CORRELATIONS IN THE SOIL – WATER – PLANT SYSTEM IN MAIZE FROM CRIŞURILOR PLAIN

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Abstract

The paper based on the researches carried out during 2007-2009 in the conditions of the preluvosoil from Agricultural Research and Development Station Oradea. This area is characterized by moderate wet climate. The following indicators for characterization of the soil-water-plant system were used: de Martonne aridity index and Domuţa climate index.

Two variants were studied: unirrigated and irrigated. Maintaining the soil water reserve on watering depth between easily available water content and field capacity determined the irrigation use. The irrigation determined the improve of the microclimate conditions, the increase of the plants water consumption, yield gains and protein content very significant bigger than in unirrigated variant. Better correlation coefficients was quantified 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).

Key words: irrigation regime, de Martonne aridity index, Domuţa climate index, yield, protein content, irrigation.

INTRODUCTION

The Crişurilor Plain is situated in the Western part of Romania and the climate is characterized as "moderate wet" (Borza I., 2007, 2009). To characterize the climate using one climate element (rainfall, temperature etc.) is not enough for such a complex issue. The climate indicators use a better opportunity (Domuţa Cr., 2008, Borza I. et al, 2009). The climate indexes use one climate element (rainfall – Topor index), two climate elements (rainfall and temperature – de Martonne aridity index, Seleaninov hydro thermal coefficient, Palfai aridity index, Teaci index, Mirkin coefficient etc.), three climate elements (rainfall, temperature, sunshine – hydro helio-thermal index) or four climate elements (rainfall, temperature, air humidity, sun brilliance – Domuţa climate index) (Grumeza N. et. al., 1989, Domuţa Cr. et al, 2008). The climate indexes are better if the coefficients for regression function with the plant parameters (yield, water consumption, etc.) (Domuţa C., 1995). When quantifying the relationship between climate and maize yield, Domuţa C., 1995, obtained better results using the hydro helio-thermal index in comparison with de Martonne aridity index, Selianinov hydrothermic coefficient. Ciobanu Gh., 2003, Domuţa C.,

2003, Pălcuţ N., 2002, Domuţa Cr., 2010, 2011, obtained better results using Domuţa climate index in comparison with de Martonne aridity index to characterize the relationship between 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 C., 2005, 2009).

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

MATERIAL AND METHODS

The paper is based on the researches carried out on the preluvosoil in the Agricultural Research and Development Station Oradea during 2007-2009. The watering depth (0-75 cm) was a fixed one (9) and the field capacity (FC = 24.2% = 2782 m^3/ha) and wilting point (WP = 10.1 = 1158 m^3/ha) had average values. Easily available water content (Wea) was established depending on texture: Wea = WP + 2/3 (FC – WP).

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

In comparison with the multiannual average (1931-2005) of 621.1 mm during the studied period, the annual rainfall was of 684.7 mm in 2006; of 556.1 mm in 2007 and of 585.7 mm in 2008.

Soil moisture at 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 at 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 which:

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

Domuţa climate index was determined using the formula (Brejea R., 2009, 2010):

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

W= water (mm); A= air humidity (%); Σt = sum of the monthly average temperature (^oC); Sb= sun brilliance.

Both de Martonne aridity index and Domuţa climate index for irrigated variant included the irrigation rate in the calculation formula (Domuţa C., 2006).

Water consumption was determined using the soil water balance method and water use efficiency was determined as a proportion between field and water consumption.

The results of the research were processed by variance analysis and regression functions (Domuţa C. et al., 2009)

RESULTS AND DISCUSSION

Optimum irrigation regime in maize

For maintaining the soil water reserve at 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 improvement of the microclimate conditions. The use of the de Martonne aridity index shows that the proportion between water and temperature improved every month with irrigation; on average, in the period April-August the values of the de Martonne aridity index increased by 105% in 2007, by 115% in 2008 and by 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 Domuţa climate index the ratio between water+air humidity and temperature+sun brilliance increased on average by 90% in 2007, by 92% in 2008 and by 144% in 2009 in the period April-August. (Table 3)

Table 3

Irrigation influence on microclimate (Domuţa 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 by 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, 48% in 2008 and 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 differences in comparison with the unirrigated variant were of 56% in 2007, 58% in 2008 and 61% 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

The protein content of the maize grains also increased very significant statistically every year. The relative differences in comparison with unirrigated variant were of 59% in 2007, 80% in 2008 and 69% in 2009 (table 5).

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; LSD $_{1\%}$= 410; LSD $_{0.1\%}$ =790				**LSD $_{5\%}$= 0.81; LSD $_{1\%}$= 1.56; LSD $_{0.1\%}$= 2.63**		
2008						
Unirrigated	5910	100	Mt	6.30	100	Mt
Irrigated	12500	212	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**		
2009						
Unirrigated	5300	100	Mt	6.68	100	Mt
Irrigated	11800	223	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 the microclimate conditions and water consumption

Both de Martonne aridity index and Domuţa climate index were used for the quantification of the link between microclimate conditions and maize water consumption. Five regression functions were tested: linear, logarithmic, polynomial, power, exponential. Using the Domuţa 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)

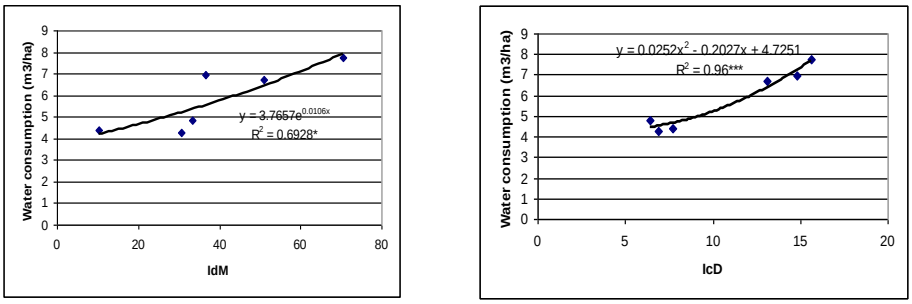

Fig. 1. The link between microclimate conditions (de Martonne aridity index, IdM; Domuţa climate index, IcD) and maize water consumption, Oradea 2007-2009

The link between microclimate conditions and yields

The link between microclimate conditions and yield is a direct one, too. The use of the Domuţa 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).

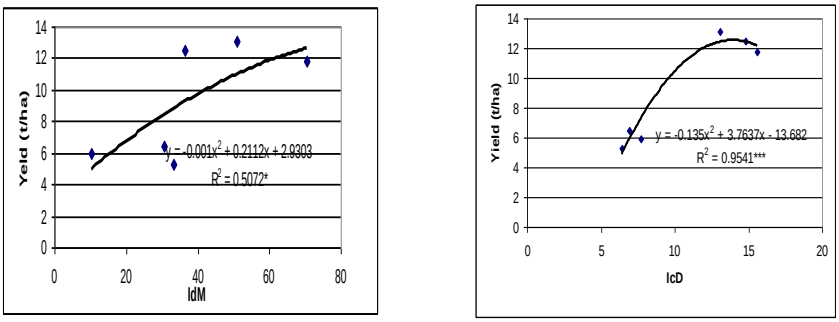

Fig. 2. The link between microclimate conditions (de Martonne aridity index, IdM; Domuţa climate index, IcD) and maize yield, Oradea 2007-2009

The link between microclimate conditions and protein content

The protein content is influenced by microclimate conditions, as well. Using the Domuţa climate index for the quantification of 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).

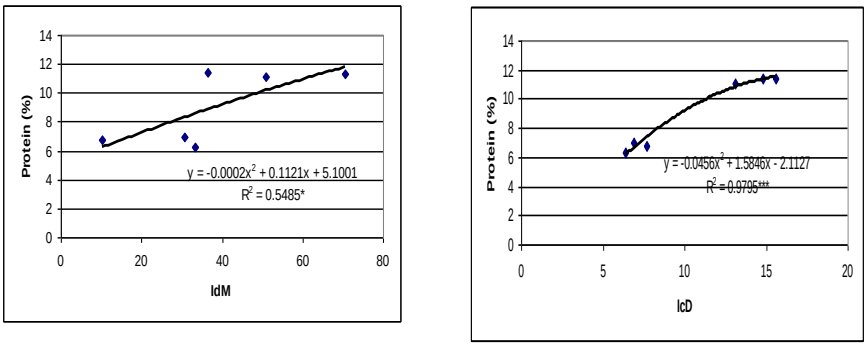

Fig. 3. The link between microclimate conditions (de Martonne aridity index, IdM; Domuţa climate index, IcD) and protein content, Oradea 2007-2009

CONCLUSIONS

The researches carried out during 2007-2009 determined the following conclusions:

- Using irrigation for maintaining the soil water reserve between easily available water content and field capacity determined the increase of

the water/ temperature ratio (de Martonne aridity index, IdM) by 105% in 2007, by 115% in 2008 and by 161% in 2009. The ratio water+air humidity/temperature+sun brilliance (Domuţa climate index, IcD) increased by 90% in 2007, by 92% in 2008 and by 144% in 2009.

- The irrigation determined the increase of the maize water consumption by 56% in 2007, by 58% in 2008 and by 61% in 2009. The yields increased very significant statistically every year, the relative differences were of 103% in 2007, of 112% in 2008 and of 123% in 2009. The protein content of the grains increased very statistically significant, too; the relative differences in comparison with the 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 using de Martonne aridity index and Domuţa climate index determined a statistically significant link.

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