# EVAPOTRANSPIRATION AND BIOPHYSICAL COEFFICIENTS OF LONG-FRUIT CUCUMBERS GROWN IN PLASTIC GREENHOUSES IN DRIP IRRIGATION CONDITIONS

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***Summary:*** *The evapotranspiration of Gergana long-fruit cucumbers was established in four years of field experimentation with drip irrigation, grown in greenhouse conditions on chromic luvisol soil in the Sofia region. Different irrigation regimes have been tested - from full satisfaction of the daily needs of the culture from water to irrigation with 20% and 40% reduced water application rates.*
*The total evapotranspiration values for the study period were determined.*
*For the needs of practice and design, the ten-day values of the biophysical coefficient Z are calculated, which depends on the biological characteristics of the crop and the weather factors. On the basis of the established relationship between evapotranspiration and evaporation, the values of the coefficient of crop in unheated plastic greenhouses are calculated as the average for the cucumber vegetation curve Ki = 1.46.*
***KEY WORDS:*** *EVAPOTRANSPIRATION, EVAPORATION, BIOPHYSICAL COEFFICIENTS, CUCUMBERS, IRRIGATION RATE, DRIP IRRIGATION, BIOPHYSICAL COEFFICIENTS.*

The optimization of the irrigation regime is one of the most important factors for the efficient use of water to obtain sustainable yields from agricultural crops. This is related to the knowledge of its elements and, above all, to evapotranspiration (ET). According to (Lamm, 1977), the major part of the water consumption of greenhouse vegetable crops is evapotranspiration, the values of which are proportional to relative humidity in the range of 60-100% of MOP.

Little and insufficient are the studies to establish the evapotranspiration of vegetable cultures grown in greenhouse conditions. In the cultivation of pepper in drip irrigation in unheated greenhouses in the Sofia region, the ET reached 668 mm (Kireva, 1989) and in the region of Plovdiv up to 554 mm (Basitov, 2006). For greenhouse tomatoes, ET reached 373 mm (Abobamera, 1992).

The aim of the research is to determine the size of the evapotranspiration and the values of the biophysical coefficients of long cucumbers grown under greenhouse conditions with drip irrigation in the Sofia field.

**Materials and method**

To establish the evapotranspiration of long-fruit cucumbers during the period 2002-2004 a field experiment was conducted in plastic unheated greenhouses at the experimental field of the Pushkarov Institute in Chelopechene, Sofia

**The following irrigation options have been tested:**

- Option 1 irrigation with 100% water application rate
- Option 2 irrigation option with 80% water application rate
- Option 3 irrigation with 60% water application rate

The size of the water application rate is calculated using the formula by (Frecman and Garzoli, 1980). To monitor the dynamics of soil moisture soil samples were taken in variant 2 (100% w.a.r.) at a depth of 0-50 cm over 10 cm, which were processed by the weight-thermostatic method. On the basis of data on soil moisture dynamics during the vegetation period, the irrigation water drainage carried out has established the evapotranspiration (ET) of long-lasting cucumbers in ten days and in general for the vegetation period. On this basis the values of the biophysical coefficients z and $k_б$ are calculated. The relationship between crop's evapotranspiration and meteorological factors - air temperature and daylight hours for every ten days in% during the year. The limit values of the individual elements of the irrigation regime of long-lasting cucumbers are established experimentally.

The values of the biophysical coefficients z and $k_б$ needed to determine the evapotranspiration (Delibaltov, Hristov, Tsonev, 1969) and (Blanney, Criddle, 1962) were calculated using the formulas:

$$ET = Z.\sum t,$$

$$Z = \frac{ET}{\sum t}$$

Where: ET is evaprtransporation in mm;

$\sum t$ – the 10 - day sum of the average daily air temperatures in °C;

Z – the biophysical factor determined for each crop according to the final temperature sum of the period.

$$ET = K_b.p.\frac{45,7.t+813}{100} \quad (1)$$

Where: $K_b = \frac{ET}{p.\frac{45,7.t+813}{100}}$ is the biophysical coefficient; (2)

*p* – the length of daylight hours for each ten-day period in% during the year;

*t* - the average ten-day air temperature in ° C during the period considered.

Coefficient of the crop – Ki (3)

$$Ki = \frac{ET}{Eo},$$

Where: Eo is the evaporation of a free water surface (evaporation) in a "A" evaporator in mm.

The soil of the experimental field of the Pushkarov Institute is a chromic luvisol, slightly sandy clayey in the ore layer, formed on the base of an old diluvia cone of filler materials. It is poorly loaded with nitrogen, on average with phosphorus and well with potassium. Average for the layer 0 - 60 cm the following water-physical properties: WHC = 22.1%; wilting point - 12.3% on the weight of absolutely dry soil; volume weight at WHC - 1.47 g / cm3. For the soil layer 0 - 100 cm, these indicators have the following values: WHC- 21,8%; wilting point - 12.3%; bulk density - 1.50 cm3. Irrigation was carried out using a droplet-type drip plant.

**Results and discussions**

For the period of the surveys during the growing season of the crop (April-July), 21 irrigations were conducted with an average water application rate of 183 m3 / ha and an irrigation rate of 3742 m3 / ha were submitted. (Table 1)

The intensity of ET influences directly the length of the between-irrigation period, and hence the number of irrigations and the size of the irrigation rate. The main part of the water consumption of long-grain cucumbers grown under greenhouse conditions is the evapotranspiration which does not differ significantly from the irrigation norms and varies in years depending on the meteorological situation and the applied irrigation regime.

***Table 1:*** *Number of irrigation, irrigation and irrigation norms by variant of long-lasting cucumbers averaged during the survey period*

| variants | 2002-2004 average | | |
|---|---|---|---|
| | Number of irrigations | Water application rate /mm/ | irrigation rate /mm/ |
| 100% M | 20 | 18,3 | 366 |
| 80% M | 20 | 14,6 | 292 |
| 60% M | 20 | 11,5 | 230 |

Highest values of evapotranspiration reached 253 mm during the dry 2004, and in the remaining years it ranges from 217 to 253 mm (Table 2). On average, over the survey period, the size of the total ET for the long-fruit cucumber growing season is 231 mm.

In the experimental years, the average daily values of the evapotranspiration range from 0.5 to 5.5 mm with two minima - at the beginning and end of the vegetation and a maximum - in July, which reaches 5.5 mm (Table 2).

In the initial phase of crop's development, the average daily values of the evapotranspiration are lower, due to the smaller size of the plants, which consume small amounts of water, a large part of the soil surface is detected, the impact of the meteorological factors is low. The magnitude of evapotranspiration during this period is mainly determined by soil humidity and near-ground air temperature. The physical evaporation of the soil prevails. The intense increase in ET, which begins in the first and second quarters of June, is associated with an intensive growth phase and reaches a mean daily value of 3.8 to 4.6 mm. Its maximum for the three years is in the first and second tenth of July and reaches 5.5 mm. At the end of the long-fruit cucumber's vegetation, with decreasing the pressure of the meteorological factors, the medium-term ET decreases and in the first ten days of August it reaches 3.7 mm (Table 2).

The values of average daily evapotranspiration (100% water application rate) varied from 0.2 to 6.5 mm in the different years, with the highest values in the dry 2004. The course of its variations during the growing season follows the development of culture and changes in meteorological factors. (Table 2).

In order to meet the needs of multilingual practice in several countries, methods and formulas have been developed to determine evapotranspiration by computational pathway.

For the calculation of the evapotranspiration of these formulas, experimental determination of the biophysical coefficients is necessary. They reflect the specifics of water consumption depending on the biological requirements of the crop, the stage of development, the manifestations of the meteorological factors

The calculated ten-day values of the biophysical coefficients based on the experimental definition of the evapotranspiration and the daily sums of the average daily air temperature (for the coefficient z, calculated by the formula by Delebaltov, Hristov, Tsonev) and the air temperature and the daily hours for every ten days in% during the year. (for $k_p$ coefficient according to the formula of Blanney, Criddle) are presented in (Table 3). Changes in the values of these coefficients follow changes in the evapotranspiration during the growing period of the culture.

The values of biophysical coefficients represent an objective basis for determining the design irrigation regime and predicting the irrigation time of the crop.

The values of the biophysical z factor of the culture range from 0.04 to 0.26 and the coefficient kb - from 0.36 to 0.89, respectively, meanwhile for the study period. (Table 2)

***Table 2:*** *Evapotranspiration and evaporation from free water surface of long-fruit cucumbers 2002-2004*

| | Average daily evapotranspiration (ET) mm | | | | | Average daily transpiration from a free water surface (Eo) mm | | | |
|---|---|---|---|---|---|---|---|---|---|
| Months | Ten days | 2002 mm | 2003 mm | 2004 mm | Average mm | 2002 mm | 2003 mm | 2004 mm | Average mm |
| May | II | 0,4 | 0,5 | 1,0 | 0,5 | - | 2,0 | 2,2 | 2,2 |
| | III | 1,8 | 2,0 | 2,0 | 2,1 | 2,5 | 2,0 | 2,0 | 2,2 |
| June | I | 4,2 | 3,1 | 4,0 | 3,8 | 2,4 | 2,5 | 2,2 | 2,3 |
| | II | 4,7 | 3,8 | 5,0 | 4,6 | 2,7 | 2,9 | 2,3 | 2,6 |
| | III | 4,8 | 4,6 | 5,5 | 5,2 | 2,7 | 3,0 | 2,7 | 2,8 |
| July | I | 5,4 | 5,40 | 5,3 | 5,3 | 3,2 | 3,0 | 3,6 | 3,3 |
| | II | 5,3 | 5,8 | 4,7 | 5,4 | 3,5 | 2,0 | 2,2 | 2,8 |
| | III | 4,1 | 6,5 | 4,2 | 4,7 | 2,9 | 2,8 | 3,0 | 2,9 |
| August | I | 3,6 | 5,1 | 3,9 | 4,4 | 2,8 | 2,5 | 3,5 | 2,9 |
| Total | | 3,9 | 4,1 | 4,0 | 4,0 | 2,9 | 2,7 | 2,6 | 2,7 |
| Total | | 223 | 253 | 217 | 231 | 232 | 240 | 238 | 237 |

When growing crops in drip irrigation facilities where plants almost daily need to recover water, the problem of forecasting the amount of water required is of paramount importance. One of the most applicable ET connections is that of the evaporation of a free water surface (EO), established by a "A" evaporator, since it is considered to be integrated with all the weather factors that influence it (Goldberg, 1976, Rey, R. 1979). The results obtained on average for the three experimental years indicate that the total growing season of the crop Eo is 237 mm and reaches the highest daily average values in the second and third day of July 2.7 mm, (Table 3). The

average daily values of the evapotranspiration are higher than those of the evaporation, with the largest differences occurring during the period of mass fertilization of the crop in the months of June-July, when the pressure of the climatic factors is greatest.

The Ki coefficient, which reflects the relationship between evapotranspiration and evaporation from free water in open areas. According to Alpev's theory, it is approximately equal to a unit for the growing season of the crop.

Determination of the dependence between Eo, determined by A-type evaporator, and ET of the cultures can be judged for the daily dimensions of ET of the culture and from there to predict the terms and sizes of the forthcoming harvests. (Cristiansen, 1976).

Greenhouse-field studies found that this ratio averaged over the vegetation period amounted to 1.46 on average over the three experimental years. The Ki coefficient varies in ten-days from 0.4 to 1.9 and reaches the highest values in the second ten-day period of July - the period of the highest stress of the meteorological factors and the highest ET. Establishing a correlation between ET and Eco under greenhouse conditions allows for a more accurate use of class A evaporator data. (Table 3)

***Table 3:*** *Biophysical coefficients for three trial years*

| Months | Ten days | evapotranspiration /ET/, mm | evaporation Eo, mm | Z | Kb | Coefficient of the crop $Ki = \frac{ET}{Eo}$ |
|---|---|---|---|---|---|---|
| May | II | 0,5 | 2,2 | 0,04 | 0,36 | 0,2 |
| | III | 2,1 | 2,2 | 0,12 | 0,39 | 1,0 |
| June | I | 3,8 | 2,3 | 022 | 0,69 | 1,7 |
| | II | 4,6 | 2,6 | 0,23 | 0,84 | 1,8 |
| | III | 5,2 | 2,8 | 0,26 | 0,87 | 1,8 |
| July | I | 5,3 | 3,3 | 0,24 | 0,88 | 1,7 |
| | II | 5,4 | 2,8 | 0,25 | 0,89 | 1,9 |
| | III | 4,7 | 2,9 | 0,20 | 0,73 | 1,7 |
| August | I | 3,7 | 2,9 | 0,19 | 0,66 | 1,3 |
| Total | | 4,0 | 2,7 | 0,18 | 0,69 | 1,46 |

## *Conclusions*

1. The total amount of evapotranspiration of long-fruit cucumbers is established. Highest values reached in the dry year of 2004 -253 mm, and in the remaining years it ranges from 217 to 253 mm
2. Established average daily values of evapotranspiration range from 0.5 to 5.5 mm with two minima - at the beginning and end of vegetation and a maximum of - in July and August, reaching up to 5.4 mm
3. For the needs of the practice and the design are calculated also the ten-day values of the biophysical coefficients (Z and k), which depend on the biological characteristics of the culture and the meteorological factors.
4. On the basis of the relationship between evapotranspiration and evaporation, the values of the coefficient of the crop in unheated plastic greenhouses are calculated.
5. Establishing a correlation between ET and Eo under greenhouse conditions allows for a higher degree of reliability when using data from a "A" evaporator.

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