EFFICIENCY OF WATER USE, UNDER THE CONDITIONS OF GLOBAL CLIMATE CHANGES IN ECOLOGICAL TOMATOES, GROWN IN SOLARIUM, USING DRIP IRRIGATION

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Abstract. *The need for food production, for a growing population, in sufficient quantities and of high quality, in the conditions of today's global climate changes represents an important challenge related to the necessity of rational management for water irrigation. In the case of the production of certified organic tomatoes, grown in the solariums, it is necessary to establish the correct water requirement administered by drip irrigation, the scheduling and warning of the waterings and the correct management of the soil moisture, in order to maximize the production. This paper proposes a simple but effective method of determining the water requirement, the scheduling and warning of watering and management of soil moisture, for the ecological culture of tomatoes grown in the solarium, in Husasau de Tinca, Bihor county, starting from the average air temperature, measured inside or outside the solarium. Potential evapotranspiration (ETP) determined with the help of air temperature using the Thornthwaite (ETP Th) and Blaney Criddle (ETP BC) relationships, have significant and distinctly significant correlative links with those measured inside the solarium using the Piche evaporimeter (ETP P) between 1999-2001. Knowing the water consumption of tomatoes grown in the solarium, for the period 1999-2001, specific crop coefficients (Kc) were determined, starting from the ETP Th. For the two systems of culture and distribution of water: without mulching (WM) and the distribution of water at the plant with T type drips and respectively mulching with black foil (mbf) and the distribution of water with microtubes (capillary tubes), the Kc have close values, between 0.55 in September and 1.03 in the May and July months. The optimum real evapotranspiration (ETRO), which is similar to the water requirement of tomatoes, for the hottest vegetation period (April - September) recorded in 2018 (T med = 20.08 ˚C) is 7543.2 m^3ha^{-1}, for the WM variant and respectively of 7262.4 m^3ha-1 in the MBF variant. The values of Water Utilisation Efficiency coefficient (WUE = 96.1 lkg^{-1}) and the Efficiency of Consumed Water (ECW = 10.5 kg m^{-3}) in the hottest growing season (2018) demonstrate the need to irrigate the organic tomatoes grown in the closed spaces and the superior utilization of water in MBF variant.*

Keywords*: potential evapotranspiration; water consumption; drip irrigation; specific crop coefficient; water use efficiency;*

INTRODUCTION

Contemporary society faces two acute problems: the need to ensure the quantity and quality of food for a population that has an average annual growth of 90 million inhabitants and that of conserving energy and ecological resources.

Tomatoes (*Lycopersicon esculentum*) are among the most appreciated vegetables, consumed fresh in our country, due to their low caloric value and high vitamin content. The importance of the production of fresh tomatoes, is also highlighted by the de minimum aid, granted by the Government of Romania, for the application of the support program of the tomato product in protected areas. For the year 2019, the annual aid of maximum 15000 euros was granted, for a cultivated area of minimum 1000 m^2 and a production of minimum 2 kgm^{-2}. (GOVERNMENT OF ROMANIA, 2019)

The production of organic tomatoes represents an important challenge, especially in the conditions of the solarium crops (which do not benefit from the contribution of precipitations) and of the global climatic changes, more and more obvious, being necessary an adequate management of the water administered with the help of the drip irrigation. (DHARA, 2014)

Accurate determination of optimal water consumption, in order to maximize crop production is very difficult, especially under protected crop conditions. The methods used to determine the Optimal Real Evapotranspiration (ETRO) are diversified, according to the factors that influence the water consumption of the crops: climatic factors, moisture and fertility of soil, vegetation phases, etc. These are grouped into direct methods, of which the water balance in the soil and the method of evapotranspirometers (lysimeters), as well as indirect methods, such as the energy balance and the aerodynamic method, are noted. (GRUMEZA *et al.* 1989)

ZHANG et al. (2011) uses for the determination of transpiration, an indirect method based on the measurement of sap flow that passes through the plant stem. The method allows continuous monitoring, with high accuracy, of water use by plants, the study of the influence of environmental factors on consumption and allows to improve, the efficiency of water use by plants. This method was, also used to estimate the water consumption of tomatoes grown in greenhouses. (HANPING et al. 2017)

Under the conditions of solar-grown crops, water consumption is dependent on a number of factors such as: culture system, indoor air temperature, foil transparency, global radiation, relative humidity, water vapor pressure, air currents, etc. For this reason, the methods of estimating water consumption are laborious, time consuming, require complex calculations and are difficult to apply by small farmers. In practice, indirect methods based on the estimation of reference evapotranspiration (ETR) with the help of evaporimeters or potential evapotranspiration, (ETP) calculated using climate data are applied, which are then transformed into crop water consumption using specific crop indices (Kc).

DÎRJA et al. (2003) in the conditions from Cluj Napoca, determine the water consumption for three vegetables grown in solarium, including the tomatoes (2000-2002) using the soil balance method and ETP determined with the relations Villele, Turk and Penman. The monthly Kc values, determined for tomatoes, differ greatly depending on the relationship used to determine ETP.

In the pedoclimatic conditions from Husasau de Tinca, Bihor county CĂRBUNAR (2005) determined for the cultivation of ecologically certified tomatoes, grown in solarium, ETRO for the period 1999-2001 using the water balance in soil method. Starting from the recordings of three Piche evaporimeters, mounted in each solarium, the specific culture coefficients (Kc) and daily water consumption (dET) were determined.

Given the large diversity of weather data required for ETP calculation, XU et al. (2001) evaluate several relationships and recommend generalizing those based on the recorded temperatures.

The present paper proposes that, starting from the data determined in Husasau de Tinca, from 1999-2001 (DOMUȚA et al. 2007), to evaluate the possibilities of determining the ETRO, Kc of the tomato crop grown in the solariums. For the hottest vegetation season (2018) recorded at the Oradea Meteorological Station, it proposes to study the possibilities of irrigation scheduling and warning, using ETP determined starting from the average air temperature.

MATERIAL AND METHODS

The research regarding the irrigation regime for the ecologically certified tomatoes, grown in solariums, drip irrigated was carried out in Husasau de Tinca, Bihor County, located in Miersigului Plain, at a distance of about 30 km from the Oradea Meteorological Station.

Organically certified tomatoes, produced in solariums without mulching (WM) and mulching using black foil (MBF) are drip irrigated, using T-type water distributors, in the first case and microtubes (capillary tubes), in the second case. In the period 1999 – 2001, the water consumption for the vegetation period was higher in the WM variant of 7153.1 m^3ha^{-1} and respectively lower in the MBF variant of 6958.3 m^3 ha^{-1} (Table 1.)

Table 1

Average monthly water consumption of tomatoes grown in solariums (m^3ha^{-1}), irrigated by drip, in Husasau de Tinca, Bihor county (1999-2001) (after: DOMUȚA et al., 2007)

Variant	APR	MAY	JUN	JUL	AUG	SEP	Total
WM	839.0	1225.5	1409.0	1840.4	1246.2	593.0	7153.1
MBF	846.3	1206.9	1423.9	1740.1	1157.3	583.8	6958.3

The soil in the experimental field is Haplic Luvisol (FLOREA et al. 2003) with a pH from neutral to weak alkaline, high humus content in the surface horizon (4.42 %) and a good supply with nutrients, as a result of annual fertilization with organic fertilizers. The average colloidal clay (< 0.002 mm) content at a depth of 0.50 m is 34.2 %, the bulk density (BD) of 1.48 gcm^{-3}, field capacity (FC) of 24.0 % and the wilting coefficient (WC) of 9.7 %. (Table 2)

Table 2.

The main chemical and hydro-physical indicators of Haplic Luvisol from solarium, Husasău de Tinca, Bihor county (after CĂRBUNAR, 2005)

The depth (cm)	0-20	20-40	40-60	0-50
pH	7.60	7.47	-	-
Humus (%)	4,42	-	-	-
$N\text{-}NO_3$ (ppm)	37.8	16.2	-	-
P_{AL} (ppm)	713	529	-	-
K_{AL} (ppm)	640	370	-	-
Colloidal clay (%)	31.5	34.1	39.8	34.2
Bulk density -BD (g cm^{-3})	1.4	1.5	1.6	1.48
Field capacity -FC (%)	24.2	23.6	24.3	24.0
Wilting coefficient -WC (%)	9.2	9.4	11.1	9.7
Minimum moisture content -MMC (%)	19.2	18.9	19.9	19,2

For the analysis of the evolution of average air temperatures, the records from the Oradea Meteorological Station from 1970-2018 were used. (ANM, 2019)

Analysis of the different types of correlative links: average outside temperatures (T outside) and average temperatures from solarium (T inside); ETP Thornthwaite (ETP Th), ETP Blaney Criddle (ETP BC) and Piche (ETP P) respectively; the evolution of Kc during the vegetation period and their statistical significance was used the program PSPP Statistical Analysis Sofware, (GNU, 2016)

The calculation of ETP values was done with the DRINC program, (TIGKAS et al. 2019) being used to determine the ETP Th relationships indicated by THORNTHWAITE (1948) and respectively for ETP BC by BLANEY et al (1950). For the calculation of the Penman Monteith reference evapotranspiration values (ETo PM), the CROPWAT 8.0 program was used (ALLEN et al. 1998).

The determination of the watering norm was done with the relation indicated by CARBUNAR 2005, for the depth of 0.50 m and the effective surfaces watered by the two irrigation systems: T type distributors, in WM variant and respectively microtubes in MBF variant:

$$m = \frac{100 \cdot H \cdot BD(FC - WC)}{\eta} \cdot y \cdot \frac{P}{100};$$

were: m – norm of water application by drip (m^3ha^{-1});
BD – volumetric weight or bulk density of the soil (tm^{-3} sau gcm^{-3});
H - depth of soil wetting (m);
FC – Field capacity for water of the soil (%);
WC – Wilting coefficient (%);
y – the fraction in the range of available moisture content (FC-WC) to be filled with water (easily accessible water between FC and MMC – minimum moisture content for watering);
P – the percentage of soil surface actually moistened;
η – the efficiency of the uniformity of the watering along the watering pipe (0.8 – 0.9)

In order to reach the proposed objectives, namely the evaluation of the efficiency of the water use administered by dripping, in the two analyzed variants, under the conditions of the climatic changes, the year with the hottest vegetation period, registered in Oradea, the year 2018 was chosen. ETRO, monthly average water consumption, irrigation regime, sources of consumption coverage for tomatoes organic culture were determined.

The coefficient of water utilization efficiency (WUE) and the efficiency of using water (EUW) and respectively the coefficient of' irrigation' water utilization efficiency (IWUE) and efficiency of using irrigation water (IEUW) were calculated using the relationships indicated by MAN et al. 2007:

$$WUE = \frac{Water\ consumption}{Annual\ production}\ (l \cdot kg^{-1}); \qquad EUW = \frac{Annual\ production}{Water\ consumption}\ (kg \cdot m^{-3});$$

$$IWUE = \frac{Irrigation\ rate}{Annual\ production}\ (l \cdot kg^{-1}) \qquad IEUW = \frac{Annual\ production}{Irrigation\ rate}\ (kg \cdot m^{-3})$$

RESULTS AND DISCUSSIONS

The connection between the monthly average T outside and the monthly average T inside

Given the multitude of factors that influence the water consumption of the crops in the solariums and the possibilities of determining the ETP in the solariums, starting from the recorded average temperatures, the correlation between T outside and T inside was tested, in Husasau de Tinca. (Figure 1)

The relationship thus established for the period 1999-2001 is linear, direct and very significant statistically ($R^2 = 0.9313$)

Under these conditions, the monthly water consumption of tomatoes can be determined starting from T outside or from T inside. This requires only a thermometer that records the maximum and minimum temperature of the day. The daily average is obtained using the two records.

ETP Th and ETP BC

Starting from the average monthly values, recorded at the Oradea Meteorological Station, between 1999-2001, the ETP Th and ETP BC values were determined, which were compared with Penman Montteith Evapotranspiration (ETo PM), considered by FAO as a standard method for calculating the reference evapotranspiration of crops. (Table 3)

Because the ETo PM values are determined using the average air temperature, relative humidity, wind speed, sun shine duration and solar radiation, it was compared with the determined ETP Th and ETP BC values.

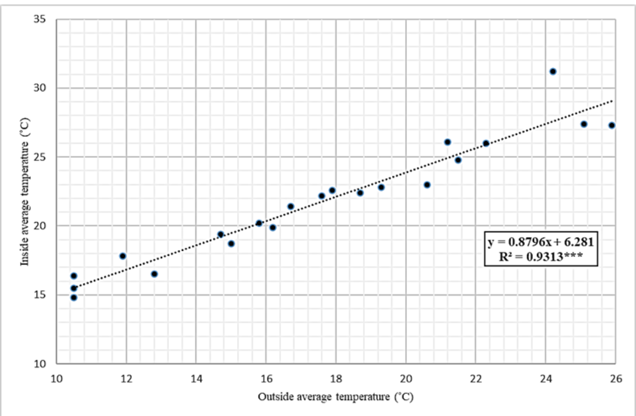

Figure 1 The relationship between the monthly average values of the T inside (˚C) and T outside (˚C) in the solarium at Husasău de Tinca (1999-2001)

Table 3

Average ETP values (mm month^{-1}) determined using climate data from Weather Station Oradea, Bihor County (1999-2001)

	ETo PM	ETP Th	Differences ETP Th – ETo PM	ETP BC	Differences ETP BC - ETo PM
Oct.	44.14	45.24	+ 1.10	81.97	+ 37.83
Nov.	20.69	14.60	- 6.09	50.02	+ 29.33
Dec.	9.01	2.48	- 6,53	25.07	+ 16,6
Jan.	8.74	1.18	- 7.56	12.19	+ 3.45
Feb.	15.49	3.20	- 12.29	27.73	+ 12.24
Mar.	37.80	22.96	- 14.84	69.17	+ 31.37
Cold season	135.87	89.66	- 46.21	266.15	+ 130.28
Apr.	70.12	56.63	- 13.49	97.55	+ 27.43
May	116.87	99.04	- 17.83	136.55	+ 19.68
Jun.	127.77	122.08	- 5.69	196.67	+ 68.90
Jul.	129.95	137.46	+ 7.51	228.88	+ 98.93
Aug.	96.95	127.12	+ 30.17	197.62	+ 100.67
Sep.	70.50	73.73	+ 3.23	118.00	+ 47.5
Warm season	612.16	616,06	+ 3.90	975.27	+ 363.11
Total	748,03	705,52	- 42.51	1241,42	+ 493.39

Comparing the average annual values (1999-2001) we can see the difference between ETo PM and ETR Th, of - 42.51 mm month^{-1}, much smaller than the difference between ETo PM and ETP BC of +493.39 mm month^{-1}. If we analyze only the vegetation period of the crops, in the case of ETP Th the difference is only = 3.90 mm month^{-1}, whereas in the case of ETP BC this is much larger, of + 363.11 mm month^{-1}.

Therefore, according to the literature (DÎRJA et al. 2003; MAN et al. 2007; XU et al. 2001) among the relations used for the determination of ETP, based on temperatures, the most indicated is ETP Th, the relation ETP BC leading at high overvaluations relative to ETo PM.

For the solarium conditions, ETP Th and ETP BC were determined using T inside, the monthly values obtained at Husasau de Tinca for the period 1999-2001 were compared with ETP P, measured inside the solariums. (Figure 2)

The correlations between the daily ETP P values on the one hand and the daily ETP Th and ETP BC values on the other hand are of the second degree polynomial type. It is noted that the best simulation of the ETP P values is obtained from the ETP Th values, the correlation being distinctly significant statistically (R^2 = 0.602) whereas, the one starting from ETP BC is only significant statistically (R^2 = 0.5333).

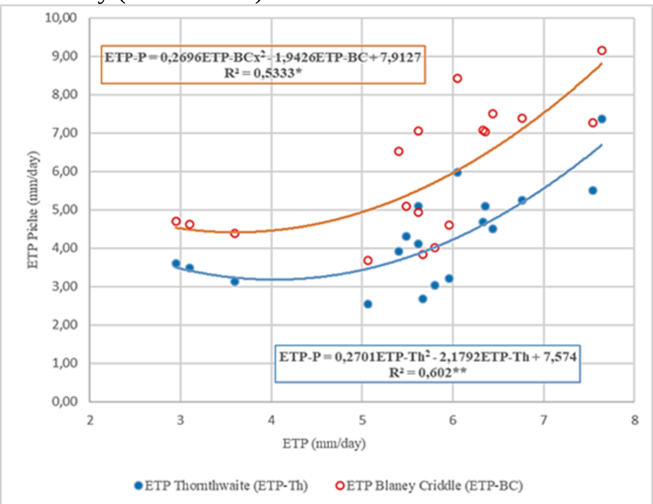

Figure 2 Correlative link between the values of ETP-P and ETP-Th and ETP-BC (mm day^{-1}) respectively in the solariums of Husasau de Tinca, Bihor county (1999-2001)

Therefore, starting from T outside or T inside, the ETP Th of the solarium crops can be determined, which is closest to the ETP P, measured inside the solariums or the ETo PM, considered standard method for field crops.

Kc for tomatoes in relation to ETP Th

Knowing the average monthly consumption of tomatoes, grown in the Husasau de Tinca solariums, in the WM and MBF variants, between 1999 and 2001, the daily average consumption and the average daily values of the ETP Th were calculated. Starting from ETP Th, the Kc for the two tomatoes cultivation variants in solariums were obtained. (Table 4)

Analyzing the evolution of the monthly Kc values for the vegetation period of the tomatoes in the solariums it is noted that the differences between the two variants are very small. The biggest difference between Kc is found in August 2001, which is 0.15. The very small difference between the average Kc values of the two varieties of tomato culture is evidenced by their evolution during the vegetation period (Figure 3)

The correlative links for the average Kc values of WM and MBF, depending on the number of days from the vegetation period are of the second degree polynomial type, significant statistically, R^2 = 0.636 for WM and R^2 = 0.6784 for MBF.

The average monthly values Kc, regardless of the variant, show a slight growth trend in the first three months, the values being close to the unit, after which their value decreases, reaching values of 0.56-0.58 in the last month.

The graphical representation of the evolution of the monthly Kc values for the analyzed WM and MBF variants is important for the irrigation scheduling and warning in the solariums. Thus, knowing the daily average values of T outside or T inside, determined as the average between the maximum and minimum values recorded by thermometers, one can calculate daily ETP Th, from the inside solarium. The dEt is determined by correcting

Table 4

The Kc values, for the tomatoes cultivation variants in solariums at Husasău de Tinca (1999-2001)

Year	Month	dEt (mm day^{-1})		ETP Th (mm day^{-1})	Kc	
		WM	MBF		WM	MBF
1999	Apr.	2.92	2.78	2.68	1.09	1.04
	May	3.97	3.90	3.22	1.23	1.21
	Jun.	4.47	4.30	4.68	0.96	0.92
	Jul.	5.94	5.81	7.37	0.81	0.79
	Aug.	3.77	3.67	5.10	0.74	0.72
	Sep.	1.60	1.50	3.48	0.46	0.43
2000	Apr.	3.09	3.05	3.03	1.02	1.01
	May	4.42	4.38	4.30	1.03	1.02
	Jun.	5.36	5.15	5.25	1.02	0.98
	Jul.	6.58	6.42	5.98	1.10	1.07
	Aug.	4.35	4.30	5.50	0.79	0.78
	Sep.	3.05	2.90	3.60	0.85	0.81
2001	Apr.	2.38	2.36	2.55	0.93	0.93
	May	3.47	3.40	4.12	0.84	0.83
	Jun.	4.26	4.33	3.91	1.09	1.11
	Jul.	5.29	4.61	4.51	1.17	1.02
	Aug.	3.94	3.33	5.09	0.77	0.65
	Sep.	1.28	1.25	3.14	0.41	0.40

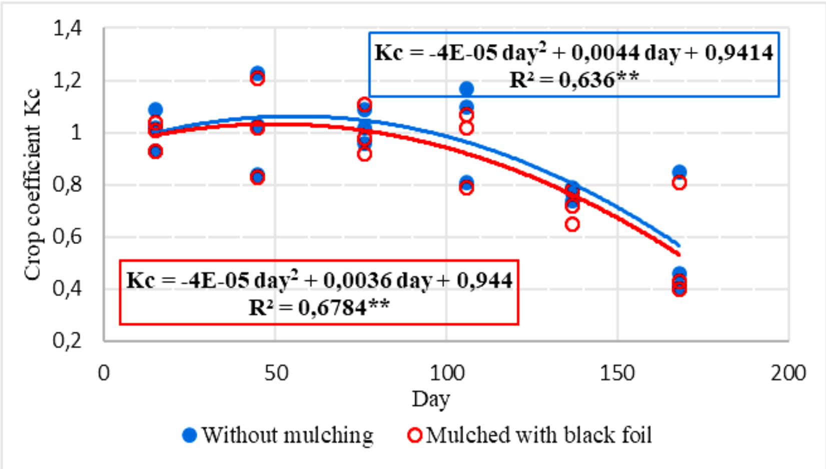

Figure 3 Evolution of the monthly Kc values during the vegetation period of tomatoes grown in solariums

daily ETP Th with Kc, determined for the two tomato cultivation variants, WM and MBF.

Watering norm m, for tomatoes grown in solariums

The drip watering norm represents the amount of water administered at one hectare of a crop, to complete the soil moisture from MMC to FC. For tomatoes grown on a Haplic Luvisol, in the Husasau de Tinca solariums, it differs for the two WM and MBF variants, due to the percentage effectively watered with the help of T type distributors (70.65 % of the surface) and 62.8 % respectively for microtubes (Table 5)

The norm of water application by drip is 275 m^3ha^{-1} in the WM variant, when the water is administered with T-type distributors and 245 m^3ha^{-1} respectively, in the MBF version where the water is distributed to the plant with microtubes.

Table 5

Calculation of the drip watering norm with T-type distributors and microtubes

Variant	H (m)	BD (gcm^{-3})	FC - MMC (%)	P/100	η	m		
						(m^3 ha^{-1})	(l m^{-2})	(l $planta^{-1}$)
WM	0.50	1.48	4.77	0.7065	0.9	275	27.5	5.4
MBFl	0.50	1.48	4.77	0.628	0.9	245	24.5	4.8

The amount of water for a plant is 5.4 l, in the first case and 4.8 l respectively in the second case.

If the drip watering system is equipped with T-type distributors with a flow rate of 1 l per hour, the administration is done in 5 hours and 15 minutes and if the flow of the distributor is 1.5 l per hour the required time is 3 hours and 45 minutes.

For microtubes (capillary tubes) with an external diameter of 3 mm and an internal diameter of 1 mm, with a flow rate of 2 l per hour, the watering time is 2 hours and 25 minutes.

Water requirement of tomatoes grown in solariums in 2018.

From the records of Oradea, from the last 48 years, for which the multiannual average is 17.64 ˚C, the hottest vegetation period of the crops was in 2018 (20.08 ˚C).

The monthly ETP Th, from the vegetation period, determined using the average monthly temperatures obtained in the solar, are between 96.7 mm $month^{-1}$ in April and 171.8 mm $month^{-1}$ in August. The total Th ETP for the vegetation period is 824.5 mm. (Table 6)

Table 6

Water requirement of tomatoes grown in solariums at Husasau de Tinca, in 2018

Month	T outside (˚C)	T inside (˚C)	ETP Th (mm $mounth^{-1}$)	ETRo (m^3 ha^{-1})	
				WM	MBF
APR	15.7	20.1	96.7	976.7	967.0
MAY	19.7	22.7	128.1	1319.4	1306.6
JUN	21.2	24.9	158.8	1619.8	1585.0
JUL	22.0	25.6	167.5	1725.3	1608.0
AUG	24.1	27.5	171.8	1322.9	1237.0
SEP	17.8	21.9	101.6	579.1	558.8
Vegetation period	20.08	23.78	824.5	7543.2	7262.4

The water requirement is higher for WM variant, of 7543.2 mm $year^{-1}$ compared to tomatoes grown in MBF variant, of 7262.4 mm $year^{-1}$.

The irrigation regime of tomatoes grown in solariums in 2018

The planting of tomatoes in the solariums was done in the second decade of March, and the last harvest in the second decade of September. The coverage of water consumption of tomatoes grown in solariums during the vegetation period of the year 2018 was made by applying 25 watering norms (27.5 l m^{-2}) to the WM version and 29 watering norms (24.5 l m^{-2}) to the variant MBF. (Table 7)

Table 7

Irrigation regime of tomatoes grown in solariums at Husasău de Tinca in 2018

	APR		MAY		JUN		JUL		AUG		SEP		Vegetation period	
	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n
WM	825	3	1100	4	1650	6	1650	6	1100	4	550	2	6875	25
MBF	735	3	1225	5	1470	6	1715	7	1470	6	490	2	7105	29

Σm – monthly irrigation rate (m^3 ha^{-1}); n – number of waterings in a month;

Coverage sources of water consumption of tomatoes grown in solariums in 2018.

The total water consumption for tomatoes grown in solariums was 7192.8 m^3ha^{-1} for WM variant, increasing to 7316.5 m^3ha^{-1} for MBF variant. The water requirement comes mainly from irrigation water (95.6 - 97.1 %) and very little from the soil water supply (2.9 - 4.4 %) (Table 8)

Table 8.

Sources of water consumption coverage in tomatoes grown in solariums at Husasau de Tinca in 2018

Variant	Total water consumption		Sources of coverage			
			Soil reserve		Irrigation	
	m^3 ha^{-1}	%	m^3 ha^{-1}	%	m^3 ha^{-1}	%
WM	7192.8	100	317.8	4.42	6875	95.58
MBF	7316.5	100	211.5	2.89	7105	97.11

Coefficients of water use (WUE, EUW, IWUE and IEUW)

The coefficient for the use of consumed water (WUE) and irrigation water used (IWUE) shows that 96.1 l and 93.7 l respectively are used for the production of 1 kg tomatoes. The efficiency of the water used (ECW, IECW) shows that for 1 kg of product, 10.5 m^3 of water and 11.1 m^3 of irrigation water respectively, are consumed. (Table 9)

Table 9

Water utilization efficiency (WUE) and Efficiency of using water (EUW) and irrigation water (IWUE and IEUW) in tomatoes grown in solariums at Husasau de Tinca in 2018

Variant	WUE		IWUE		EUW		IEUW	
	l kg^{-1}	%	l kg^{-1}	%	kg m^{-3}	%	kg m^{-3}	%
WM	102.0	100	97.9	100	9.8	100	10.2	100
MBF	90.2	88.4	87.6	89.5	11.1	113,3	12.3	120.6
Average	96.1		93.7		10.5		11.1	

From the point of view of the use of water, we note the more efficient use of the consumed water and irrigation water in the case of the MBF variant of tomato cultivation in the Husasau de Tinca solariums.

CONCLUSIONS

For the conditions of tomato cultivation in solariums, the crop ETRo determination. using ETP Th, calculated with the help of T inside or starting from T outside shows the advantage that the method is simpler, there is the possibility of measuring the daily average temperatures and easier to apply by the farmers.

ETP Th is the best method for evaluating ETo having values closer to ETo PM and it correlates better with ETP P measured inside tomato-grown solariums, than ETP BC.

Using Kc for tomatoes, determined with the help of ETP Th, can calculate dEt, which can be used, for irrigation scheduling and warning.

The cultivation of tomatoes in solariums, in the MBF variant requires watering norms of 24.5 l $m^{-2,}$ lower than the WM variant, where the watering norm is 27.5 l m^{-2}.

The annual water requirement for the hottest vegetation period, the year 2018 is 7543.2 m^3ha^{-1} in the WM version and 7262.4 m^3ha^{-1}, respectively in the MBF version.

For the same year, 25 watering norms (6875 m^3ha^{-1}) are required for WM variant and 29 watering norms (7076 m^3ha^{-1}) respectively, for MBF variant. The sources of consumed water coverage, in 2018 are mainly from irrigation water (95.6 - 97.1 %)

The coefficients WUE, ECW, IWUE and IECW show the superiority of the MBF variant, which has higher values of the water use coefficients and the efficiency of water use, compared to the WM variant.

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