean fruit weight and irrigation water, E_t or the fruit yield. Infrequently watered treatments had higher mean fruit weight than frequently watered ones. Moreover, in both irrigation intervals, treatments applied with the most amount of water had the highest mean fruit weight.

Plant Height (PH): Plant heights of treatments at the last harvest are showed in Table 2. The more irrigation water was applied, the higher the plant height was obtained. There were significant positive linear correlations ($p<0.01$) between PH and irrigation water, E_t, the fruit yield, or the FN. Consequently, increase in PH increased the fruit number; therefore, the fruit yield. The plant height became the most important vegetative parameters affecting the fruit yield.

Plant Coverage (PC): Plant coverage increased by irrigation water and E_t (Fig. 2). Because if the environmental condition is favorable, the green pepper countinues to grow and increase its canopy the growth period. Significant positive linear correlations ($p<0.01$) were observed between PC and irrigation water, E_t, the fruit yield, or the FN. Increase in plant coverage increased the FN; therefore, the fruit yield. Enlargement in PC, an indicator of better plant growth, resulted in the enhancement of the plant photosynthetic area. Fruit yield increased in respect to performed photosynthesis. As plant develops, PC increases; therefore, E_t and photosynthesis get larger because transpiration increases [22].

The number of plant lateral branches (LBN): There were significant positive correlations ($p<0.01$) between the number of lateral branches and irrigation water, E_t, the fruit yield the FN or plant coverage. The more LBN was, the

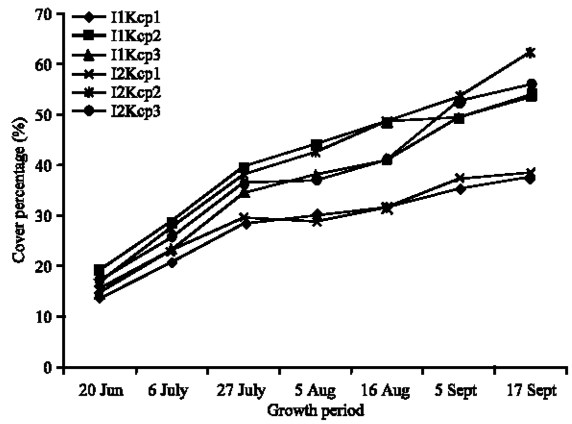

Fig. 2: Plant coverage in time

larger plant coverage was and the more FN was, therefore, the more the fruit yield was.

Plant Stem Diameter (PSD): Plant stem diameters of treatments at the soil surface level were measured in the last harvest. Significant positive linear correlations ($p<0.01$) were observed between PSD and irrigation water, E_t, the fruit yield, LBN, or the FN. The larger PSD was, the more irrigation water, E_t and lateral branches, therefore, the fruit number and fruit yield were. Consequently, the stem diameter and lateral branches were among the most important vegetative traits increasing the fruit yield.

Soil water content before and after the irrigations: Soil water contents in the treatments measured at 90 cm depth of soil profile before and after the irrigations are shown in Fig. 3. While soil content was close to wilting point (110 mm) before irrigation, it tented to reach the field capacity (205 mm) after irrigations. I2 treatments were closer to wilting point before irrigation than I1 treatments. On the other hand, I2 treatments were closer to field capacity after irrigation than I1 treatments because water amount in I2 treatments per irrigation was more than the other. As stated in Meiri *et al.* [2], plants took more water from soil in infrequently irrigated treatments.

In general, soil content before and after irrigations was gradually decreased towards the end of the experiment. This might be due the fact that irrigation could not compensate plant water consumption and some of the previously stored water at soil profile was used up towards the end of the season. Because much more water applied with increasing K_{cp} coefficients, the soil water content of treatments with high K_{cp} values were higher before and after irrigations than others. On the other hand, although the same amount of water was applied to

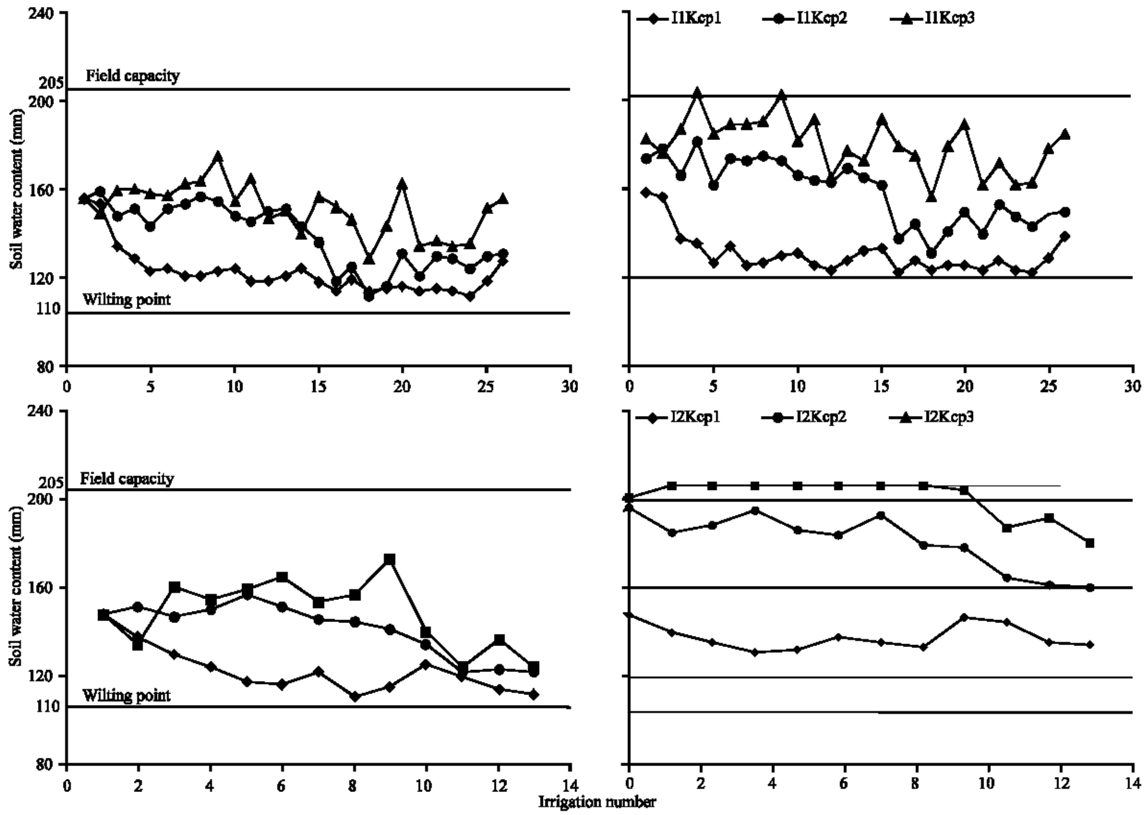

Fig. 3: Soil water contents measured at the initiation and after irrigations of I1 and I2 treatments

the both irrigation intervals, I2 treatments had a little bit more fruit yield than I1 treatments because I2 treatments were much closer to field capacity.

For optimum yield levels, the soil water depletion in most climates should not exceed 30 to 40 percent of the total available soil water. Light irrigation applications are required due to the low depletion level. Irrigation frequencies of 4 to 7 days are common [3]. Wierenga and Saddig [23] observed significant decreases in green pepper fruit yield as the water amount decreased in the soil. Moreover, they stated that it was necessary to irrigate green pepper plants before they used up more than 25% of the available water in the soil. Saddig [23] also determined a significant increase in crop water stress index for green peppers when more than 25% of the available soil water was taken up. In our study we had the similar results because we obtained more green pepper fruit yields from the treatments having more water in the soil before the irrigations. I2K_{cp}3 treatment where the highest yield obtained under 50±5 mm evaporation (about 4-5 day interval) and K_{cp}3, showed an agreement with above findings.

Water use efficiencies: Even though maximum fruit yields were obtained from K_{cp}3 treatments, irrigation water use efficiencies (IWUE) of these treatments were the lowest (Table 2). Although the total yield increased as irrigation water increased, the low yield amount per unit of irrigation water in K_{cp}3 treatments did not allow to get the highest economical yield from them. Costa and Gianquinto [24] informed that in most cases, WUE decreased with increasing water consumption, which was similar to our results. The highest IWUE values in frequently and infrequently watered treatments were obtained from the I1K_{cp}1 treatment (2.4 kg m^{-3}) and I2K_{cp}2 (2.5 kg m^{-3}) respectively. Treatments irrigated with higher amount of water had generally lower IWUE values. However, the irrigation frequency did not have any significant effect on IWUE. As it stated in Kanber *et al.* [25], treatments with low irrigation water amount but high fruit yield resulted in the highest IWUE values. Goldberg *et al.* [26] stated that irrigation time was more effective than total amount of irrigation water; when plants irrigated with limited amount of water in early growth stage, they grew better and their photosynthetic efficiency increased.

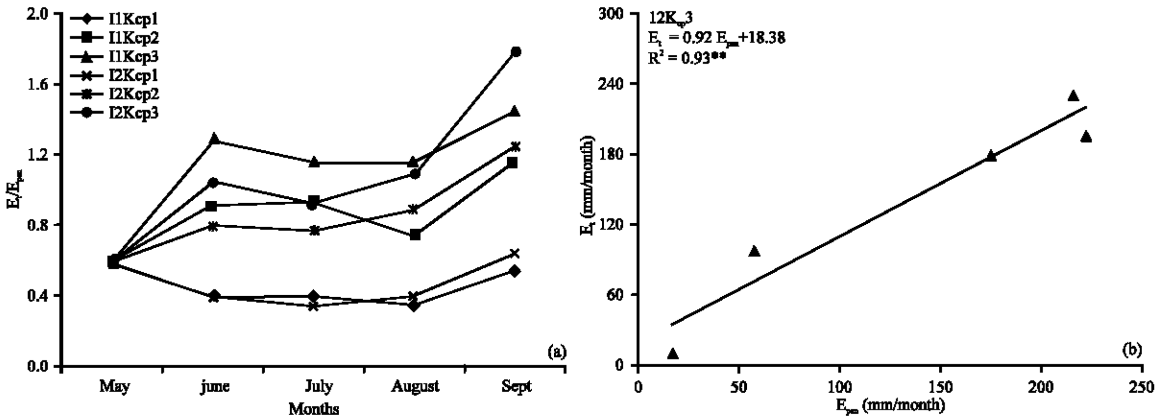

Fig. 4: Variation in E_t/E_{pan} ratio in growing period (a) and correlation between E_t and E_{pan} (b)

WUE values varied from 2.0 to 2.4 kg m^{-3} and the highest values were determined in I2 treatments. Furthermore, because E_t increased with irrigation water, WUE values were close to IWUE values. It was reported that the WUE for harvested yield for fresh green pepper containing about 90 percent moisture varied between 1.5 and 3.0 kg m^{-3} [27].

Irrigation compensations (I_{rc}) in both irrigation intervals were generally higher in treatments irrigated with high amount of water than those irrigated with low amount of water. I_{rc} values of I1 treatments were lower than those of I2 treatments. This was because plants in frequently watered treatments used much water and found water much more easily without encountering to water stress than those infrequently watered ones. Moreover, frequently irrigated treatments easily lost much more water by radiation due to the fact that the depth of the water applied once was lower than infrequently irrigated ones. Therefore, the soil water contents of I1 treatments before irrigation were much closer to wilting point than those of I2 treatments and plants in I1 treatments used more water than applied irrigation water. Consequently, in the areas where irrigation water is limited, I2K_{cp}2 treatment has to be taken into consideration in order to get the maximum yield per applied water amount because low WUE decreases productivity and increases crop production cost [28].

E_t/E_{pan} ratio: There was a significant positive linear correlation ($p<0.01$) between E_t and E_{pan} (Fig. 4). This is in line with other studies [9, 28] showing a close relation between E_t and E_{pan}. Therefore, using pan evaporation in order to schedule the irrigations was a right and proper decision taken in this study.

E_t/E_{pan} curves of the same kind treatments were similar and they changed seasonally in the range from 0.34 to 1.76. The least watered treatments had the smallest E_t/E_{pan} ratio. E_t/E_{pan} rate of the all treatments inclined to increase until the last harvest. This is because of continuous inflorescence, fruit setting and fruit harvesting of green pepper plants until the last days of the long production season [29]. Moreover, continuous vegetative growth and enlargement in plant coverage also increased the E_t/E_{pan} ratio. At the end of the growing period, plants had larger canopies with many flowers on them and could not produce marketable acceptable fruit because of lower weather temperature after September; therfore, the production period was terminated. Because, a significant linear correlation ($p<0.01$) was determined between E_t and plant coverage (Table 4). Wierenga [18] informed that there was increased E_t/E_{pan} ratios with increasing of leaf area index. Doorenbos and Kasam [15] stated that in annual plants, there were an increase in E_t/E_{pan} ratio in the middle of growing period, then this increase stabilized and E_t/E_{pan} ratio decreased at the end of the season. Furthermore, Goldberg *et al.* [26] informed that there was a positive linear correlation between E_t/E_{pan} ratio and plant canopy until plant canopy covered 80% of soil in plant rows. Our results were also in an agreement with this statement.

CONCLUSIONS

In this study, the highest green pepper yield (16.85 t ha^{-1}) obtained from I2K_{cp}3 treatment which irrigated at 50±5 mm evaporation interval with the highest amount of water. K_{cp} significantly affected the yield ($p<0.001$); however, irrigation interval and IxK_{cp} interaction had no significant effect on it. Yield response factor (K_y) was determined as 0.91. Fruit number was also significantly affected by K_{cp}. The highest yield per applied irrigation water was obtained from the I2K_{cp}2 treatment Treatments irrigated with higher water amount had generally low IWUE and WUE values than others. I_{rc} of the treatments improved with the increasing amount of applied water. E_t/E_{pan} ratio among the treatments ranged from 0.34 to 1.76. There were also significant linear positive relationships ($p<0.01$) among I_r, E_t, the plant growth and fruit traits. Increase in FN affected by LBN and SD improved the fruit yield. The highest earliest yield was obtained from K_{cp}3 treatment which the most watered treatments.

In conclusion, although there was no significant effect of irrigation intervals, 50±5 mm evaporation intervals with 1.10 of K_{cp} for peppers grown in field and climate conditions in Van or similar conditions can be recommended to obtain higher yield and to save time and labor. Furthermore, the equation ($E_t = 0.92\ E_{pan}+18.38$) determined for the K_{cp}3 treatment can be applied in irrigation scheduling in pepper. Moreover, in the areas where the irrigation water is scarce, it will be more suitable to choose the I2K_{cp}2 treatment in order to get higher yield per applied irrigation water.

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