Evapotranspiration of pepper grown in unheated greenhouses under drip irrigation

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Summary: *To determine the evapotranspiration of the pepper, variety "Golden Medal" grown in plastic unheated greenhouses in an experimental test field in Chelopechene, Sofia region, irrigation options were tested from fully satisfying the crop's water needs to 20% and 30% increased irrigation of irrigation rates and a variant irrigated with 100% irrigation rate. An environmentally friendly and water-saving irrigation technique was used. The evapotranspiration of the culture and the evaporation from a free water surface were experimentally determined. Based on the calculated values of evapotranspiration and evaporation from a free water surface (evaporation) determined by a class "A" evaporation pan, the values of the biological coefficient of the culture in unheated plastic greenhouses were calculated, and the average for the vegetation period of pepper is 1.35.*

Introduction

There are few and insufficient studies to establish the evapotranspiration of vegetable crops grown under greenhouse conditions. In the cultivation of pepper variety "Kalinkov" under drip irrigation in unheated greenhouses in the Sofia region, ET reaches 668 mm (Kireva, R., 1987), and under conditions of rain in open areas it changes from 452 to 562 mm. (Dulov, Sl., 1976)

One of the most applicable relationships of ET is considered to be that of evaporation from a free water surface (Eo), determined by a class "A" evaporation pan, because it is assumed to be integrated for all meteorological factors that affect it. (Goldberg, S.D. 1967).

The establishment of the dependence between Eo, (evaporation from a free water surface) determined with a class "A" evaporation pan and ET (evapotranspiration) of crops can be used to determine the daily amounts of ET of the crop, so to predict the dates and sizes of the upcoming harvests. (Cristiansen, I., E. Bescind. 1976).

This study aims to determine the evapotranspiration and evaporation of pepper variety "Gold Medal" irrigated with ecologically clean irrigation technology under greenhouse conditions.

Materials and methods

The studies to determine the evapotranspiration and evaporation of pepper variety "Gold Medal" grown in plastic unheated greenhouses were conducted in the period 1993-1994 in the experimental field of the "Pushkarov" Institute in Chelopechene, Sofia

The following irrigation options were tested:

Pre-irrigation humidity – 90% of field capacity

- 130% realization of the irrigation rate /variant 1/;
- 120% realization of the irrigation rate /variant 2/;
- 100% realization of the irrigation rate /variant 3/;
- 100% implementation of the irrigation rate established for the "A" class evaporation pan. (Evaporation) /variant 4/.

The irrigation rate for class "A" evaporation pan is calculated according to the formula

m= E0 .Ki.K, (1),

where: m is the size of the irrigation rate, mm;

E0 - evaporation from a free water surface according to class "A" evaporation pan, mm;

Ki – biological coefficient of culture;

K- coefficient for reducing the irrigation rate, taking into account the area occupied by the plants in one decare. In the experiment, K =0.67 t.s., 67% of the area is irrigated.

Irrigation rates for the other variants are calculated according to the formula:

$$m = [10.H\alpha.(FC - \delta_T)].K,$$

where: m is the size of the irrigation rate in mm;

α – the volume density of the soil in gr/cm3;

H – depth of the active soil layer in m (in the experiment H = 0.5 m);

FC – marginal field moisture content in % relative to the absolute dry weight of the soil;

$\delta t\ pr.vl$ – pre-irrigation soil moisture in % relative to the absolute dry weight of the soil;

– the coefficient of reduction of the irrigation rate, taking into account the area occupied by the plants in 1 dka. In the experiment, K = 0.67 i.e. 67% of the area is irrigated.

With drip irrigation, the amount of the entire irrigation rate is not given, as with other irrigation methods. A reduction is required at the expense of the non-irrigated area. For this purpose, the formula of [Ferckman, Grazoliq 1980] was used, considering the planting scheme. After calculating the irrigation rate for option 3, the rates of the other options are determined based on its size.

The experimental determination of the evapotranspiration of pepper for the growing season was made based on the data on the dynamics of soil moisture and the performed irrigation rates for a variant with 100% implementation of the irrigation rate. The determination was made by the water balance method layer by layer through 10 cm and in general for the soil layer 0-50 cm depth, in which more than 85% of the main root system of the crop is located. The evapotranspiration (ET) of pepper was calculated for ten days and in total for the growing season based on dimension values of the indicators.

Water balance calculations were carried out according to the formula:

ET = Wstart. – Wkr. + m,

where, ET – evapotranspiration, mm;

Wstart. – water stock in the 0-50 cm layer at the beginning of the period for which ET is calculated, mm;

Wkr. – water stock in the 0-50 cm layer at the end of the period in mm; m – irrigation rate, mm.

Based on the calculated values of evapotranspiration and evaporation from a free water surface (evaporation) determined by a class "A" evaporation pan, since it is considered to be integrated for all meteorological factors that influence it. (Goldberg, 1976) the biological coefficient of pepper:

Ki=ET/Eo (4),

where; ET evapotranspiration mm;

Eo - evaporation from a free water surface (evaporation) with a class "A" evaporation pan, mm;

Ki - coefficient of culture.

Results and discussions

When growing vegetable crops under greenhouse conditions, their water needs are met almost entirely by irrigation, which is why evapotranspiration for the growing season is almost entirely equal to the irrigation rate.

It varies during the growing season of the crop and depends on the weather conditions and the applied irrigation regime. The total evapotranspiration for the entire vegetation period of pepper on average for the research period is 440 mm. (Table 1)

It is of great importance to determine not only the water consumption for the entire vegetation but also that during the individual periods of pepper development, expressed through its average diurnal course.

On average for the experimental years, the average day-night values of evapotranspiration vary from 0.5 to 5.5 mm with two minima - at the beginning and end of the growing season and

one maximum - in the second and second ten days of August, which reach values up to 5.5 mm. (Table 1). (Fig. .1)

In the cultivation of crops under greenhouse conditions, irrigated by drip, in which the plants have to restore the spent amounts of water almost daily because the irrigation is characterized by great dynamism, the problem of predicting the irrigation is essential.

One of the most applicable ET relationships is considered to be that of evaporation from a free water surface (E0)

The results obtained, averaged over the three experimental years, show that the total for the vegetation period of the crop is 326 mm and reaches the highest average day-night values during the first ten days of August, 2.8 mm. (Table.1). The average day-night values of evapotranspiration are higher than those of evaporation, with the greatest differences occurring during the period of mass fruiting of the crop (July, August) when the tension of meteorological factors is greatest.

The Ki coefficient, which reflects the relationship between evapotranspiration and evaporation from a free water surface in open areas, according to the theory of (Alpatev, 1966), is approximately equal to one for the vegetation period. Studies under greenhouse conditions show that the values of this coefficient are higher and reach 1.35 on average for the vegetation period of the crop.

The coefficient Ki varies by ten days from 0.16 to 2.1 and reaches the highest values in July and August – the period when the tension of meteorological factors is greatest. Establishing a correlative relationship between evapotranspiration (ET) and evaporation from a free water surface (Eo) determined with a class "A" evaporation pan under greenhouse conditions represents an objective basis for determining the design irrigation regime and predicting the time for irrigation of the culture and enables more safe use of data from a class "A" evaporation pan. (Table 1). (Fig.1)

Table 1. *Total and average day-and-night evapotranspiration (ET, mm/24 h), evaporation (Eo, mm/24 h), and biological coefficient (K_i) of pepper which were established under different regimes of drip irrigation in Chelopechene, Sofia. All data are average values for the research period of 1993-1994*

Months	**Ten-days (decade)**	**ET (mm/24 h)**	**E_o (mm/24 h)**	**$K_i = ET/E_o$**
June	First	0.5	3.1	0.16
	Second	1.5	3.1	0.48
July	First	3.0	3.2	0.93
	Second	4.5	3.0	1.5
	Third	4.8	2.2	1.9
August	First	5.5	2.8	1.96
	Second	5.5	2.6	2.1
	Third	4.5	2.5	1.8
September	First	4.4	2.2	2.0
	Second	4.0	2.5	1.6
	Third	3.2	1.9	1.68
October	First	2.0	2.1	0.95
	Second	0.5	0.9	0.55
Average		**3.37**	**2.5**	**1.35**
Total sum		**440**	**326**	-

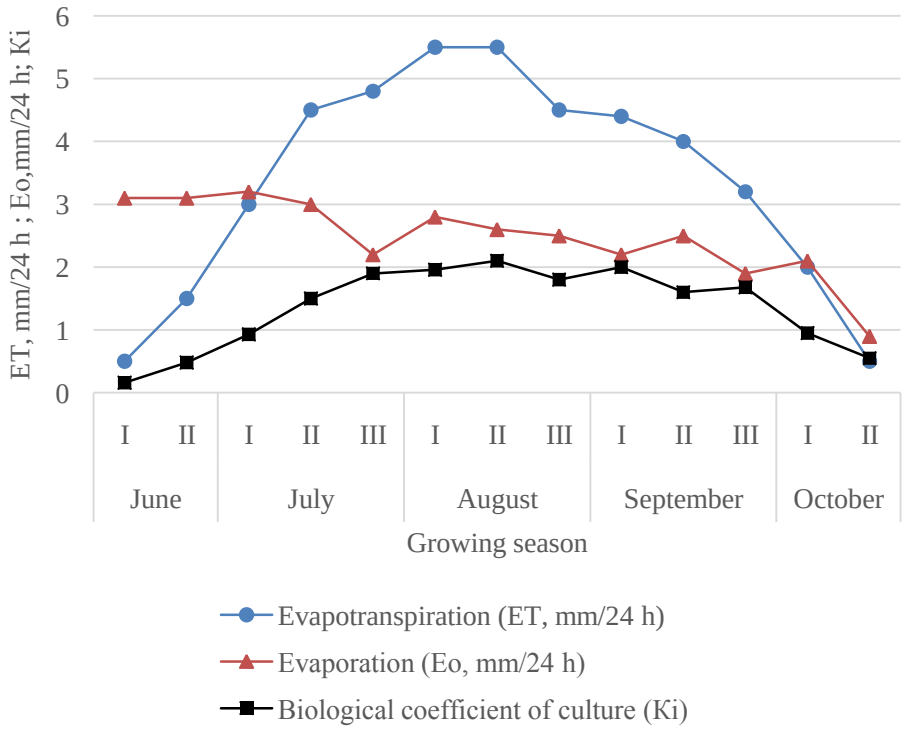

Fig. 1. *Average (over the 1993-1994 period) day-and-night values of evapotranspiration (ET, mm/24 h), evaporation (E_o, mm/24 h) from a free water surface and biological coefficient (K_i of pepper grown under greenhouse conditions in the experimental field located near Chelopechene, Sofia*

Conclusions

The total evapotranspiration for the entire vegetation period of pepper averaged throughout the search was 440 mm.

Based on the established relationship between evapotranspiration and evaporation, the values of the biological coefficient of the culture in unheated plastic greenhouses were calculated, with an average of 1.35 for the pepper growing season.

On average for the experimental years, the average day-night values of evapotranspiration vary from 0.5 to 5.5 mm with two minima - at the beginning and end of the growing season and one maximum - in the second and second ten days of August, which reach values of up to 5.5 mm.

The establishment of a correlative relationship between ET and Eo under greenhouse conditions enables more reliable use of the data from class "A" evaporation pan.

The determined values of the biological coefficient represent an objective basis for determining the design irrigation regime and predicting the time for irrigation of the culture.

Literature

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