THE CROP ROTATION AND IRRIGATION INFLUENCE ON MAIZE YIELD IN THE CRIŞURILOR PLAIN CONDITIONS

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Abstract: *Maize is a vegetal specie with a big potential due a large utilisation like food sources for people and animals and for industry. Optimizing of the water regime assures the integral use of the yield potential of the maize hybrids. In the same time, natural resources of the water are more and more used as consequence decrease continously and the increase of the water use efficiency in maize. The researches were made during 2006-2008 in a long term trial placed in 1990 on the preluvosoil from Agricultural Research and Development Station Oradea. characterized by the presence of the horizons Bt_1 (34-54 cm depth) and Bt_2 (54-78 cm depth); the colloid clay eluviation determined to appear the El horizon with 31.6% colloid clay. On 0-20 cm depth, the soil has a big percentage of macroagregates (Φ > 0.25 mm), 47.5% bulk density is of 1.41 g/cm^3 and total porosity is median one, hydraulic conductivity is of 21.0 mm/h. The values of the pH indicates a low acid soil, humus, total nitrogen, phosphorus and potassium content are low. The source of irrigation water was a drill of 15 m depth. The chemical parameters of the irrigation water were the following: fixed mineral residue 0.5 g/l; SAR index 0.52; CSR index= -1.7%; N. Florea class = II; there are not some problemes regarding the use of irrigation use. Two factors were studied: crop rotation (maize-monocrop; maize-wheat; maize-soybean-wheat) and water regime (unirrigated and irrigated). In comparison with unirrigated and irrigated monocrop, in the maize-wheat crop and especially in the maize-soybean-wheat very significant yield gains were obtained: 15.7% and 17.8% in the maize-wheat crop rotation and 44% and 28.3% in the maize-soybean-wheat crop rotation. In the all three crop rotation variants and in the all years studied the irrigatin determined the yield gains very significant statistically. The experiences gives the possibility of a study of crop rotation that has become a need in maize crops because of the Diabrotica virgifera, virgifera attacks, compared to older than previous literature that recommended monocrop or repeated crops. 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".*

***Key words*:** *crop rotation, maize, yield, protein content, irrigation*

INTRODUCTION

The maize represents a food rich in energetic concentrated substances of 355 kcal for 100 g of flour with 15% humidity, as against 352 kcal for the wheat flour, 348 kcal for the rye flour and 346 kcal for the peeled barley. (MUNTEAN L.S. et. al., 2008). As food, the maize has also a few lacks – the diminished quantity of essential aminoacids like lysine and indole amino-propionic acid, the lack of C and D vitamins etc. – , however it remains the basic nutriment in animals foraging, being used as concentrates for fowl and swine or as ensilage for bovine. It is considered that the fifth part of the maize international production is used directly in human alimentation, but there is a trend to reduce the direct consumption, more obvious in the industrial nations, where the direct consumption represents 60%. The greatest part (72%) of the maize international production is used in animals foraging, in the industrial nations reaching 88% of the production, and in the emergent countries 27.9% The maize represents a

very valuable raw material for the industry. Out of maize seeds oils, maize starch, alcohol, glucose, vegetable jelly, dextrin, lactic acid, pigments, acetone, synthetic rubber etc are extracted. Out of the maize stalk paper, carton, nitrocellulose, methanol, ethanol may be made etc. (CRISTEA M. and co., 2004).

The researches from Crişurilor Plain about crop rotation influence on yield maize emphasized the differences statistically assured in comparison with maize monocrop in the wheat maize crop rotation and the biggest differences in the maize-soybean-wheat crop rotation (BORZA I., 2006, 2007). Other researches (DOMUŢA C., 2006, 2007, 2008) demonstrated a higher level of the protein content in the maize grains from irrigated variant in comparison with unirrigated variant. Our researches study the separate and combinate influence of the crop rotation and and irrigation on level and quality of the yield.

The results researches was calculated using the variance analysis method (DOMUŢA C., 2006)

MATERIAL AND METHODS

The research were carried out in Oradea on a preluvosoil with the pH value of 6.8, having 1.75% of humus content, 22.0 ppm and 145.4 ppm for the phosphorus and potassium contents. The hydrostability of the macro-aggregates on the ploughed depth was high (47.5%) and the total porosity was medium (46%). The bulk density was high on all the soil's profiles. (1.41-1.65 g/cm^3). The field capacity and the wilting point had medium values in all soil profile (23.6 – 25.1 % respectively 9.2-14.2 %) and the easily available water content was established at 2/3 from the difference between the field capacity and the wilting point.

The experiment started in 1990 and the factors studied are: Factor A: crop rotation: a_1 – maize, monocrop; a_2 - maize-wheat; a_3 maize–wheat- soybean; Factor B: water regime: b_1– unirrigated; b_2 – irrigated, maintaining the soil water reserve on the watering depth (0-75 cm for maize between the easily available water content and the field capacity.

Protein content in maize was determined using the usual methods.

RESULTS AND DISCUSSIONS

The research period was characterized by rainfall bigger than multiannual average in 2006 (684.0 mm vs. 615.1 mm) and smaller than multiannual average in 2007 and 2008 (556.1 mm and 585.7 mm vs 615.5 mm). In all the three year, the annual average temperature was situated over the multiannual average. The air humidity had the values smaller than multiannual average in the all three years. (table 1)

Table 1

Climate elements of the agricultural year 2006 – 2008, Oradea (after Meteorological Station Oradea)

Agricultural year	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Average
Air temperature °C													
2006	11.0	4.2	0.7	2,2	0,9	2,7	12,0	15,9	19,2	23,2	19,1	17,0	10,7
2007	11.2	6.6	2.3	4,3	4,7	8,7	12,2	18,2	22,2	23,6	22,3	14,4	12,6
2008	10.3	3.7	- 0.4	1,4	3,4	6.5	11.6	16.9	21.0	20.3	22.0		10.7
Multiannual average*	10.7	5.3	0.6	- 2.0	0.3	5.0	10.4	15.8	19.0	20.8	20.3	16.2	10.2
Rainfall- mm													
2006	6.8	14.3	82.3	32.8	60.1	68.6	90.1	79.8	77.2	28.8	139.1	5.0	684.9
2007	24.4	27.4	9.7	36.8	69.3	13.0	3.2	80.6	50.5	67.6	82.4	91.2	556.1
2008	75.1	62.6	29.4	21.3	12.5	67.9	43.3	38.9	92.1	69.3	27.3	46.0	539.7
Multiannual average*	40.1	49.2	50.7	34.5	38.4	34.6	47.2	61.4	85.2	71.0	58.0	45.8	614.9
Air humidity%													
2006	74	78	81	78	83	77	72	66	67	59	77	69	73
2007	70	79	84	79	81	63	46	61	59	53	63	72	66
2008	84	78	91	79	66	66	55	67	62	73	63		71
Multiannual average*	79	84	88	85	86	86	72	72	73	69	71	75	78

* Average on the period 1931 - 2007

The crop rotation and irrigation influence on maize yield level

In 2006, the smallest yields were obtained in the maize monocrop both in unirrigated conditions (4970 kg/ha), and in irrigated conditions (7560 kg/ha). The maize-wheat crop rotation determined the increase of the yields with 20% and 19% very significant statistically. The biggest yields were obtained in the maize-soybean-wheat crop rotation both in the irrigated and in the irrigated variant, 46%. The irrigation determined the yield gains very significant statistically in the all three crop rotation; in average on the crop rotation, the yield gains was of the 52%, very significant statistically (table 2)

Table 2

Crop rotation and water regime influence on maize yield (kg/ha), Oradea 2006

Crop rotation	Water regime				Average on the crop rotation	
	Unirrigated		Irrigated			
	kg/ha	%	kg/ha	%	kg/ha	%
Maize -monocrop	4970	100	7560	100	6270	100
Maize -wheat	5940	120	8980	119	7460	119
Maize-wheat-soybean	7260	146	11040	146	9150	146
Average on the regime	606	100	9190	152	-	-

	Crop rotation	Water regime	Water regime x Crop rotation	Crop rotation x Water regime
$LSD_{5\%}$	230	120	210	190
$LSD_{1\%}$	390	230	360	310
$LSD_{0,1\%}$	580	490	520	470

The yields obtained in 2007 were smaller than the yields obtained in 2006, but the differences in comparison with maize monocrop were bigger than the differences registered in 2006 (table 3)

Table 3

Crop rotation and water regime influence on maize yield (kg/ha), Oradea 2007

Crop rotation	Water regime				Average on the crop rotation	
	Unirrigated		Irrigated			
	kg/ha	%	kg/ha	%	kg/ha	%
Maize -monocrop	3020	100	6100	100	4560	100
Maize -wheat	4320	143	8760	144	6540	143
Maize-wheat-soybean	5240	174	10300	169	7770	170
Average on the regime	4190	100	839	200	-	-

	Crop rotation	Water regime	Water regime x Crop rotation	Crop rotation x Water regime
$LSD_{5\%}$	250	140	240	200
$LSD_{1\%}$	390	300	410	340
$LSD_{0,1\%}$	560	450	630	520

The biggest yields both in the unirrigated conditions and in the irrigated conditions were registered in 2008. Relative differences in comparison with maize manocrop were the smallest from the studied period: 15.6% in unirrigated conditions and 17.8% in irrigated conditions in maize-wheat crop rotaion in 2007, 44% respectively 27.1% in maize-wheat-soybean crop rotation in 2008. (table 4)

Table 4

Crop rotation and water regime influence on maize yield (kg/ha), Oradea 2008

Crop rotation	Water regime				Average on the crop rotation	
	Unirrigated		Irrigated			
	kg/ha	%	kg/ha	%	kg/ha	%
Maize -monocrop	6190	100	9900	100	8045	100
Maize -wheat	7160	115.6	11670	117.8	9445	117
Maize-wheat-soybean	8910	144	12710	128.3	10810	134
Average on the regime	7420	100	11426	154	-	-

	Crop rotation	Water regime	Water regime x Crop rotation	Crop rotation x Water regime
$LSD_{5\%}$	250	180	310	280
$LSD_{1\%}$	390	260	560	430
$LSD_{0,1\%}$	610	410	990	760

In average on the studied period, in comparison with maize monocrop, in the maize-wheat crop rotation the relative yield gains of 23% and 25% were obtained in unirrigated conditions; the differences determined in the variant with maize-wheat-soybean crop rotation were biggest: 51% in unirrigated conditions and 44% in irrigated conditions. The irrigation determined the yield gains very significant statistically every year, in average on the studied period the difference in comparison with unirrigated variant was of 64% (table 5)

Table 5

The average of the results regarding the crop rotation and irrigation influence on maize yield (kg/ha), Oradea 2006-2008

Crop rotation	Water regime				Average on the crop rotation	
	Unirrigated		Irrigated			
	kg/ha	%	kg/ha	%	kg/ha	%
Maize -monocrop	4730	100	7850	100	6290	100
Maize -wheat	5810	123	9800	125	7810	125
Maize-wheat-soybean	7140	151	11350	144	9250	147
Average on the regime	5890	100	9670	164	-	-

	Crop rotation	Water regime	Water regime x Crop rotation	Crop rotation x Water regime
$LSD_{5\%}$	250	140	230	210
$LSD_{1\%}$	370	250	410	320
$LSD_{0,1\%}$	610	510	605	540

The crop rotation and irrigation influence on protein content

In 2006 the smallest content of the protein was registered in the maize monocrop: 8.27% in unirrigated variant and 10.09% in irrigated conditions. In the wheat-maize crop rotation the protein content increased with 6.4% in unirrigated variant and with 7.8% in irrigated variant. The biggest protein content was registered in the maize-wheat-soybean; the differences in comparison with maize monocrop were of 19.7% in unirrigated variant and of 23.8% in irrigated variant. The same sense of the differences were registered in 2007 and 2008 but the absolute values of the protein content were smaller than 2006 (table 6).

Table 6

Crop rotation influence on protein content (%) of the grains in unirrigated and irrigated maize, Oradea 2006-2008

Variant	Water regime				Average on crop rotation	
	Unirrigted		Irrigated			
	%	%	%	%	%	%
2006						
Maize -monocrop	8,27	100	10,09	100	9,18	100
Maize -wheat	8,80	106,4	10,88	107,8	9,84	107,2
Maize-wheat-soybean	9,90	119,7	12,26	123,8	11,08	120,6
2007						
Maize -monocrop	7,0	100	9,16	100	8,08	100
Maize -wheat	7,40	105,7	10,02	109,3	8,8	108,9
Maize-wheat-soybean	9,02	128,8	11,12	121,4	10,07	124,6
2008						
Maize -monocrop	6,75	100	9,02	100	7,89	100
Maize -wheat	7,18	106,4	9,98	110,6	8,58	108,7
Maize-wheat-soybean	8,86	131,2	11,38	126,2	10,12	128,3

The protein production obtained from the maize grains had the smallest values in the maize monocrop; in the maize-wheat crop rotation the protein production is bigger and in the maize-wheat-soybean crop rotation the biggest protein productions were obtained both in unirrigated and irrigated variant (table 7)

Table 7

Crop rotation influence on protein production of the unirrigated and irrigated maize, Oradea 2006-2008

Variant	Water regime				Average on crop rotation	
	Unirrigted		Irrigated			
	Protein					
	Kg/ha	%	Kg/ha	%	Kg/ha	%
2006						
Maize -monocrop	411	100	763	100	587	100
Maize -wheat	523	127	977	128	750	130
Maize-wheat-soybean	719	175	1353	177	1036	176
2007						
Maize -monocrop	211	100	559	100	385	100
Maize -wheat	320	152	894	160	607	158
Maize-wheat-soybean	473	224	1145	205	809	210
2008						
Maize -monocrop	418	100	892	100	655	100
Maize -wheat	518	123	1164	131	839	128
Maize-wheat-soybean	789	189	1446	162	1176	171

CONCLUSION

The researches carried out during 2006-2008 in the experiment placed on the preluvosoil from Agricultural Research and Development Station Oradea in 1990 determined the next conclusions:

- The smallest yields maize were obtained in the maize monocrop all the three zears. In the maize –wheat crop rotation and especially in the maize-wheat-soybean crop rotation a bigger yields, very significant statistically, were obtained.

- The irrigation, maintaining soil water reserve on the watering depth (0-75 cm) between easily available water content and field capacity determined the yields gains very significant statistically, every year.
- The protein content of the maize grains from maize-wheat crop rotation and especially from maize-wheat-soybean crop rotation had bigger values than the values from maize monocrop. As well the protein production were bigger and relative differences were bigger than the differences between gross yield.
- The irrigation determined the improve of the protein content in the all crop rotation studied.

x

x x

The yield gains determined by crop rotations and irrigation and the improve of the protein content of the grains show the importance of these elements of the technology in maize from Crişurilor Plain.

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