PhD THESIS

Possibilities of using cover crops for fighting against surface errosion in pedo-climatic conditions of North-West Romania

SUMMARY OF Ph.D. THESIS

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CONTENTS

INTRODUCTION

Soil erosion is a gradual process that occurs when the impact of water or wind loosens and removes soil particles, causing the soil to deteriorate. Soil degradation and poor water quality due to erosion and surface runoff have become serious problems worldwide. Soil erosion by water occurs when the bare slope soil surface is exposed to rainfall, and the intensity of rain exceeds the soil absorption rate or infiltration rate, which leads to soil runoff on the surface (MUQI ET AL., 2018; PANITIŞ AND DÎRJA, 2022b; ROMAN, 2008; XIONG ET AL., 2018).

1. General considerations

Most of the factors act simultaneously, conditioning each other, increasing or decreasing the intensity of the erosion phenomenon. Soil erosion is the most urgent and current problem for Romania's agriculture and for the entire national economy, as well as for the state of landscapes and the environment for human survival (CANDREA ŞI DÎRJA, 2023). Agriculture is negatively affected by soil erosion, but also contributes to it, as land use and land management are among the main driving forces of soil erosion (CANDREA ŞI DÎRJA, 2024a). Soil erosion has a strong environmental impact and high economic costs; to mitigate these effects, soil and water conservation strategies are needed (CANDREA ŞI COLAB., 2024b).

2. The cover crops

The introduction of green manures, or in other words, cover crops in irrigated areas, has been suggested as an economic approach for soil maintenance and water quality without reducing harvested agricultural products (BENINCASA ET AL.,2010; GABRIEL AND QUEMADA, 2011; SALMERÓN ET AL.,2010). Green manures replace fallows in crop rotations during the fall or winter periods and are completed before the subsequent main crop is sown.

3. Research objectives

The doctoral thesis considers specific objectives developed for the evaluation of the level of soil surface erosion, its influence on corn production and the effect of the use of green fertilizers, depending on the location on the slope, in order to study: quantitative and qualitative soil losses , the influence of erosion on the physico-chemical properties of the soil and the corn production recorded at the level of the land located in the experimental device. Also, the objectives refer to the comparative study of the influence of green fertilizers on the physico-chemical properties of arable soils on the slope according to the particularities of the experimental device recommended on corn production.

4. Environmental peculiarities of the experimental site

The experimental device is located 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 (General Geographical Atlas of Romania, 1980).

5. Material and method

The biological material consists of meadows dominated by lucerne, but also maize and plant species considered suitable for use as green manures. Pioneer PR38A24 corn hybrid was used. It is part of the FAO group 350. Plant species considered suitable for use as green manures are: peas, lupine, rye, rape and ryegrass. These were administered either in pure culture (peas and lupine) or in two variants of the mixture, respectively lupine + rye + rapeseed and peas + ryegrass + rye.

The chemical materials consist of the laboratory reagents used to determine the nutrient content of the soil, to which is added the conventional fertilizer, namely N90P45K90. Thus, the following chemical materials were used for the laboratory analyses: silver sulfate, orthophosphoric acid 85%, Mohr's salt solution 0.1N, acetate solution - ammonium lactate, molybdenum blue. Physical materials consisted of laboratory utensils (Erlenmeyer flasks, burettes, glass electrode, graduated cylinders, sieves, filters), analytical balance, soil sampling probe, laboratory equipment (pH-meter heating installations, flame photometer, spectrophotometer). The experiments were carried out in order to study the level of soil surface erosion, observations and determinations were made regarding quantitative and qualitative soil losses, but also on the physico-chemical indicators of soil quality (total degree of structuring of soil aggregates, density apparent, soil hydraulic conductivity, soil water reserve, water utilization efficiency, soil acid reaction, humus content, mobile phosphorus content, mobile potassium content and productivity of maize and meadow crops) to which is added the study of the productivity of eroded land on the slope, by taking laboratory analysis samples, calculating and interpreting the results and formulating relevant conclusions regarding the topic addressed. For the study of solutions to improve the eroded soil on the slope, for which in the doctoral thesis I proposed the use of green manures, the plant species considered suitable to be used as green manures were used. The observations were made by means of the same physico-chemical indicators used in the study of soil erosion.

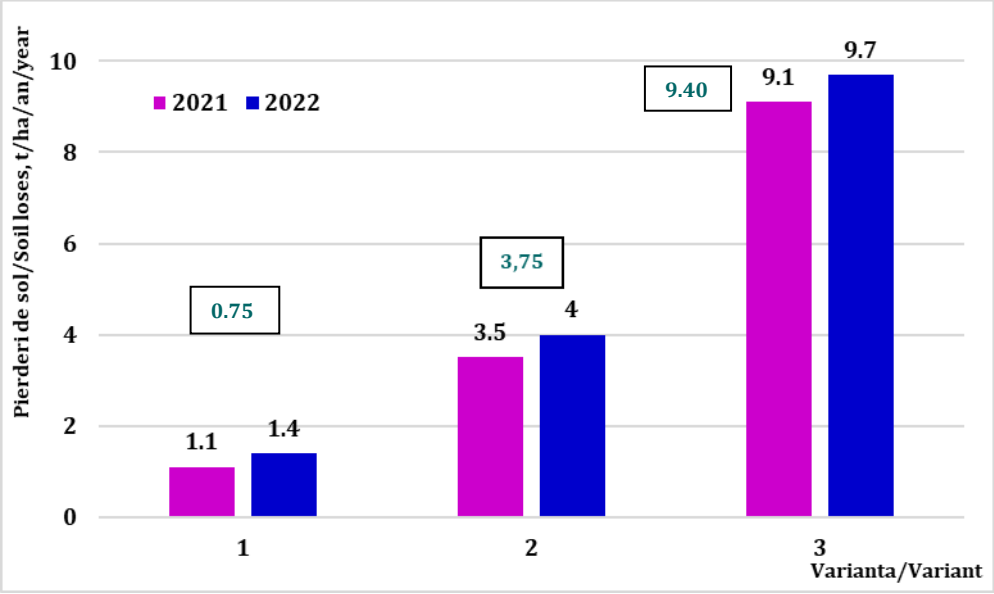
The statistical methods used refer to the use of the least squares method (LSD5%) for the calculation of the differences between the experimental variants at the 5% significance threshold. The components of basic statistics were calculated, simple Pearson correlations, multivariate analysis was applied, through its component Principal Factor Analysis (PCA) in order to test the level of correlation of the variance of the main factors identified as influencing the indicators under study with each of the

elements of interest characteristic of the study carried out. The STATISTICA v.8.0 for Windows program was used for statistical processing.

6. Results and discussions

The results obtained as a result of the experiments related to the doctoral thesis, highlight the possibilities of utilizing green fertilizers in order to improve the arable soils on the slope in an experimental device located in a representative area for the present study, namely Valea Mare de Criş, Bihor County. In order to evaluate the level of land surface erosion, its influence on corn production and the effect of the use of green manures, depending on the location on the slope, indicators established for this purpose are analyzed.

In order to study the surface erosion of the land located in the experimental field, the following are analyzed: quantitative and qualitative soil losses, the influence of erosion on the physico-chemical properties of the soil, the productivity of the corn crop and the main factors involved in the process, depending on the experimental variants.



1 - Control experimental variant, meadow; 2 –Experimental variant cultivated with maize by level curves; 3 – Experimental variant cultivated with maize by direction hill-valley.

Fig. 6.1. The soil loses recorded in eroded arable field according to experimental variants, 2021– 2022

The results obtained in the experimental field on the eroded slope with a slope of 10% highlight statistically significant differences between the corn productions obtained at the base of the slope compared to the productions obtained at the top of the slope. The differences are greater in the situation where the corn was cultivated in

the hill-valley direction and not in the direction of contour lines. According to the least squares test (LSD5%), statistically significant differences are recorded between the corn productions corresponding to the experimental variants (Table 6.23).

Table 6.23

The maize yield (t/ha) recorded in eroded arable field according to experimental variants, 2019 – 2020

Issue	t/ha	%
Experimental variant 2a cultivated with maize by level curves, peak	4.18b	100
Experimental variant 2b cultivated with maize by level curves, base	5.01b	119,86
Experimental variant 3a cultivated with maize by direction hill-valley, peak	3.68b	88,04
Experimental variant 3b cultivated with maize by direction hill-valley, peak	4.97b	119,14
Mean	4,46	
CV (%)	14,28	
$LSD_{5\%}$	11,344	
F	3,429*	

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%.

The averages of maize production recorded at the top of the slope, for contour 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 N90P45K90, organically with manure and by administering green fertilizers (lupine + rye + rapeseed). The lowest average corresponds to the 1st control variant, respectively 4.18 t/ha (Table 6.55).

Table 6.55

The maize production recorded in eroded arable field (peak of the slope) when conventional and unconvetinal fertiliers 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 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, $N_{90}P_{45}K_{90}$; 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 N90P45K90 (14a) – 5.53 t/ha, organic with manure (13a) – 5.48 t/ha and by administration of green fertilizers (lupin + rye + rapeseed, 10a) – 5.47 t/ha and the lowest for variant 8a control, respectively 3.68 t/ha. 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

Regarding the corn 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 N90P45K90 (7b), organically with manure (6b) and by administering mixed green fertilizers (lupine + rye + rapeseed, 3b; peas + ryegrass + rye, 5b). The lowest average corresponds to the control variant 1b, respectively 5.01 t/ha. 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 6.56).

Table 6.56

The maize production recorded in eroded arable field (base of the slope) when conventional and unconvetinal fertiliers 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 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, $N_{90}P_{45}K_{90}$; 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.

7. CONCLUSIONS AND RECOMMENDATIONS

According to the results of the present study, it is observed that the losses of soil and nutrients (humus, phosphorus, potassium), recorded at the level of arable land, in the pedoclimatic conditions of the experimental field located on a slope located on the territory of Valea Mare de Criș commune, Bihor county , with a slope of 12%, values are recorded that exceed the maximum limits allowed in the case of corn cultivation in the hill-valley direction, respectively: 9.2 t/ha/year in 2019 – 9.5 t/ha/year in 2020 for soil losses, (210 kg/ha/year in 2019 and 226 kg/ha/year in 2020 for humus, (3.22 kg/ha/year in 2019 and 3.20 kg/ha/year in 2020) for phosphorus and (2.54 kg/ha/year in 2019 and 2.68 kg/ha/year in 2020, for potassium.

The highest maize production averages are reported for contour cropping technology, both for the top of the slope (4.18 t/ha) and for the base (5.01 t/ha), and the differences between productions both between those reported for the base and the top of the slope as well as those related to the cultivation technology in the hill-valley direction are statistically ensured (LSD5%). Strong and very strong correlations are identified between the maize productions recorded according to the experimental variant. The same two main factors out of the total of four identified were taken into account as in the case of the physical-chemical indicators studied, respectively the experimental variant and the location of the culture. The experimental variant is the main factor positively correlated with the technology of corn cultivation in the hill-valley direction at the base of the slope and the location is the main factor correlated very strongly, positively, with the technology of cultivation on level curves, also at the base of the slope. It is found that the location of the crop at the base of the slope has the strongest influence on production.

The highest pH averages, which highlight a weakly acidic reaction, are reported for the fertilization carried out at the base of the slope in the case of the corn cultivation technology in the hill-valley direction, with green manures in a lupine + rye + rapeseed mixture, respectively 6.39 pH units and peas + ryegrass + rye, respectively 6.23 pH units, and the lowest in the case of the technology of corn cultivation on level curves, for the lack of fertilization (5.64 pH units) and the administration of soil fertilization with green manure in pure culture, peas (5.82 pH units). The highest averages of the nutrient content of the soil located in the experimental field are reported for the administration of green manures in the lupine + rye + rapeseed mixture, for the technology of corn cultivation on level curves: 2.96 ppm (at the base of the slope) for humus, 38.95 ppm for mobile phosphorus in the supplied medium category and 198.66 ppm for mobile potassium in the supplied medium category.

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 green manure administration, pure crop fertilization administration with lupine green manure and peas and peas + ryegrass + rye, respectively, and administering conventional fertilization with $N_{90}P_{45}K_{90}$.

Based on the results of the present study, regarding the reduction of soil losses, but also of nutrients (humus, phosphorus, potassium), in the pedoclimatic conditions of the experimental field located on a slope located on the territory of Valea Mare de Criș commune, Bihor County, with the slope of 12%, it is recommended to avoid the technology of corn cultivation in the hill-valley direction. As a result of the results of the study of the physico-chemical indicators that are important in assessing the level of land erosion in the experimental field, which highlights the fact that they are strongly influenced by both the culture technology and its location, it is recommended that in the case of eroded land in the placement of crops on the slope should be carried out according to its specifics, obtaining a higher productivity, but in the case of crops on level curves. The analysis of the possibilities of using green fertilizers for the improvement of arable soils on slopes made by studying the physical-chemical indicators highlights the advantages of using them, especially of their mixtures. Thus, to improve the total degree of structuring of soil aggregates with a diameter greater than 25 mm, it is recommended to administer the mixture of peas + ryegrass + rye, while to reduce the apparent density and penetration resistance of the soil and increase the hydraulic conductivity and utilization efficiency water, it is recommended to administer the mixture of lupine + rye + rapeseed green fertilizers. It is also recommended to administer the mixture of green lupine + rye + rapeseed fertilizers in order to correct soil acidity and improve its nutrient content (humus, mobile phosphorus, mobile potassium), in the pedoclimatic conditions of the Valea Mare de Criș area, Bihor County. In the practice of administering green fertilizers, it is recommended to pay more attention to the location of the culture on level curves, or in the hill-valley direction, in order to improve the physico-chemical indices of the level of soil erosion. With regard to the productive aspects related to the corn crop, based on the studies carried out in the present doctoral thesis, it is also recommended to administer the mixture of green fertilizers lupine + rye + rape under the conditions of the location of the crop on level curves.

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