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RATIONAL USE OF OFF-SEASON RAINFALL AND WATER CONSUMPTION IN IRRIGATED CROPS IN THE CONDITIONS ON THE UPPER BASIN OF THE RIVER PRUT

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Abstract
Water consumption of agricultural plants can be considered one of the main elements of the assessment needed for irrigation. Covering water needs during the growing season is done by applying irrigation. Quantitative studies on evapotranspiration performed on maize and sunflower crops showed different values. The average water consumption calculated according to the Thornthwaite method recorded the highest values in June, July and August. For the maize crop, the highest water consumption was reached in July (1480 m^3 / ha or 27.1% of the total consumption), during which time the pollination, the growth of the cobs and the formation of the grain take place. In sunflower cultivation, the highest consumption was recorded in July (1302 m^3 / ha or 28.2% of total consumption) and correspond to the phases of growth of the flowering head (inflorescence) and seed formation. The purpose of this paper is to establish the need for hydro-amelioration arrangements through a correct irrigation regime during the growing season following the results obtained based on water consumption in the crops studied. The present paper presents the results of water consumption in maize and sunflower crops, calculated according to the Thornthwaite method, as well as the correction coefficients for potential evapotranspiration conditions on the upper Prut river basin.

Keywords: evapotranspiration, irrigation, Thornthwaite, water consumption

1. INTRODUCTION

One of the main current problems in the operation of irrigation systems is the need to rationalize the water consumption use in this hydro-amelioration process (Sandu et al., 2010). Water consumption of agricultural plants is a major zoning element of irrigated agriculture (Păltineanu et al., 2007). At the same time it is an essential element in establishing the regime of crop irrigation (Popescu, 1978, Pereira et al, 2013). The extension of the irrigated areas in the northeastern area of Romania is a problem of rational agricultural exploitation, where the application of a correct irrigation regime has an important role (Ionescu-Sisești,1982). In the analysis of the hydrological balance, without groundwater intake, two conventional periods of the year are considered: the vegetation period (1. IV-1.X) and the cold period (1. X-1.IV). The water balance in the soil is expressed by an equation in which the quantities of water received by the soil from precipitation, groundwater and irrigation are taken into account, respectively the total water consumption represented by evapotranspiration and plant transpiration (Ceaușu et al., 1976).

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In achieving the water consumption during the vegetation period of the crops, the special importance of the value of the initial reserve is highlighted. Precipitation is noted as an element of the natural environment on which no assessments of reliable quantitative and qualitative forecast can be made. The term of "total water consumption" constitutes in irrigation conditions "the optimal real evapotranspiration" (ETRM) corresponding to obtaining large productions in the conditions of the most efficient use of water (Popescu, 1978).
Evapotranspiration from the Jijia-Prut common meadow falls between 500-600 mm / year and increases with altitude. At the same time, the values of potential evaporation recorded below 150 m altitude are specific to the meadow sector and are conditioned by the average annual air temperature. (Pantazică, 1974; Erhan, 1979; Mihăilă, 2006)

2. MATERIALS AND METHODS

In the analysis were used the results obtained in the experiments of establishing the water consumption in irrigation conditions in the experimental fields of the company SC Agralmix SA in the period 2020-2021. The experiments are located on a weak chernozem type soil - medium leached, with groundwater at depth and having a good storage capacity. The area has a rainfall regime that varies between 450-500 mm, according to the data recorded by the Andrieșeni meteorological station.
Experimental water consumption was established based on soil water balance in corn and sunflower crops. The maize crop totaled five corn hybrids : *DKC4751*, *DKC5007*, *DKC5031*, *DKC5092*, *DKC5182* and the sunflowe crop totaled three hybrids: *P64LE25*, *P64LE99*, *P64LE136*. The determination of water consumption was done by the indirect Thornthwaite method. This method was done by applying the formula for determining potential evapotranspiration (PET):

$$\mathbf{PET=160}\left(\frac{10*t}{I}\right)^{a} k_e * k_p \text{ , where:}$$

PET - potential evapotranspiration; **t** - average monthly temperature;
I - annual thermal index; **ke** - correction coefficient depending on latitude;
kp - correction coefficient depending on the plant.

Water consumption was calculated based on the temperatures recorded at the weather station installed in the experimental field and were used the correction coefficients from the literature for the forest-steppe area.

3. RESULTS AND DISCUSSIONS

Although previous experiments have been conducted out to determine water consumption, obtaining high yields is influenced by the proper application of the irrigation regime. The results obtained in the experimental cultures highlighted the need for irrigation, especially in different phenological stages. For maize cultivation, the total water consumption was 5774 m^3/ha/year. During the vegetation period, the highest consumption was registered in July, during which the following stages of growth and development take place acording to BBCH: inflorescence emergence, flowering and anthesis, development of fruit. The average daily consumption with the highest values was registered in June, July and August (Table 1).

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Table 1. Experimental water consumption in maize and sunflower crops (Andrieșeni 2020-2021)

Months and decades		Maize crop			Sunflower crop		
		m^3/ha	*% of total*	*m^3/ha/ day*	*m^3/ha*	*% of total*	*m^3/ha/ day*
IV	1	-	-	-	173	3.1	17.5
	2	-	-	-	171	3.1	
	3	193	3,3	19,3	196	3.5	19.6
	monthly	193	3.3	19.3	543	9,7	18.1
V	1	227	3.9	22.7	303	5.4	30.3
	2	127	2.2	12.7	190	3.4	19.0
	3	315	5.5	28.5	227	4.1	20.6
	monthly	669	11.6	21.3	720	12.9	23.3
VI	1	362	6.3	36.2	417	7.5	41.7
	2	513	8.9	51.3	518	9.3	51.8
	3	466	8.1	46.6	602	10.8	60.2
	monthly	1341	23.3	44.7	1538	27.6	51.3
VII	1	489	8.5	48.6	613	11.0	61.3
	2	510	8.8	51.0	459	8.2	45.9
	3	528	9.1	48.0	630	11.3	57.3
	monthly	1527	26.4	49.3	1702	30.5	54.8
VIII	1	360	6.2	36.0	450	8.1	45.0
	2	400	6.9	40.0	363	6.5	36.3
	3	585	10.1	53.1	232	4.2	21.1
	monthly	1344	23.2	43.0	1045	18.8	34.1
IX	1	283	4.9	28.3	-	-	-
	2	171	2.9	17.1	-	-	-
	3	246	4.3	24.6	-	-	-
	monthly	700	12.1	23.3	-	-	-
Annual		5774	100.0	35.4	5548	100.0	36.3

At sunflower crop the total water consumption was 5548m^3/ha/year. The highest consumption was recorded in July (1702 m^3/ha or 30.6 %of the total vegetation period, respectively 54.8 m3/ha/day) and corresponded to the phases of growth the disc of inflorescence and seed formation. High consumption was also recorded in June (1535 m3/ha), when it took place the stem elongation (*39 BBCH*) and the inflorescence emergence (*59 BBCH*). The determination of water consumption in shorter periods (decades) may better correspond to the requirements imposed on the forecast of watering, due to the dynamics of climatic factors and those of the developmental stages of phenophases that repeat cyclically.

In the maize crop, the precipitations fell in the studied period, covered approximately 51.6% of the total water consumption, the irrigation regime 26.4%, and the soil water reserve 22 %. In the sunflower crop, it is observed that the annual precipitation provides 48.2% of the total water consumption, the irrigation regime covers 30.2%, and the soil water reserve 21.6%. Following the data in table 3, it results that irrigation is necessary to complete the total water consumption, in the critical phases of the crops, by approximately 26-35%.

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Table 2. Total water consumption in the studied crops (Andrieşeni 2020-2021)

Crop	ETRM	Ar		Σm		Ri-Rf	
	m3/ha	m3/ha	% ETRM	m3/ha	% ETRM	m3/ha	% ETRM
Maize	5774	2981	51.6	1525	26.4	1268	22.0
Sunflower	5548	2675	48.2	1675	30.2	1198	21.6

Table 3. Correction coefficients of potential evapotranspiration depending on the culture, in the forest-steppe area

Crop	The months of the vegetation period					
	IV	V	VI	VII	VIII	IX
Maize	1.09	0.89	1.02	1.24	1.18	0.80
Sunflower	1.48	0.87	1.32	1.39	0.94	-

** Merculiev et al. (1970)*

Table 4. Water consumption according to the Thornthwaite method (Andrieşeni 2020-2021)

Months and decades		**Maize crop**			**Sunflower crop**		
		m^3/ha	*% of total*	*m^3/ha/ day*	*m^3/ha*	*% of total*	*m^3/ha/ day*
IV	1	142	2.6	14.2	109	10.4	10.9
	2	119	2.2	11.9	92	2.0	9.2
	3	207	3.8	20.7	143	3.1	14.3
	monthly	488	8.6	15.6	344	7.5	11.5
V	1	226	4.2	22.6	361	7.8	36.1
	2	224	4.1	22.4	376	8.1	37.6
	3	290	5.3	26.4	466	10.1	46.6
	monthly	740	13.6	23.6	1203	26.0	38.7
VI	1	331	6.1	33.1	407	8.8	40.7
	2	348	6.4	34.8	429	9.3	42.9
	3	380	7.0	38.0	466	10.1	46.6
	monthly	1059	19.5	35.3	1302	28.2	43.4
VII	1	470	8.6	47.0	373	8.1	37.3
	2	464	8.5	46.4	370	8.0	37.0
	3	546	10.0	49.6	433	9.4	39.4
	monthly	1480	27.1	47.7	1176	25.5	37.4
VIII	1	395	7.3	39.5	207	4.5	20.7
	2	370	6.8	37.0	194	4.2	19.4
	3	372	6.8	33.8	596	12.0	19.3
	monthly	1137	20.9	36.8	596	12.0	19.3
IX	1	207	3.8	2.7			
	2	183	3.4	18.3			
	3	161	3.0	16.1			
	monthly	551	10.2	18.4			
Annual		5432	100.0	29.7	4261	100.0	32.2

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Water consumption calculated as a function of temperature, according to the Thornthwaite method, highlights lower values in the peak months than in experimental consumption. The consumption differences are smaller for maize crop than for sunflower crop, the results being influenced by the calculation relationship, being considered only the temperature as a single factor, as well as the correction coefficients used for the forest-steppe area (Table 3).
The observations showed a lower evapotranspiration in conditions of higher air temperature, at a high humidity and calm atmosphere, than in conditions of lower temperature, with deficit of atmospheric humidity and the presence of wind. The use of the correction coefficients determined in the forest-steppe area, will lead to the reduction of consumption differences given by different methods, and the Thornthwaite relation can be considered one of the accepted methods by accuracy and advantageous by efficient way of determining water consumption in agricultural crops.
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4. CONCLUSIONS

An agricultural crop, during the vegetation period, consumes water through the physiological process of sweating, achieving a productive consumption of water and by evaporation at the soil surface, achieving an unproductive consumption of water. The total water consumption of an agricultural crop can be defined as the sum of productive consumption and non-productive consumption of a crop, to which is added the amount of water which is lost by infiltration into the deep layers of the soil, as well as water consumed by weeds.
Based on the knowledge of the water consumption of an agricultural crop, the need for water during the vegetation period, and the
supplementation of the necessary water during the vegetation period is made by applying irrigation.
Research conducted in the period 2020-2021 aimed at establishing water consumption for corn and sunflower crops. The two methods used: the direct method of water balance in the soil and the indirect method of Thornthwaite highlighted the fact that for both maize and sunflower the highest water consumption is during the vegetation period which corresponds to the phases of growth, flowering, and seed seeding.
Determination of water consumption by Thornthwainte method with the help of correction coefficients specific to the area can be considered an efficient method of determining water consumption, and watering forecast can be established according to the dynamics of meteorological factors as well as plant growth phenophases.

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