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The Influence of the Cover Crops on the Maize Production Obtained on Eroded Sloping Arble Field

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Abstract

The cover crops used to control erosion, supply nutrients and mitigate nitrate leaching, could be a powerful tool for reclamation of soils degraded by erosion. The present study was carried out in order to analyze the influence of the use of cover crops on the maize production recorded in an sloping eroded experimental field located on an eroded slope. The research was carried out on an eroded land on a slope, cultivated with pasture dominated by alfalfa and maize belonging to the Pioneer PR38A24 hybrid. A bifactorial experiment was organized, with the factors represented by the type of cover crop and the location of the crop. The plant species considered suitable for use as green fertilizers are: lupine, rapeseed, rye, ryegrass, vetch, and the conventional fertilizer is $N_{90}P_{45}K_{90}$. Both at the base of the slope and at its top, the highest maize production averages are reported in the case of the application of maize cultivation technology on contour lines, under the conditions of the administration of conventional fertilization. Cultivation technology is the main factor that is not positively correlated with any fertilization solution, while crop location is the main factor very strongly positively correlated with: administration of mixed cover crops, in pure culture and administration of conventional fertilization.

Keywords: conventional fertilization, lupine, rapeseed, rye, ryegrass, vetch.

1. Introduction

The introduction of cover crops, or in other words, cover crops in irrigated areas, has been suggested as an economical approach to maintain soil and water quality without reducing the quality and quantity of harvested agricultural products [2, 7, 10].

Cover crops replace crop rotation techniques. Used for erosion control [4], nutrient supply [7] and mitigation of nitrate leaching [3], cover crops could be a powerful tool for reclaiming degraded soils. In any case, soil recovery is a slow process and it is necessary to determine the time required for cover crops to have a significant impact on soil recovery functionality.

The integration of cover crops into crop rotations presents an opportunity to increase the sequestration of soil carbon and organic matter [6]. Increasing soil organic carbon (SOC) in soils with low organic matter content is crucial for improving soil quality and affects many physical and chemical processes, such as stabilization of soil or plant structure [4]. Furthermore, in semi-arid climates, biomass production is low and increasing soil organic carbon content is particularly difficult. Within the framework of the present objective, we set out to quantify the effect of the use of cover crops on the productivity of the soil located on sloping eroded land, under the conditions of maize and meadow cultivation. The present study was carried out in order to analyze the influence of cover crops on the maize

production recorded at the level of the sloping eroded experimental field.

2. Material and Method

The research carried out in the village of Valea Mare de Criș, which belongs to Borod commune, Bihor County, on a sloping eroded land, with a slope value of 12°, cultivated with pasture dominated by alfalfa and maize belonging to the Pioneer PR38A24 hybrid with good suitability for the sloping land. The experimental plots had an area of 50 m^2 each one. The study of the productivity of the sloping eroded land was carried out by quantifying the corn production corresponding to the use of seven experimental variants:

1 - Control experimental variant not ferilized;
2 - Experimental variant 2, lupine;
3 - Experimental variant 2, lupine + rye + rapeseed;
4 – Experimental variant 4, vetch;
5 - Experimental variant 5, vetch + ryegrass + rye;
6 - Organic fertilization with manure, 60 t/ha;
7 - Conventional fertilization, $N_{90}P_{45}K_{90}$.

The plant species considered suitable for use as cover crops are: vetch, lupine, rye, rapeseed and ryegrass. There were administered as pure culture (vetch and lupine), and also in two mixture variants, lupine + rye + rapeseed and vetch + ryegrass + rye, respectively, and the conventional fertilizer was e $N_{90}P_{45}K_{90}$.

The experiments were carried out in order to identify the influence of solutions to improve the sloping eroded soil concerning its productivity in the case of maize culture, according to the method of randomized blocks, in three repetitions, each plot having an area of 50 m^2. A bifactorial experiment was organized, with the factors represented by the type of cover crops (in pure culture and in mixtures of three species each) and the location of the culture (on contour lines and in the hill-valley direction). The statistical methods used are represented by: the least squares method (LSD5%), the calculation of simple Pearson correlations and the multivariate analysis, through its component Principal Factor Analysis (PCA), with the help of the STATISTICA v.8.0 for Windows program [5].

3. Results and Discussions

The averages of maize production recorded at the top of the slope, for contour lines cultivation, show the highest values for variants 7a, 6a and 3a, respectively 6.14 t/ha, 6.08 t/ha and 5.92 t/ha fertilized conventionally with $N_{90}P_{45}K_{90}$, organically with manure and by administering cover crops (lupine + rye + rapeseed). The lowest average corresponds to the 1st control variant, respectively 4.18 t/ha (Table 1).

Table 1. The maize production recorded in eroded arable field (peak of the slope) when conventional and unconventional fertilizers are used, 2019 – 2020

Experimental variant	t/ha	%	Experimental variant	t/ha	%
Maize cultivated on sloping land by level curves			Maize cultivated on sloping land, hill-valley direction		
1a	4.18bc	100	8a	3.68cd	100
2a	5.27ab		9a	4.95ac	
3a	5.92ab		10a	5.47ad	
4a	5.18ab		11a	4.62ac	
5a	5.48ab		12a	5.29ad	
6a	6.08ac		13a	5.48ad	
7a	6.14ac		14a	5.53ad	
Mean	5.46		Mean	5.01	
CV (%)	12.53		CV (%)	13.42	
$LSD_{5\%}$	7,5.12		$LSD_{5\%}$	6.523	
F	3,115*		F	4.091*	

1 - Control experimental variant not fertilized; 2 - Experimental variant 2, lupine; 3 –Experimental variant 2, lupine + rye + rapeseed; 4 – Experimental variant 4, vetch; Experimental variant 5, vetch + ryegrass + rye; 6 - Organic fertilization with manure, 60 t/ha; 7 - Conventional fertilization, $N_{90}P_{45}K_{90}$; CV% –variation coefficient; LSD –Least Significant Differences; F – Fisher coefficient; the means with same letter are statistically insignificant; a - $p > 0,05\%$; b – $p < 0,05$; c – $p < 0,01$; d – $p < 0,001$.

For the maize production averages recorded in the case of hill-valley cultivation, the highest values are also reported for the experimental variants corresponding to conventional fertilization with $N_{90}P_{45}K_{90}$ (14a) – 5.53 t/ha, organic with manure (13a) – 5.48 t/ha and by administration of cover crops (lupin + rye + rapeseed, 10a) – 5.47 t/ha and the lowest for variant 8a control, respectively 3.68 t/ha (Table 1).

Differences between maize yields are statistically ensured, in all cases at different significance thresholds.

For both cultivation systems, on level curves and for the one in the hill-valley direction, respectively, according to the test of the smallest differences, calculated for the 5% significance threshold (LSD5%), statistically significant differences are recorded between the means of maize production, depending on the experimental variants (Table 1).

Regarding the maize production recorded at the base of the slope, the averages recorded for cultivation on level curves show the highest values for variants 7b, 6b, 5b and 3b, respectively 7.51 t/ha, 7.45 t/ha and 6.83 t/ha fertilized conventionally with $N_{90}P_{45}K_{90}$ (7b), organically with manure (6b) and by administering mixed cover crops (lupine + rye + rapeseed, 3b; vetch + ryegrass + rye, 5b). The lowest average corresponds to the control variant 1b, respectively 5.01 t/ha (Table 6.56). For the maize production averages recorded in the case of cultivation in the hill-valley direction, the highest values are reported for the experimental variants corresponding to conventional fertilization with $N_{90}P_{45}K_{90}$ (14b) – 7.33 t/ha, organic with manure (13a) – 7.29 t/ha and by administration of cover crops (lupine + rye + rapeseed, 10a) – 7.24 t/ha and the lowest for variant 8b control, respectively 4.97 t/ha (Table 1). Differences between maize yields are statistically ensured, in all cases at different significance thresholds. Both for the cultivation system on level curves and for the one in the hill-valley direction, according to the test of the smallest differences, calculated for the 5% significance threshold (LSD5%), statistically significant differences are recorded between the means of maize production, depending on the experimental variants (Table 2).

Table 2. The maize production recorded in eroded arable field (base of the slope) when conventional and unconventional fertilizers are used, 2019 – 2020

Experimental variant	t/ha	%	Experimental variant	t/ha	%
Maize cultivated on sloping land by level curves			Maize cultivated on sloping land, hill-valley direction		
1b	5.01cd	100	8b	4.97d	100
2b	6.83abc		9b	6.53abd	
3b	7.41bd		10b	7.24abd	
4b	6.22ab		11b	6.08ad	
5b	6.83ab		12b	6.49ad	
6b	7.45abd		13b	7.29abd	
7b	7.51abd		14b	7.33abd	
Mean	6.75		Mean	6.56	
CV (%)	13.28		CV (%)	12.98	
$LSD_{5\%}$	5.963		$LSD_{5\%}$	5.119	
F	3.623*		F	4,391*	

1 - Control experimental variant not fertilized; 2 - Experimental variant 2, lupine; 3 –Experimental variant 2, lupine + rye + rapeseed; 4 – Experimental variant 4, vetch; Experimental variant 5, vetch + ryegrass + rye; 6 - Organic fertilization with manure, 60 t/ha; 7 - Conventional fertilization, $N_{90}P_{45}K_{90}$; CV% –variation coefficient; LSD –Least Significant Differences; F – Fisher coefficient; the means with same letter are statistically insignificant; a - $p > 0,05\%$; b – $p < 0,05$; c – $p < 0,01$; d – $p < 0,001$.

In order to test the appropriateness of the analysis of the main components, the intensities of the correlations between the maize productions recorded according to the experimental variant are calculated. Due to the fact that in most cases, the intensities of the correlations are strong and very strong (Table 3), we consider that the condition of conducting the principal components analysis is met. In this analysis, the study was carried out on the entire experimental device, for both locations, taking into account only the type of fertilization. Four main factors influencing maize production are identified: the type of fertilization (which consists of the administration of cover crops, combinations of cover crops, conventional synthetic fertilizer $N_{90}P_{45}K_{90}$ and organic - manure), location, crop and soil type. Due to the fact that only the first two of the four factors present Eigenvalues above unity, only these are considered (Fig. 1, Table 4).

Thus, for maize production, it is found that 55.42% of the variance corresponding to the main factor "type of fertilization with cover crops" is not positively correlated with any fertilization variant. A proportion of 31.04% of the variance corresponding to the experimental factor "crop location" is very strongly and positively correlated with:

• experimental variant 2 in which the lupine cover crop was used,

• experimental variant 3 corresponding to the mixture of cover crops lupine + rye + rapeseed and with

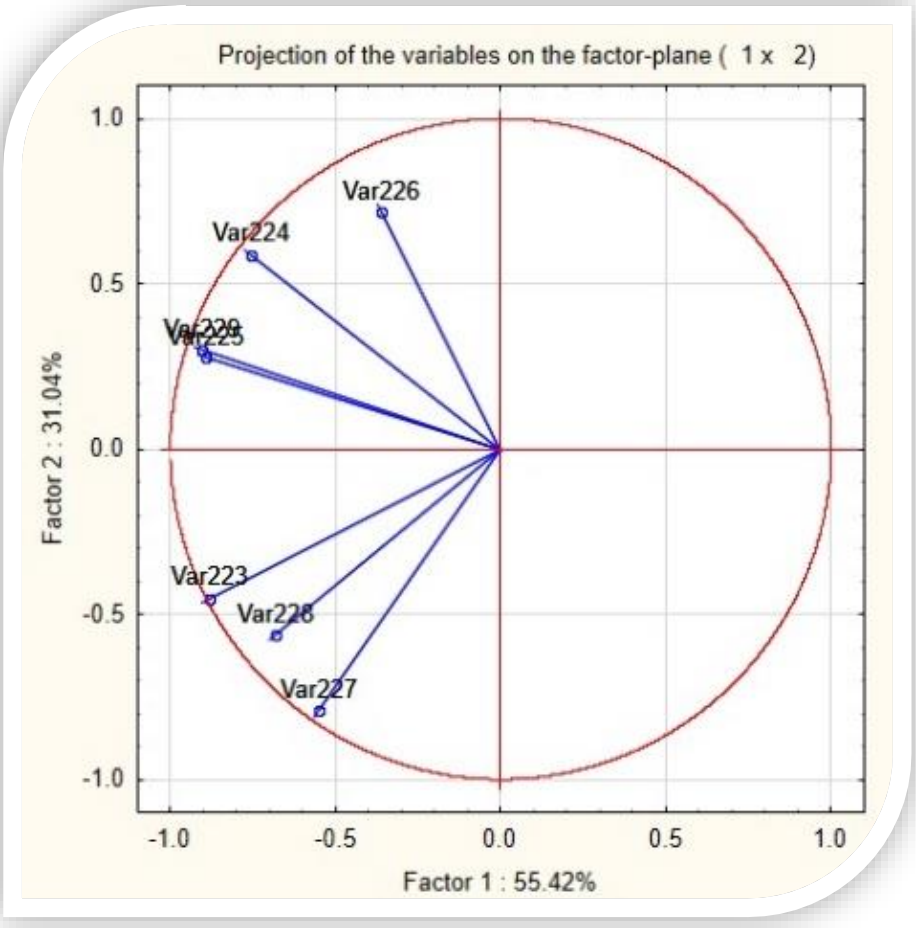
• experimental variant 7 corresponding to the use of the conventional fertilizer $N_{90}P_{45}K_{90}$.

The proportion of 31.04% of the variance corresponding to the experimental factor "crop location" is strongly positively correlated, according to the study of the load values of the main factors (Table 4) of the projection of the variables in the plane of the main factors (Fig. 1) with the experimental Variant 4, where vetch cover crop is administered.

Table 3. The simple correlations between the soil traits important for assessing the erosion level of arable field according to experimental variants, 2019 – 2020

Issue	2	3	4	5	6	7
1	R=-0.397; R^2=0.157	R=0.621; R^2=0.385	R=0.625; R^2=0.390	R=0.185; R^2=0.034	R=0.880; R^2=0.774	R=0.852; R^2=0.725
2		R=-0.805; R^2=0.648	R=-0.579; R^2=0.335	R=-0.192; R^2=0.036	R=0.615; R^2=0.378	R=0.732; R^2=0.535
3			R=0.181; R^2=0.669	R=0.211; R^2=0.044	R=0.483; R^2=0.233	R=0.568; R^2=0.322
4				R=0.246; R^2=0.060	R=0.677; R^2=0.458	R=0.532; R^2=0.283
5					R=0.726; R^2=0.527	R=0.788; R^2=0.620
6						R=0.862; R^2=0.743

R – Coefficient of correlation; R^2 – Coefficient of determination; 1 - Control experimental variant not fertilized; 2 - Experimental variant 2, lupine; 3 –Experimental variant 2, lupine + rye + rapeseed; 4 – Experimental variant 4, vetch; Experimental variant 5, vetch + ryegrass + rye; 6 - Organic fertilization with manure, 60 t/ha; 7 - Conventional fertilization, $N_{90}P_{45}K_{90}$; 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; c – p < 0,01; d – p < 0,001.



Var 223 –Control experimental variant not ferilized; Var 224 –Experimental variant 2, lupine; Var 225 – Experimental variant 2, lupine + rye + rapeseed; Var 226 – Experimental variant 4, vetch; Var 227 – Experimental variant 5, vetch + ryegrass + rye; Var 228 –Organic fertilization with manure, 60 t/ha; Var 229 – Conventional fertilization, $N_{90}P_{45}K_{90}$.

Figure 1. The projection of the variables involved in the study of the hydro stability of the soil microaggregates in the plans of the principal factors PF1 and PF2

Table 4. The Principal Components Analysis applied to the study of hydro stability of the soil microaggregates recorded in experimental field

Eigenvalue	Total variance, %	Cumulative Eigenvalue	Total variance cumulative, %	Factor	Factor loading
3.879	55.421	3.879	55.421	Factor 1 – Experimental variant	-0.882
2.172	31.042	6.052	86.463		-0.759
					-0.891
					-0.361
					-0.553
					-0.683
					-0.907
0.696	9.947	6.748	96.410	Factor 2 - Crop placement	-0.450
0.251	3.589	7.000	100		0.587
					0.275
					0.716
					-0.792
					-0.563
					0.297

Also, the study of the load values of the main factors (Table 4) and the projection of the variables in the plan of the main factors (Fig. 1) highlights the fact that for both main factors analyzed the variances are negatively correlated with the same experimental variants, respectively: variant 1 unfertilized control and variant experimental 5 corresponding to the cover crops mixture of vetch + rye grass + rye and experimental Variant 6 corresponding to organic fertilization with manure.

4. Conclusions

For the top of the slope, the highest averages of maize production are reported in the case of the application of maize cultivation technology on level curves, under the conditions of administration of conventional fertilization $N_{90}P_{45}K_{90}$, which corresponds to an average equal to 6.14 t/ha and organic fertilization with manure to which corresponds an average equal to 6.08 t/ha, the differences between them being statistically insignificant (LSD5%).

Regarding the administration of cover crops, the highest average production, over the entire experimental period, corresponds to the fertilization with cover crops lupine + rye + rapeseed mixture and is equal to 5.48 t/ha, the differences between this and those previously mentioned being statistically assured (LSD5%). The study carried out for the base of the slope shows that the highest averages of maize production are also reported in the case of the application of maize cultivation technology on level curves, under the conditions of the administration of conventional fertilization $N_{90}P_{45}K_{90}$, which corresponds to an average equal to 7.51 t/ ha and organic fertilization with manure, which corresponds to an average equal to 7.45 t/ha, the differences between them being statistically insignificant (LSD5%).

Regarding the administration of cover crops, the highest average production, over the entire experimental period, corresponds to the fertilization with cover crops in a lupine + rye + rapeseed mixture and is equal to 7.41 t/ha, the differences between this and those previously mentioned not being statistically assured at the 5% significance level (LSD5%).

Strong and very strong correlations are identified between the recorded maize yields depending on the green manure fertilization solution. The same two main factors out of the total of four identified were taken into account as in the case of the studied physico-chemical indicators, namely culture technology and culture location. Cultivation technology is the main factor that is not positively correlated with any fertilization solution, while crop location is the main factor very strongly positively correlated with: lupine + rye + rape cover crops mixture administration, pure crop fertilization administration with lupine cover crop and vetch and vetch + ryegrass + rye, respectively, and administering conventional fertilization with $N_{90}P_{45}K_{90}$.

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