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CLIMATE CHANGE AND ITS IMPACT ON WATER CONSUMPTION IN THE MAIN AGRICULTURAL CROPS OF THE ROMANIAN PLAIN AND DOBROGEA

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Abstract

Drought is the limiting factor that manifests itself on the largest agricultural area.The agricultural areas most vulnerable to soil water scarcity are those of Dobrogea, the south of the Romanian plain, the south-east and east of Moldova, as well as the west of the Tisei Plain. The purpose of the research was to calculate the moisture deficit and the need for water for irrigation based on climate scenarios made with different global climate models, as well as determining the water consumption of irrigated crops according to the expected climate change in the Romanian climate regime. In order to predict the effects of climate change, it was followed in the areas served by Constanta and Tecuci weather stations the modification of the elements of the irrigation regime in case of possible increases in average temperatures by 2^0C respectively 5^0C. The management of irrigation water in a given area was established according to the estimated moisture deficit as the difference between water consumption and useful rainfall during the growing season of crops.

***Key words**: limited water supplying, watering rate, irrigation norm, water consumption.*

INTRODUCTION

The global climate is undergoing dramatic and irreversible changes. Climate change will also lead to variability in agricultural production, increasing extreme weather events such as heat waves, droughts, and heavy rainfall. Limiting dangerous climate change requires huge reductions in emissions, as well as the use of alternatives to fossil fuels world-wide (Dragotă et al., 2019). It is estimated that human activities can cause a rise of global temperature by 1ºC above pre-industrial levels, with a likely range of 0.8ºC to 1.2ºC (Huppmann et al., 2018). Global warming will likely reach 1.5 ºC between 2023 and 2052 if it continues to rise at the same intensity. Analysing the long-term warming trend of the pre-industrial period, the observed global average temperature for the decade 2006-2015 was 0.87ºC (IPCC Press Release, 2018). The negative impact on the economy, health, nature, agriculture and population varies across Europe, depending on the region and territory (European Environment Agency EEA, 2014). The agricultural sector contributes approximately 10% to the total anthropogenic greenhouse gas emissions in the EU-27 (EEA, 2010). Crop production varies each year, being heavily influenced by fluctuations in climatic conditions and by extreme meteorological events (Wheeler et al., 2013).
Climate variability influences all sectors of the economy, but agriculture remains the most vulnerable, and its impact is more acute at present, because climate change and variability is becoming more and more pronounced (Chitu et al., 2015). In Romania, the effect of climate change is felt, and these will be manifested by increasing temperatures, changing the rainfall regime, melting ice and snow, and raising sea levels.
Extreme weather phenomena leading to negative environmental impacts (floods and droughts) will become more frequent and intense in many regions (Rummukainen, 2012). Effects on ecosystems, economic sectors, population health, and vulnerability vary from region to region (Daniel et al., 2019). Due to climate change, production will be significantly

reduced unless action is taken accordingly. The important role belongs to breeders to create varieties and hybrids with a low consumption of evapotranspiration (IPCC Press Release, 2018). The climatic changes have increased the growth of weeds, insect pests and diseases in many geographic areas, and increased problems for sustainable agriculture (Bojariu et al., 2015). Agronomic approaches such as adjusting sowing dates, nutrient management, water management, use of plant hormones and osmoprotectors, should be applied significantly to mitigate the negative effect of climatic parameters (Mustafa et al., 2023). The impact of climate change on yields of main crops in the world is expected to be negative (Roudier et al., 2011) while the exact impact remains highly uncertain when elevated temperatures, higher atmospheric CO_2 and changed rainfall occur simultaneously (Roudier et al., 2011). If specific action is not taken and people continue to consume current levels of fossil fuels (e.g. oil and coal), the average temperature of the Earth will rise by 2ºC to 6.4ºC by the end of the 21st century (IPCC Press Release, 2018).The average global temperature has increased by 0.74ºC over the past 100 years (1906-2005) (Korean Meteorological Agency, 2008; Rasul et al., 2012; Abbas et al., 2017; Bokhari et al., 2017).

MATERIALS AND METHODS

The objective of the research paper was to calculate the moisture deficit, the need for water for irrigation, as well as the water consumption of maize based on climate scenarios. To achieve this objectives, three possible climatic scenarios were established namely:

1. Tn - current average temperatures;
2. Tn +2ºC - increasing of current average temperatures with 2ºC;
3. Tn +5ºC - increasing of current average temperatures with 5ºC.

The ETRO value was estimated by Thornthwaite method, based on correlation between water consumption of a crop and air average temperature. Depending on the values of the average normal temperatures, the values of the average monthly temperatures were obtained in the case of increase by 2ºC or 5ºC. After obtaining these values, the annual values of the thermal index were calculated for the three climatic scenarios (Tn; Tn+2ºC and Tn+5ºC) in the two pedoclimatic areas, Dobrogea and the Romanian Plain (Table 1).

Table 1. Monthly, annual average temperature and monthly and annual thermal index values (ºC) at Tecuci and Constanta meteorological stations during 1991-2020 period

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	SUM I
Tecuci													
t_m°C	-1.8	0.3	5.2	11.4	17.2	21.1	22.9	22.4	16.9	10.9	5.2	-0.3	-
i	0.00	0.01	1.06	3.48	6.49	8.82	10.01	9.68	6.32	3.26	1.06	0.00	50.1
t_m°C +2°C	0.2	2.3	7.2	13.4	19.2	23.1	24.9	24.4	18.9	12.9	7.2	-0.1	-
i	0.01	0.31	1.74	4.45	7.67	10.15	11.37	11.02	7.49	4.20	1.74	0.0	60.1
t_m°C+5°C	1.2	5.3	10.2	16.4	22.2	26.1	27.9	27.4	21.9	15.9	10.2	0.2	
i	0.12	1.09	2.94	6.04	9.55	12.21	13.50	13.14	9.36	5.76	2.94	0.0	76.6
Constanta													
t_m°C	0.0	1.8	5.8	10.9	16.7	21.3	23.4	23.0	18.0	12.5	7.1	1.7	-
i	0.00	0.21	1.25	3.26	6.21	8.97	10.35	10.08	6.95	4.10	1.70	0.20	53.2
t_m°C +2°C	2.0	3.8	7.8	12.9	18.7	23.3	25.4	25.0	20.0	14.5	9.1	3.7	-
i	0.25	0.66	1.96	4.20	7.37	10.28	11.71	11.44	8.16	5.01	2.48	0.63	64.1
t_m°C+5°C	5.0	6.8	10.8	15.9	21.7	26.3	28.4	25.0	20.0	17.5	12.1	6.7	
i	1.00	1.59	3.21	5.76	9.23	12.35	13.87	11.44	8.16	6.66	3.81	1.56	78.6

i = monthly thermal index
I= annual thermal index

With the obtained values it was possible to calculate the Etro for the maize crop according to climatic scenarios and pedoclimatic zones. In the calculations of the water balance in the soil the values of the initial reserves, of the minimum ceilings and of the watering norms specific to the two studied areas were used. Romania being crossed by the 45th parallel it is quite possible that the current value of annual precipitation will remain the same. In the paper the soil water balance was calculate using the current rainfall values. Thus, the rainfall values used in the soil water balance calculations where the average values over of at least 29 years (1991-2020) of the studied areas with the calculation assurance of 80% (Table 2).

Table 2.Average rainfall (mm) recorded at Constanta and Tecuci meteorological stations in 1991-2020 period

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	SUM I-XII	SUM V-IX
Constanta	26.5	21.6	29.0	32.1	45.2	57.5	64.1	36.4	49.7	38.7	33.8	35.0	469.6	285
Tecuci	24.0	23.8	31.0	41.3	54.9	73.4	58.5	50.6	50.3	51.2	35.1	36.0	530.1	329

After calculating the soil water balance for the maize crop in the two pedoclimatic areas and for the three scenarios, a 2 x 3 bifactorial model was obtained. The need to apply irrigation for a particular area is determined according to the moisture deficit calculated as the difference between water consumption and water supply sources of the soil and maize.

RESULTS AND DISCUSSIONS

The average daily evapotranspiration will increase in the two pedoclimatic areas studied by 2 m^3/ha/day in the case of 2ºC and 5 m^3/ha / day in the case of heating with 5ºC increase, which requires finding technical and agrophytotechnical methods to create genotypes with a reduced sweating coefficient and which react positively in the case of moisture stress (Table 3).

The total optimal real evapotranspiration will increase by values that will exceed 1,246 m^3/ha in the case of 5ºC heating of the average temperature, which means an important volume of irrigation water that must ensure the normal growth and development of plants (Table 4).

Table 3. Synthesis of data on the influence of the increase in average temperatures in the maize crop on the average daily evapotranspiration between 1991-2020 period

Variant		Daily ETRO		Diferences and Significance	
		m^3/ha	%	m^3/ha	Signif
Constanta	t_n	32	100	Control	
	t_n + 2ºC	34	106.25	2	***
	t_n + 5ºC	37	115.62	5	***
Tecuci	t_n	33	100	Control	
	t_n + 2ºC	35	106.06	2	***
	t_n + 5ºC	38	115.15	5	***

LSD 5%=0.75 LSD 1%= 1.03 LSD 0.1 %=1.35

Table 4. Synthesis of data on the influence of the increase of average temperatures in the maize crop on the total average evaporation between 1991-2020 period

Variant		Total ETRO		Differences and Significance	
		m^3/ha	%	m^3/ha	Signif
Constanta	t_n	5,225	100	Control	
	t_n + 2ºC	5,522	106.26	297	***
	t_n + 5ºC	5,963	114.12	738	***
Tecuci	t_n	5,370	100	Control	
	t_n + 2ºC	6,109	113.76	739	***
	t_n + 5ºC	6,616	123.20	1,246	***

LSD 5%=167.53 LSD 1%= 222.35 LSD 0.1 %=291.85

Table 5. Synthesis of data on the influence of the increase in average temperatures on the average water deficit in the maize crop between 1991-2020 period

Variant		Hydric deficit		Differences and Significance	
		m^3/ha	%	m^3/ha	Signif
Constanta	t_n	3,240	100	Control	
	t_n + 2ºC	3,526	108.64	286	***
	t_n + 5ºC	3,957	122.13	717	***
Tecuci	t_n	3,865	100	Control	
	t_n + 2ºC	4,341	112.32	476	***
	t_n + 5ºC	4,841	125.25	976	***

LSD 5%=222.43 LSD 1%= 310.28 LSD 0.1 %=421.65

With the increase of the average temperatures will increase and the values of the moisture deficit and the average water requirement for irrigation At Constanta in case of increase of average temperatures by 5ºC deficit will be 3,957 m^3/ha and at Tecuci with 4,841 m^3/ha.

The average irrigation water requirement will be between 1,239 m^3/ha and about 2,817m^3/ha at an increased temperature higher by 5ºC. This need for irrigation water will reduce the irrigated areas if the volume of irrigation water used today is maintained or the current irrigated areas are maintained but with the use of additional volumes of irrigation water. The increase in the need for irrigation water will increase the expenditure on irrigation water and the need for equipment and manpower (Table 5 and Table 6).

Table 6. Synthesis of data on the influence of the increase of average temperatures in the maize crop on the average water requirement between 1991-2020 period

Variant		Water need		Differences and Significance	
		m^3/ha	%	m^3/ha	Signif
	t_n	742	100	Control	
Constanta	t_n + 2ºC	1164	156.87	422	**
	t_n + 5ºC	1239	166.98	497	**
	t_n	1300	100	Control	
Tecuci	t_n + 2ºC	1732	13.23	432	**
	t_n + 5ºC	2817	216.69	1517	***

LSD 5%=233.72 LSD 1%= 419.48 LSD 0.1 %=654.94

Table 7. Synthesis of data on the influence of average maize temperature increase on the number of waterings between 1991-2020

Variant		Number of watering		Differences and Significance	
		m^3/ha	%	m^3/ha	Signif
	t_n	3	100	Control	
Constanta	t_n + 2 ºC	5	166.67	2	***
	t_n + 5 ºC	6	200.00	3	***
	t_n	7	100	Control	
Tecuci	t_n + 2 ºC	8	114.30	1	***
	t_n + 5 ºC	9	128.57	2	***

LSD 5%=0.25 LSD 1%= 0.36 LSD 0.1 %=0.49

Table 8. Synthesis of data on the influence of average maize temperature increase on average irrigation rate between 1991-2020

Variant		Average irrigation rate		Differences and Significance	
		m^3/ha	%	m^3/ha	Signif
	t_n	2835	100	Control	
Constanta	t_n + 2ºC	4725	166.67	1890	***
	t_n + 5ºC	5670	200.00	2835	***
	t_n	3934	100	Control	
Tecuci	t_n + 2ºC	4496	114.30	562	***
	t_n + 5ºC	5058	128.57	1124	***

LSD 5%=202.3 LSD 1%= 286.70 LSD 0.1 %=393.69

In the two studied locations will increase the number of waterings depending on the average temperature that will be achieved, namely by 2 in the case of heating with 2ºC of the normal average temperature and by 3 waterings in the case of heating with 5ºC of the normal average temperature.

The irrigation norm will exceed the current norm by about 1,800 m^3/ha in Constanta and by 562 m^3/ha in Tecuci in the case of heating with 2ºC of the normal average temperature and in the case of increasing the average temperature by up to 5ºC the irrigation norm depending on the pedoclimatic area will increase by 1,124-2,835 m^3/ha (Table 7 and Table 8).

CONCLUSIONS

Due to these climatic changes, the aridification process will intensify, the periods of droughts being more numerous and of longer duration. The association between atmospheric and pedological drought will have particularly damaging effects for agricultural crops, diminishing or totally compromising the crops. By 2029, the average temperatures in our country are expected to increase by 1.5ºC, and by 2099 by 2-5ºC, depending on the climate scenario (IPCC, 2013).

The average daily evapotranspiration will increase in both areas by about 6% if the temperature rises by 2ºC and by about 15 % at a temperature above 5ºC. The average water deficit is possible to increase by more than 15% at tn + 2ºC and by 19% at tn+5ºC.

As regards the average water requirement for irrigation, it will increase compared to the current values with values of approximately 61% at tn + 2ºC and 74% at tn + 5ºC. The studied area presents the most favourable pedological conditions for the growth and development of the maize crop, but in the case of increasing the average temperature it is necessary to find technical and agrophytotechnical methods for reducing the water consumption an important role in this regard will be played by the breeders who have to create genotypes with a reduced sweating coefficient, and which react positively in the case of.

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