THE CROP ROTATION AND THE IRRIGATION INFLUENCE ON SOIL FERTILITY PARAMETERS AND ON THE WHEAT YIELD IN THE CRISURILOR PLAIN CONDITION

Şandor Maria, Domuţa Cornel, Domuţa Cristian, Borza Ioana, Brejea Radu, Vuşcan Adrian*

*University of Oradea, Faculty of Environmental Protection, Gen.Magheru St., No.26, 410048, Oradea, e-mail: scdaoradea@yahoo.com

Abstract

The paper is based on the researches carried out in a long term trial placed in 1990 on the preluvosoil from Agricultural Research and Development Station Oradea. In comparison with unirrigated and irrigated wheat-monocrop, in wheat-maize crop rotation, structure degree increased with 10% and 13% and in the wheat-maize-soybean with 23% and 24%. In comparison with the bulk density registered in the wheat monocrop in the wheat-maize crop rotation the average value on the 0-20 cm depth decreased with 2.1% in unirrigated variant and with 1.3% in the irrigated variant; the differences registered in the wheat-maize-soybean were of 5.6% and 3.4%. As consequence, the values of the total porosity increased in comparison with the values registered in wheat monocrop; the values of the air porosity increased, too. Penetration rezistance had the smallest values in wheat-monocrop: 17.3 kgf/cm^2 and 19.5 kgf/cm^2; in wheat-maize crop rotation, the values of the penetration decreased and in the wheat-maize-soybean crop rotation were registered the smallest values. In these conditions, in comparison with the wheat monocrop variant, in the wheat-maize crop rotation, the values of the hydraulic conductivity increased with 16.3% in unirrigated conditions and with 20.2% in irrigated variat; in the wheat-maize-soybean crop rotation, the differences were bigger: 33.9% and 51.8%. All the years studied, the smallest values of the wheat yield were registered in the wheat-monocrop; the yield increased in the wheat-maize crop rotation and the biggest yields were registered in the with-maize-soybean crop rotation. The irrigation determined the yield gains very significant statistically every year studied.

Key words: wheat, maize, soybean, crop rotation, irrigation, yield gains

INTRODUCTION

The importance of the crop rotation on the quantity of the yield is well-knwon (Budoi Gh., Penescu A., 1996; Guş P. et al., 1998; Domuţa C., 1995, 2005). The paper presents the results of the research regarding the influences of the crop rotation and of the irrigation in an experiment placed in 1990 at the Agricultural Research and Development Station Oradea. The results regarding the level of the yield and protein, gluten, content, fall index and deformation index are emphasized.

MATERIAL AND METHODS

The researches 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 profiles of the soil. (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 were: Factor A: crop rotation: a_1 – wheat, monocrop; a_2 - wheat-maize; a_3 – wheat – maize – soybean; Factor B: water regime: b_1 – unirrigated; b_2 – irrigated, maintaining the soil water reserve on the watering depth (0-50 cm for wheat) between the easily available water content and the field capacity.

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

RESULTS AND DISCUSSIONS

Modifications of the soil structure degree

Wheat-maize crop rotation and especcialy the wheat-maize-soybean crop rotation determined the improvement in the structure degree: 33.55% in unirrigated conditions in comparison with 37.01% and 36.57% and in comparison with 41.23% and 40.35%. (table 1)

Table 1

Crop rotation and irrigation influence on soil structure, Oradea 1990-2011

Crop rotation	Aggregates (%)				Total
	ϕ>5 mm	ϕ >2 mm	ϕ >1 mm	ϕ >0.25 mm	%
UNIRRIGATED					
1. Wheat –monocrop	0.34	3.18	2.15	27.88	33.55
2. Wheat-maize	0.39	3.88	3.10	29.64	37.01
3. Wheat-maize-soybean	1.01	4.26	3.84	32.12	41.23
IRRIGATED					
1. Wheat –monocrop	0.28	3.02	2.26	26.90	32.46
2. Wheat-maize	0.34	3.39	2.94	29.90	36.57
3. Wheat-maize-soybean	0.96	4.01	3.28	32.10	40.35

Modifications of the bulk density, total porosity and air porosity

The biggest values of the bulk density, both in unirrigated and in irrigated conditions, were registered in wheat-monocrop: 1.43 g/cm^3 and 1.46 g/cm^3 at 0-20 cm depth; in wheat-maize crop rotation the values of the bulk density were smaller by 2.1% and 1.3%. The most favorable values of the bulk density were registered in wheat-maize-soybean crop rotation and the differences in comparison with the wheat monocrop were of 5.6% in unirrigated conditions and of 3.4% in irrigated conditions. (table 2)

Table 2

Crop rotation and irrigation influence on bulk density (BD) of the soil, Oradea 1990-2011

Depth -cm-	Crop rotation					
	Wheat -monocrop		Wheat-maize		Wheat-maize-soybean	
	BD					
	g/cm^3	%	g/cm^3	%	g/cm^3	%
UNIRRIGATED						
0-10	1.37	100	1.34	97.9	1.30	94.9
10-20	1.48	100	1.45	98.0	1.40	94.6
0-20	1.43	100	1.40	97.9	1.35	94.4
IRRIGATED						
0-10	1.41	100	1.38	97.9	1.36	96.5
10-20	1.50	100	1.48	98.7	1.45	96.7
0-20	1.46	100	1.44	98.7	1.41	96.6

As a consequence, the smallest values of the total porosity (46.2% in unirrigated variant and 45.1% in irrigated variant) were registered in the wheat monocrop: in wheat-maize crop rotation, the values were bigger by 2.3% and by 2.2% and in the wheat-maize-soybean were registered the biggest differences in comparison with the wheat-monocrop. (table 3)

Table 3

Crop rotation and irrigation influence on total porosity (TP) of the soil. Oradea 1990-2011

Depth -cm-	Crop rotation					
	Wheat -monocrop		Wheat-maize		Wheat-maize-soybean	
	TP					
	%	%	%	%	%	%
UNIRRIGATED						
0-10	48.3	100	49.3	102.3	50.9	105.4
10-20	44.2	100	45.2	102.3	47.2	106.8
0-20	46.2	100	47.2	102.3	49.1	106.1
IRRIGATED						
0-10	46.8	100	47.9	102.4	48.7	104.1
10-20	43.4	100	44.2	101.9	45.3	104.4
0-20	45.1	100	46.1	102.2	47.0	104.3

Regarding the soil air porosity, the smallest values were registered in the wheat-monocrop: 12.3% in the unirrigated variant and 10.4% in irrigated one. In wheat-maize crop rotation, the values of the air porosity increased, the differences being of 13.8% and 15.4%. The biggest values of the air porosity were registered in the maize-wheat-soybean crop rotation; the differences in comparison with wheat-monocrop were of 36.6% in the unirrigated variant and of 30.0% in the irrigated variant. (table 4)

Table 4

Crop rotation and irrigation influence on air porosity (AP) of the soil, Oradea 1990-2011

Depth -cm-	Crop rotation					
	Wheat -monocrop		Wheat-maize		Wheat-maize-soybean	
	PA					
	%	%	%	%	%	%
UNIRRIGATED						
0-10	15.2	100	16.9	111.2	19.4	127.6
10-20	9.3	100	11.0	118.3	14.2	152.7
0-20	12.3	100	14.0	113.8	16.8	136.6
IRRIGATED						
0-10	12.7	100	14.6	115.0	15.8	124.4
10-20	8.0	100	9..3	116.3	11.1	138.9
0-20	10.4	100	12.0	115.4	13.5	130.0

Modifications of the penetration rezistance

The biggest values, 17.3 kgf/cm^2 in unirrigated conditions and 19.5 kgf/cm^2 in irrigated conditions, were registered in the wheat-monocrop. In wheat-maize crop rotation, the values of the penetration rezistance decreased by 10.1% in unirrigated conditions and by 11.9% in irrigated conditions. The biggest differences in comparison with the wheat-monocrop were registered in the wheat-maize-soybean crop rotation: 19.7 % in unirrigated variant and 20.5% in irrigated variant. (table 5)

Table 5

Crop rotation and irrigation influence on penetration rezistance (PR) of the soil, Oradea 1990-2011

Depth -cm-	Crop rotation					
	Wheat -monocrop		Wheat-maize		Wheat-maize-soybean	
	RP					
	kg/cm^2	%	kg/cm^2	%	kg/cm^2	%
UNIRRIGATED						
0-10	15.0	100	13.2	88.0	12.0	80.0
10-20	19.6	100	17.8	90.8	15.8	80.6
0-20	17.3	100	15.5	89.9	13.9	80.3
IRRIGATED						
0-10	17.3	100	14.6	84.4	13.0	75.2
10-20	21.6	100	19.8	91.7	18.1	83.8
0-20	19.5	100	17.2	88.1	15.6	79.5

Modifications of the hydraulic conductivity

The crop rotations influenced the values of the hydraulic conductivity, too. The smallest values were registered in wheat-monocrop, 12.0% in unirrigated variant and 10.3% in irrigated variant. In the wheat-maize crop rotations, the values of the hydraulic conductivity increased by

16.3% in the unirrigated variant and by 20.2% in the irrigated variant. The biggest values of the hydraulic conductivity were registered in the wheat-maize-soybean crop rotation, 16.6 mm/h in unirrigated variant and 15.5 mm/h in irrigated variant; the relative differences were of 33.9% and of 51.8%. (table 6)

Table 6

Crop rotation and irrigation influence on hydraulic conductivity (K) of the soil, Oradea 1990-2011

Depth -cm-	Crop rotation					
	Wheat -monocrop		Wheat-maize		Wheat-maize-soybean	
	K					
	mm/h	%	mm/h	%	mm/h	%
UNIRRIGATED						
0-10	13.9	100	15.8	113.7	18.2	130.9
10-20	11.1	100	13.2	118.9	15.2	136.9
0-20	12.0	100	14.0	116.3	16.6	133.9
IRRIGATED						
0-10	11.1	100	13.2	118.9	16.1	145.1
10-20	9.4	100	11.4	121.3	14.9	158.5
0-20	10.3	100	12.3	120.2	15.5	151.8

Crop rotation and the influence of irrigation on wheat yield

In the years studied, the smallest wheat yields were registered in wheat monocrop, both in the unirrigated conditions (2080 kg/ha in 2009, 4070 kg/ha in 2010, 3270 kg/ha in 2011) and in the irrigated conditions (4220 kg/ha in 2009, 4810 kg/ha in 2010 and 5830 kg/ha in 2011). (table 7, 8, 9)

In the wheat-maize crop rotation, the wheat yields increased in comparison with wheat monocrop. The annual differences registered in unirrigated conditions were of 460 kg/ha in 2009, 640 kg/ha in 2010 and of 710 kg/ha in 2011: in irrigated conditions the differences were of 790 kg/ha in 2009, of 1100 kg/ha in 2010 and of 680 kg/ha in 2011.

The biggest differences between the wheat yields determined in the wheat monocrop were registered in the wheat-maize-soybean crop rotation. In the unirrigated conditions the differences were of 1460 kg/ha in 2009, of 1750 kg/ha in 2010 and of 1590 kg/ha in 2011. In the irrigated conditions, the differences were of 1900 kg/ha in 2009, of 2290 kg/ha in 2010 and of 1840 kg/ha in 2011.

The irrigation use determined the yield gains very significant statistically both in the droughty years 2009 and 2011 and in the rainy year 2010. On average on the crop rotation studied, the yield gains determined by irrigation were of 89.3% in 2009, of 22% in 2010 and of 65% in 2011. (table 7, 8, 9)

The results of the researches sustain the need of the crop rotation with soybean because the physical parameters of the soil fertility are improved and the yield gains obtained are very significant statistically. The results sustain the need of the irrigation, too, both in the droughty years and in the rainy years.

Table 7

Crop rotation and irigation influence on wheat yield, Oradea 2009

Crop rotation	Water regime		Difference		Average
	Unirrigated	Irrigated	Kg/ha	%	
Wheat -monocrop	2080	4220	2140	102.9	3150^{Ct}
Wheat-maize	2540	5010	2470	197.2	3775
Wheat-maize-soybean	3540	6120	2670	175.4	4875
Average	2720	5150	2430	189.3	-

	Crop rotation	Water regime	Water regime x Crop rotation	Crop rotation x Water regime
$LSD_{5\%}$	170	130	310	290
$LSD_{1\%}$	310	240	490	410
$LSD_{0.1\%}$	540	410	720	650

Table 8

Crop rotation and irigation influence on wheat yield, Oradea 2010

Crop rotation	Water regime		Difference		Average
	Unirrigated	Irrigated	Kg/ha	%	
Wheat-monocrop	4070	4810	740	19	4440^{Ct}
Wheat-maize	4710	5920	1210	26	5315
Wheat-maize-soybean	5820	7100	1280	22	6460
Average	4870	5943	-	-	-

	Crop rotation	Water regime	Water regime x Crop rotation	Crop rotation x Water regime
$LSD_{5\%}$	180	140	320	280
$LSD_{1\%}$	290	250	460	410
$LSD_{0.1\%}$	470	390	670	590

Table 9

Crop rotation and irigation influence on wheat yield, Oradea 2011

Crop rotation	Water regime		Difference		Average
	Unirrigated	Irrigated	Kg/ha	%	
Wheat -monocrop	3270	5830	2560	178	4550^{Ct}
Wheat-maize	3980	6510	2530	164	5245
Wheat-maize-soybean	4860	7670	2810	158	6265
Average	4037	6670	2633	165	-

	Crop rotation	Water regime	Water regime x Crop rotation	Crop rotation x Water regime
$LSD_{5\%}$	215	182	310	240
$LSD_{1\%}$	326	296	530	460
$LSD_{0.1\%}$	510	472	820	712

CONCLUSIONS

The researches were carried out in a long term trial placed in 1990 on the preluvosoil from Agricultural Research and Development Station Oradea. In comparison with wheat-monocrop, in the wheat-maize and especially in wheat-maize-soybean crop rotation the smallest structure degrees (33.55% in unirrigated variant and 32.46% in irrigated variant) were registered. In wheat-maize crop rotation the structure degrees increased by 10% and 13% and in the wheat-maize-soybean crop rotation by 23% and 24%.

In comparison with the bulk density registered in the wheat monocrop, in the wheat-maize crop rotation the average value on the 0-20 cm depth decreased by 2.1% in unirrigated variant and by 1.3% in the irrigated variant; the differences registered in the wheat-maize-soybean were of 5.6% and 3.4%. As a consequence, the values of the total porosity increased in comparison with the values registered in wheat monocrop; the values of the air porosity increased, as well.

Penetration rezistance had the smallest values in the wheat-monocrop: 17.3 kgf/cm^2 and 19.5 kgf/cm^2; in wheat-maize crop rotation, the values of the penetration decreased and the smallest values were registered in the wheat-maize-soybean crop rotation. In these conditions, in comparison with the wheat monocrop variant, in the wheat-maize crop rotation, the values of the hydraulic conductivity increased by 16.3% in unirrigated conditions and by 20.2% in irrigated variat; in the wheat-maize-soybean crop rotation, the differences were bigger: 33.9% and 51.8%.

During all the years studied, the smallest values of the wheat yield were registered in the wheat-monocrop; the yield increased in the wheat-maize crop rotation and the biggest yields were registered in the wheat-maize-soybean crop rotation. The irrigation determined the yield gains very significant statistically each studied year.

The results of the researches sustain the need for crop rotation with leguminous and the need for irrigation of wheat in Crisurilor Plain.

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