CLIMATE DROUGHT IN MAIZE FROM CRISURILOR PLAIN, ORADEA 2011-2013

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Abstract

Climate drought was analyzed using two indicators and the field research were carried out during 2011-2013 in the Agricultural Research and Development Station Oradea, in the area of the moderate wet climate. The soil from research field is a luvosoil. For quatification of the climate conditions one of the most known climate indicator from Romania – de Martonne aridity index – was used and a new climate indicator – Domuţa climate index was used too. Two variants were studied: unirrigated and irrigated. Using the irrigation for maintaining the soil water reserve between easily available water content and field capacity determined the increase of the water/ temperature report (de Martonne aridity index, IdM) with 105% in 2011, with 115% in 2012 and with 161% in 2013. The report water + air humidity/temperature + sun brilliance (Domuţa climate index, IcD) increased with 90% in 2011, with 92% in 2012 and with 144% in 2013. The irrigation determined the increase of the maize water consumption with 51% in 2011, with 84% in 2012 and with 65% in 2013. The yields increased very significant statistically every year, the relative differences were of 103% in 2011, 137% in 2012 and of 175% in 2013. The protein content of the grains increased very significant statistically, too; the relative differences in comparison with unirrigated variant were of 59% in 2011, of 80% in 2012 and of 69% in 2013.Better correlation coefficients was quatified for links climate conditions-water consumption, climate conditions-yields, climate conditions-protein content using the indicator "Domuta climate index", than using the indicator "de Martonne index"; the explanation consists of the bigger number of climate elements used: 4 (water, air, humidity, temperature) in comparison with 2 (water, temperature).

Keywords: de Martonne aridity index, Domuţa climate index, water consumption, yield, protein content, irrigation

INTRODUCTION

The Crişurilor Plain is situated in the NorthWestern part of Romania and the climate is characterized like „moderate wet" (1). To characterize the climate using one climate element (rainfall, temperature etc.) is not enough for a so complexe probleme. The climate indicators use offers a better opportunity. The climate indexes use one climate element (rainfall – Topor index), two climate elements (rainfall and temperature – de Martonne aridity index, Seleaninov hydrotermic coefficient, Palfai aridity index, Teaci index, Mirkin coefficient etc.), three climate elements (rainfall, temperature, sun brilliance – hydroheliothermic index) or four climate elements (rainfall, temperature, air humidity, sun brilliance – Domuţa climate index) (9, 8,7,6). The climate indexes is better if the coefficients for regression functions with the plant parameters (yield, water consumption, etc.) are better. (3). For quantification the relationship between climate and maize yield, Domuţa C.,

1995, obtained better results using the hydroheliothermic index in comparison with de Martonne aridity index, Selianinov hydrothermic coefficient. Ciobanu Gh., 2003, Domuța C., 2003, Pălcuț N., 2003, obtained better results using Domuța climate index in comparison with de Martonne aridity index for characterization the relationship climate - yield for research data obtained in a long term trial with different doses and combinations of the fertilizers and for behavior characterization of different maize hybrids (5, 8).

The paper used the most known climate index from Romania (de Martonne aridity index) and Domuța cimate index for maize microclimate characterization and for quantification the link between microclimate conditions and water consumption, yield and protein content of the grains.

MATERIAL AND METHOD

The paper based on the researches carried out in Agricultural Research and Development Station Oradea during 2011-2013 on the preluvosoil. The watering depth (0-75 cm) was a fixed one (9) and field capacity (FC = 24.2% = 2782 m^3/ha) and wilting point (WP = 10.1 = 1158 m^3/ha) have median values. Easily available water content (Wea) was established in function of texture: Wea = WP + 2/3 (FC – WP).

A drill is the water source for irrigation and their quality for irrigation is very good: pH = 7.2; Na^+ = 12.9%; mineral residue = 0.5 g/l; CSR = -1.7; SAR = 0.52.

In comparison with multiannual average (1931-2005) of 621.1 mm during the studied period the annual rainfall were of 684.7 mm in 2011; of 556.1 mm in 2012 and of 585.7 mm in 2013.

Soil moisture of 0 – 75 cm depth was determined ten to ten days. In the variant without irrigation suspending the moment of the irrigation use was when the soil water reserve on 0 – 75 cm depth decreased to easily available water content.

De Martonne aridity index (IdM) was determined using the formula

$$IdM = \frac{12p}{t+10}$$ In wich:

p= monthly rainfall (mm); t= average temperature on the month (^oC)

Domuța climate index was determined using the formula:

$$IcD = \frac{100W + 12.9A}{\sum t + Sb}$$ in wich:

W= water (mm); A= air humidity (%);

Σt = sum of the monthly average temperature (^oC);

Sb= sun brilliance.

Both de Martonne aridity index and Domuța climate index for irrigated vriant included the irrigation rate in the calculation formula (8)

Water consumption was determined using the soil water balance method and water use efficiency was determined like report between field and water consumption.

Results research was processed by variance analysis and with the regression functions (8)

RESULTS AND DISCUSSION

Optimum irrigation regime in maize

For maintaining the soil water reserve on 0-75 cm between easily available water content and field capacity the following irrigation rates were used: 3310 m^3/ha in 2011, 4380 m^3/ha in 2012 and 3400 m^3/ha in 2013. (table 1)

Table 1

Optimum irrigation regime used in maize, Oradea 2011-2013

Year	April		May		June		July		August		April-August	
	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n
2011	300	1	900	2	900	2	460	1	750	2	3310	8
2012	700	2	900	2	620	2	700	2	1460	4	4380	12
2013	-	-	500	1	900	2	1300	3	700	2	3400	8

Σm= irrigation regime; n= number of rates

Irrigation influence on maize microclimate

The irrigation determined the improve of the microclimate conditions. The use of the de Martonne aridity index shows that the report between water and temperature improved every month with irrigation; in average on the period April-August the values of the de Martonne aridity index increased with 105% in 2011, with 115% in 2012 and with 161% in 2013. (Table 2)

Using the Domuța climate index the report between water+air humidita and temperature+ sun brilliance increased in average on the period April-August with 90% in 2011, with 92% in 2012 and with 144% in 2013. (Table 3)

Table 2

Irrigation influence on microclimate (de Martonne aridity index, IdM) in maize, Oradea 2011-2013

Variant	April		May		June		July		August		April-August	
	de Martonne aridity index, IdM											
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
2011												
Unirrigated	1.7	100	34.3	100	18.8	100	24.1	100	30.6	100	21.9	100
Irrigated	17.9	1006	51.3	150	37.5	199	67.0	278	51.0	167	44.9	205
2012												
Unirrigated	24.0	100	17.4	100	35.7	100	26.9	100	10,2	100	22.8	100
Irrigated	24.0	100	39.7	228	75.1	211	69.6	259	36,5	358	48.9	215
2013												
Unirrigated	6.5	100	11.9	100	39.3	100	11.4	100	33.3	100	20.5	100
Irrigated	31.1	478	51.5	433	59.4	151	55.1	483	70.6	212	53.5	261

Table 3

Irrigation influence on microclimate (Domuța climate index, IcD) in maize Oradea, 2011-2013

Variant	April		May		June		July		August		April-August	
	de Martonne aridity index, IdM											
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
2011												
Unirrigated	1.4	100	10.8	100	6.0	100	6.9	100	9.4	100	6.9	100
Irrigated	5.8	414	15.7	145	11.1	185	18.0	261	15.0	160	13.1	190
2012												
Unirrigated	9.8	100	5.8	100	11.2	100	8.1	100	3.5	100	7.7	100
Irrigated	9.8	100	12.0	207	22.3	199	19.6	242	10.3	295	14.8	192
2013												
Unirrigated	2.7	100	4.1	100	12.1	100	2.7	100	10.4	100	6.4	100
Irrigated	9.5	352	15.1	368	17.8	147	14.8	548	20.8	200	15.6	244

Irrigation influence on maize total water consumption

The values of the total water consumption increased in the irrigated variant with 31% in 2011, 84% in 2012 and 65% in 2013. In the covering sources of the optimum water consumption, the irrigation participated with 53% in 2011, with 56% in 2012 and with 46% in 2013 (Table 4).

Table 4

Irrigation influence on total water consumption in maize, Oradea 2011-2013

Variant	Total water consumption		Covering sources			
	m^3/ha	%	Soil water reserve m^3/ha	Rainfall m^3/ha	Irrigation	
					m^3/ha	%
2011						
Unirrigated	3247	100	490	2757	-	-
Irrigated	6210	191	143	2757	3310	53
2012						
Unirrigated	4280	100	1300	2980	-	-
Irrigated	7847	184	512	2980	4380	56
2013						
Unirrigated	4480	100	1510	2970	-	-
Irrigated	7397	165	1027	2970	3400	46

Irrigation influence on yield and protein content

The irrigation determined the yield gains very significant statistically every year; the relative differences in comparison with unirrigated variant were of 103% in 2011, of 137% in 2012 and of 175% in 2013. (Table 5)

The protein content of the maize grains increased very significant statistically, too every year. The relative differences in comparison with unirrigated variant were of 59% in 2011, of 80% in 2012 and of 69% in 2013 (Table 5).

Table 5

Irrigation influence on yield and protein content of the maize grains,Oradea

Variant	Yield			Protein content		
	kg/ha	%	Statistically significant	%	%	Statistically significant
2011						
Unirrigated	6470	100	Mt	7.0	100	Mt
Irrigated	13120	203	xxx	11.12	159	xxx
$LSD_{5\%}$=240; $LSD_{1\%}$= 410; $LSD_{0.1\%}$ =790				$LSD_{5\%}$= 0.81; $LSD_{1\%}$= 1.56; $LSD_{0.1\%}$= 2.63		
2012						
Unirrigated	5910	100	Mt	6.30	100	Mt
Irrigated	14010	237	xxx	11.36	180	xxx
$LSD_{5\%}$=190; $LSD_{1\%}$= 310; $LSD_{0.1\%}$ =570				$LSD_{5\%}$= 0.50; $LSD_{1\%}$= 1.06; $LSD_{0.1\%}$= 2.00		
2013						
Unirrigated	5300	100	Mt	6.68	100	Mt
Irrigated	14600	275	xxx	11.29	169	xxx
$LSD_{5\%}$=210; $LSD_{1\%}$= 330; $LSD_{0.1\%}$ =640				$LSD_{5\%}$= 0.59; $LSD_{1\%}$= 1.15; $LSD_{0.1\%}$= 1.96		

The link between microclimate conditions and water consumption

Both de Martonne aridity index and Domuța climate index were used for cuantification the link between microclimate conditions and maize water consumption. Five regression functions was tested: linear, logarithmic, polynomial, power, exponential. Using the Domuța climate index a correlation coefficient of 0.96 was obtained in comparison with 0.69, the coefficient obtained using the de Martonne aridity index for the quantification and yield. (fig.1)

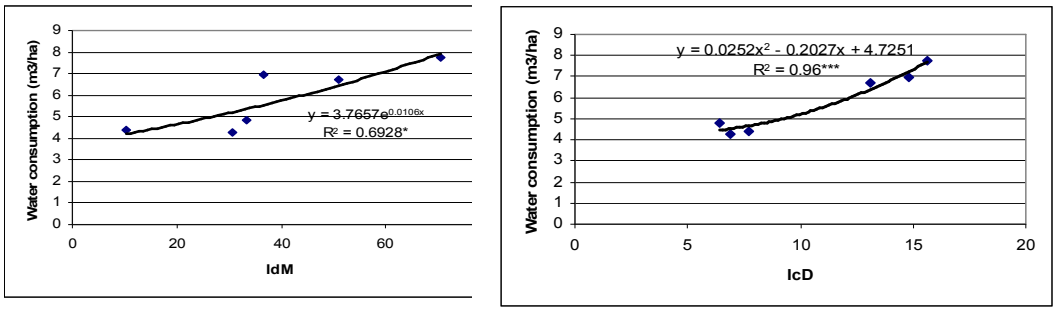

Fig. 1 The link between microclimate conditions (de Martonne aridity index, IdM; Domuța climate index, IcD) and maize water consumption, Oradea 2011-2013

The link between microclimate conditions and yields

The link between microclimate conditions and yield is a direct too. The use of the Domuța climate index determined a better quantification of the link microclimate-yield than the use of the de Martonne aridity index: R^2= 0.9541 vs R^2=0.5072 (figure 2)

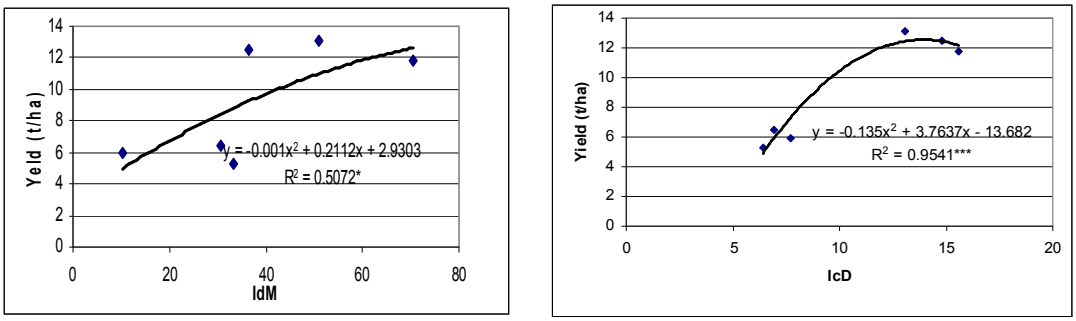

Fig. 2 The link between microclimate conditions (de Martonne aridity index, IdM; Domuța climate index, IcD) and maize yield, Oradea 2011-2013

The link between microclimate conditions and protein content

The protein content is influenced by microclimate conditions, too. Using the Domuța climate index for quantification the link between the microclimate conditions and protein content of the maize a bigger regression function (R^2= 0.96) was obtained in comparison with the use of the Martonne index (R^2= 0.6928)

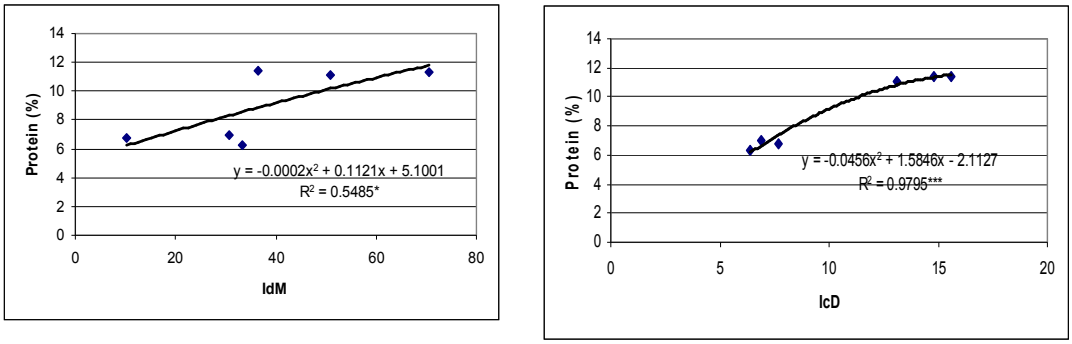

Fig. 3 The link between microclimate conditions (de Martonne aridity index, IdM; Domuța climate index, IcD) and protein content, Oradea 2011-2013

CONCLUSIONS

The researches carried out during 2011-2013 at Agricultural Research and Development Station Oradea determined the following conclusions:

- Using the irrigation for maintaining the soil water reserve between easily available water content and field capacity determined the increase of the water/ temperature report (de Martonne aridity index, IdM) with 105% in 2011, with 115% in 2012 and with 161% in 2013. The report water + air humidity/temperature + sun brilliance (Domuța climate index, IcD) increased with 90% in 2011, with 92% in 2012 and with 144% in 2013.
- The irrigation determined the increase of the maize water consumption with 51% in 2011, with 84% in 2012 and with 65% in 2013. The yields increased very significant statistically every year, the relative differences were of 103% in 2011, 137% in 2012 and of 175% in 2013. The protein content of the grains increased very significant statistically, too; the relative differences in comparison with unirrigated variant were of 59% in 2011, of 80% in 2012 and of 69% in 2013.
- The direct links, statistically assured, were registered between microclimate conditions and water consumption, yields and protein content of the grains. The microclimate quantification by de Martonne aridity index detrmined the links significant statistically and microclimate quantification by Domuța climate index determined the links very significant statistically.

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