DETERMINATION OF WATER CONSUMPTION FOR WINTER WHEAT IN SOUTHERN ROMANIA. CASE STUDY: CARACAL PLAIN, AGRICULTURAL YEAR 2017-2018

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Abstract: The main purpose of this study is to analyse the water requirements for the winter wheat crop in relation to the annual precipitation regime. The analysis is performed for the Caracal Plain, a division of the Romanian Plain. The Cropwat 8.0 software was used in order to determine the water requirements. This study uses the series of daily climate data from the Caracal meteorological station (MS), for the agricultural year 2017-2018. The analyzed output data are: the crop evapotranspiration, the effective precipitation and irrigation requirements. The results of the analysis show that although the agricultural year is a rainy year, it is necessary to complete the soil moisture deficit in the months when the optimal precipitation requirements for the winter wheat is not ensured.

Keywords: water consumption, winter wheat, Cropwat 8.0 software, Caracal Plain.

Introduction

The winter wheat, both due to its socio-economic value and to its extensive crop areas, is the most important agricultural commodity in Romania. The winter wheat is more productive than the spring wheat in Romania and that is why it occupies 99% of the total arable land (Roman and Epure, 2013). The main climatic factors with an important role in the growth, development and productivity of the winter wheat are: the temperature, the precipitation and the light (Povară, 2000). Precipitation is the main natural source of water supply for the soil, and consequently, the water consumption of the crop becomes a very important element for the establishment and correct application of any irrigation scheme. The water resources offered by the continental temperate climate of Romania to the winter wheat are generally favorable, in most crop areas and throughout the growing season (Povară, 2000). However, the variability of the monthly and annual precipitation amounts and their uneven distribution in time and space determine the water risk situations with serious effects on the vegetation and yields in agriculture. Thus, measures are needed to prevent and reduce these effects, regardless of the crop situation, in non-irrigated or irrigated regime (Mateescu, 2004).

The purpose of this study is to analyze the water requirements, according to the annual regime of monthly precipitation, for the winter wheat crop, at the level of the agricultural year 2017-2018, in the area of the Caracal Plain.

The study area is part of the Romanian Plain, the most important agricultural region of Romania. The Caracal Plain is located in the Southern Romania, being a subdivision of the Romanați Plain, which is characterized by a homogeneous landscape, altitudes between 45-190 m and fertile chernozems with high bioenergetic potential and good production capacity (Constantin and Vătămanu, 2015). The

study area represents 7% of the surface of the Romanian Plain (Institutul de Geografie, 2005) (Figure 1).

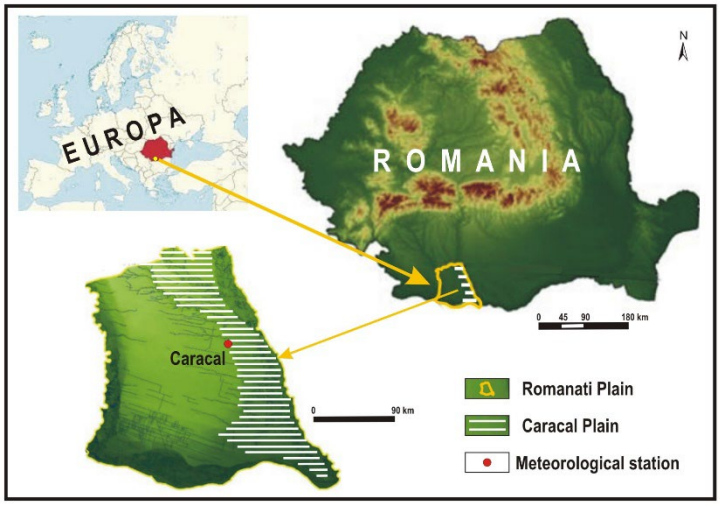

figure 1. The location of the study area and the meteorological station in Romania.

1. Data and methods

In order to determine the water requirements, the Cropwat 8.0 software, developed by the FAO's Land and Water Development Division for irrigation planning and management has been used. All the information regarding the calculation and the method used by this software are described over the papers published by FAO, namely *No. 33* "*Yield response to water*" (Doorenbos and Kassam, 1979) and *No. 56* "*Crop Evapotranspiration – Guidelines for computing crop water requirements*" (Allen *et al.*, 1989). In Romania, the model was applied by Stăncălie *et al.* (2010) and Stan *et al*. (2014 and 2017) for estimating the evapotranspiration for different agricultural crops (maize, peas).

The daily climate input data for the Cropwat 8.0 software comes from the Caracal meteorological station (MS), which belongs to the National Meteorological Administration (NMA), for the agricultural year 01.09.2017-31.08.2018. The meteorological-climatic parameters used are the maximum and minimum air temperature, the relative humidity, the duration of sunshine, the precipitation and wind speed for the period 01.09.2017-31.08.2018. To these climatic data are added the phenological data of the winter wheat and the pedospheric characteristics of the study area (Table 1).

Table 1. The planting and harvesting dates for winter wheat and the Cropwat soil input data in Caracal Plain, for the agricultural year 2017-2018.

Planting date	Harvesting date	Soil texture	Total available soil moisture (mm/m)	Rooting depth (cm)	Initial available soil moisture (mm/m)
05.X.2017	01.VII.2018	sandy loam	240.0	40	168.0

An important result of this software is the crop water requirements (CWR) defined as the amount of water needed in order to compensate the amount of water lost by plants through evapotranspiration (ETc.), from planting to harvesting, depending on the specific climate of the region where they are grown (Steduto *et al.*, 2012). The parameters resulted and analyzed after running the Cropwat 8.0 software, for CWR are: the crop evapotranspiration – ETc. (mm); the effective rain which represents the amount of water that enters into soil – Eff. rain (mm) and the irrigation requirements – Irr. req. (mm).

2. Results and discussions

The study area, for the analyzed agricultural year, was characterized by an annual average air temperature of 12.7°C and an annual amount of precipitation of 712.2 mm. In the multiannual regime (1901-1990), the Caracal MS is characterized by an annual temperature of 10.9°C and an annual amount of precipitation of 541.7 mm (Constantin et al, 2018). Over the months of the agriculture year 2017-2018, the air temperature and precipitation values ranged from 1.0°C in January and February to 24.6°C in August and from 8.4 mm in April to 128.0 mm in June, respectively (figure 2). Small precipitation amounts, below 40 mm, were recorded in the study area in September, January, May and August (figure 2).

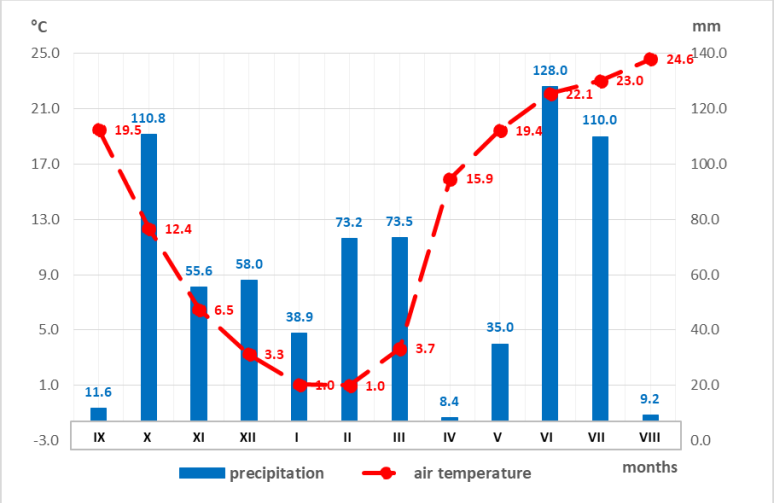

figure 2. The annual regime of the monthly averages of air temperature and of the monthly precipitation amounts at the Caracal meteorological station, for the agricultural year 2017-2018 (Source: NMA archive for temperature and precipitation values).

In Romania, according to the latest experimental results, the precipitation amounts, exemplified in figure 3, are estimated to be optimal for the winter wheat (Sandu et al., 2010). The critical period, for the winter wheat, in terms of water requirements, is the monthly interval May-June.

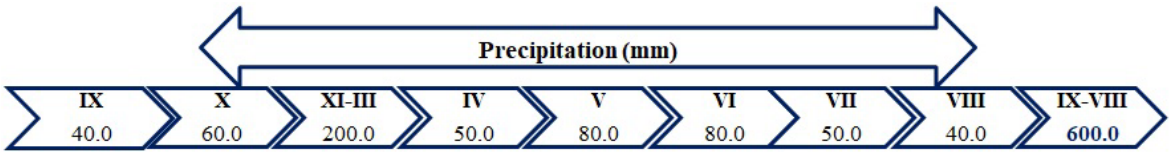

figure 3. The optimal requirement of the winter wheat for the precipitation (mm) – reference thresholds (Source: after Sandu et al., 2010).

Correlating the information in figures 2 and 3, the great fluctuation of the precipitation quantities from one month to another is highlighted, thus, some months being with precipitation deficit, while others being with surplus of precipitation, during the same agricultural year. This variability in precipitation is a limiting factor, acting as a risk factor for the crop.

The results obtained with the Cropwat software for the crop evapotranspiration (ETc.) oscillate for the study area between 1.1 mm for the first decade of July, due to the harvest of winter wheat on 01.07.2018, to 137.9 mm in May, a month with precipitation deficit (Table 2). ETc is dependent on both the climatic and the pedological conditions of the study area.

The model has also calculated the effective rain (Eff. rain) which records values between 3.4 mm in July and 101.7 mm in June (Table 2). This parameter is dependent on the amount and intensity of precipitation, but also on the phenological phase of the agricultural crop. Also, the higher the value of

this parameter is, the lower the irrigation requirements are (Irr. req.) For the winter wheat, Irr. req. varies between 0.0 mm for the monthly interval October-February to 104.8 mm in May, one of the months with the highest water consumption for this crop (Table 2).

Table 2. Cropwat results regarding crop evapotranspiration (ETc.), effective rain (Eff. rain) and irrigation requirements (Irr. req.) in Caracal Plain, for the agricultural year 2017-2018 (Source: Cropwat 8.0 software).

MS	Data Output	X	XI	XII	I	II	III	IV	V	VI	VII	Total
Caracal	ETc. (mm)	12.9	5.6	3.5	6.8	12.6	39.6	96.9	137.9	81.9	1.1	398.8
	Eff. rain (mm)	81.0	50.8	52.5	36.6	64.5	64.8	8.4	33.2	101.7	3.4	496.9
	Irr. req. (mm)	0.0	0.0	0.0	0.0	0.0	1.2	88.5	104.8	11	1.1	206.6
meaning of colors		minimum value					maximum value					

Analyzing the results at the development stage scale, one may observe that the precipitations have a good distribution especially in the initial and development stage, when the Etc. values do not exceed 10-20 mm/decade. With the intensification of the ETc. in the middle and late stage (values of over 40-50 mm/decade), the water demand increases direct proportion, so the Irr. req. has values between 30-40 mm/decade (figure 4). It can also be seen from figure 4, that the highest demand for crop irrigation water is in the middle stage, in April and May. May recorded the highest crop irrigation water requirements of 104.8 mm, while monthly precipitation was only 35 mm. This crop irrigation water requirement in May was distributed by decades such as: 34.9 mm (1st decade), 32.3 mm (2nd decade) and 37.6 mm (3rd decade) (figure 4).

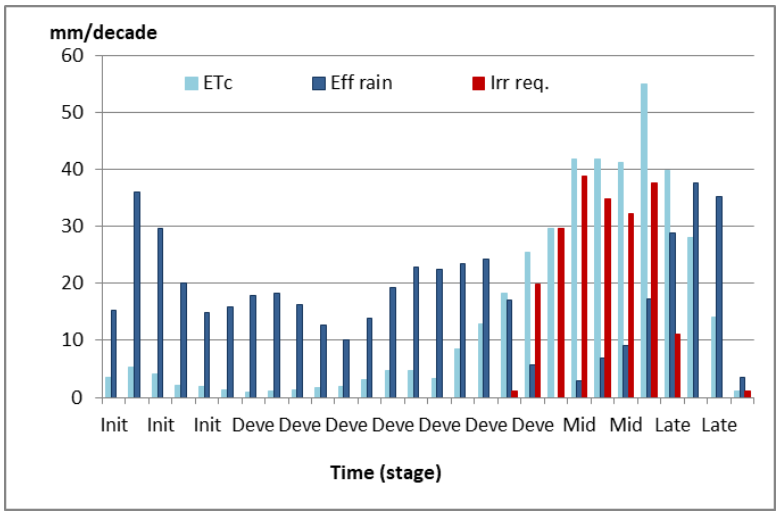

figure 4. CRW – Cropwat results regarding the crop evapotranspiration (ETc.), the effective rain (Eff. rain) and irrigation requirements (Irr. req.) at Caracal MS for the agricultural year 2017-2018 (Stages of the crop: initial – Init, development – Deve, middle – Mid and late) (Source: Cropwat 8.0 software).

Conclusions

The amount of precipitation and their distribution by months and the critical vegetation intervals are variable in time and space, compared to the optimal limits specific to each month, season or agricultural year as a whole. Significant deviations in both the negative and positive directions from the optimal limits cause unfavorable conditions for the growth and development of plants, during the vegetation. Although the water resources in the study area are generally favorable, due to the great variability of the monthly and annual amounts of precipitation, they become a limiting factor.

In the analysis of the water requirement for the winter wheat cultivation in the Caracal Plain, although the amount of rainwater for the agricultural year 2017-2018 is optimal, framing the year as rainy, the variation of the precipitation amount from one month to another determines irrigation requirements. In the climatic conditions specific to the Caracal Plain, the application of irrigation to the winter wheat, in natural conditions, for the analyzed agricultural year, is required from the last decade of March to the first decade of June.

The use of such software programs, such as Cropwat, helps to establish the irrigation norm and the moment of its application, in order to ensure a better management of irrigations, in order to optimize the yields of the agricultural crops.

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