THE IRRIGATION INFLUENCE ON MAIZE MICROCLIMATE IN THE CRIŞURILOR PLAIN CONDITIONS

Domuţa Cristian, Bara Vasile, Bara Camelia, Bara Lucian

**University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea, Romania, e-mail: cristian_domuta@yahoo.com*

Abstract

The paper based on the results researches carried out during 2007-2009 on the preluvosoil from Agricultural Research and Development Station Oradea. The microclimate is characterized by de Martonne aridity index (IdM) and Domuţa climate index (IcD). The irrigation determined the improve of the climate index values. There are a better quatification of the link between microclimate conditions and water consumption, yield and protein content of the maize grains using the climate index Domuţa (IcD) in comparison with de Martonne aridity index, the explanation is more vegetation factors used by Domuţa climate index (water, air humidity, air temperature, light) in comparison with de Martonne aridity index (water, air temperature).

Keywords: maize, microclimate, water consumption, yield, protein, Domuţa climate index, de Martonne aridity index

INTRODUCTION

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) (Grumeza N. et al., 1989, Domuţa, 1995, 2003, 2005, 2009).

The use of the irrigation determines the improve of the microclimate conditions; the values of the climate indexes used increase very significant in comparison with the values calculated for unirrigated variant (Domuţa, 1995, Tuşa, 1997, Petrescu 1999). The climate indexes is better if the coefficients for regression functions with the plant parameters (yield, water consumption, etc.) are better. (Domuţa, 1995). For quantification the relationship between climate and maize yield, Domuţa, 1995, obtained better results using the hydroheliothermic index in comparison with de Martonne aridity index, Selianinov hydrothermic coefficient. Ciobanu, 2002, Domuţa, 2003, Pălcuţ, 2003, obtained better results using Domuţa 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 (Domuţa, 2005, 2009).

The paper used the most known climate index from Romania (de Martonne aridity index) and Domuţa 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 METHODS

The paper based on the researches carried out in Agricultural Research and Development Station Oradea during 2007-2009 on the preluvosoil. There is a big hydro stability (47.5%) of the aggregates (Φ = 0.25 mm) on ploughingland and bulk density (1.41 g/cm^3) indicates a low settling and total porosity is median; hydraulic coefficient on the subjacent depth of the ploughing layer bulk density characterizes the soil like moderate and very settled and total porosity is small and very small. Hydraulic conductivity is big (21.0 mm/h) on 0-20 cm; median (10.5 mm/h; 4.4 mm/h) on 20 – 40 cm and 40 – 60 cm and very small (1.0 mm/h) on 60 – 80 cm. The watering depth (0-75 cm) was a fixed one (Grumeza et al., 1989) 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); (Canarache, 1990); their values for 0-75 cm are 19.5% and 2240 m^3/ha.

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 2006; of 556.1 mm in 2007 and of 585.7 mm in 2008.

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. In the variant with irrigation suspending in different months didn't irrigate in these months.

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 (^{o}C)

Characterization class: < 15 arid; 15–24 demiarid; 24–30 moderate drought; 31–35 moderate wet I; 36–40 moderate wet II; 41–50 wet; 51–60 wet I; 61–80 wet II; 81–100 very wet; >100 excessive wet (Domuța, 2009)

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 (^{o}C); Sb= sun brilliance.

Characterization class: < 3 excessive drought; 3.1–5 very drought; 5.1–7 droughty; 7.1–9 median droughty; 9.1–12 median wet; 12.1–15 wet I; 51-60 wet I; 15.1–18 wet II; 18.1–25 wet II; >25 excessive wet (Domuța, 2009)

Both de Martonne aridity index and Domuța climate index for irrigated vriant included the irrigation rate in the calculation formula (Domuța, 2009)

Water consumption was determined using the soil water balance method.

Results research was processed by variance analysis and with the regression functions (Domuța, 2009)

RESULTS AND DISCUSSIONS

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: 2950 m^3/ha in 2007, 3320 m^3/ha in 2008 and 4200 m^3/ha in 2009. (table 1)

Table 1

Optimum irrigation regime used in maize, Oradea 2007-2009

Year	April		May		June		July		August		April-August	
	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n	Σm	n
2007	300	1	400	1	500	1	1200	4	550	4	2950	8
2008	-	-	500	1	1020	2	1100	3	700	2	3320	8
2009	500	1	900	2	500	1	1300	3	1000	2	4200	9

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 2007, with 115% in 2008 and with 161% in 2009. (table 2).

Table 2

Irrigation influence on microclimate (de Martonne aridity index, IdM) in maize, Oradea 2007-2009

Variant	April		May		June		July		August		April-August	
	de Martonne aridity index, IdM											
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
2007												
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
2008												
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
2009												
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

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 2007, with 92% in 2008 and with 144% in 2009. (table 3)

Table 3

Irrigation influence on microclimate (Domuța climate index, IcD) in maize, Oradea, 2007-2009

Variant	April		May		June		July		August		April-August	
	de Martonne aridity index, IdM											
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
2007												
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
2008												
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
2009												
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 56% in 2007, 58% in 2008 and 61% in 2009. In the covering sources of the optimum water consumption, the irrigation participated with 44% in 2007, with 48% in 2008 and with 54% in 2009 (table 4)

Irrigation influence on yield and protein content

The irrigation determined the yield gains very significant statistically every year; the relative difference in comparison with unirrigated variant were of 56% in 2007, of 58% in 2008 and of 61% in 2009. (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 2007, of 80% in 2008 and of 69% in 2009 (table 5).

Table 4

Irrigation influence on total water consumption in maize, Oradea 2007-2009

Variant	Total water consumption		Covering sources			
	m^3/ha	%	Soil water reserve m^3/ha	Rainfall m^3/ha	Irrigation	
					m^3/ha	%
2007						
Unirrigated	4302	100	490	3812	-	-
Irrigated	6719	156	143	3812	2950	44
2008						
Unirrigated	4410	100	1300	3110	-	-
Irrigated	6942	158	512	3110	3320	48
2009						
Unirrigated	4820	100	2280	2540	-	-
Irrigated	7767	161	1027	2540	4200	54

Table 5

Irrigation influence on yield and protein content of the maize grains, Oradea 2007-2009

Variant	Yield			Protein content		
	kg/ha	%	Statistically significant	%	%	Statistically significant
2007						
Unirrigated	6470	100	Mt	7.0	100	Mt
Irrigated	13120	203	xxx	11.12	159	xxx
$LSD_{5\%}$	**240**			**0.81**		
$LSD_{1\%}$	**410**			**1.56**		
$LSD_{0.1\%}$	**790**			**2.63**		
2008						
Unirrigated	5910	100	Mt	6.30	100	Mt
Irrigated	12500	212	xxx	11.36	180	xxx
$LSD_{5\%}$	**190**			**0.50**		
$LSD_{1\%}$	**310**			**1.06**		
$LSD_{0.1\%}$	**570**			**2.00**		
2009						
Unirrigated	5300	100	Mt	6.68	100	Mt
Irrigated	11800	223	xxx	11.29	169	xxx
$LSD_{5\%}$	**210**			**0.59**		
$LSD_{1\%}$	**330**			**1.15**		
$LSD_{0.1\%}$	**640**			**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)

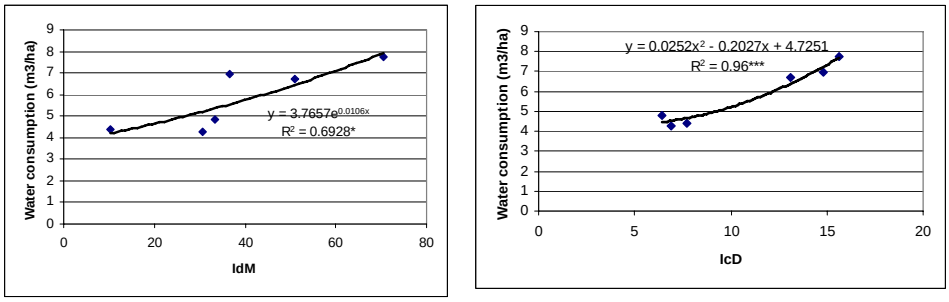

Fig. 1 The link between microclimate conditions (de Martonne aridity index, IdM; Domuța climate index, IcD) and maize water consumption, Oradea 2007-2009

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)

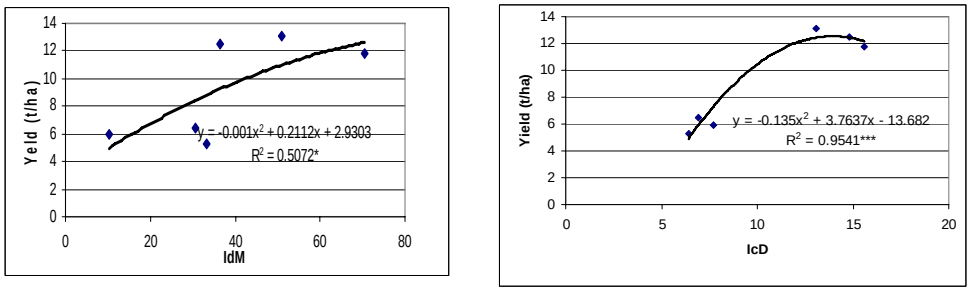

Fig. 2 The link between microclimate conditions (de Martonne aridity index, IdM; Domuța climate index, IcD) and maize yield, Oradea 2007-2009

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)

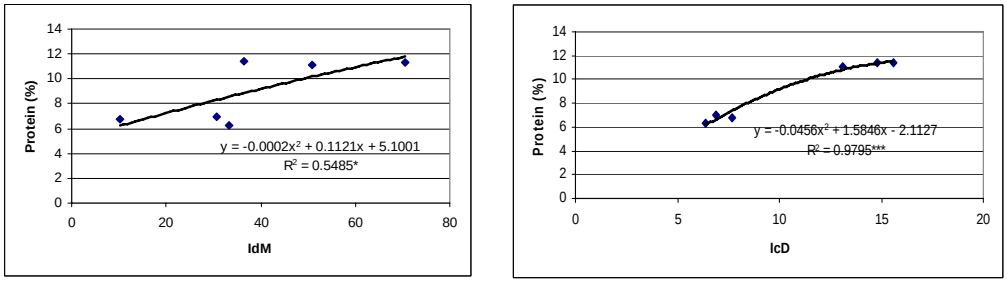

Fig. 3 The link between microclimate conditions (de Martonne aridity index, IdM; Domuța climate index, IcD) and protein content, Oradea 2007-2009

CONCLUSIONS

The researches carried out during 2007-2009 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 2007, with 115% in 2008 and with 161% in 2009. The report water+air humidity/temperature+ sun brilliance (Domuța climate index, IcD) increased with 90% in 2007, with 92% in 2008 and with 144% in 2009.
- The irrigation determined the increase of the maize water consumption with 56% in 2007, with 58% in 2008 and with 61% in 2009. The yields increased very significant statistically every year, the relative differences were of 103% in 2007, f 112% in 2008 and of 123% in 2009. The protein content of the grains increased very significant statistically, too; the relative differences in comparison with unirrigated variant were of 59% in 2007, of 80% in 2008 and of 69% in 2009.
- 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 a link significant statistically and microclimate quantification by Domuța climate index determined a link very significant statistically.

Acknowledgments

The researches were carried out in the project: PN-II-ID-PCE-2008; 1103/2009 ”Study of the relationships in the soil-water-plant-atmosphere system on the land affected succesivelly by excess and deficit of moisture from North Western Romania regarding the improve of the yield quantity and quality”.

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