IRRIGATION POSSIBILITIES OF THE SOILS FROM THE NORTHERN AGRICULTURAL REGION OF THE REPUBLIC OF MOLDOVA LOCATED IN THE RIVER BASIN OF THE PRUT

Valentina ANDRIUCĂ[1], Raisa LOZAN[1], Anatol TĂRÎȚĂ[2]

e-mail: valandriuca@yahoo.com

Abstract

Currently, irrigation is considered one of the main factors for regulating and improving the soil moisture regime, but the establishment of soil irrigation systems for fruit trees in some agricultural areas of the Republic of Moldova is problematic and deficient.Researching soil cover within the river basins, evaluating the suitability of lands and soils for irrigation, highlighting the ecological problems that may occur, simultaneously with evaluating the quality of various water types suitable for irrigation represent current and important issues for all agricultural areas of the Republic of Moldova. The problem becomes even more pressing in connection with the adoption of the „Regulation on the use of groundwater for drip irrigation of agricultural land occupied by horticultural crops" (GD RM 635/2020 of 19.08.2020). Previously, the irrigated land in the Republic of Moldova included mostly typical and carbonate chernozems and some alluvial soils. The paper aims to avoid and minimize the impact of anthropogenic degradation of soils affected by intensive agriculture, under different crops, including fruit plantations and consequently not compromising long-term investments, such as establishing horticultural plantations, given that groundwater is unacceptable for irrigation, therefore the soils, depending on their suitability, can create ecological irrigation problems. Soil cover and water quality in various localities of the 2nd ecopedological district of the Republic of Moldova were investigated. The soil type of Moșeni village, administrative district Râșcani, consists of cambic chernozems in proportion of 75%. Here, over 100 ha of intensive orchards were established and the water suitable for irrigation is missing.

Key words: irrigation, chernozems, groundwater, water quality, irrigation indices.

Irrigation and soils represent two interdependent components, addressed in the National Development Strategy „Moldova 2030", adaptation strategies and sustainable management of water resources - important elements of sustainable agriculture, current climate change, drought conditions in the Republic of Moldova and in the region.

Drought is the extreme climatic phenomenon, which induces a major economic and social impact on the economy, the agricultural sector, the crop productivity, and its incidence in the last two decades in the Republic of Moldova has increased significantly. Out of the 38 episodes of seasonal drought registered after 1945, 13 episodes occurred in the period after 2000, of which 9 were assessed as catastrophic, and under these conditions the irrigation water represents a real solution.

Researching soil cover within the river basins, evaluating the suitability of lands and soils for irrigation, highlighting the ecological problems that may occur, simultaneously with evaluating the quality of various water types suitable for irrigation represent current and important issues for all agricultural areas of the Republic of Moldova.

The problem becomes even more pressing in connection with the adoption of the „Regulation on the use of groundwater for drip irrigation of agricultural land occupied by horticultural crops" (GD RM 635/2020 of 19.08.2020).

Previously, the irrigated land in the Republic of Moldova included mostly typical and carbonate chernozems and some alluvial soils.

MATERIAL AND METHOD

As research objects served the soil cover, soils and water quality in some localities characteristic for the hilly forest-steppe of the Middle Prut Valley, the North Moldavian Plateau, the Bălți Plain, situated in the administrative districts Glodeni, Râșcani and Edineț.

The soil cover was investigated using cartographic methods, while the physico-chemical and physical characteristics according to the

[1] State Agrarian University of Moldova, Chisinau, Republic of Moldova
[2] Institute of Ecology and Geography, Chisinau, Republic of Moldova

methods accepted by the ecopedological monitoring:

a) Humus - I. Tiurin's method modified by Simacov (STAS 26213-84);

b) Hygroscopic water content (analytical coefficient) - thermostatic method;

c) Aqueous and saline pH - potentiometric method;

d) Calcium carbonate ($CaCO_3$) - gas volumetric method, calcimetry;

e) Adsorbed cations (exchange) - complexometric method in 3 N solution of NaCl;

f) Determining the granulometric composition according to N. Cacinschi (pipette method), soils dispersion degree using tetrasodium pyrophosphate (Na4PO) of 4% (STAS 12536-79).

The assessment of irrigation water quality was performed using several methods, based on

different criteria for determining some limiting indices (SAR, Na (%), the ratio of sodium ions, chlorine and sulfate in water).

The irrigation water analysis bulletin included:

•Total content of soluble salts (mineralization);

• Relative calcium, magnesium and sodium content;

• Water reaction (pH value);

• Chloride content.

The quality of irrigation water for was evaluated according to the SAR index, knowing the content of Na^+, Ca^{2+} and Mg^{2+} ions in the water and it was calculated according to the formula:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

The Stebler coefficient or the irrigation coefficient (Ka) was used to assess the probability of a secondary salinization of the soil, caused by the poor quality of used irrigation water. The determination of the coefficient is made according to the ratio between the content of Na^+, Cl^-, SO_4^{2-} (mval).

RESULTS AND DISCUSSIONS

The soil type of the 2nd ecopedological district, the Hilly Forest-Steppe of the Middle Prut, represented by chernozems - typical moderately humiferous (over 22%), typical weakly humiferous (4.7%), carbonate (1.4%), cambic (8. 4%) and luvic (7.8%), typical gray soils (2%) and light gray soils (4.4%) represent a specific object of irrigation, including for fruit crops.

The research and evaluation of the soil cover, the systematic list of soils from several localities in the Republic of Moldova highlight their inhomogeneity, especially in the river basins of the rivers Ciuhur, Camenca, Ciuhureț, while on the terraces closer to the Prut river the list of soils increases.

For the localities of Moșeni (Vasileuți), Boroseni, Zăicani, Șapte Bani located in the administrative district Râșcani - the number of soil contours is respectively: 16, 21, 49, 37.

These localities, besides the chernozems (luvic, levigated - cambic), have registered large areas of gray soils. In Boroseni and Vasileuti, 75% of the surface is occupied by cambic chernozems, and in Șapte Bani the gray soils occupy approx. 9%, while the cambic (levigated) chernozems and luvic chernozems approx. 41%. It is obvious that the land ownership and privatization in the Republic of Moldova did not took into consideration the homogeneity of the distributed agricultural land and the specifics of the agricultural areas. Table 1 presents data on the irrigated areas of some localities in Râșcani administrative district, which also include land not suitable for irrigation.

Table 2 presents some characteristics of the soil cover of some researched localities, and table 3 presents the physico-chemical characteristic of some evaluated soils. Based on complex multilateral research on the chernozems included in the irrigation fund of the Republic of Moldova (Ursu A., Sinchevici Z., 1988; Filipciuc V., 1995; Gumaniuc A., 2004), there were highlighted and described multiple ecological problems related to the irrigation of chernozems and land that refers to good soil favorability classes for irrigation. Levigated-cambic chernozems, luvic chernozems, grizioms are soils presenting difficulties in applying irrigation systems, given that they register elluvial-illuvial differentiated by texture, agrophysical characteristics and others.

It was determined (Filipciuc V., 1995; Gumaniuc A., 2004), that irrigation water represents the main natural limiting factor that largely determines the productivity of agricultural crops and the level of soil supply with accessible water. At present, water quality is problematic in the 2nd ecopedological district, as well as on the entire territory of the Republic of Moldova.

The water from a number of water sources, mine-type wells, accumulation lakes, planned to be used for irrigation, was analyzed and evaluated in Boroseni and Moșeni villages, Râșcani district (*table 5*).

Data presented in tables 4 and 5 indicate that the water did not correspond to the irrigation requirements. Obtained results (*table 6*) indicate the interrelationship between the water quality parameters for irrigation and the type of chernozems in Boroseni village from Râșcani

administrative district.The results show that the SAR constitutes 24.2, and the water used for chernozems irrigation induces a strong danger of solonization, the harmful accumulation of Na in most soils, consequently it cannot be used for irrigation. The irrigation index was determined depending on the percentage of Na content, compared to the sum of sodium, calcium and magnesium, which reaches the value of 60.3, thus the analyzed water is unsafe for irrigation.

Based on the above-mentioned, we can conclude that the researched water cannot be used for irrigation as it induces serious ecological risks.

Table 1

The irrigated land fund in the administrative district Râșcani, 2020

№	Town hall	Total area of irrigated land at the beginning of the previous year (ha)	Total area of irrigated land at the end of the year (ha)	Of which	
				It is irrigated (ha)	It is not irrigated for various reasons (ha)
1.	Borosenii-Noi	115	115	115	-
2.	Mihăileni	25	25	25	-
3.	Nihoreni	47	47	47	-
4.	Pociumbăuți	219.39	35	35	188.39
5.	Pociumbeni	165.63	-	-	165.63
6.	Recea	12	12	12	-
7.	Sturzeni	151	151	151	-
8.	Văratic	37.68	-	-	37.68
9.	Zăicani	275.45	72	72	205.48
Total:		1048.15	457	457	597.18

Table 2

Representative soils in Boroseni village, Rascani district

№	Soil type	Area, ha	% of the total area	Bonitation degree		
				According to characteristics	Vineyards	Orchards
1	Luvic chernozem moderately humiferous clay-loamy	19	0.9	88	70	95
2	Luvic chernozem weakly eroded clay-loamy	8	0.4	70	86	86
3	Deep levigated humiferous loamy-clay chernozem	995	48.6	93	55	108
4	Medium deep levigated moderately humiferous clay-loamy chernozem	71	3.5	85	86	100
5	Levigated weakly eroded loamy-clay chernozem	248	12.1	68	77	81
6	Levigated weakly eroded clay-loamy chernozem	230	11.2	75	96	90
7	Levigated moderately eroded clay-loamy chernozem	172	8.4	56	86	70
8	Levigated strongly eroded clay-loamy chernozem	77	3.7	47	72	60
9	Typical deep humiferous loamy-clay chernozem	14	0.6	99	52	103
10	Typical medium deep moderately humiferous clay-loamy chernozem	7	0.3	90	82	95
11	Typical weakly eroded loamy-clay chernozem	21	1.0	72	73	77

Table 2 (continuation)

Representative soils in Boroseni village, Râșcani district

№	Soil type	Area		Bonitation degree		
		ha	%	According to characteristics	Vineyards	Orchards
1	Gray loamy-clay	71.00	3.4	61	68	68
2	Gray clay-loamy	88.00	4.22	68	85	76
3	Gray light loamy-clay	18.00	0.86	70	68	81
4	Gray light clay-loamy	94.00	4.51	78	85	90
5	Deep loamy-illuvial-alluvial moderately humiferous loamy-clay chernozems	135.00	6.48	79	56	86
6	Deep levigated moderately humiferous loamy-clay chernozems	109.00	5.23	85	62	90

Table 3

Physico-chemical indices of the soils in Boroseni village, Râșcani district

№	Soil type	Depth, cm	Hygroscp ic water, %	Humus According to Tiurin, %	The sum of adsorbed cations, me/100g sol	Adsorbed cations, me/100 g sol		Carbonate content, %	pH KCl	pH H2O	Granulometric composition, %	
						Ca^{++}	Mg^{++}				>0,01	<0,01
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Cambic chernozem deep moderately humiferous loamy-clay	0-10	5.63	4.35	23.7	20.9	2.8		5.8		37.31	62.69
		30-40	5.85	3.45	22.4	20.3	2.1		5.2			
		50-60	5.92	3.45				1.0	5.6		36.75	63.25
		70-80	5.11	1.37				20.6	6.4			
		85-95	5.04	1.18				13.8	6.6	7.9	49.83	50.17
		150-160	4.75								33.72	66.28
2	Cambic chernozem deep levigated moderately humiferous loamy-clay	0-10	5.70	4.24	22.0	19.8	2.2		6.3		34.15	65,85
		25-35	5.78	4.45	23.9	21.2	2.7		5.9			
		45-55	6.15	3.29					5.9		29.17	70,83
		60-70	6.22	2.04					6.7			
		75-85	6.30	1.25					7.0		34.74	65.26
		150-160	5.33					17.4		7,8	34.62	65.38
3	Typical chernozem deep moderately humiferous clay-loamy	0-10	5.5	4.9	30.9	25.2	5.7		6.9		48	52
		30-40	5.5	4.6	32.1	26.5	5.6		7.0			
		50-60	5.5	2.9					7.2		47	53
		70-80	5.5	1.8						7,7		
		90-100	5.3	1.7				1.7		7,8	44	56
		180-190	4.6							8,2	38	62
4	Luvic chernozem weakly eroded loamy-clay	0-10	6.38	2.90	20.0	16.6	3.4		4.7		30.75	69.25
		15-25	6.15	3.22	22.2	19.3	2.9		5.2			
		35-45	6.45	2.51	23.2	22.0	1.2		5.2		29.64	70.36
		50-60	6.61	0.78					5.5			
		70-80	6.22						5.5		36.33	63.67
		150-160	5.11					16.2		7.8	28.35	71.65
5	Carbonate chernozem weakly eroded loamy-clay	0-10	6.61	2.35	25.8	23.7	2.1	2.4		8.0	32.52	67.48
		15-25	6.45	2.90	26.6	22.7	3.9	2.4		8.0		
		30-40	6.15	3.49				0.9		7.6		
		50-60	6.08	3.10				0.8		8.2	38.73	61.27
		70-80	5.85	0.92				11.0		8.5	36.67	63.33
		140-150	5.04					14.8		8.5	39.53	60.47

Table 4

The quality of different water sources in Edineț district *
*** 1-artesian well; 2-lake; 3-spring; 4-mine *well***
(MAC - Maximum Admissible Concentration)

Indicator	1	2	3	4	MAC
Fixed residue, mg/dm^3	1070	723	809	1100	1000
Sodium, mg/dm^3	408	172	209	124	200
Calcium, mg/dm^3	4.0	35	31	132	100
Magnesium, mg/dm^3	2.0	83	73	102	80
Bicarbonates,mg/dm^3	704	727	897	807	Unlimited
Sulphates, mg/dm^3	245	69	43	173	500
Chlorides, mg/dm^3	51.0	88	32	78	350
Nitrates, mg/dm^3	1.1	1.0	11	33	50
Nitrites, mg/dm^3	0.02	0.0	0.025	0.028	0
Ammonium, mg/dm^3	2.2	3.3	0	0	0.05 (0.5 fish breeding)
Hardness, me/dm^3	0.35	8.4	7.7	15.4	8.0
pH	7.4	7.6	7.5	7.3	6.5-8.5
Irrigation coefficient (SAR)	17.0 Bad	3.7 Medium	4.6 Medium	1.9 Medium	0-10
Percentage of sodium, % Na	98 unusable	47 acceptable	54 acceptable	25 good	<60
Stebler coefficient	2.3 dissatisfying	5.8 satisfying	3.7 dissatisfying	27 good	>18

Table 5

Qualitative characteristics of some water sources in Râșcani district

Indicator	CMA, drinking water	Artesian well, Moseni, 2021	Well nr. 2, Zaicani, 2012	Lake, Zaicani, 2012
Fixed residue, mg/dm^3	1000	1029	549	912
Calcium, mg/dm^3	100	6.94	56.4	68.9
Magnesium, mg/dm^3	80	3.06	79.2	57.6
Sodium, mg/dm^3	200	301.8	39.9	192.2
Hydrocarbonates, mg/dm^3	Unlimited	695.4	549.1	719.2
Sulphates, mg/dm^3	500	236.4	37.1	106.5
Chlorides, mg/dm^3	350	35.5	39.4	60.4
Nitrates, mg/dm^3	45	5.6	30.6	12.2
Nitrites, mg/dm^3	0	3.82	0	0
Ammonium, mg/dm^3	0.05	0.08	0	0.03
Hardness, me/dm^3	8.0	0.64	8.95	8.12
pH	6.5-8.5	7.45	7.72	7.92

Table 6

Values of the irrigation water quality parameters

Criterion	Râșcani - Boroseni	Acceptable value for chernozem (Filipciuc V., 1996)			
		Carbonatic	Ordinary	Typical	Levigated
Calcium, % din Ca+Mg+Na	21.6	> 40	> 40	> 45	> 45
Magnesium, % din Ca+Mg	45.5	< 50	< 50	< 50	< 50
Sodium, % din Ca+Mg+Na	60.3	<40	< 35	< 30	< 30
Mineralization, mg/dm^3	0.912	< 0.8	< 0.8	< 0.7	< 0.7
Reaction (pH)	7.92	8.2	8.2	8.2	8.2
Chlorides, mg/dm^3	60.4	105	105	105	105

CONCLUSIONS

The soil cover in the Republic of Moldova is very inhomogeneous, and the quality of soils and groundwater registers the chemistry of the rocks.

The more inhomogeneous the soil quality, the more differentiated the water quality.

Compared to the Dniester basin, the soils of the Prut river basin represent more complicated objects for irrigation.

The land fund structure of the 2nd ecopedological district records a relatively high share of cambic, luvic chernozems, grizioms, and the irrigation of fruit crops will cause multiple ecological problems, including soil degradation.

In most localities of the 2nd ecopedological district, the main source of water suitable for irrigation is the Prut river, groundwater, water from lakes and others evaluated water sources is unacceptable for irrigation.

Analyzed groundwater's contains large amounts of sodium and this will consequently cause the salinization of some lands, dispersal and loss of humus from the soil, degradation of properties, worsening of hydro-physical regimes of the soil etc.

ACKNOWLEGMENTS

This paper has been founded by Research Project (RM) 20.80009.5107.04

REFERENCES

Filipciuc V., 1995 - *Buletin de monitoring ecopedologic (pedoameliorativ)* ed. II. Chişinuă, 51p.

Filipciuc V., 1996 - *Recomandări pentru prevenirea degradării cernoziomurilor irigate*, Chişinuă, 51p.

Florea N., Sălăceanu. V., 1987 - *Metodica elaborării studiilor pedologice.* Partea II. Bucureşti, 348 p.

Gumaniuc A., 2004 - *Irigarea şi fertilizarea culturilor agricole în condiţii de subasigurare cu apă.* Chişinuă, p. 323

Урсу А., Синкевич З., **1980** - *Охрана почв в условиях интенсификации сельского хозяйственного производства.* Кишинев, „Картя Молдовенеаскэ”, 165 с**.**

Ропот Б., 1990 *- Прогнозный водно-солевой режим почв и грунтовых вод Юго-Заподного региона Молдавии.* Проблемы мелиорации почв Молдавии. Сборник статей. Молдавский Научно-исследовательский институт почвоведения и агрохимии им. „Н.Димо”, НПО „Плодородие”. Кишинев „Штиинца”, 146 с.