MEASURING WATER CONSUMPTION IN GRAIN MAIZE THROUGH INDIRECT METHODS IN THE CONDITIONS OF SANNICOLAU MARE, TIMIS COUNTY, ROMANIA

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Abstract. *Water consumption in plants is the amount of water used by the plants in the process of transpiration and the amount of water evaporated at soil level. This is a both productive water consumption represented by the volume of water absorbed by the roots and a non-productive water consumption resulted from the amount of water lost through evaporation at soil level. To evaluate water demands in agricultural crops, they are represented as potential evapotranspiration that represents field perennial grass-covered soil water consumption. Optimal real evapotranspiration is the water consumed by cultivated plants allowing crops economically effective. Grain maize has a specific moderate water consumption but, given the long vegetation period, it is rather high. Maximum water demands in grain maize are during blooming and grain filling. We calculated monthly and yearly potential evapotranspiration and established hydro-climate and curve balance for the studied years; we also characterised them climatically by comparing monthly and yearly temperatures and precipitation with zonal ones. We also determined water consumption in grain maize at Sânnicolau-Mare (Timiş County, Romania) in the years 2013 and 2014 through indirect methods – the Thornthwaite method (the most common in the conditions of our country); the Lawry Jonson (an extremely quick method) and the Blaney-Cridle method. We could see, after analysing water consumption in grain maize, that, in the year 2013, total water consumption was the highest, ranging between 7990 m^3/ha and 5130 m^3/ha. In the year 2014, total water consumption was lower, ranging between 7820 m^3/ha and 4935 m^3/ha. The highest monthly water consumptions were in June, July and August in both studied years. In the same months, the necessary water supplied through irrigations ranged between 1790 m^3/ha and 200 m^3/ha in July and May, respectively. In the year 2014, water demand was lower than in the year 2013: 2580 m^3/ha during vegetation and higher in August, 1170 m^3/ha. The highest water consumption in grain maize was determined using the Balney-Cridle method, and the lowest one was determined using the Lawry-Jonson method. Therefore, we can draw the conclusion that we need to supplement through irrigations the necessary water in grain maize because it is not supplied by precipitations.*

Keywords: *grain maize, evapotranspiration, total water consumption, monthly water consumption, mean daily water consumption*

INTRODUCTION

Soil water consumption in plants is the amount of water lost through both soil surface evaporation and plant transpiration. In establishing water consumption, it is important to ensure optima plant development to get both economically and qualitatively optimal yields. [1],[5] ,[6]

The need to irrigate crops is established depending on soil water consumption and precipitations; therefore, irrigation is necessary when water consumption in crops is higher than useful water from precipitations.[4],[2]

In crops, optimal real evapotranspiration is the water consumption that ensures economically optimal crops.[1],[3]

Grain maize is one of the most common crops irrigated in Romania: though it has a moderate water consumption, due to its long vegetation period, it has a high water consumption rate.[2]

MATERIAL AND METHODS

In this paper, we analyse the following parameters:

- Mean monthly and annual temperature rates and their evolution during the period analysed, with differences to multiannual means;
- Annual precipitation and precipitation rates during vegetation in Sânnicolau Mare, Timiş County, Romania, with their evolution and differences to multiannual means;
- Monthly, annual and vegetation period evapotranspiration rates calculated with the Thornthwaite formula;
- Annual and vegetation period hydro-climate balance rates.

Potential evapotranspiration was calculated with the Thornthwaite method (1948) based on air mean temperature with the formula[2]:

$$ETP = 16\left(\frac{10 \cdot tn}{I}\right)^{a} \cdot K$$

where:

ETP – monthly potential evapotranspiration (mm);

tn – monthly mean temperature (°C);

I – area thermal index (sum of monthly thermal indices);

$$I = \sum_{n=1}^{12} i_n$$

$$i_n = \left(\frac{t_n}{5}\right)^{1,514}$$

a = exponent depending on I;

$a = 0.0000006751\ I^3 - 0.00007711\ I^2 + 0.0179211\ I + 0.49239.$

I_n = monthly thermal index (Oncia, 2009).

To characterise the climate synthetically, we used **hydro climate balance** = Precipitations – Potential evapotranspiration.[7]

Optimal real evapotranspiration or a crop's water consumption allows economically effective crops; it is calculated with the formula [4]:

$$ERO = Kp \times ETP$$

where:

- Kp – the coefficient characteristic to a crop and soil and climate area;

- ETP – potential evapotranspiration calculated with the Thornthwaite method (m^3/ha).

The **Blaney-Cridle Method** is an indirect method of determining plant water consumption; it can be calculated with the formula [4]:

$$E = 0.254 (1.8 xt + 32) x P x K (mm)$$

where:

t – monthly mean temperature (°C);

P, K – coefficients.

The **Lawry-Johnson Method** is the best method in measuring water consumption, but the results are not accurate; it can be calculated with the formula:

$$E = 45 x t (m^3/ha)$$

where:

t – monthly mean temperature (°C).

RESULTS AND DISCUSSIONS

Analysis of monthly and annual temperatures in the two study years in Sânnicolau Mare shows that the year 2014 was the hottest, with an annual mean of 13.5°C, compared to the year 2013, when the annual mean was 12.2°C. During vegetation, the year 2013 was hotter than the year 2014, as shown in Figure 1.

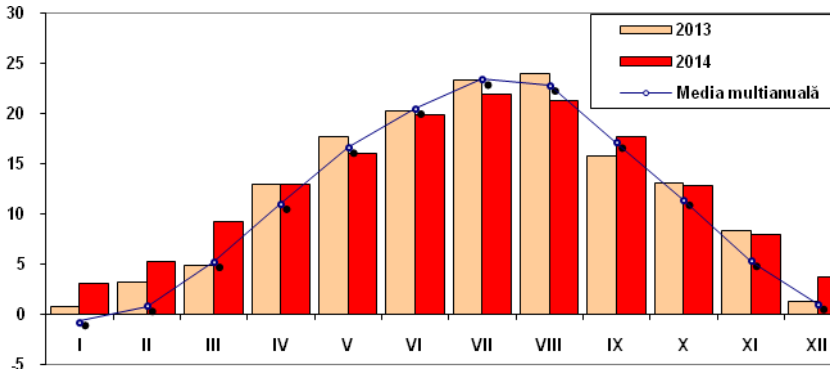

Figure 1. Monthly mean temperatures (°C) in Sânnicolau Mare (2013-2014)

From the point of view of precipitations, the year 2013 is characterised by rainfall deficit compared to multiannual means and to the year 2014, as shown in Figure 2.

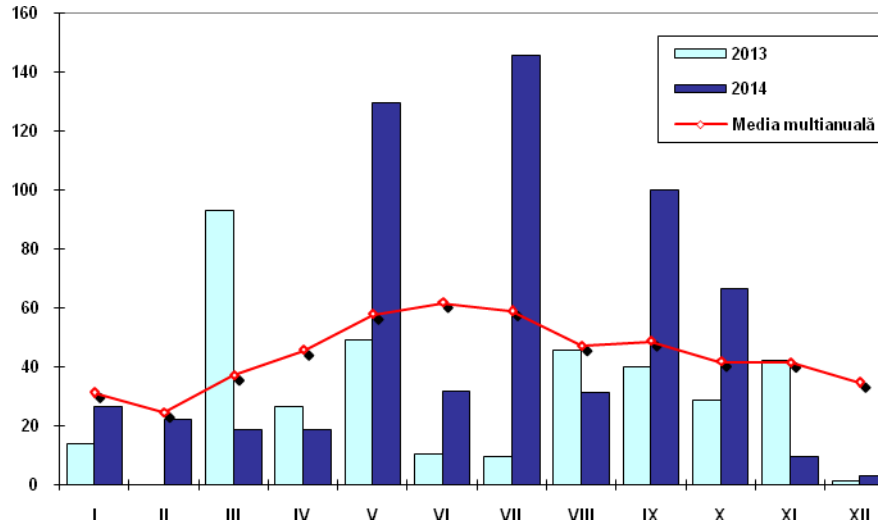

Figure 2. Monthly mean precipitations (mm) in Sânnicolau Mare (2013-2014)

Analysing Figures 3 and 4 and hydric deficits, we can see that, in the year 2013, there was a prolonged deficit of moisture from April until October. In the year 2014, however, there was no hydric deficit except for June and August (it was an exceeding hydric year, a rainy one).

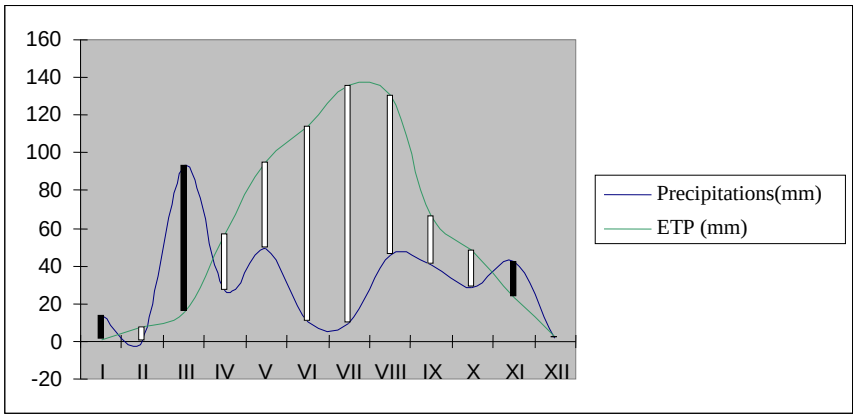

Figure 3. Hydro climate balance in Sânnicolau Mare (2013)

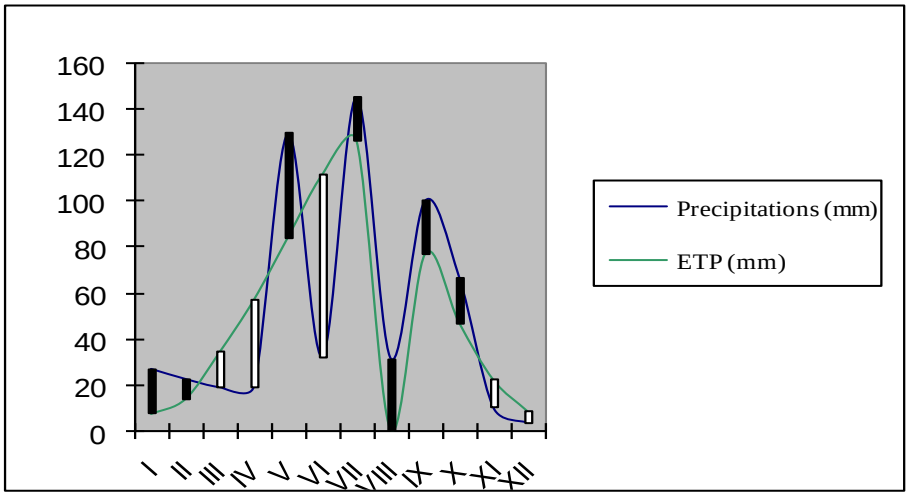

Figure 4. Hydro climate balance in Sânnicolau Mare (2014)

The values of water consumption are different and they depend on the area, on the climate conditions in the experimental years, on temperatures, on precipitations, on the soil, and on the method used to determine them.[1],[2]

Based on research conducted in the literature, the average daily consumption on corn crop varies between 17-57m^3/ha in the forest steppe zone, with a total consumption of 6246m^3 / ha and reaches a maximum daily average for July of 62m^3 / ha in the moderate steppe area, ie a total consumption of 6676m^3 / ha.[1]

In this paper, water consumption was determined through indirect methods using calculus formulas and the methods Thornthwaite, Blaney-Cridle and Lawry-Johnson.

The Thornthwaite Method is a reference method for the calculus of water consumption through indirect methods and a standard for direct calculus methods for the conditions of Romania.

Results show monthly, total water consumption and monthly and daily mean values.

Tables and figures below show that the highest water consumptions in grain maize were determined with the Blaney-Cridle Method, while the lowest ones were determined through the Lawry-Johnson Method.

Total mean water consumption calculated with the three methods was 6578 m^3/ha in the year 2013 and 6344 m^3/ha in the year 2014, as shown in Figures 5-8.

The highest monthly and daily water consumptions were in June-August in both experimental years, with maximum values in July ranging between 1549 m^3/ha and 1315 m^3/ha.

Daily mean water consumption was maximal in the year 2013, in July (50 m^3/ha/day), and in the year 2014 (47 m^3/ha/day).

The lowest daily mean values were in April 2013 and September 2014, ranging between 23 and 31 m^3/ha/day.

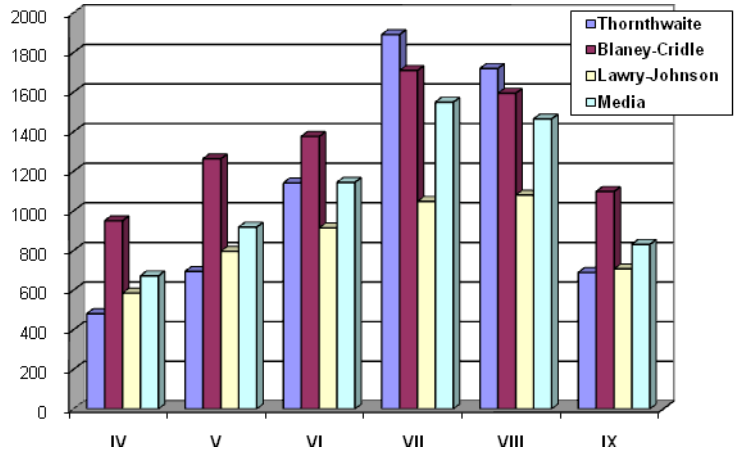

Figure 5. Monthly mean water consumption (m^3/ha) in grain maize in Sânnicolau Mare (2013)

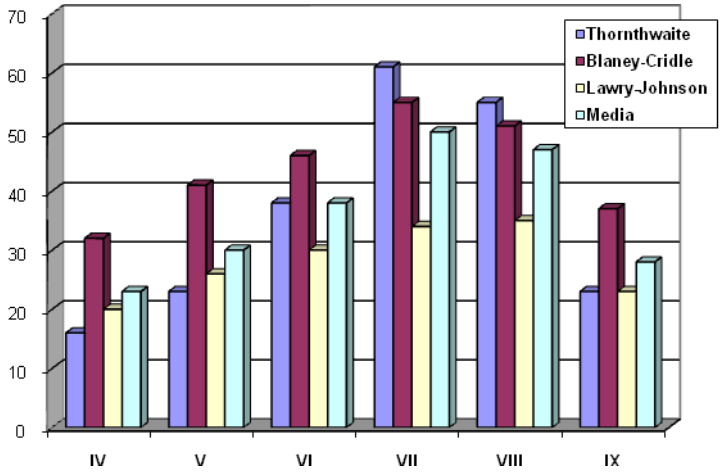

Figure 6. Daily mean water consumption (m^3/ha/day) in grain maize in Sânnicolau Mare (2013)

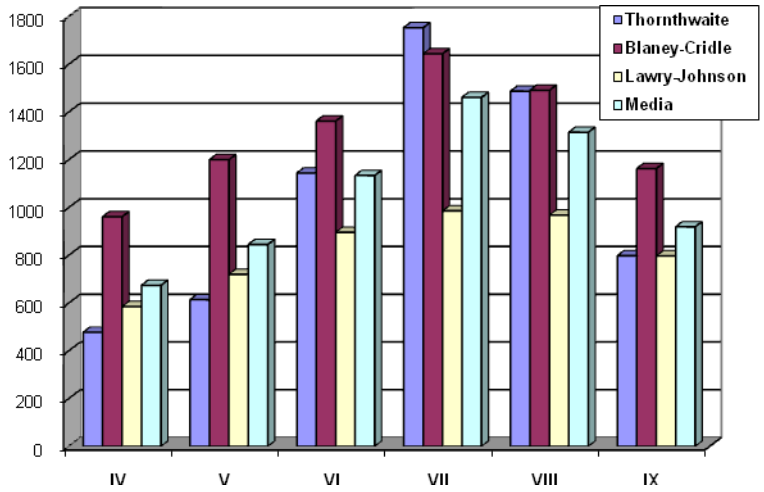

Figure 7. Monthly mean water consumption (m^3/ha) in grain maize in Sânnicolau Mare (2014)

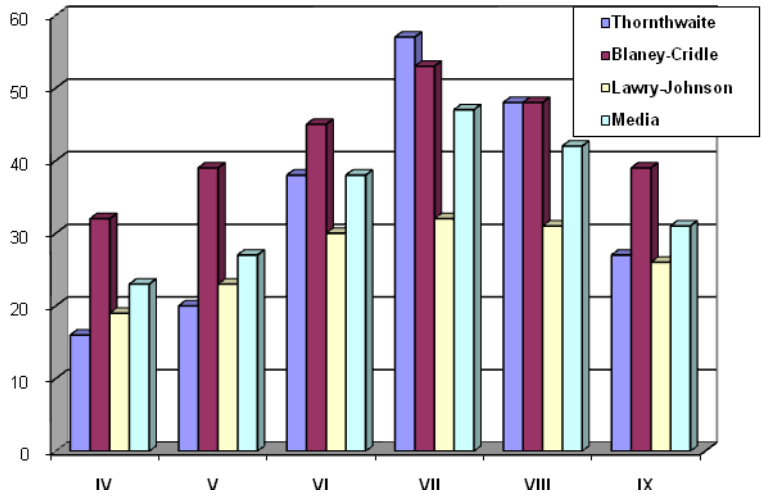

Figure 8. Daily mean water consumption (m^3/ha/day) in grain maize in Sânnicolau Mare (2014)

Table 1 shows that, in the year 2013, grain maize in Sânnicolau Mare benefited from only 27.5% water from precipitations, the rest of 4780 m^3/ha being ensured by irrigations.

In the year 2014, the necessary water in grain maize was covered 73% from precipitations because it was a rainy year. In the year 2014, they needed 2580 m^3/ha to supplement the necessary water.

Table 1

Precipitation water (mm) in grain maize in Sânnicolau Mare (2013-2014)

Months	PP (mm)	ETRO consumption (mm)	Precipitation coverage (%)	Necessary water (mm)
Grain maize 2013				
IV	26,6	48,1	55,3	21
V	49,4	69,4	71,2	20
VI	10,6	114,1	9,3	103
VII	9,8	189,0	5,2	179
VIII	45,6	171,9	26,5	126
IX	40,2	68,9	58,3	29
Sum	182,2	661,7	27,5	**478**
Grain maize 2014				
IV	18,8	47,7	39,4	29
V	129,6	61,4	211	-
VI	32,0	114,4	27,9	82
VII	145,6	175,3	83,0	30
VIII	31,2	148,7	20,9	117
IX	100,2	79,8	125,6	-
Sum	457,4	627,4	72,9	**258**

CONCLUSIONS

- After analysing the thermal regime of the years 2013-2014 in Sânnicolau Mare, Timiș County, Romania, we can see that the year 2014 was the hottest, with a mean annual temperature of 13.5°C, followed by the year 2013, with a mean annual temperature of 12.2°C (the normal temperature of the area is (11°C)
- From the point of view of precipitations, the year 2014 had excess rainfall, like the year 2013: in both years, the annual sum of precipitations was higher than the normal one;
- The highest hydric deficits were in the year 2013 (335 mm) over a long period (April-October), while in the year 2014, the hydric deficit was very low (94.96 mm) only in July-August;
- The highest total water consumption was in the year 2013, with the highest values calculated using the Blaney-Cridle Method, while the lowest values were calculated with the Lawry-Johnson Method, with values ranging between 6578 m^3/ha and 6344 m^3/ha;
- In the year 2013, water consumption in grain maize in Sânnicolau Mare consisted on only 27% water from precipitations and they needed to cover 4780 m^3 of water from irrigations, while in the year 2014 the necessary water came 75% from precipitations.

BIBLIOGRAPHY

BIOLAN I., SERBU I., TUSA C.G., MARDARE FLORICA, 2016, Irigarea Culturilor agricole- tehnologii, Ed. AGIR, Bucuresti;

FAZAKAS P., IENCIU ANISOARA, 2006, Irigarea Culturilor, Ed. Eurobit, Timisoara;

IENCIU ANISOARA, ONCIA SILVICA, PEPTAN CARMEN, FAZAKAS PAL**,** 2010, Assesing drought risk in Timisoara during the last decade, Research Journal of Agricultural Science, Timisoara;

SAVU P., BUCUR D., JITAREANU S.I., 2005, Imbunatatiri funciare si Irigarea Culturilor- Lucrari practice, Ed. I.Ionescu de la Brad, Iasi;

ŞMULEAC LAURA, 2010, The study of potential evapotranspiration in the Banat plain in 1897- 2011, Research Journal of Agricultural Science (ISSN 2066-1843, vol.42 (3)1-908, Timisoara;

ŞMULEAC LAURA, SIMONA NIȚĂ, ANIȘOARA IENCIU, ADRIAN ŞMULEAC, DICU DANIEL - Topographic survey for the monitoring of the impact of the Brua/Rohuat pipe on water flow in the irrigation system at Fântânele, Arad County, Romania, SGEM2016 Conference Proceedings, ISBN 978-619-7105-81-0 / ISSN 1314-2704, 2 - 5 November, 2016, Book 3 Vol. 3, 333-340, 2016

MAN T.E., SABĂU N.C., CÎMPAN GABRIELA, BODOG MARINELA, 2010, Hidroameliorații, Vol I şi II, Editura Aprilia PRINT Timişoara, pg. 497;