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TESTING THE INFLUENCE OF EROSION ON SOIL CHEMICAL INDICATORS

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Abstract

Soil erosion is one of the most widespread forms of soil degradation. The research was conducted with the aim of identifying the influence of erosion on chemical traits of moderately sloppy degraded luvisoil, using appropriate indicators. The experiment is located in Borod commune, Bihor County. To carry out the study of the level of soil erosion, a bifactorial experiment was organized, with the factors represented by the type of crop (meadow and corn) and the location of the crop (on contour lines and in the hill-valley direction). The biological material consists of alfalfa-dominated grasslands and maize maintained on typical, moderately eroded Luvisol. It is found that for the exploitation of the meadow, the highest values of the nutrient content are recorded, compared to the corn crop. The chemical indicators of soil quality are strongly influenced by the location of the crop, the location of the crop at the base of the slope having the strongest influence, but in the case of pH and mobile phosphorus content, located at the top of the slope.

Key words: *differences, dry matter, fertilizer, irrigation, water.*

INTRODUCTION

Soil erosion is one of the most widespread and major forms of soil degradation, having a strong impact on the environment as well as an economic one (Govaertes et al., 2006; Sestras et al., 2013). Soil erosion encompasses both geomorphological and land degradation aspects, posing environmental risks that impact human livelihoods (Stavi & Lal, 2011). Detrimental effects of erosion in connection with crop cultivation may encompass constrained root development, diminished water availability, decreased soil fertility, and unfavorable physical circumstances (Cojocaru, 2019; Babur et al., 2016; Havaee et al., 2015; Xiao-Li et al., 2010).
In the agricultural sector, it is estimated that approximately 10% of the land surface affected by erosion globally, of which 66.58% is surface affected by water erosion, of which 20.5% with strong and excessive intensity, respectively 33.42% by wind erosion from which 4.7% with strong and excessive intensity, according to the data provided by the International Soil Reference Center (Pintaldi et al., 2018; https://www.isric.org/).
The use of appropriate indicators (total degree of structuring of soil aggregates, apparent density, soil hydraulic conductivity, soil water reserve, water utilization efficiency, soil acid reaction, humus content, mobile phosphorus content, mobile potassium content and productivity corn culture and meadows), makes it possible, through quantification, to highlight the influence of erosion and/or existing crops on the physico-chemical properties of the soil (Abbasi et al., 2007; Imaz et al., 2010; Nael et al., 2004; Biali et al., 2016).
The research was conducted with the aim of identifying the influence of erosion on chemical traits of moderately sloapy degraded luvisoil, using appropriate indicators.

MATERIALS AND METHODS

The trial was carried on in the Odadei Depression in the west of our country, respectively on the territory of the village of Valea Mare de Criș, which belongs to Borod commune, Bihor County, during 2021-2022. The results are expressed as means by two years. The soil taxonomic unit is the typical moderately eroded Luvosol, loamy/loamy on clays, to which specific morphological characters correspond. Also, the mentioned soil type, in the experimental device, corresponds to the following particularities (Domuţa, 2012): hill area, slope with a slope of 10-15%, W-SW, groundwater depth, 5-10 m, parent material of the soil, clays and medium texture on the surface and fine in depth, slightly acid soil reaction, low humus content in the first horizon and extremely low in the next, very low nitrogen content, extremely low phosphorus content and low potassium content.

The biological material consists of alfalfa-dominated meadows and corn. Pioneer PR38A24 corn hybrid was used. It is part of the FAO 350 group (https://www.corteva.ro/produse-si-solutii/seminte-corteva/porumb-pioneer-P0217.html), is included in thermal zone 5 (1000-1200ºC), being a semi-early hybrid.

The experiments were carried out in order to study the level of soil erosion and to identify solutions to improve the eroded soil on the slope, according to the method of randomized blocks, in three repetitions, each plot having an area of 50 m^2. In order to carry out the study of the level of soil erosion, a bifactorial experiment was organized, with the factors represented by the type of crop (meadow and corn) and the location of the crop (on contour lines and in the hill-valley direction).

The experimental variants are: V1 - Control, meadow, peak; V2 - Control, meadow, base; V3 - Culture with maize by level curves, peak; V4 - Culture with maize by level curves, base; V5 - Culture with maize by direction hill-valley, peak; V6 - Culture with maize by direction hill-valley, base.

Soil humus is determined titrimetrically (Tiurin method), pH is determined potentiometrically, mobile potassium and mobile phosphorus are extracted by the Egner-Riehm-Domingo method using an acetate-ammonium lactate solution, phosphorus is measured photocolorimetrically with blue molybdenum according to the Murphy-Riley method, and potassium is measured flamphotometrically (Domuța & Sabău, 2000).

The Kolmogorov-Smirnov statistic was applied to assess how well the data conforms to a normal distribution. Likewise, a Kaiser-Meyer-Olkin value of 0.732 and Bartlett’s test of sphericity, yielding a chi-square value of 677 (with a p-value < 0.0001), affirmed the appropriateness of the data for factor analysis (Merce & Merce, 2009).

RESULTS AND DISCUSSIONS

In addition to the decrease in the quality of the physical properties of the soil, erosion also causes the decrease in the quality of its chemical properties. In the experimental field as it results from the results that will be presented next, results obtained following the laboratory analyzes of the samples collected from the profiles in which the physical analyzes were also performed.

The study of the pH values, reported for the analyzed soil taken from the top and base of the slope, highlights the existence of a slightly acidic character for all the experimental variants. The most pronounced acidic character, located in the value range belonging to the slightly acidic domain, corresponds to pH = 5.49, reported for the soil located at the top of the slope, corresponding to V5. The weakest acid character corresponds to pH = 5.85, reported for the soil located at the base of the slope, corresponding to experimental V5. Between the soil pH evolutions, depending on the experimental variants, according to the LSD5% test, no significant differences are recorded (Table 1). pH values corresponding to surface eroded soil obtained in our study, which frames between 5.49 and 5.85 show an increase of pH in eroded soil, but it is lower compared with values mentioned by Nosarti (2013) of 7.22 or 7.25 depending of use categories. Even though and Bílá et al. (2020) of 7.52 in control soil, and 7.67 in eroded soil, respectively, while Gabbasova et al. (2016) obtained pH values of 7.9 units of pH in moderate eroded light gray forest soils.

At the top of the slope, the humus content of the soil is lower than at the base of the slope, for all experimental variants, but the differences between the humus content at the top and base of the slope, within the three experimental variants, are not statistically significant. Compared to the control variant 1, the humus content is 14.65% for variant 1b, with 10.61% for variant 2b. In the case of the other experimental variants, the humus content is lower: by 4.55% in the case of variant 2a, by 10.10% for variant 2b and by 3.03% for variant 3b.

Between the evolutions of the humus content, no significant differences are recorded. The soil corresponding to all the experimental variants is characterized as having a medium content of humus (Table 1). The humus content of eroded luvisoil identified in our study frames within 1.78-2.27%, which is lower compared with results reported by Rogobete & Grozav (2011) for eroded luvisoil (2.38%), or by Gabbasova et al. (2016) who obtained values of 2.77% humus content in moderate eroded light gray forest soils.

The position on the slope differentiates the content of the soil in mobile phosphorus, in a much more obvious way, compared to the previously analyzed soil quality indicators. For variant 1b control, at the base of the slope a content of mobile phosphorus was determined equal to 29.31 ppm (V2) with 61.13% more than at the top of the slope (V1), the soil here being characterized as poorly supplied with phosphorus. Similar developments are also recorded in the other experimental variants. For the experimental version 2b, at the base of the slope, a content of mobile phosphorus equal to 26.14 ppm was determined, and at the top of the slope, a content equal to 17.58 ppm.

For V6, at the base of the slope, a content of mobile phosphorus equal to 22.34 ppm was determined, and at the top of the slope, a content equal to 14.92 ppm.

Compared to V1, the phosphorus content of the soil is 3.45% lower in the case of V3, and by 17.92% in the case of V5, but by 43.71% higher in the case of V4 and by 22.81% in the case of V6 (Table 1).

Table 1. The soil humus content recorded in eroded arable field according to experimental variants

Issue	pH	%	Humus %	%	P, ppm	%	K, ppm	%
Control experimental variant 1a, meadow, peak – V1	5.61a	100	1.98a	100	18.19ac	100	123.44a	100
Control experimental variant 1b, meadow, base – V2	5.67a	98.94	2.27a	114.65	29.31ca	161.13	129.89a	105.23
Experimental variant 2a cultivated with maize by level curves, peak – V3	5.59a	100.36	1.89a	95.45	17.58ac	96.65	119.46a	96.78
Experimental variant 2b cultivated with maize by level curves, base – V4	5.64a	99.47	2.19a	110.61	26.14ca	143.71	127.62a	103.39
Experimental variant 3a cultivated with maize by direction hill-valley, peak – V5	5.49a	102.19	1.78a	89.90	14.92bd	82.02	112.86a	91.43
Experimental variant 3b cultivated with maize by direction hill-valley, base – V6	5.85a	95.90	1.92a	96.97	22.34c	122.81	121.14a	98.14
Mean	5.64		2.01		21.41		122.41	
CV (%)	2.11		9.36		25.81		4.97	
$LSD_{5\%}$	49.171		8.913		4.294		34.516	
F	0.816^{ns}		3.693^{*}		3.582^{*}		4.083^{*}	

CV% – variation coefficient; LSD – Least Significant Differences; F – Fisher coefficient; the means with same letter are statistically insignificant; a - $p > 0.05\%$; b – $p > 0.05\%$.

Soil characterized by poor supply of mobile phosphorus is reported for all experimental variants. Between the evolutions of the content in mobile phosphorus, depending on the experimental variants, according to the test (LSD5%), statistically significant differences are recorded. For all experimental variants, at the top of the slope the content of mobile phosphorus in the soil is lower than at the base of the slope, the differences between the content of mobile phosphorus in the soil at the top and base of the slope, within the three experimental variants, are statistically significant at different thresholds meaning. The soil is poorly supplied with mobile phosphorus in the case of the experimental variants, but at the base of the slope the recorded values exceed them (Table 1). And in the case of the content in mobile potassium, the position on the slope differentiates the content of the soil in the mentioned element. Mobile phosphorus values corresponding to surface eroded soil obtained in our study, which frames between 14.82 ppm and 29.31 ppm, is much lower compared with values mentioned by Nosarti (2013), of 550 ppm or 590 ppm depending on use categories. Bílá et al.

(2020) also find higher mobile phosphorus content, both in control and eroded soil of 76.8 ppm, and 71.39 ppm, respectively.

For V2, at the base of the slope, a mobile potassium content equal to 129.89 ppm was determined, 5.23% more than at the top of the slope for the control version 1a. For V4, a mobile potassium content equal to 127.62 ppm was determined at the base of the slope, and a content equal to 119.46 ppm at the top of the slope. For V6, a mobile potassium content equal to 121.14 ppm was determined at the base of the slope, and a content equal to 112.86 ppm at the top of the slope.

Compared to V1, soil potassium content is 3.22% lower in V3, 8.57% in V5 and 1.86% in V6, but 3.39% higher in V4. For all experimental variants, the soil is characterized by poor supply of mobile potassium. Between the evolutions of the mobile potassium content, depending on the experimental variants, according to the test (LSD5%), statistically significant differences are recorded.

For all experimental variants, at the top of the slope the content of mobile potassium in the soil is lower than at the base of the slope, the differences between the content of mobile potassium in the soil at the top and base of the slope, within the three experimental variants, are not statistically significant.

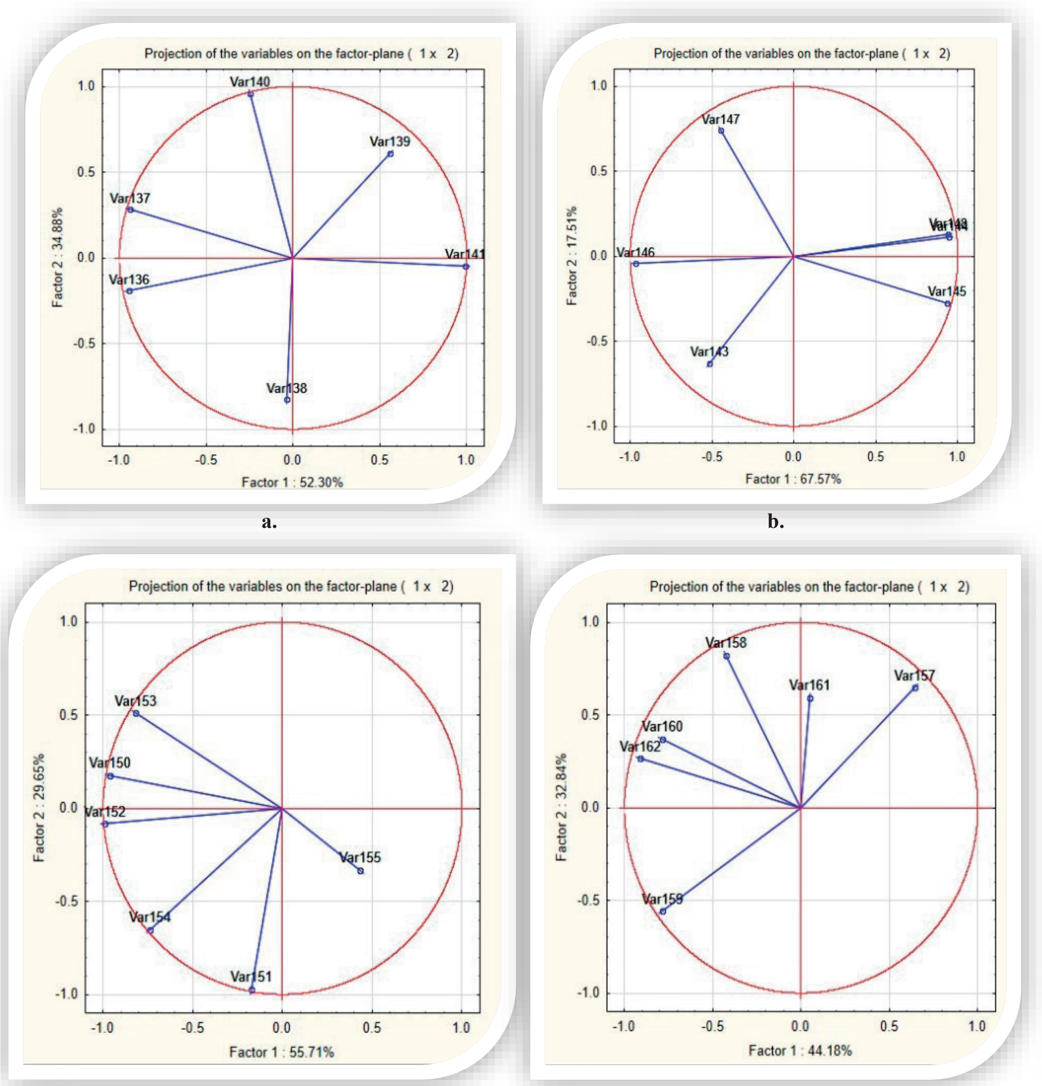
The study highlights the fact that neither the position on the slope nor the crop, or the location on the slope, statistically significantly influences its mobile potassium content (Table 1).

In order to test the feasibility of the analysis of the main components, the intensities of the correlations between the indicators corresponding to the chemical characteristics of the soil important in assessing the level in which the erosion of the land in the experimental field influences the mentioned characteristics are calculated. Due to the fact that in most cases, the intensities of the correlations are medium and strong, the condition of conducting the analysis of the principal components is met (Table 2). Four main factors influencing soil reaction are identified, respectively: experimental variant, location, culture and soil type (Figure 1a - 1d, Table 3).

Table 2. The simple correlations between the chemical soil traits important for assessing the erosion level of slowly arable field according to experimental variants

Issue	Humus, %	Phosphorus, ppm	Potassium, ppm
		V1	
Humus, %	R=0.221; R^2=0.048	R=-0.727; R^2=0.528	R=0.215; R^2=0.976
Phosphorus, ppm		R=0.435; R^2=0.230	R=0.832; R^2=0.692
Potassium, ppm			R=0.594; R^2=0.352
		V2	
Humus, %	R=0.109; R^2=0.011	R=-0.145; R^2=0.021	R=0.348; R^2=0.121
Phosphorus, ppm		R=0.893; R^2=0.797	R=0.783; R^2=0.613
Potassium, ppm			R=0.676; R^2=0.456
		V3	
Humus, %	R=0.190; R^2=0.036	R=-0.748; R^2=0.560	R=0.547; R^2=0.299
Phosphorus, ppm		R=0.331; R^2=0.110	R=0.604; R^2=0.365
Potassium, ppm			R=0.249; R^2=0.062
		V4	
Humus, %	R=0.078; R^2=0.006	R=-0.498; R^2=0.248	R=0.264; R^2=0.070
Phosphorus, ppm		R=0.557; R^2=0.310	R=0.402; R^2=0.162
Potassium, ppm			R=0.585; R^2=0.342
		V5	
Humus, %	R=0.653; R^2=0.426	R=-0.756; R^2=0.572	R=0.326; R^2=0.106
Phosphorus, ppm		R=0.861; R^2=0.741	R=0.415; R^2=0.172
Potassium, ppm			R=0.482; R^2=0.232
		V6	
Humus, %	R=0.455; R^2=0.310	R=-0.773; R^2=0.598	R=0.231; R^2=0.053
Phosphorus, ppm		R=-0.789 ; R^2=0.623	R=0.489; R^2=0.239
Potassium, ppm			R=0.520; R^2=0.270

R - coefficient of correlation; R^2 - coefficient of determination; V1 - Control, meadow, peak, V2 - Control, meadow, base, V3 - Culture with maize by level curves, peak, V4 - Culture with maize by level curves, base, V5 - Culture with maize by direction hill-valley, peak, V6 - Culture with maize by direction hill-valley, base.



c. d.

a - soil reaction (pH); b - humus soil content; c - phosphorus soil content; d - potassium soil content;
Var 136 - Control experimental variant 1, meadow, peak; Var 137 - Control experimental variant 1, meadow, base; Var 138 - Variant cultivated with maize by level curves, peak; Var 139 - Variant cultivated with maize by level curves, base; Var 140 – Variant cultivated with maize by direction hill-valley, peak; Var 141 - Variant 3 cultivated with maize by direction hill-valley, base; Var 143 - Control experimental variant 1, meadow, peak; Var 144 - Control experimental variant 1, meadow, base; Var 145 – Variant cultivated with maize by level curves, peak; Var 146 – Variant cultivated with maize by level curves, base; Var 147 - Variant cultivated with maize by direction hill-valley, peak; Var 148 – Variant 3 cultivated with maize by direction hill-valley, base, Var 149 - Control experimental variant 1, meadow, peak; Var 150 - Control experimental variant 1, meadow, base; Var 151 - Variant cultivated with maize by level curves, peak; Var 152 - Variant cultivated with maize by level curves, base; Var 153 - Variant cultivated with maize by direction hill-valley, peak; Var 154 - Variant 3 cultivated with maize by direction hill-valley, base; Var 157 - Control experimental variant 1, meadow, peak; Var 158 - Control experimental variant 1, meadow, base; Var 159 - Variant cultivated with maize by level curves, peak; Var 160 - Variant cultivated with maize by level curves, base; Var 161 - Variant cultivated with maize by direction hill-valley, peak; Var 162 - Variant 3 cultivated with maize by direction hill-valley, base.

Figure 1. The projection of the variables involved in the study of the soil traits in the plans of the principal factors

Table 3. The Principal Components Analysis applied to the study of the soil reaction recorded in experimental field

Eigenvalue	Total variance, %	Cumulative Eigenvalue	Total variance cumulative, %	Factor	Factor loading
			pH		
					-0.944
3.137	52.296	3.137	52.296		-0.941
				Factor 1 - Experimental variant	-0.037
					0.556
2.092	34.881	5.230	87.1776		-0.248
					0.993
					-0.190
0.740	12.342	5.971	99.520		0.283
				Factor 2 - Crop placement	-0.826
					0.610
0.028	0.479	6.000	100		0.958
					-0.046
			Humus		
					-0.515
4.053	67.565	4.053	67.565		0.945
				Factor 1 - Experimental variant	0.934
					-0.965
1.050	17.508	5.104	85.074		-0.450
					0.940
					-0.629
0.878	14.634	5.982	99.708		0.111
				Factor 2 - Crop placement	-0.275
					-0.044
0.017	0.291	6.000	100		0.740
					0.126
			Phosphorus		
					-0.956
3.342	55.707	3.342	55.707		-0.231
				Factor 1 - Experimental variant	-0.997
					-0.805
1.778	29.646	5.121	85.3543		-0.771
					-0.956
					0.253
0.810	13.514	5.932	98.869		-0.960
				Factor 2 - Crop placement	-0.020
					0.589
0.067	1.131	6.000	100		-0.614
					0.253
			Potassium		
					0.641
2.650	44.180	2.650	44.180		-0.426
				Factor 1 - Experimental variant	-0.783
					-0.784
1.970	32.8430	4.621	77.023		0.051
					-0.909
					0.648
0.912	15.208	5.533	92.232		0.822
					-0.558
0.466	7.767	6.000	100	Factor 2 - Crop placement	0.371
					0.594
					0.265

The experimental variant, which accounts for 52.30% of the variance, is positively correlated with the soil response in the case of corn, both on the level curves and the hill-valley direction at the soil base. The location of the crop is responsible for 34.88% of the variance and is positively correlated with the soil reaction in the case of: the exploitation of the meadow at the base of the land, the cultivation of corn on contour lines, at the base of the land and the cultivation of corn on the hill-valley direction, at the top of the eroded land in slope (Figure 1a, Table 3).

For soil humus content, the experimental variant is responsible for 67.56% of the variance and the location for 17.51%. The factor represented by the experimental variant is positively correlated with: the humus content of the soil in the case of the exploitation of the meadow and the plumb in the hill-valley direction, at the base of the land and the plumb on contours, at the top of the land. The location of the culture is positively correlated with the humus content of the soil in the case of the exploitation of the meadow at the base of the land and the plumb in the hill-valley direction, both at the top and at the base of the eroded land on the slope (Figure 1b, Table 3). For the mobile phosphorus content of the soil, the experimental variant is responsible for 55.716% of the variance and the location for 29.65% (Figure 1c, Table 3). The factor represented by the experimental variant is positively correlated with the mobile phosphorus content of the soil for the corn crop in the hill-valley direction, at the top of the field (Figure 1c, Table 3).

The location of the crop is positively correlated with the mobile phosphorus content of the soil in the case of the alfalfa crop at the top of the field and in the case of plum grown on contour lines, at the base of plowed land at the top, as well as at the base of eroded land cultivated on the slope. The experimental variant factor is responsible for 44.18% of the variance and is positively correlated with the mobile potassium content of the soil in the case of alfalfa cultivation, at the top of the land and of maize cultivated in the hill-valley direction, also at the top of the eroded land on the slope (Figure 1d, Table 3).

CONCLUSIONS

The highest pH averages, indicating a slightly acidic reaction, are reported for the soil located at the base of the slope, but they do not differ statistically significantly at the 5% significance level from those reported at the top of the slope. The environments fall within the limits of 5.49 pH units - 5.85 pH units, corresponding to the corn cultivation technology in the hill-valley direction, both at the top and at the base of the slope.

The highest soil nutrient content averages located in the experimental field are reported for the base of the slope: 1.92 ppm - 2.27 ppm for humus classified as supplied medium, 22.34 ppm - 29.31 ppm for mobile phosphorus classified in the poorly and medium supplied categories and 121.14 ppm - 129.89 ppm for mobile potassium in the poorly supplied category.

Regarding the culture, it is found that for the exploitation of the meadow, the highest values of the nutrient content are recorded, compared to the culture of corn, a fact also explained by the highest degree of water retention in the case of this technology, compared to those of the culture of corn.

Medium and strong correlations are identified between the indicators corresponding to the chemical properties of the soil. Two main factors were considered, namely the experimental variant and the location of the culture. The chemical indicators of soil quality are strongly influenced by the location of the crop, with the mention that, in this case, the location of the crop at the base of the slope has the strongest influence on them, but in the case of pH (soil reaction) and mobile phosphorus content the location at the top of the slope must also be considered.

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