INFLUENCE OF THE IRRIGATION ON SOIL PROPERTIES IN A LONG TERM TRIAL FROM ORADEA

Domuţa Cornel*

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

Abstract

The paper is based on the researches carried out in the long term trial placed on the preluvosoil from Oradea in 1976, for establishing the soil water balance. In the irrigated variant the soil moisture was determined 10 to 10 days for maintaining the soil water reserve on irrigation depth (0 – 50 cm for wheat and bean, 0 – 75cm for maize, sunflower, soybean, sugarbeet, potato and alfalfa 1st year and 0 – 100 cm for alfalfa nd year) between easily available water content and field capacity. Thus, an average irrigation rate of 2560 m³/ha was used in the 9 experimental crops. The average of the annual rainfall for the 1976 – 2010 period was pf 625.0 mm. The technologies used were correlated with the needes of the crops, such as melioration, crop rotation, chemical fertilizers in accordance with the chemical export on the yield, manure (20 t/ha) used in potato and sugarbeet. After 35 years of irrigation use the soil structure degree (38.62%) did not decrease when compared to the unirrigated maize – wheat crop rotation (37.01%). Bulk density, total porosity, penetration resistance and hydraulic conductivity have worse values than the ones in the unirrigated variant. The humus content is very close to the humus content determined in 1976, the phosphorus and the potassium content increased very much in comparison with the initial content (117 ppm vs 22.0 ppm); (180.0 ppm vs 102 ppm). The use of the adequate fertilization system and of the irrigation water with a good qaulity (SAR = 0.52; CSR = -1.7; pH = 7.2 did not determine a decrease of the pH value of the soil.

Key words: structure, bulk density, humus, irrigation.

INTRODUCTION

Drought and desertification are the major problems of the world in the context of the climate change (Page et al., 1982, Doorembos and Pruitt, 1992, Kay and Angers, 1999, Lado et al., 2005, Wakindiki and Ben-Hur, 2002, Brejea et al, 2008). There are climatic changes in Romania, too (A. Canarache, 1990); Dobrogea and the South-Eastern part are considered the area with desertification (Brejea, 2009). Other areas are an important part of Moldavia, the Romanian Plain and a small part of the Western Plain (C. Domuta, 2005). The Crisurilor Plain is part of the Western Plain and it has been known for its large areas with water logging and drought and also for the rainfall that is not in accordance with the optimum water requirement of the crops (Domuta, 2008). In 1968 the researches regarding the irrigation crop started in Girisu de Cris and in 1976 the researches regarding the crop water consumption were carried out in Oradea (Domuta, 2003, Grumeza and Kleps, 2005, Borza, 2006).

The researches regarding the irrigation use in the Crisurilor Plain emphasized the irrigation opportunity in the sustainable agriculture system, the yield gains produced by irrigation were statistically significant every year, the maize, soybean and sugar beet yields showed improvements in their stability and quality, and the water use efficiency improved, as well (Borza, 2007). The correlations quantified in the soil-water-plant-atmosphere system (soil moisture-yield, soil moisture – yield gains, water consumption – yield, climate indexes – yield) and the economical efficiency sustained the irrigation opportunity in this area (Domuta, 2003, Grumeza and Kleps, 2005, Domuta, 2007, Domuta, 2010).

The paper presents the irrigation impact on the main physical and chemical properties of the soil based on a 35 years' study.

MATERIAL AND METHODS

The researches were carried out in the long term trial placed in 1976 on the preluvosoil from Oradea, in order to study the soil water balance and the crop water consumption. The research data was compared with the data determined in an experiment with wheat-maize crop rotations near the research field for water balance study. The crop rotation used in the research field for the soil water balance study was a melioration one: alfalfa 1st year – alfalfa 2nd year – maize – bean – wheat – soybean – sugar beet – sunflower – potato.

In the ploughed land, the colloid clay content is of 31.5%.

The field capacity (FC) is a medium one on the soil profile and the wilting point (WP) has a medium value to 80 cm depth and a high value below this depth. The easily available water content (Wea) was established considering the soil's texture[6]. As a consequence, the following formula was used: Wea=WP+2/3(FC-WP).

During the research period (1976-2010), on the irrigation depth (0-50 cm for wheat and bean; 0-75 cm for maize, soybean, sunflower, sugarbeet, potato, alfalfa 1st year; 0-75 cm for alfalfa 2nd year) ten to ten days determinations of the soil moisture permitted to maintain the soil water reserve between the easily available water content and the field capacity. The accomplishment of this objective determined the use of 2,560 m^3/ha of irrigation water in the studied period and in the studied crops.

The water source for irrigation is ground water at a 15 m depth. The main chemical properties of the irrigation water used are presented in table 1. The natrium content (12.9%) is low and the salinization potential is low, too (CSR=-17; SAR=0.52) (table 1).

The crop technologies included the use of the chemical fertilizers according to the yield export for every crop and a medium rate on the melioration crop rotation: N 140 kg/ha s.a, P_2O_5 110 kg/ha s.a and K_2O 90 kg/ha s.a. In the sugar beet and the potato crop a dose of 40 t/ha of manure was used.

The hydrostability of the macrostructure (aggregates >0.25 mm) was determined using the Cseratzki method (Gh. Budoi, A. Penescu, 1996). The bulk density, hydraulic conductivity and the penetration resistance were determined using the same cylinders with a volume of 100 cm^3. The humus content, pH, the mobile phosphorus and mobile potassium content were determined using the common methods of the agrochemistry laboratories, in a laboratory of the Agricultural Research and Development Station Oradea.

The research data was analyzed using the variance analysis method (C. Domuta, 2006).

Table 1

Chemical parameters of the irrigation water used in the research field, Oradea

Ca^{2+}	Mg^{2+}	Na^{+}	K^{-}	CO_3^{2-}	HCO_3	CL^{-}	SO_4^{2-}	pH	Na %	Rezid. min. fix g/l	SAR	CSR	Class N. Florea
mg/liter													
49,1	44,0	20,8	2,7	-	266,8	35,4	80,3	7,3	12,9	0,5	0,53	-1,8	II

RESULTS AND DISCUSSION

The irrigation influence on the soil structure

The soil aggregates with a diameter bigger than 0.25 mm from the variant with irrigated melioration crop rotation had a value of 38.62%, higher than the value (37.01%) determined in the variant with unirrigated wheat-maize crop rotation but the difference (1.61%; 4%) is not statistically assured. In the variant with unirrigated melioration crop rotation, the hydrostability of the macro aggregates increased statistically significant in comparison with the unirrigated wheat-maize and an important difference (12.58%; 32.6%) was registered in comparison with the irrigated melioration crop rotation (table 2).

Table 2

Irrigation influence (1976-2010) on the hydro stability of the macrostructure, in the conditions of the preluvosoil from Oradea

Crop rotation	Macrostructure hydrostability		Difference		Statistical significance
	%	%	%	%	
1.Unirrigated wheat–maize	37.01	100	-	-	Control
2. Irrigated melioration crop rotation	38.62	104	1.61	4	-
3. Unirrigated melioration crop rotation	51.20	138	14.19	38	xxx

LSD 5% 2.01; LSD 1% 3.95; LSD 0.1% 6.03

Analyzing the situation of the macro aggregates for every determined diameter, a very different situation was registered regarding the macro aggregates with a diameter >5.0 mm; in the variant with unirrigated melioration crop rotation a value (2.80%) 618% higher than the value (0.39%) from the unirrigated wheat-maize crop rotation was determined; the value (0.62%) from the irrigated melioration crop rotation is by 39% higher than the value registered in the unirrigated wheat-maize crop rotation. There were differences regarding the hydro stability of the macro aggregates in the 2.0 mm, 1.0 mm and 0.25 mm case, too (table 3).

Table 3

Macro aggregates diameter (mm) under the irrigation influence in the conditions of the preluvosoil from Oradea

Crop rotation	Macro aggregates diameter							
	>5 mm		2.1-5 mm		1.1-2.0 mm		0.25 – 1.0 mm	
	%	%	%	%	%	%	%	%
1.Unirrigated wheat–maize	0.39	100	3.88	100	3.10	100	29.64	100
2. Irrigated melioration crop rotation	0.62	139	2.88	74	3.45	111	31.64	107
3. Unirrigated melioration crop rotation	2.80	718	3.90	101	3.76	121	40.74	137

The irrigation influence on the bulk density and on the total porosity

In the variant with unirrigated wheat-maize crop rotation, the value of the bulk density (1.34 g/cm^3) is high. In the variant with irrigated melioration crop rotation, the value of the bulk density (1.40 g/cm^3) increased statistically significant but is situated in the same characterization class. The value from unirrigated melioration crop rotation (1.20 g/cm^3) is statistically significant lower than the value registered in the wheat-maize crop rotation emphasizing the importance of the melioration crop rotation in the evolution of the physical properties of the soil (table 4).

Table 4

Irrigation influence (1976-2010) on the bulk density of the preluvosoil from Oradea

Crop rotation	Bulk density		Difference		Statistical significance
	g/cm^3	%	g/cm^3	%	
1.Unirrigated wheat–maize	1.34	100	-	-	Control
2. Irrigated melioration crop rotation	1.40	104.5	0.06	4.5	x
3. Unirrigated melioration crop rotation	1.20	89.6	-0.14	-10.4	000

LSD 5% 0.05; LSD 1% 0.09; LSD 0.1% 0.13

As a consequence, in comparison with the total porosity (49.4 %) determined from the unirrigated wheat-maize crop rotation, in the irrigated melioration crop rotation a smaller value was determined (47.1%) but the values are situated in the same characterization class. The value of the total porosity (54.7%) in the unirrigated melioration crop rotation is statistically very significant, higher than the one registered in the unirrigated wheat-maize crop rotation (table 5).

Table 5

Irrigation influence (1976-2010) on the total porosity of the preluvosoil from Oradea

Crop rotation	Total porosity		Difference		Statistical significance
	%	%	%	%	
1.Unirrigated wheat–maize	49.4	100	-	-	Control
2. Irrigated melioration crop rotation	47.1	95.4	-2.3	-4.6	0
3. Unirrigated melioration crop rotation	54.7	110.8	5.3	10.8	xxx

LSD 5% 0.9; LSD 1% 2.6; LSD 0.1% 4.9

The irrigation influence on the penetration resistance

In the irrigated melioration crop rotation the value of the penetration resistance (31.38 kg/cm^2) is statistically significant higher than the value (29.3 kg/cm^2) determined in the unirrigated wheat-maize crop rotation but the values are situated in the same characterization class, a median one. In unirrigated conditions, the melioration crop rotation determined a decrease of the penetration resistance with 32.7% statistically very significant. The characterization class changes to "small", in this case (table 6).

Table 6

Irrigation influence (1976-2010) on the penetration resistance of the preluvosoil from Oradea

Crop rotation	Penetration resistance		Difference		Statistical significance
	kg/cm^2	%	kg/cm^2	%	
1.Unirrigated wheat–maize	29.3	100	-	-	Control
2. Irrigated melioration crop rotation	31.38	107.1	0.8	7.1	x
3. Unirrigated melioration crop rotation	19.71	67.3	-3.7	-32.7	000

LSD 5% 0.6; LSD 1% 1.4; LSD 0.1% 3.5

The irrigation influence on the hydraulic conductivity

Irrigation did not have a statistically significant influence, the value of the hydraulic conductivity registered in the melioration crop rotation, 13.5 mm/h being very close to the value registered in the wheat-maize crop rotation (14.0 mm/h). In the unirrigated melioration crop rotation, the hydraulic conductivity (20.6 mm/h) is statistically very significant higher than the value determined in the unirrigated wheat-maize crop rotation (table 7).

Table 7

Irrigation influence (1976-2010) on the hydraulic conductivity of the preluvosoil from Oradea

Crop rotation	Hydraulic conductivity		Difference		Statistical significance
	mm/h	%	mm/h	%	
1.Unirrigated wheat–maize	14.0	100	-	-	Control
2. Irrigated melioration crop rotation	13.5	96.5	-0.5	-3.5	-
3. Unirrigated melioration crop rotation	20.6	147.2	6.6	47.2	xxx

LSD 5% 1.7; LSD 1% 3.1; LSD 0.1% 5.6

The irrigation influence on the humus content

With regard to the humus content (1.7%) in the start year of the researches conducted in the melioration crop rotation conditions and good soil management practices, a very close value (1.8%) was registered in the irrigated variant in 2010. In unirrigated conditions the melioration crop rotation and the applied soil management determined the increase of the humus content (1.9%) in comparison with the start year; the difference (11.8%) is distinctively significant (table 8).

Table 8

Irrigation influence (1976-2010) on the humus content of the preluvosoil from Oradea

Specification	Humus		Difference		Statistical significance
	%	%	%	%	
1. In 1976	1.70	100	-	-	Control
2. In 2010 (irrigated)	1.67	98.3	-0.03	-1.7	-
3. In 2010 (unirrigated)	1.90	111.8	0.20	11.8	xx

LSD 5% 0.07; LSD 1% 0.12; LSD 0.1% 0.21

The irrigation influence on the pH value

In 2010, the soil reaction (pH=6.0) in the irrigated variant increased distinctively significant, in comparison with the value of the soil reaction (pH=5.81) determined in the start year of the experiment. The explanation consists of the Ca^{2+} high content of the irrigation water used in the research field. In the unirrigated variant the pH value (5.58) decreased distinctively significant due to the use of chemical fertilizers (table 9).

Table 9

Irrigation influence (1976-2008) on the pH values of the preluvosoil from Oradea

Specification	pH		Difference		Statistical significance
	Value	%	Value	%	
1. In 1976	5.81	100	-	-	Control
2. In 2010 (irrigated)	6.00	103.3	0.29	3.3	xx
3. In 2010 (unirrigated)	5.58	96.1	-0.23	-3.9	00

LSD 5% 0.11; LSD 1% 0.17; LSD 0.1% 0.31

The evolution of the mobile phosphorus and potassium after 33 years of good soil management practices

The mobile phosphorus content of the preluvosoil from the research field in the start year, 22.0 ppm was low, but after 33 years of good agriculture practices – melioration crop rotation with alfalfa, chemical fertilizers doses in accordance with the yield export – the mobile phosphorus content became very good, 117.0 ppm in unirrigated conditions and 109.0 ppm in irrigated conditions; the differences in comparison with the start year are statistically very significant both in unirrigated and irrigated conditions (table 10).

Table 10

The influence of irrigation on protein content in maize. Oradea, 1987 – 2010

Variant	Total nitrogen content in maize kernels		Protein content in kernels	
	%	%	kg/ha	%
Unirrigated	1.42	100	556.94	100
Irrigated	1.70	119.7	1311.52	235.4

The mobile potassium content of the preluvosoil in the start year (183.0 ppm) was high and, after 35 years, the mobile potassium content was very high, 290.0 ppm in unirrigated conditions and 240.0 ppm in irrigated conditions; the differences in comparison with the start year are statistically very significant (table 11).

Table 11

The influence of the irrigation on the big tubers share from potatoes, Oradea 1976 – 2010

Variant	The big tubers share		Variation interval of big tubers share
	Values %	%	
Unirrigated	75,6	100	71,6-82,5
Irrigated	84,4	111.6	80,1-92,4

CONCLUSIONS

The researches that were carried out in the long term trial with crop rotation placed on the preluvosoil from Oradea, in 1976, in the Northern-Western part of Romania, led to the following conclusions:

- In the melioration crop rotation with alfalfa, after 35 years of a correct irrigation use, the hydro stability degree of the macro aggregates (38.62%) did not decrease in comparison with the unirrigated wheat-maize crop rotation. In unirrigated conditions, the value (51.2%) determined in the melioration crop is very significant, higher than the value determined in the wheat-maize crop rotation; the highest differences were registered in the aggregates with a diameter bigger than 5 mm.
- In the irrigated melioration crop rotation, the bulk density, total porosity, penetration resistance and the hydraulic conductivity had worse values than the ones in the unirrigated wheat-maize crop rotation. In the unirrigated melioration crop rotation, the values were very significant better than the values from unirrigated wheat-maize.
- After 35 years of a correct irrigation use and in the conditions of the melioration crop rotation and organic and chemical fertilization in accordance with the yield export, the humus content did not decrease significantly in comparison with the initial content of 1.67% vs. 1.4%; in the unirrigated variant the difference is statistically significant bigger than the initial content.
- The use of the irrigation water with a Ca^{2+} high content determined an increase of the pH value distinctively significant (6.0 vs. 5.81) in comparison with the initial pH. In the unirrigated variant, the chemical fertilizers use determined a distinctively significant decrease (5.5 vs. 5.81) of the pH in comparison with the initial value.
- The mobile phosphorus increased in comparison with the initial value (22.0 ppm) with 39.5% in the irrigated variant and with 431.9% in the unirrigated variant. The increase of the mobile potassium was of 31.2% and 58.5%. All the differences in comparison with the initial values are statistically very significant.

Based on a 35 years correct use of irrigation and of a superior soil management, the paper emphasizes that the soil structure did not decrease and the main chemical properties of the soil improved in 2010 compared to the initial values (in 1976).

Acknowledgments

The researches were carried out in the project: PN-II-ID-PCE-2008; 1047/2009 ”The Study of Influences of Some Technological Elements upon the Wheat Yield Quality in the Conditions of the North-Western part of Romania”.

REFERENCES

1. Borza Ioana, 2006, Cercetări privind influenţa unor măsuri fitotehnice asupra valorificării apei de către cultura porumbului în condiţiile Câmpiei Crişurilor. Teză de doctorat USAMV Cluj-Napoca pp. 189-201.
2. Borza Ioana, 2007, Valorificarea apei de către cultura porumbului din Câmpia Crişurilor. Editura Universităţii Oradea, pp.195-208.
3. Ioana Borza, Cornel Domuţa, Maria Şandor, Cristian Domuţa, Radu Brejea, Adrian Vuşcan, Anuţa Jurca, 2010, Researches regarding the irrigation influence on water use efficiency in potato in the Crişurilor Plain conditions, Research Journal of Agricultural Science Timisoara Vol. 42 (1) 1-688, pp. 22-26.
4. Brejea R., Domuta C., Sandor M., Samuel A.D., Bara V., Ciobanu Gh., Sabau N.C., Ciobanu C., Bara C., Domuta Cr., Bara L., Borza I., Gatea M., Vuscan A., 2008, The study of physical, chemical and enzymatical properties of the land from a former bauxite quarry in the Padurea Craiului Mountains in the context of ecological reconstruction. Carpathian Journal of Earth and Environmental Sciences, Baia Mare. Vol. 3 No. 2 pp. 49-63.
5. Brejea R., 2009, Tehnologii de protecţie sau refacere a solurilor. Editura Universităţii din Oradea, pp. 78-92.
6. Budoi Gh., Penescu A., 1996, Agrotehnică Editura CERES, Bucureşti, pp. 130-180.
7. A. Canarache, 1990, Fizica solurilor agricole, Editura CERES, Bucureşti, pp. 20-90.
8. Domuţa C., 2003, Oportunitatea irigaţiilor în Câmpia Crişurilor. Editura Universităţii din Oradea, pp. 7-45.
9. Domuţa C., 2005, Irigarea culturilor, Editura Universităţii din Oradea, pp.170-230.
10. Domuţa C., 2006, Tehnică experimentală, Editura Universităţii din Oradea, pp. 15-60.
11. Domuţa C. (coordonator), 2007, Asolamentele în Câmpia Crişurilor. Editura Universităţii din Oradea, pp. 15-80.
12. Domuţa Cr., 2008, The influence of the irrigation on the water consumption, yield and on the water use efficiency in the maize from Crişurilor Plain, Analele Univ. Oradea, Fascicula Protectia Mediului.
13. Domuţa Cr., Domuţa C., Şandor Maria, Samuel Alina, 2008, The influence of irrigation on the soil water plant sistem relationships in the maize crop from the Crisurilor Plain, Lucrările Ştiinţifice Facultatea Agricultură Timişoara, Editura Agroprint – Symphosium : “Trends in European Agriculture Development”. pp. 283.
14. Cristian Domuţa, Cornel Domuţa, 2010, Irigarea porumbului în Câmpia Crişurilor, Editura Universităţii din Oradea, pp. 113-157.
15. J. Doorembos, W.O. Pruitt, 1992, Crop water requirements. FAO Irrigation and Drainage Paper no.24, FAO Rome, Italy, pp. 120-170.
16. Grumeza N., Klepş Cr., 2005, Amenajările de irigaţii din România. Editura Ceres Bucureşti, pp.170-213.
17. B.P. Kay, D.A. Angers, 1999, Soil structure. Handbook of Soil Sciences. CRC Press New York, pp. 23-47.
18. M. Lado, M. Ben-Hur and S. Assouline, 2005, Effects of Effluent Irrigation on Seal Formation, Infiltration, and Soil Loss during Rainfall. Published in Soil Science Society Agronomy Journal 69, pp. 1432-1439.
19. A.L. Page, R.H. Miller And D.R. Keeney, 1982, Methods of Soil Analysis, Part 2- Chemical and Microbiological Properties, Second Edition. American Society of Agronomy, Inc, SSSA, pp. 17-50.
20. I.I. Wakindiki, M. Ben-Hur, 2002, Soil mineralogy and texture effects on structural crust formation, 17th World Congress of Soil Science, Bangkok, Thailand, 14-20 August, 2002.