CHARACTERIZATION OF A PASTURE AREA BASED ON SOIL AGROCHEMICAL INDICES AND IMPROVEMENT MEASURES

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Abstract

The study evaluated the quality of the soil within an agricultural area, the category of pasture use, in terms of agrochemical indices. A surface of 485.94 ha was studied, from the area of Brebu Nou locality, Caras-Severin County, Romania. The agricultural land under study falls into the category of pasture use. Soil samples were taken, and the agrochemical indices determined for the evaluation of the studied agricultural land were represented by the soil pH, humus content (H, %), phosphorus content (P, ppm), potassium content (K, ppm), nitrogen index (NI, %), and the degree of supply of basic cationic (V, %). The data obtained for the 119 studied plots were grouped in 10 groups, depending on the pH value, with a variation of 0.1 pH units per group. Based on the determined agrochemical indices, a high variability was found regarding the soil supply with phosphorus (CV_P = 56.1509) and the soil supply with potassium (CV_K = 42.5579). Low values of CV were recorded for pH (CV_{pH} = 4.7231) and for humus (CV_H = 5.2127), and intermediate values for NI (CV_{NI} = 25.2418) and for V (CV_V = 24.8559). From the analysis of the average values, on the 10 groups obtained, it was found that 79% of the studied area (385.15 ha) has a strongly acidic pH (groups G1 - G7), and 21% of the surface (100.79 ha) has a moderate acidic pH (groups G8 - G10). According to the PCA, PC1 explained 44.051% of the variance and PC2 explained 32.812% of the variance. Regression analysis facilitated the obtaining of models in the form of equations ($p < 0.001$, $R^2 = 0.764$ to $R^2 = 0.827$), and 3D and isoquants graphical models, which described the variation of phosphorus and potassium in relation to soil acidity and soil humus.

Key words: *acidity, calcareous amendments, models, pasture, soil pH, soil quality*

INTRODUCTION

The evaluation of agricultural lands based on specific, ecological and agrochemical indicators, is important and has been used in various studies in relation to the category of land use [9], different types of agricultural systems [10], [27], agricultural practices and technologies [3], [5], [32], [34], [35], agricultural crops and production [21], [29], economic aspects [19], soil type and fertilizers [4], soil health [17], [26], [36], soil improvement measures [2], [12], [36], soil protection policies [20].
The variation of the agrochemical indices is the result of the factors and conditions of soil formation and evolution, but also of the anthropic factor through some agricultural practices [8], [28].
Soil limitations in terms of their health, as well as agricultural production and farm profitability, have been studied and ranked among the main limiting CEC (cationic exchange capacity), nutrients and soluble carbon [36].
Acidity is a limiting factor in soil fertility over large areas of land around the world, and numerous studies have addressed issues regarding soil acidity assessment, adverse effects on crops, and the formulation of remedial solutions [1], [11], [22], [30].
In relation to the acidification phenomenon, studies have been conducted on soil monitoring in different soil and climate zones, at different categories of agricultural land use, and correlated with agricultural crops, crop technologies, and improvement measures [16].
The acidity of the soil in the case of pastures has a number of disadvantages, which are found in the floristic composition, biomass production and its quality, which is a major

constraint in economic and social terms, but also ecological. Various studies have been conducted to assess the level of acidity on grassland land, in relation to soil and climate conditions, nutrient regime, the presence and effect of aluminum, changeable forms (Al^{3+}), and ameliorative measures [25], [18], [31].

The present study analyzed and characterized the soil quality based on agrochemical indices, within an agricultural area with land occupied by pastures.

MATERIALS AND METHODS

The study evaluated the quality of the soil within an agricultural area, the category of pasture use, in terms of agrochemical indices.

The land taken in the study with an area of 485.94 ha is located in the area of Brebu Nou locality, Caras-Severin County, Romania, Figure 1. The study was conducted in 2020, and the samples were taken in April.

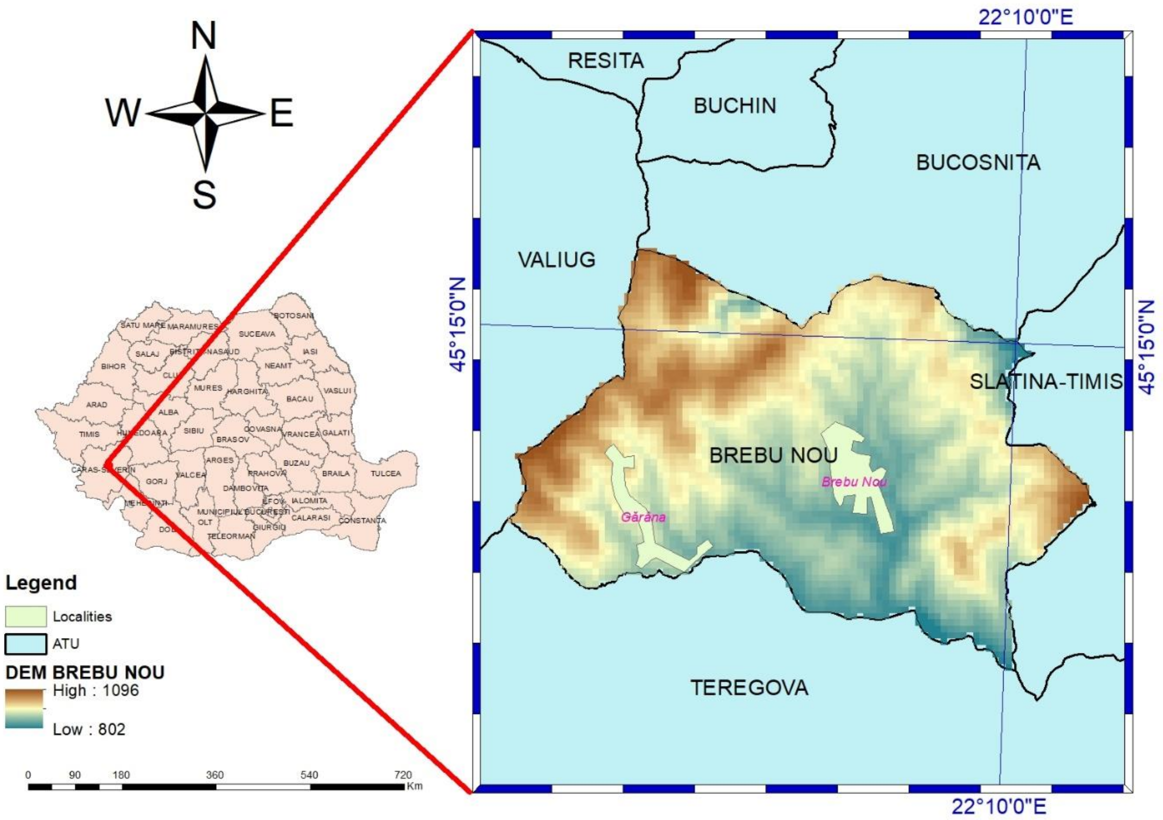

Fig. 1. Study area, Brebu Nou locality, Caras-Severin County, Romania [7]
Source: Original image, generated by authors.

Considering the orography of the land in the study area, the land area approached included plots with variable area, between 0.03 ha to 62.20 ha.

The agrochemical indices taken into account and determined for the assessment of the soil quality were represented by pH, phosphorus content (P, ppm), potassium content (K, ppm), humus content (H, %), nitrogen index (NI, %), the degree of saturation in basic cations (V, %). Standardized laboratory methods were used for the determination [23], [6], and the determinations were made within the OSPA Timisoara Laboratory.

Depending on the pH values, a grouping of plots was made in 10 groups (G1 to G10), with a variation interval between groups of 0.1 pH units. The degree of spatial variability of the land was evaluated in terms of soil pH, humus content (H) and main macro elements (P, K).

Data analysis was performed through the Anova Test to assess the presence of variance in the data set, and statistical safety (Alpha = 0.001, $p < 0.05$).

Descriptive statistical analysis was used to evaluate the variation of the data (min, max), to calculate the standard error (SE), the

coefficient of variation (CV). The correlation analysis was used to evaluate the direct interdependence between the analyzed agrochemical indices (correlation coefficient, r). PCA was used to evaluate the distribution of land groups (based on soil pH) in relation to the main agrochemical indices considered.
PAST software [13], EXCEL calculation module and Wolfram Alpha (2020) software [33] were used for data analysis and graph generation.

RESULTS AND DISCUSSIONS

The study analyzed an area of 485.94 ha, in the area of Brebu Nou locality, Caras-Severin County, Romania, in order to characterize the agricultural land in the category of pasture use. From the analysis of the main agrochemical indices of land characterization, data were obtained for 119 plots. The data were grouped into 10 groups, depending on the pH value, with a variation of 0.1 pH units per group. For the grouping of the studied area, the soil pH was taken into account, because it presented the most restrictive values, in terms of soil fertility and agricultural productivity. The data obtained are presented in Table 1.

Table 1. Field groups according to pH values

Groups	Surface	Agrochemical indices (average value)			
		pH	V	H	NI
	(ha)		(%)		
G1	15.95	4.45	11.49	4.61	0.53
G2	27.03	4.54	11.49	4.06	0.47
G3	18.82	4.68	11.49	4.50	0.52
G4	120.13	4.73	13.70	4.55	0.63
G5	62.07	4.86	20.87	4.21	0.88
G6	139.08	4.95	20.87	4.55	0.95
G7	2.07	5.06	20.87	4.33	0.91
G8	29.76	5.13	14.76	4.29	0.64
G9	67.79	5.23	14.36	4.28	0.62
G10	3.24	5.40	20.87	4.32	0.90
TOTAL	485.94				
SE		±0.02	±0.37	±0.02	±0.01

Source: Original data, results from field study and soil sample analysis.

The content of phosphorus (P, ppm) and potassium (K, ppm) was determined, and the values were in great limits of variation, in accordance with the orography and the natural factors of influence on the land, the pasture category, in the study area. In the case of phosphorus, the values were in the range P = 23.23 to 35.30 ppm (average values per study group), and potassium was in the range K = 136.70 to 352.50 ppm (average values per study group). The graphical distribution of the P and K values, with the representation of the outliers' values is shown in Figure 2.

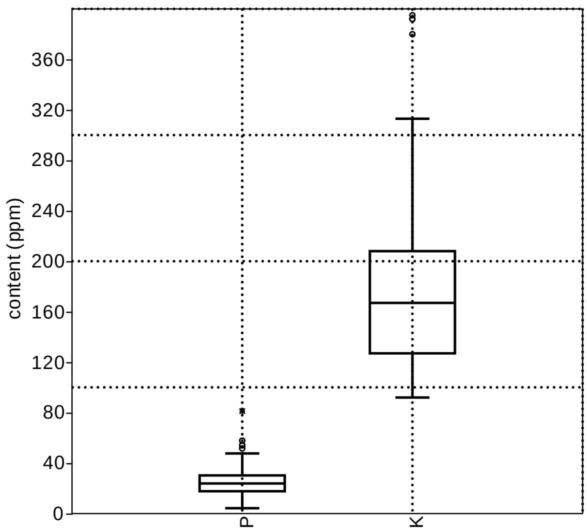

Fig. 2. Graphic distribution of variation range for P and K (ppm) and outlier values, pasture land, Brebu Nou, Caras-Severin County, Romania
Source: Original chart, general based on the results obtained.

Anova Test, single factor, highlighted the presence of the variance in the data set, and the statistical safety of the data obtained for the characterization of the land under study, Table 2.

Table 2. Anova Test, single factor (Alpha=0.001)

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3442006	6	573667.7	256.7718	5.7E-185	2.1086
Within Groups	1845411	826	2234.154			
Total	5287417	832				

Source: Original data, obtained from the calculation

The analysis of the land surface studied under the aspect of spatial variability was made in relation to each agrochemical index considered, through the coefficient of variation (CV). Thus, based on the determined agrochemical indices, a high variability was found regarding the supply of soil with phosphorus (CV_P = 56.1509) and the supply of soil with potassium (CV_K = 42.5579). Low values of CV were recorded for pH (CV_{pH} = 4.7231) and for humus (CV_H = 5.2127), and intermediate values for nitrogen index (CV_{NI} = 25.2418) and for degree of saturation in basic cations (CV_V = 24.8559).

The soil pH showed a reduced spatial variability, but the pH values frame the soil in the group of moderately - strongly acid soils [23], [6]. The reaction of the soil greatly influences the regime and the availability of nutrients for crop plants, and in the case of the present study, the pH values were in the range with high effects of decreasing the bioavailability of phosphorus in particular, but also potassium (as macro elements considered).

Due to the fact that pH was the most restrictive factor for soil fertility, a ranking of the plots studied according to pH values was made and a grouping of them in 10 groups, with a variation of 0.1 pH units (Table 1).

Analyzing the total area studied in relation to the 10 groups obtained, we found a different share of area on each group. Thus, most of the studied area (139.08 ha) was in the pH = 4.90 - 5.00 group, with a value of 28.62%, followed by the pH = 4.70 - 4.80 group, in which it was 120.13 ha, with a value of 24.72%. The smallest area (2.07 ha) was in the pH = 5.0 - 5.1 group, with a value of 0.43%. The percentage values of the studied area are shown graphically in Figure 3.

From the analysis of the average values of the 10 land groups, PCA led to the diagram in figure 4. PC1 explained 44.051% of variance and PC2 explained 32.812% of variance. The main components considered were the soil pH, the content of P, K and H, as a biplot. In relation to these components, the analyzed groups were oriented in relation to the recorded values, respectively the groups G5, G7, G8, G9 and G10 were associated with the pH; Groups G2, G3 and G5 were associated with P and K, and groups G1, G4 and G6 were associated with H.

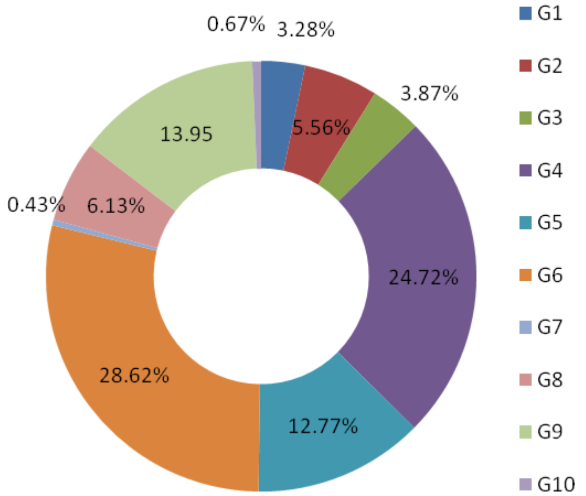

Fig. 3. Distribution by pH groups of the studied land area, pasture category, Brebu Nou area, Caras-Severin County
Source: Original chart, generated based on data.

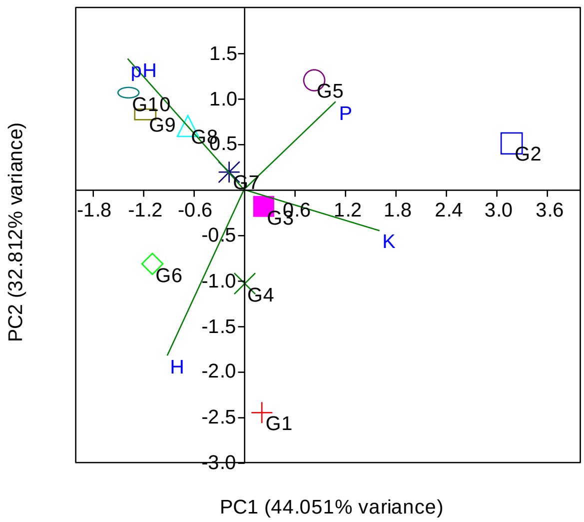

Fig. 4. PCA diagram, correlation matrix, in relation to pH, P, K, H indices
Source: Original diagram, generated based on data.

Under the present conditions, identified on the basis of the soil agrochemical indices considered, an assessment was made of how soil pH and humus content (H, %), as agrochemical indices, with high soil stability, influenced the variation the content of phosphorus (P, ppm) and potassium (K, ppm). For this, regression analysis was used.

The variation of the phosphorus content (P, ppm) in the soil depending on the soil pH and degree of saturation in basic cations (V, %) was described by equation (1), under conditions of R^2 = 0.764, $p < 0.01$, F = 74.0726. The graphical distribution of the variation P according to the pH of the soil (x-axis) and the degree of cationic bladder (V, %) is shown in the form of a 3D model in figure 5 and in the form of isoquants in figure 6.

$$P = a\,x^2 + b\,y^2 + c\,x + d\,y + e\,xy + f \qquad (1)$$

where: P – phosphorus content in the soil (ppm);
x – soil pH;
y – degree of saturation in basic cations (V);
a, b, c, d, e, f – coefficients of the equation (1);
a = 3.3556850
b = 0.0941337
c = -5.0087355
d = 6.7661717
e = -2.0514464
f = 0

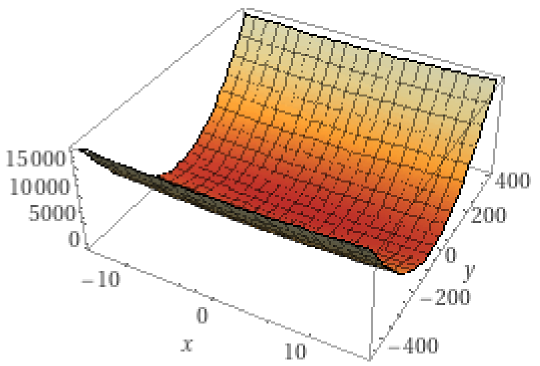

Fig. 5. 3D graphical representation of variation of phosphorus content (P, ppm) depending on soil pH (x-axix) and V (y-axix), pasture category, under study conditions
Source: Original graph, generated based on data

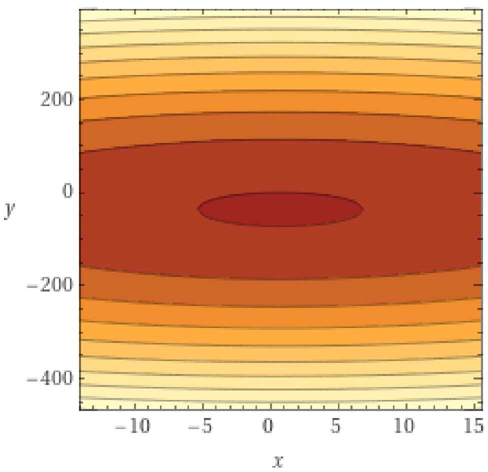

Fig. 6. Graphic representation in the form of isoquants regarding the variation of the phosphorus content (P, ppm) depending on the soil pH (x-axix) and V (y-axix), pasture category, under study conditions
Source: Original graph, generated based on data.

In relation to the pH of the soil and the humus content (H, %), the variation of the P content was described by equation (2), under conditions of $R^2 = 0.827$, $p < 0.001$, $F = 108.7696$. The graphical distribution of the variation P as a function of pH and H is represented in the form of a 3D model, figure 7, and in the form of isoquants, figure 8.

$$P = a\,x^2 + b\,y^2 + c\,x + d\,y + e\,xy + f \qquad (2)$$

where: P – phosphorus content in the soil (ppm);
x – soil pH;
y –humus content (H);
a, b, c, d, e, f – coefficients of the equation (2);
a = -1.3193847
b = -35.5914707
c = -97.9359179
d = 175.4431978
e = 21.3810539
f = 0

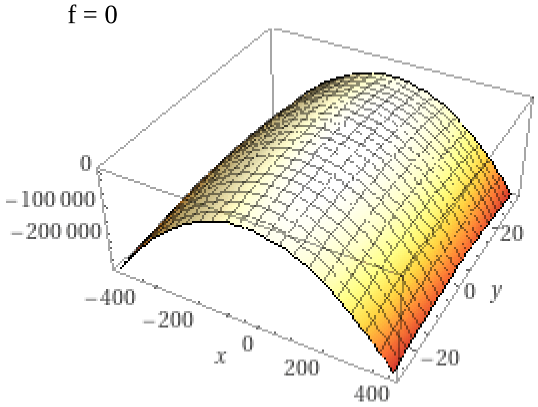

Fig. 7. 3D graphical representation of variation of phosphorus content (P, ppm) depending on soil pH (x-axix) and H (y-axix), pasture category, under study conditions
Source: Original graph, generated based on data

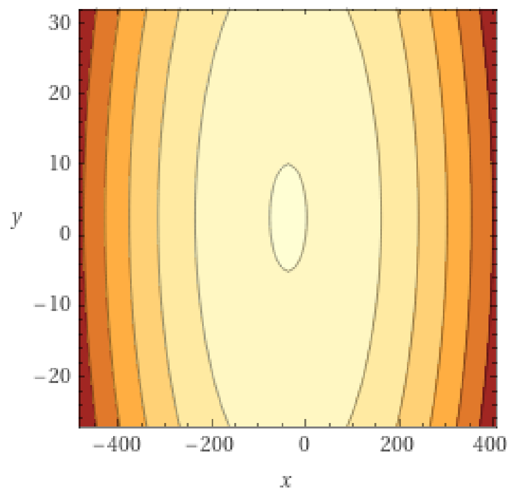

Fig. 8. Graphic representation in the form of isoquants regarding the variation of the phosphorus content (P, ppm) depending on the soil pH (x-axix) and H (y-axix), pasture category, under study conditions
Source: Original graph, generated based on data.

The variation of the K content in the soil as a function of pH and V was described by equation (3), under conditions of $R^2 = 0.827$, $p < 0.001$, $F = 84.3391$. The graphical distribution of the variation K as a function of pH and V is represented in the form of a 3D model in Figure 9 and in the form of isoquants in figure 10.

$$K = a\,x^2 + b\,y^2 + c\,x + d\,y + e\,xy + f \qquad (3)$$

where: K – potassium content in the soil (ppm);
x – soil pH;
y – degree of saturation in basic cations (V);
a, b, c, d, e, f – coefficients of the equation (3);
a = -119.4370042
b = -0.6498946
c = 589.1927351
d = -129.9921807
e = 30.7210689
f = 0

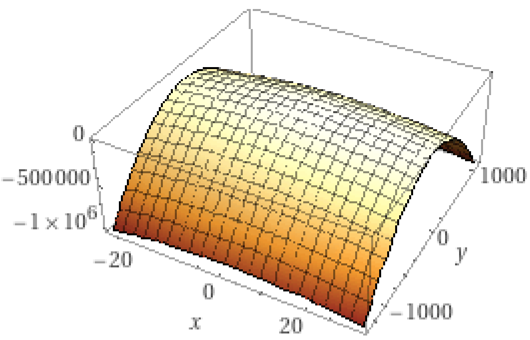

Fig. 9. 3D graphical representation of variation of potassium content (K, ppm) depending on soil pH (x-axix) and V (y-axix), pasture category, under study conditions
Source: Original graph, generated based on data

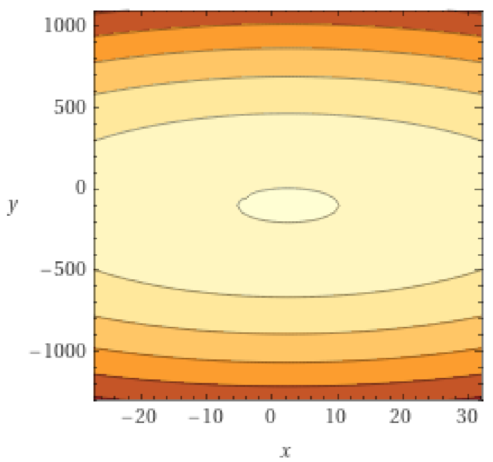

Fig. 10. Graphic representation in the form of isoquants regarding the variation of the potassium content (K, ppm) depending on the soil pH (x-axix) and V (y-axix), pasture category, under study conditions
Source: Original graph, generated based on data.

In relation to the scale of pH values, and interpretation of soil acidity, from the analysis of average values, it was found that 79% of the analyzed area (385.15 ha) had a strongly acid pH (groups G1 - G7), and 21% of the surface (100.79 ha) showed a moderate acid pH (groups G8 - G10), Figure 11. From the studies at national level, and the monitoring of the soils, in Romania the acid soils amount to about 3.5 million ha [14], with limitations regarding the agricultural productions, in relation to the category of use of the agricultural lands.

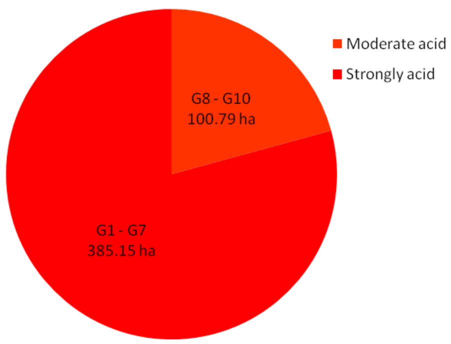

Fig. 11. Graphic representation of the land surface studied in terms of soil acidity intensity
Source: Original graph, generated based on calculated data.

Given the limitation of the production potential of agricultural land, pasture category, taken into account, due to the moderately acidic and strongly acidic reaction of the soil, a first recommended measure is to improve soil acidity by applying calcareous amendments.

The correction of the soil acidity is imposed on the entire surface, with variable doses of amendments in relation to the concrete situation for each plot, quantified by the values of the studied agrochemical indices. The estimated effect is expected starting with the first year from the treatment of the soil with amendments, and continues for a period of 3-4 years, in relation to the dose of amendment applied, as well as subsequent agro technical works.

Soil improvement by correcting acidity is a necessary and more accessible method of improving the nutrient regime of the soil for plant nutrition, in the context of a sustainable management of acid soils [24], [11], [15].

At the same time, against the background of the current energy crisis, and the high prices of synthesis fertilizers, soil improvement measures can compensate, even if partially, the application of fertilizers, by mobilizing nutrients from the soil. Limestone amendments are more affordable in price compared to synthetic fertilizers, and such ameliorating products come from natural deposits, present in our country, and thus are more accessible to farmers. The application technique is a classic one, adapted to local field conditions, and can be accompanied by a superficial soil harrowing work to incorporate the applied product, and increase the effectiveness of the improvement work. In addition, surface organic fertilizers (manure from cattle or sheep) can be administered, which supplement the nutrients and increase the effectiveness of the soil amendment work [24], [15].

From the analysis of the graphical models obtained for the variation P and K depending on the soil pH, V (%), and H (%), a pronounced dependence of the phosphorus content (P, ppm) and potassium (K, ppm) on pH was found, as well as the degree of saturation in basic cations.

The analysis of the variation of P in relation to soil pH and V (%), equation (1), figures 4 and 5, showed that at a variation of pH in the recorded range (4.45 to 5.40; average values), a high importance a shows the degree of soil saturation in basic cations (V,%).

Associated with low pH values (high acidity) the content of basic cations (eg Ca, Mg) is low in the soil, and the P regime is deficient for plants. The administration of calcareous amendments (eg calcium carbonate, calcium oxide, dolomite), will lead to an increase in the content of basic cationic in the soil, which will lead to the correction of the pH and the improvement of the nutrient regime (especially P) for plant nutrition.

CONCLUSIONS

Soil acidity is a major limiting factor for the study land area, which accounts for 79% of the pasture area as strongly acidic pH and 21% of the area as moderate acidic pH.

The high variability showed the content of P and K, nutrients whose regime was pronouncedly affected by both the pH of the soil and the degree of soil saturation in basic cations (V, %). The main ameliorating measure is the correction of acidity by applying calcareous amendments, associated with other agro technical and cultural measures.

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