CLASSICAL AND MODERN METHODS USED IN ASSESSING REFERENCE EVAPOTRANSPIRATION

Loredana COPĂCEAN, Silvica ONCIA

University of Agricultural Sciences and Veterinary Medicine of Banat „Regele Mihai I al României", Timisoara
Calea Aradului, nr. 119, Timişoara, e-mail: lorecopacean@yahoo.com

Abstract *Evapotranspiration, a phenomenon that affects and/or determines a number of processes such as pedological, climatic, hydrological, agrochemical, value is defined and determined by numerous methods and means, based on a variable number of factors, depending on the method applied. Results of the quantitative evaluation of evapotranspiration are of particular importance, given the fact that based on their follow is focused prevention or control of certain natural phenomena and / or anthropogenic. The main purpose of this study is to determine the reference evapotranspiration (ETo) by "classical" methods, but also by "modern" methods, applied using specialized software, to highlight quantitative and qualitative differences resulting from the application of the two types of methods. Also, the present paper aims to highlighting the importance of information systems in the calculation of ETo From the literature, we selected three "classical" methods for calculating the reference evapotranspiration, respectively: Thornthwaite method, Lawry-Johnson method and Ivanov method. The results will be compared with those obtained by the "computerized" FAO Penman-Monteith method, this method was applied using software CROPWAT 8.0. On the basis of the four methods of calculation, ETo was determined under the climatic conditions of the region Timisoara, different values are obtained depending on the applied calculation algorithm. Compared to conventional methods for calculating ETo, FAO Penman-Monteith method use, offers a number of advantages: increases calculation speed because it uses automatic means, reduce the calculation error, use a larger number of indicators thus increasing reliability of results, enables the graphical representation of the results. Compared with the FAO Penman-Monteith method, ETo values are generally lower when using the Ivanov method and are higher when using Lawry-Johnson method. Application Thornthwaite method provided results close to those obtained using FAO method, especially in the range from April to November - vegetation period of most crop plants. Therefore, the results of the determination reference evapotranspiration varies depending on the calculation algorithm applied and may thus to influence the subsequent analysis and estimates that this parameter is involved.*

Keywords: *calculation, method, quantity, evapotranspiration.*

INTRODUCTION

In the literature, evapotranspiration - a phenomenon that affects and/or determines a number of processes such as pedological, climatic, hydrological, agrochemical - value is defined and determined by numerous methods and means, on behalf of a variable number of factors, depending on method applied. Whichever method is used, the results of the quantitative evaluation of this phenomenon are particularly important given the fact that based on their follow focus prevention or control of certain natural phenomena and/or anthropic.

In the useful time, some classical methods used in assessing evapotranspiration are gradually "computerized" in order to increase the accuracy and speed of calculation, to reduce the error and take into account a large number of characteristic parameters.

MATERIALS AND METHODS

The main purpose of this study is to determine the reference evapotranspiration (ETo) by „classical" methods and „modern" methods, applied using specialized software, to highlight quantitative and qualitative differences resulting from the application of the two types of methods. Also, through this paper, it is intended that they emphasize the importance of information systems in calculating ETo through them is possible to apply complex algorithms, which take into account a number of factors much higher compared with conventional methods.

From the literature, we selected three "classical" methods, which is calculated the reference evapotranspiration, respectively: Thornthwaite method, Lawry-Johnson method and Ivanov method. The results of applying these methods will be compared with results of the FAO Penman-Monteith method, applied method using software CROPWAT 8.0 [5].

For this study, were taken from the Regional Meteorological Center Crişana Banat, Timisoara [4] climate data on: air temperature, rainfall, relative humidity, wind speed and duration of sunshine.

RESULTS AND DISCUSSION

Evapotranspiration, natural phenomenon that exerts influence on hydrological processes, soil, vegetation, etc., can be determined by several methods, which take into account different indicators (temperature, precipitation, vapor pressure, humidity, etc.), these methods are chosen according to the purpose.

In this study, for calculation of the reference evapotranspiration (ETo) were used three calculation methods set out in the literature, such as:

a. Thornthwaite method, using the air temperature of the climate element, so ETo was determined according to the relation (1), taken from GRUMEZA N., ET AL, 1988:

$$ETP = 1.6 \times (\frac{10 \times t}{I})^{a} \times K \quad (1)$$

where: ETP - potential evapotranspiration or reference evapotranspiration (mm); t - average temperature of the month for which is calculated ETP (°C); a - empirical coefficient determined by relation (2):

$$a = 0.000000675 \times I^3\_ 0.0000771 \times I^2 + 0.01792 \times I + 0.49239 \quad (2)$$

K - coefficient of brightness corresponding geographic position (latitude) of study area; I - thermal index of the study area, the sum of the 12 monthly indices (i), calculated by the relation (3), relation extracted from GRUMEZA N., ET AL, 1988:

$$i = (\frac{tn}{5})^{1.514} \quad (3)$$

tn - normal monthly average temperature (°C).

b. Lawry-Johnson method, which takes into account also the average monthly air temperature, according to the relation (4), relation taken from ONCIA SILVICA, 1998:

$$E = 45 \times t \quad (4)$$

where: E - potential evapotranspiration (mm); t - average monthly air temperature (°C).

c. Ivanov method, by which potential evapotranspiration is calculated based on the average air temperature and humidity, according to the relation (5), relation taken from ONCIA SILVICA, 1998:

$$E = 0.0018([25 + t])^2(100 - a) \quad (5)$$

where: E - potential evapotranspiration (mm); t - air temperature (°C); a - relative humidity (%).

Based on the three methods of calculation described above was determined ETo under the climatic conditions of the region Timisoara.

ETo has different values depending on the calculation algorithm applied (Table 1).

Table 1

ETo (mm/month) in the region Timisoara in 2012

Months	**Metodh of determination**		
	Thornthwaite method	Lawry-Johnson method	Ivanov method
1	1,21	3.15	15.46
2	-	-23.9	11.18
3	26,88	31.5	77.41
4	65,40	59.4	86.68
5	102,86	77.4	96.17
6	146,24	102.2	155.60
7	169,88	113.9	191.30
8	141,68	104.9	193.20
9	96,41	86.85	134.20
10	48,34	54	46.82
11	24,57	36	29.40
12	1,21	-0.9	9.96
Monthly average	-	-	**1047,38**

Scientific and technical progress made in recent decades has left its mark on the means and methods of measuring evapotranspiration. Thus were created specialized software which can be calculated using various parameters, including the ETo. One such software is CropWat 8.0 [5], developed by FAO and used mainly in agriculture, in calculating the water requirement for crops, as well as setting irrigation schemes.

FAO Penman-Monteith method, used to estimate ETo, applied using CROPWAT 8.0 software, is based on several parameters, synthesized in the relation below [3]:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad (6)$$

where: ETo - reference evapotranspiration (mm), Rn - net radiation at the crop surface (MJ/m^2/day), G - ground heat flux density (MJ m^{-2} day^{-1}), T - average temperature air (°C), u_2 - monthly average wind speed (m s^{-1}), es - saturation vapor pressure (kPa), it - the actual vapor pressure (kPa), es - it - vapor pressure deficit saturation (kPa), Δ - curve slope of the vapor pressure (kPa °C^{-1}), γ - constant psychrometers (kPa °C^{-1}).

Compared to traditional calculation methods, the "automatic" FAO Penman-Monteith method have at least three major advantages:

- reference evapotranspiration is determined taking into account a larger number of factors involved in the production of this phenomenon (relation 6)
- reducing or even eliminating human error which may occur following the introduction of data and manual calculations
- increasing the accuracy and speed of calculation.

To perform a comparative analysis of results obtained by the two methods, ie by classical methods and by FAO method to determine the ETo, were used the same sets of data from the meteorological station of Timisoara, for 2012.

FAO Penman-Monteith method used to determine the ETo, four meteorological parameters respectively: average monthly temperature (°C), relative humidity (%), average wind speed (m/s) and duration of sunshine (hours) - is brought average daily recorded in that month (Figure 1). On the basis of these data, using equation (6), is calculated the average radiation (MJ/m^2/day) and the reference evapotranspiration (mm/month).

Country: Romania Station: Timisoara

Altitude: 86 m. Latitude: 45.46 °N Longitude: 21.15 °E

Month	Avg Temp	Humidity	Wind	Sun	Rad	ETo
	°C	%	m/s	hours	MJ/m²/day	mm/month
January	0.7	87	2.1	3.0	5.0	13.24
February	-5.3	84	1.8	4.2	7.8	11.87
March	7.0	58	2.0	7.4	14.1	54.22
April	13.2	67	2.0	6.5	16.3	77.79
May	17.2	70	1.9	7.0	19.1	103.26
June	22.7	62	1.8	9.7	23.5	143.53
July	25.3	58	2.0	9.7	23.0	165.72
August	23.3	54	1.7	9.9	21.4	146.44
September	19.3	62	1.7	7.3	15.1	94.98
October	12.0	81	1.7	4.9	9.3	42.99
November	8.0	85	1.6	3.3	5.6	21.99
December	-0.2	91	1.8	1.9	3.7	9.80
Average	11.9	72	1.8	6.2	13.7	885.83

Figure 1 Reference evapotranspiration in 2012 determined by CropWat 8.0 software

To seize the qualitative and quantitative differences between the results obtained by applying the four methods for determining the ETo, these results are presented comparatively in Figure 2.

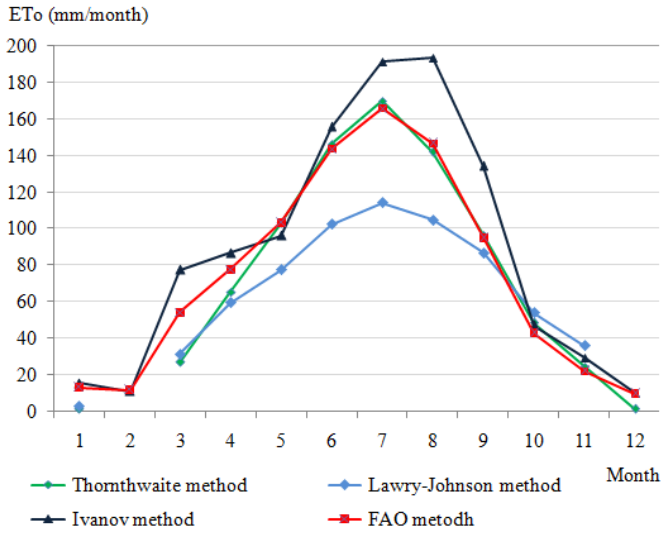
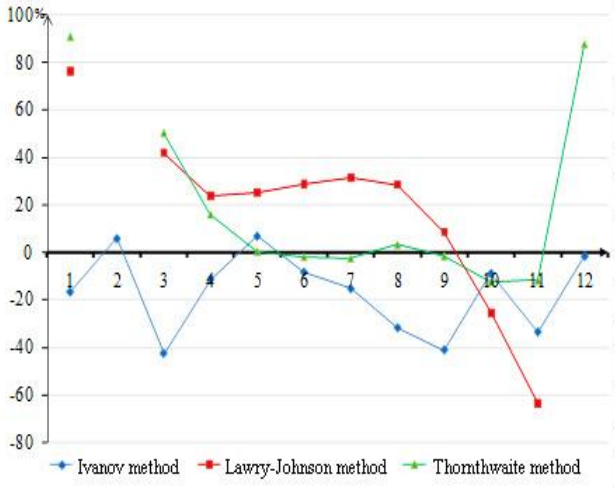


Figure 2 Reference evapotranspiration in the region Timisoara calculated by different methods

Analysis of Figure 2 highlights the following:

- depending on the method applied, we obtained different values ETo, differences are more pronounced between March to October
- regardless of the calculation method applied, ETo values are maximum in summer, consistent with the values of temperature also high
- in the trajectory followed by ETo values in the year 2012, no significant difference is detected according to the method of calculating the threshold regardless of where they are situated: values increase from February, recorded maximum in summer, fall sharply at the end of this season and shows a slight decrease during autumn - winter.

Compared FAO Penman-Monteith method, ETo values determined by the three classical methods deviations positive or negative, depending on the formula and period, a situation illustrated in Figure 3.



Months	Ivanov method	Lawry-Johnson method	Thornthwaite method
1	-16.76	76.21	90.86
2	5.81	-	-
3	-42.77	41.91	50.42
4	-11.43	23.64	15.93
5	6.86	25.04	0.38
6	-8.41	28.79	-1.88
7	-15.43	31.26	-2.51
8	-31.93	28.36	3.25
9	-41.29	8.55	-1.51
10	-8.91	-25.61	-12.44
11	-33.69	-63.71	-11.73
12	-1.63	-	87.65

Figure 3 Deviations from the FAO Penman-Monteith method (%)

The data presented in Figure 3 shows that:

- Ivanov method, except for the months of February and May, ETo values obtained are lower than those determined by the FAO method, the largest differences being in March and September (lower values by approx. 40%)
- Lawry-Johnson method, the values obtained are much higher than those calculated by the method of FAO, with the exception of October (-25.61%) and November (-63.71%), the most prominent being noticed positive differences in January (+ 76.21%)
- application Thornthwaite method provided results similar to those obtained using FAO method, except for January (+90.86%), March (+50.42%) and December (+87.65%); during April - November between results of the two methods are not significant differences.

So, based on the above it can be stated that the results obtained in determining reference evapotranspiration varies by calculation algorithm applied and thus can influence further analyzes and estimates, which involve this parameter.

CONCLUSION

Depending on the method applied, in the year 2012 in Timisoara area, were obtained different values ETo. These quantitative differences may influence the results subsequently obtained if calculations include values of this parameter.

Compared to conventional methods for calculating ETo, FAO Penman-Monteith method is used, applied with CropWat software, offers a number of advantages among which may be mentioned the following:

- enhances computing speed, using automated means
- reduce the calculation error
- using a larger number of indicators, thus increasing reliability of results

- enables the graphical representation of the results.

Compared with the FAO Penman-Monteith method, ETo values are generally lower when using the Ivanov method and higher when using Lawry-Johnson method.

These quantitative differences may influence the results subsequently obtained and calculations involving this parameter, which can have unwanted consequences in terms of prevention and control of certain natural phenomena and/or anthropic.

Application Thornthwaite method provided results similar to those obtained using FAO method, especially in the range from April to November - the vegetation period of most crop plants - when ETo values are the highest.

BIBLIOGRAPHY

[1] GRUMEZA N., şi colab, *Consumul de apă al plantelor cu aplicaţii în proiectarea şi exloatarea amenajărilor de irigaţii,* Redacţia de propagandă tehnică agricolă, Bucureşti, 1988

[2] ONCIA SILVICA, *Cercetări cu privire la consumul de apă al principalelor culturi irigate în condiţiile Câmpiei Banatului*, Teză de doctorat, Timişoara, 1998

[3] ••• *Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage*, paper 56, ISBN 92-5-104219-5, on-line at: http://www.fao.org/docrep/x0490e/x0490e06.htm#chapter%202%20%20%20fao%20penman%20monteith%20equation

[4] ••• Arhiva Centrului Regional de Meteorologie Banat-Crişana, Timişoara

[5] ••• http://cropwat.software.informer.com/8.0/