VARIABILITY OF PASTURES BASED ON SOIL QUALITY INDICES

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Abstract. The study evaluated the spatial variability of pastures, in the area of Sânpetru Mare, Timis County, Romania. The analyzed area included 80 plots in six size categories in relation to the surface: 0.01-1.0 ha (25 plots), 1.01-2.0 ha (21 plots), 2.01-5.0 ha (19 plots), 5.01-25.0 ha (5 plots), 25.01-50.0 ha (6 plots), and 50.01-100.0 ha (4 plots). Soil pH, humus (H, %), phosphorus (P, ppm), and potassium (K, ppm) were determined, and the values for V (%) and NI (%) were calculated. The series of values presented normal distribution (r=0.854 for pH, r=0.956 for P, r=0.986 for K and r=0.829 for H). Very strong correlation was recorded between pH and V (r=0.962) and between NI and H (r=0.969), p<0.001. Strong correlation was recorded between NI and pH (r=0.838), p<0.001) and moderate correlations between H and pH (r=0.757) and between NI and H (r=0.748), p<0.001. Based on PCA, PC1 explained 62.723% of variance, and PC2 23.247% of variance, in relation to pH, H, P and K, as soil quality indices. Spline models described pH and H content variation in relation to the plots size category (Psc), under statistical safety conditions ($\bar{\varepsilon} = 2.0722\,E-05$; $\bar{\varepsilon} = 6.06\,E-05$).
Keywords: *agricultural land, cluster analysis, PCA, Pearson's correlations, Spline models*

Introduction

Agricultural lands and plant production systems based on plant cultivation are important in relation to food security and various sustainable development objectives at local, regional, and wider scale as well (Viana et al., 2022).

Agricultural lands are periodically evaluated in relation to various socio-economic and ecological criteria, such as the development plan, land competitiveness, use categories, productivity, agricultural systems, and technologies, etc. (Gutzler et al., 2015; Paz et al., 2020; Appelt et al., 2022; Ruiz-Varona et al., 2022; Sun et al., 2022).

In relation to the main purpose and objectives, different methods and methodologies were used to evaluate agricultural land (Burger, 1998; Tóth-Naár et al., 2018; Viana et al., 2022).

In relation to the productivity of agricultural lands, the evaluation methods are based on the quantification of soil fertility indices, most frequently the soil reaction, the content of organic matter (humus), the content and mobility of nutritional elements (macro- and micro-elements). Research studies evaluated the productivity of agricultural land in different areas and climatic conditions, agricultural systems, land, and soil, in relation to the specific crops in the study area (Ranamukhaarachchi and Begum, 2005; Oldfield et al., 2019; Voltr et al., 2021).

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Some studies have assessed how soil quality/fertility indices have changed in relation to agricultural practices, such as crop structure, fertilization, tillage, irrigation, etc. (Gross and Glaser, 2021; Jordon et al., 2022).

The spatial and temporal variability of agricultural land is also of interest and has been evaluated in many studies, as a result of its importance in relation to land use, management, performance, land value and market, as well as other purposes (Pandey et al., 2019; Popescu et al., 2020; Kosma et al., 2022).

The fragmentation of habitats and agricultural land has also been studied both from the perspective of ecosystems, biodiversity, landscape functionality and land productivity (Adhikari and Hansen, 2018; Andersson et al., 2021; Tiang et al., 2021).

In relation to soil fertility, agricultural systems, the structure of crops and the level of productivity of the lands, the variation of agricultural production was evaluated in relation to the cultivated land but also to the applied fertilization (Boldea et al., 2015; Bărdaș et al., 2022).

The objective of the present study was to evaluate the variability of pasture agricultural land based on soil agrochemical indices in relation to the plots size category (Psc), and to describe based on mathematical methods and models, the variability of the area considered.

Materials and Methods

The study evaluated the spatial variability in the case of an agricultural area, pasture category, based on soil fertility indices. The agricultural land considered in the study, with a total surface of 668.99 ha, was in the area of Sânpetru Mare, Timis County, Romania, *Figure 1* (ESRI, 2014). Within the analyzed area, the natural layout of the plots considered in the study was in two obvious directions, included between the coordinates: NW 46.062428°, 20.787513°, NE 46.062752°, 20.811785°, SE 46.053865°, 20.811852°, SW 46.053354°, 20. 788197°, and, respectively between the coordinates: NW, 46.120539°, 20.785160°, NE 46.120053°, 20.799172°, SE 46.103434°, 20.802862°, SW 46.103228°, 20.786436°.

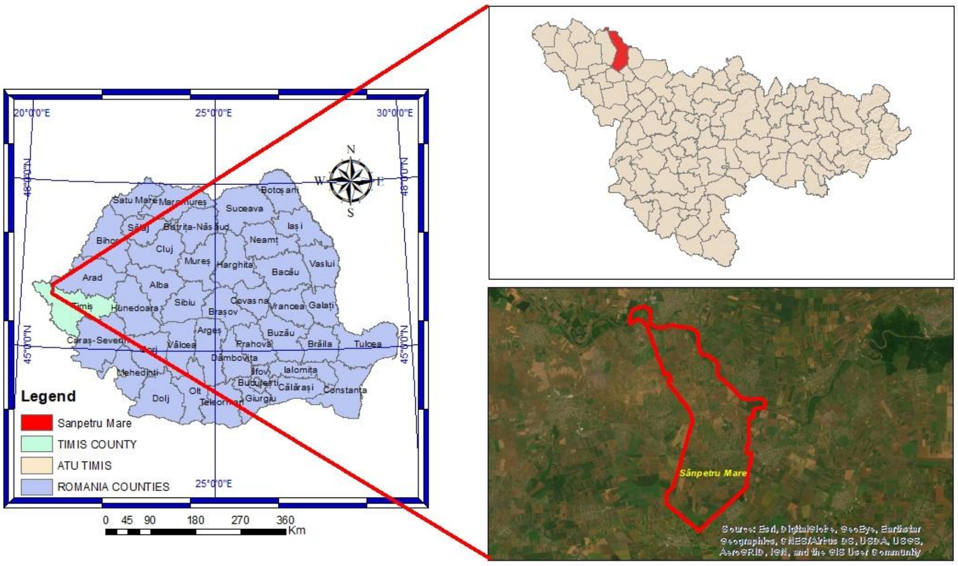

Figure 1. *Study area, Sânpetru Mare locality, Timis County, Romania*

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The land in the researched area was covered by pastures, which included mesophilic species and hydrophilic associations: *Poa pratensis* L., *Bromus inermis* Leyss., *Dactylis glomerata* L., *Trifolium pratense* L., *Lolium perenne* L., *Ranunculus acer* L., *Festuca pratensis* Huds., *Vicia* sp. L., *Achillea millefolium* L., *Mentha pulegium* L., *Rubus caesius* L., *Fragaria vesca* L., *Lotus tenuis* Waldst. & Kit. ex Willd., *Polygonum hydropiper* (L.) Dalabre.

The field phase of the study, namely the collection of soil samples, took place during October 2019. In accordance with the purpose of the study, soil samples were collected. The soil samples were collected with the agrochemical soil sampler, at a depth of 20 cm from the soil level. An average soil sample was composed of 25 partial subsamples. The land surface considered in the study presented a natural fragmentation into plots of different sizes. On the plots of up to 10 ha, an average soil sample was taken (consisting of 25 partial sub-samples). On the larger plots, each soil sample was taken from an area of 10 ha. Each sample contained about 500 g of soil.

Based on the soil samples, agrochemical indices considered representative in relation to the land use category were determined, for the characterization of soil fertility: soil reaction (pH), humus content (H, %), phosphorus content (P, ppm) and potassium content (K, ppm). In addition, the degree of saturation in basic cations (V, %) and nitrogen index (NI, %) were calculated. Nitrogen index (NI) was calculated in relation to humus content (H, %) and degree of saturation in basic cations (V, %), according to the relation $NI=(H\times V)/100$.

The determination of the soil reaction (pH), the content of humus (H, %), phosphorus (P, ppm) and potassium (K, ppm) was made based on accredited methods, within the OSPA Timisoara Laboratory, accredited by RENAR. For the evaluation of the considered land area, the entire series of values related to the 80 plots was used, as well as the average values, within six plot size categories (Psc).

As a result of the high variability of the land plots surface, from 0.13 ha to 96.00 ha, a grouping of the plots was made according to the surface in 6 size categories (Plot size category - Psc; Psc 1, 0.01 - 1.00 ha ; Psc 2, 1.01 – 2.00 ha; Psc 3, 2.01 – 5.00 ha; Psc 4, 5.01 – 25.00 ha; Psc 5, 25.01 – 50.00 ha; Psc 6, 50.01 – 100.00 ha). The classification and placement of plots into classes was based on semi-natural plot size. To assess soil quality indices, samples were taken on each plot with a surface area of at least 10 ha, and on sampling areas created within the plots, in the case of plots with larger surfaces.

The coefficient of variation (CV) was calculated to assess the level of variability within the data series for each determined or calculated agrochemical index.

The multicriteria analysis (Principal Component Analysis, and Cluster Analysis) was used to evaluate the distribution and association of the land plots in relation to the studied agrochemical indices.

Spline model was used in the regression analysis, as a result of the fact that it is an established tool, which has implemented a large number of modeling options based on spline functions (Perperoglou et al., 2019). Spline functions have been the subject of numerous studies and researches, communicated in established books and reference articles, and show applicability in various fields, such as astronomy, computer science, engineering, life sciences, physics etc. (Eddargani et al., 2022; Lamberti and Remogna, 2022). In general, spline functions are appreciated because they show continuity of curvature, which ensures a good accuracy of expression (Lenda and Marmol, 2022).

Adequate statistical safety parameters were considered for the purpose of interpreting the results and confirming the statistical safety (r, R^2, p).

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The software Past (Hammer et al., 2001), the software JASP (2022) and the statistical calculation module in EXCEL were used for the analysis, processing, and interpretation of the obtained data.

Results and Discussions

In the study, to evaluate the variability of agricultural land, 80 plots of land, pasture category, in the area of Sânpetru Mare, Timis County, Romania, with a total area of 668.99 ha, were studied and analyzed. Based on soil samples and specific analyses, the values for the soil fertility indices taken into account (pH, H, P, K) were obtained, and the values for the degree of saturation in basic cations (V) and for the nitrogen index (NI) were calculated. On the basis of Descriptive Statistics, the values from *Table 1* were obtained, which show the framing limits (min, max) of the data set (80 parcels), and a series of representative statistical parameters. The initial values (plot area, agrochemical indices) were presented as variation limits and statistical parameters for the general characterization of the data series. The specific analyzes in the content of the study (correlations, PCA, CA, CV, spline functions) were made by plot size classes (Psc).

Table 1. *The statistical values for soil quality indices and the studied land area*

Statistical parameters	S (ha)	pH	V	H	P	K	NI (%)
			(%)		(ppm)		
N	80	80	80	80	80	80	80
Min	0.13	5.81	62.4	3.51	29.88	174	2.2
Max	96	7.89	100	4.98	161.95	967	4.93
Sum	668.99	587.54	7541.81	365.51	7031.22	43556.00	344.71
Mean	8.36	7.34	94.27	4.57	87.89	544.45	4.31
Std. error	2.01	0.07	1.40	0.06	4.47	23.77	0.09
Stand. dev	17.94	0.65	12.49	0.56	40.00	212.62	0.78
Median	1.65	7.59	100.00	4.88	71.85	557.00	4.73
25 prcntil	0.82	7.16	96.99	3.89	57.06	338.50	3.34
75 prcntil	4.09	7.75	100.00	4.98	122.08	702.00	4.83
Skewness	3.1445	-1.5610	-1.9822	-1.1264	0.4195	0.1647	-1.2176
Kurtosis	10.2518	1.0802	2.1348	-0.5585	-1.2234	-0.7537	-0.1222
Geom. mean	2.16	7.31	93.27	4.53	78.92	499.25	4.22
Coeff. var	214.5186	8.8139	13.2458	12.1704	45.5113	39.0528	18.2061

The pH values were between 5.91-7.89±0.07, and in close relation with the soil reaction, the degree of supply with basic cations (V, %) showed values between 62.40-100.00±1.40. The humus content (H) presented values between 3.51-4.98±0.06, and the nitrogen index (NI), in accordance with the agrochemical indices H and V, presented values between 2.20-4.93±0.09. The phosphorus content (P, ppm) varied between 29.88-161.95±4.47 ppm, and the potassium content (K, ppm) varied between 174.00-967.00±23.77 ppm.

The distribution of the series of values for the determined soil quality indices (pH, P, K and H) is presented in *Figure 2*, under conditions of a high level of statistical confidence (r=0.854 in the case of pH; r=0.956 in the case of P; r =0.986 in the case of K; r=0.829 in the case of H).

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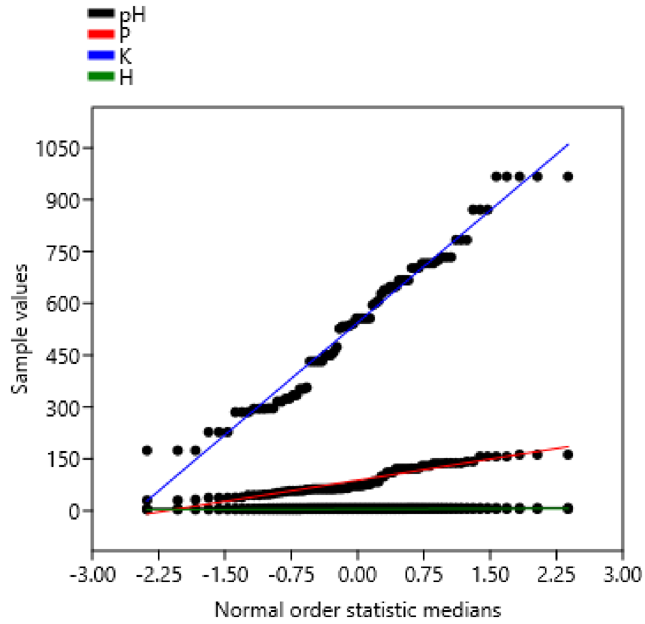

Figure 2. *Normal probability plot for the series of pH, P, K and H values, under the study conditions*

Based on the coefficient of variation (CV), the variability of the agrochemical indices for assessing soil fertility was analyzed. Phosphorus showed the highest level of variation (CV_P=45.5113), followed by potassium (CV_K=39.0528), and the lowest level of variation was recorded in the case of soil reaction (CV_{pH}=8.8139). The nitrogen index showed variability at CV_{NI}=18.2061, and the humus content (H) and the degree of saturation in basic cations (V) showed similar levels (CV_H=12.1704, CV_V=13.2458). The agricultural area, the pastures category, presented a high degree of fragmentation, in terms of the plots' surfaces, a fact highlighted on the basis of the value of the coefficient of variation (CV_S=214.5186).

As a result of the high variability in terms of the surface of the plots studied (from the plot of 0.13 ha to the plot of 96.00 ha), a grouping of the land plots was made by size categories: 0.1 – 1.0 ha (25 plots), 1.01 – 2.0 ha (21 plots), 2.01 – 5.0 ha (19 plots), 5.01 – 25 ha (5 plots), 25.01 – 50.0 ha (6 plots) and 50.01 – 100 ha (4 plots) (*Table 2*). The disproportionate distribution of the plots number by Psc clases, shows a high land fragmentation, and a high spatial variability in terms of plot size.

Table 2. *Classification of the plots studied by size category*

Plot size category	Plots number in category	Plot category code	The plots included in the category (numerical study code)
0.01 – 1.00 ha	25	Psc 1	8, 11, 14, 15, 16, 17, 20, 24, 25,2 6, 29, 30, 39, 40, 49, 50, 54, 55, 56, 58, 61, 62, 67, 69, 70
1.01 – 2.00 ha	21	Psc 2	2, 3, 4, 12, 18, 22, 23, 34, 35, 43, 47, 48, 51, 53, 57, 59, 64, 65, 74, 78, 79
2.01 – 5.00 ha	19	Psc 3	1, 5, 7, 13, 19, 27, 28, 31, 33, 36, 41, 46, 52, 63, 66, 68, 75, 76, 77
5.01 – 25.00 ha	5	Psc 4	10, 37. 60, 73, 80
25.01 – 50.00 ha	6	Psc 5	6, 9, 21, 45, 71, 72
50.01 – 100.00 ha	4	Psc 6	32, 38, 42, 44

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The correlation analysis on the entire data series highlighted variable levels of correlation between the studied agrochemical indices, under statistical safety conditions (*Table 3*). Very strong, positive correlations were recorded between pH and V (r=0.962, p<0.001) and between NI and H (r=0.969, p<0.001). Strong correlation was recorded between NI and pH (r=0.838, p<0.001). Moderate correlations were recorded between H and pH (r=0.757, p<0.001) and between NI and H (r=0.748, p<0.001). Weak correlations were recorded between H and V (r=0.657, p<0.001), between P and H (r=0.567, p<0.001), between P and K (r=0.597, p<0.001), and between NI and P (r=0.567, p<0.001), respectively. Also, other correlations of weak intensity, but statistically ensured, were recorded.

Table 3. *The correlation table in the case of the analysis of the entire data series*

Variable		pH	V	H	P	K	NI
pH	Pearson's r	—					
	p-value	—					
V	Pearson's r	0.962***	—				
	p-value	< .001	—				
H	Pearson's r	0.757***	0.657***	—			
	p-value	< .001	< .001	—			
P	Pearson's r	0.495***	0.496***	0.567***	—		
	p-value	< .001	< .001	< .001	—		
K	Pearson's r	0.204	0.032	0.353**	0.597***	—	
	p-value	0.070	0.781	0.001	< .001	—	
NI	Pearson's r	0.838***	0.748***	0.969***	0.567***	0.333**	—
	p-value	< .001	< .001	< .001	< .001	0.003	—

* p < .05, ** p < .01, *** p < .001

The correlation analysis was also done within each plot size category (Psc1 to Psc 6), and the values obtained for the correlation coefficient, within each Psc category, are presented in *Table 4*. From the analysis of the correlation coefficient values by Psc categories, in the Psc 1 category (0.0 – 1.0 ha, 25 plots) two very strong correlations were found (r=0.954 between pH and V, r=0.960 between IN and H), a moderate correlation (r=0.750 between IN and pH), and the other correlations were low in intensity.

Within the category Psc 5 (25.01 - 50.00 ha, 6 plots) the most very strong correlations (in number of 10) and strong correlations (in number of 4) were recorded, which suggests that it is the category of surface size with balance between the analyzed agrochemical indices, which indicate the level of soil fertility. In the case of the other Psc categories (Psc 2, Psc 3, Psc 4, and Psc 6), intermediate values regarding the number and level of correlations were recorded, the series of values for the correlation coefficient being presented in *Table 4*.

The large number of very strong and strong correlation recorded in the case of this category of plot size (Psc 5), shows that for the study area these sizes of pasture plots are more balanced under the ratio "plot size / soil quality indices", and it could therefore be a reference in the "Economic - Social - Ecological" triangle (ESE triangle). These results could be considered in studies in the field of circular economy and sustainable development in agriculture and the rural environment. In the case of the smaller (Psc 1 to Psc 4) or larger (Psc 6) surface categories, fragmentation and natural spatial

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variability led over time to the divergent evolution of the agrochemical indices, an aspect reflected by the correlation level. Recent studies in the context of the circular economy, have considered important different types of ecological interactions at the ecosystem level for the economic interest of practitioners (Selvan et al., 2023).

Table 4. *The correlation table in the case of data analysis by Psc categories*

Psc 1	S	pH	V	H	P	K	NI
S							
pH	0.175						
V	0.251	0.954					
H	-0.066	0.694	0.523				
P	-0.110	0.454	0.386	0.531			
K	-0.345	0.193	-0.035	0.394	0.648		
NI	-0.051	0.750	0.594	0.960	0.517	0.376	

Psc 2	S	pH	V	H	P	K	NI
S							
pH	-0.131						
V	-0.048	0.909					
H	-0.243	0.731	0.527				
P	-0.128	0.434	0.421	0.643			
K	-0.315	0.327	0.085	0.507	0.693		
NI	-0.228	0.819	0.636	0.989	0.633	0.487	

Psc 3	S	pH	V	H	P	K	NI
S							
pH	-0.155						
V	-0.092	0.972					
H	-0.075	0.946	0.983				
P	0.026	0.447	0.538	0.478			
K	-0.227	0.127	0.021	-0.103	0.432		
NI	-0.092	0.978	0.992	0.992	0.486	-0.016	

Psc 4	S	pH	V	H	P	K	NI
S							
pH	-0.209						
V	-0.292	0.965					
H	-0.330	0.962	0.987				
P	0.429	0.562	0.609	0.503			
K	0.764	-0.071	-0.198	-0.302	0.492		
NI	-0.263	0.990	0.987	0.991	0.547	-0.184	

Psc 5	S	pH	V	H	P	K	NI
S							
pH	-0.599						
V	-0.611	0.986					
H	-0.709	0.957	0.971				
P	-0.671	0.888	0.947	0.951			
K	-0.592	0.928	0.858	0.856	0.696		
NI	-0.668	0.984	0.992	0.992	0.945	0.883	

Psc 6	S	pH	V	H	P	K	NI
S							
pH	0.130						
V	0.105	0.986					
H	0.050	0.531	0.383				
P	0.987	0.283	0.263	0.105			
K	-0.279	-0.734	-0.828	0.168	-0.407		
NI	0.108	0.779	0.663	0.945	0.207	-0.162	

Under the aspect of the spatial variability of the land studied based on the recorded values, the situation was differentiated in relation to each agrochemical index considered in the study.

Based on the pH values, the studied land showed a moderately acidic reaction on 17.20% of the surface, a slightly acidic reaction on 21.77% of the surface, a neutral reaction on 2.29%, and a slightly alkaline reaction on 58.74% of the surface.

Based on the phosphorus content (P, ppm), it was estimated that medium supply was identified on 10.48% of the surface, good supply on 45.12% of the surface, and very good supply on 44.40% of the surface.

Based on the potassium content values (K, ppm) it was estimated that 9.69% of the surface had a good supply, and 90.31% of the surface had a very good supply. In terms of the humus content (H, %), it was estimated based on the determined values that the entire studied area fell into the medium supply category. Based on the values of the nitrogen index (NI, %), it was estimated that 49.55% of the surface fell into the medium supply class, and 50.45% fell into the high supply class.

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Based on the values of the agrochemical indices, amelioration measures were deemed necessary on a surface of 115.08 ha, with a moderately acidic reaction. Attention is also recommended for the surface with a weak alkaline reaction, in order to prevent the salinity from increasing. The entire surface requires monitoring, differentiated in relation to each determined agrochemical index.

The improvement of the soil reaction would determine the improvement of the mineral nutritional elements regime in soil, on the respective agricultural land.

PCA and Cluster Analysis were used to evaluate the distribution of plots and their grouping based on similarity in relation to agrochemical indices determined in soil samples. The PCA and CA statistical methods were performed both on the complete series of data, as well as on surface size categories (*Table 2*).

Based on the PCA on the entire data series, the distribution diagram of the land plots was generated (*Figure 3(a)*), in relation to the main agrochemical indices (pH, H, P, and K) considered, within which PC1 confirmed 62.723 % variance, and PC2 confirmed 23.247% of variance.

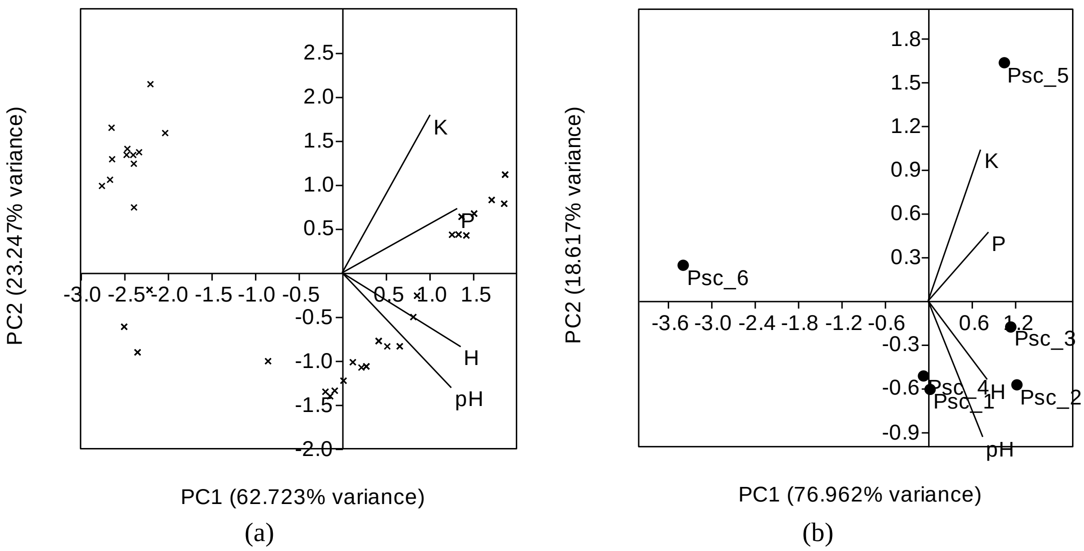

Figure 3. *PCA diagram, correlation, of the distribution of plots in relation to the main agrochemical indices, as biplot; (a) – general analysis on all surfaces; (b) – analysis on average Psc values*

The PCA analysis on the average values of the main agrochemical indices (pH, H, P, and K) in relation to the Psc categories (Psc 1 to Psc 6) led to the PCA diagram (*Figure 3(b)*), in which PC1 confirmed 76.962 % of variance, and PC2 confirmed 18.617 % of variance.

The cluster analysis made on the complete series of values, led to the dendrogram in *Figure 4*, under statistical safety conditions (Coph.corr.=0.762). Several clusters and sub-clusters were formed, within which the plots were associated on the basis of similarity in relation to the considered agrochemical indices (pH, H, P and K).

In the case of the average values of the agrochemical indices, by plot size category (Psc), the decreasing variation of the pH values and the humus content (H) with the size of the land surfaces was found. Spline type model described the most faithfully the variation of the two indices in relation to the plots size.

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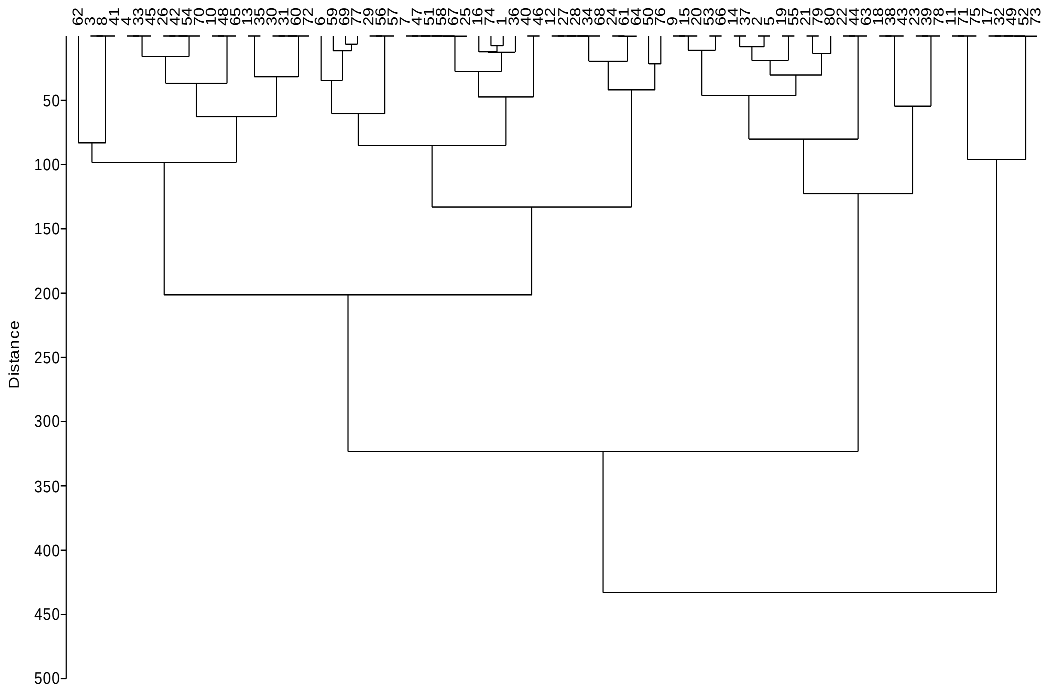

Figure 4. *Dendrogram of association of land plots, based on Euclidean distances, in relation to the values of the pH, H, P, and K soil quality indices*

The statistical values resulting from the Spline model, and the average error according to *Equation (1)*, are presented in *Table 5* for the soil reaction (pH), and in *Table 6* for the humus content (H). The graphic distribution, based on the Spline model, of the pH values in relation to the average surface (Psc, ha) is presented in *Figure 5*, and the distribution of the humus content values (H) is presented in *Figure 6*.

$$\bar{\varepsilon} = \left(\sum_{i=1}^{n} \varepsilon_i\right) / n = \left(\sum_{i=1}^{n} \left|\frac{ys_i - y_i}{y_i}\right|\right) / n \qquad \text{(Eq.1)}$$

From the analysis of the data regarding the land plots surface (S, ha), in the studied area, a high level of variability was found, quantified based on the values of the coefficient of variation in relation to the surface (CV_S=214.5186).

Table 5. *Statistical values related to the spline model, to describe the variation of soil reaction (pH) in relation to the average Psc surface*

Trials data		**Soil reaction (pH) in relation to the average Psc surface**			
No	x_i	y_i	ys_i	e_i	$I_{i/1}$
Psc 1	0.554	7.35	7.3828	0.0045	1.000
Psc 2	1.441	7.5	7.4505	-0.0066	1.009
Psc 3	3.393	7.38	7.3971	0.0023	1.002
Psc 4	11.476	7.23	7.2296	-5.5325E-05	0.979
Psc 5	35.368	7.11	7.11	0.00	0.963
Psc 6	72.705	6.79	6.79	0.00	0.920
				$\bar{\varepsilon} = 2.0722E-05$	

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Table 6. *Statistical values related to the spline model, to describe the variation of hummus content (H) in relation to the average Psc surface*

Trials data		**Hummus (H) in relation to the average Psc surface**			
No	$\mathbf{x_i}$	$\mathbf{y_i}$	$\mathbf{ys_i}$	$\mathbf{e_i}$	$\mathbf{I_{i/1}}$
Psc 1	0.554	4.51	4.5594	0.0109	1.000
Psc 2	1.441	4.63	4.5995	-0.0065	1.0088
Psc 3	3.393	4.70	4.6704	-0.0063	1.0243
Psc 4	11.476	4.66	4.6711	0.0024	1.0245
Psc 5	35.368	4.49	4.4895	-0.00011	0.9847
Psc 6	72.705	3.97	3.9701	2.52E-05	0.8708
				$\bar{\varepsilon} = 6.06\,\text{E}-05$	

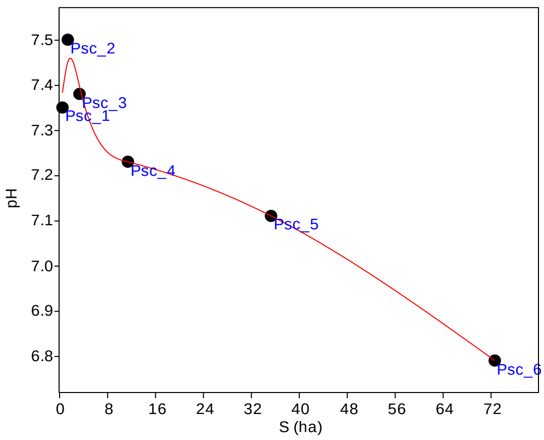

Figure 5. *Graphical distribution of pH values in relation to the average Psc surface*

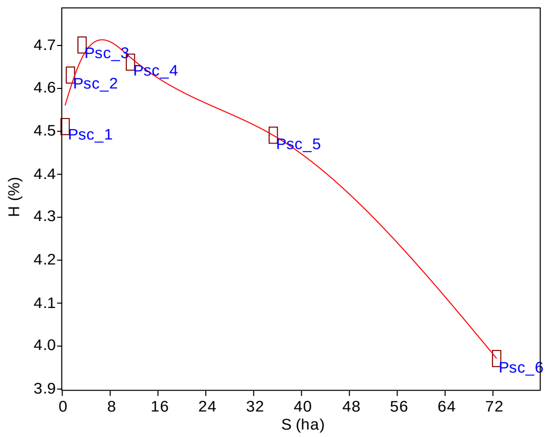

Figure 6. *Graphical distribution of H values in relation to the average Psc surface*

Among the 80 plots that constituted the total study area (668.99 ha), it was found that 25 plots have an area between 0.01 - 1.00 ha, with an average area of Psc=0.554 ha, and 21 plots have an area between 1.01 – 2.00 ha, with an average area of Psc=1.441 ha.

The two categories represent, in number of plots, 57.50% of the total studied plots. Plots with an area between 2.01 - 5.00 ha represent 23.75%, with an average size Psc=3.393 ha; plots with an area between 5.01 - 25.00 ha represent 6.25%, with an average area Psc=11.476 ha; plots with an area between 25.01 - 50.00 ha represent 7.50% with an average area Psc=35.368 ha; and plots with an area between 50.01 - 10.00 ha represent 5.00%, with an average area Psc=72.705 ha. The graphic distribution of the number of plots in relation to the size by Psc category is presented in *Figure 7*.

The variability of agricultural land is of interest and has been studied in relation to land use categories (Pandey et al., 2019), land cover changes (Mihăilescu and Cîmpeanu, 2019), soil quality (Vójcik-Leń et al., 2020), agricultural lands in peri-urban areas (Zhou et al., 2019), or with other criteria and indicators.

In relation to the categories of use, properties and land use, various studies reported small areas in some farms (e.g., less than 0.5 ha, especially family, subsistence farms), along with larger areas, within the framework of which the soil quality was evaluated (Pandey et al., 2019).

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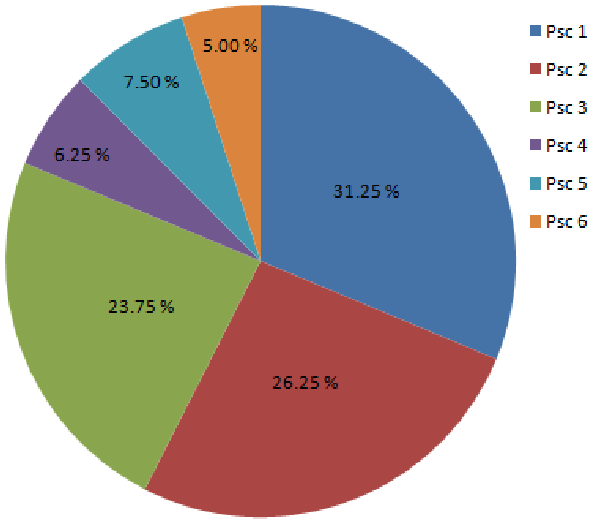

Figure 7. *Percentage distribution of the plots studied in relation to the Psc classification category*

For the study of agricultural land variability, different methods based on complex analyzes (algorithms, remote sensing, statistical analyses, fractal analysis, reconstructions, predictions, etc.) were used, in relation to the intended purpose (Herbei et al., 2015; Vójcik-Leń et al., 2020; Winkler et al., 2021).

Sui et al. (2022) used different equation-type models, in a complex study in which the fragmentation of agricultural land was also addressed in relation to influencing factors specific to the reference area.

The evaluation of the degree of agricultural land fragmentation based on models was done in different studies in relation to the appropriate technology applied and productivity at the farm level (Orea et al., 2015), in relation to the management at farms level, especially small family farms (Timofti et al., 2015).

Also, different models were used to evaluate soil quality and generate maps useful in land and farm management (Bertici et al., 2022; Bilas et al., 2022; Samaei et al., 2022). Samaei et al. (2022) communicated values of safety parameters (between 0.196** and 0.408**, ** representing the significance for the probability of 1%) for different evaluation models of soil quality indices, in a comparative study for agricultural and pasture lands, as a category of use.

Spline functions and models were used for the spatial analysis and modeling of some field tests and studies (Boer et al., 2020; Piepho et al., 2022), in studies of spatial and temporal land surface variation (Devi et al., 2020), in studies of yield variation as "genotype × environment" interaction (Bustos-Korts et al., 2021), in the description of the growth of the root system in rice (Yang et al., 2022), and many other studies.

The present study found Spline models that described in statistical safety conditions the variation of soil reaction (soil pH, $\bar{\varepsilon} = 2.0722\mathrm{E}-05$) and humus content (H, $\bar{\varepsilon} = 6.06\mathrm{E}-05$) in relation to the plots size categories (Psc) in study conditions.

Also, there was a variation in the correlation level between the agrochemical indices considered within the plots size categories (Psc). A high number of correlation (very strong and strong) between the agrochemical indices, was recorded in the case of the size category 25.01 – 50.00 ha (Psc 5).

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Within this plot size category (Psc 5), ten very strong correlations were recorded between the considered agrochemical indices (r=0.928 between K and pH, up to r=0.992 between IN and V) (*Table 4*).

The recorded results show the better quality of the soil in the case of plots with medium size areas (in the study conditions), and at the same time may suggest the interest of farmers for this land size category, for the purpose of maintenance works, which ensure high productivity. At the same time, the lands with smaller surfaces did not benefit from maintenance works, or these were occasional and minimal. The small pasture areas within the present study have a marginal position, between cultivated agricultural land (arable), and the Mures meadow, in the form of islands (meanders), and the maintenance was reduced for these reasons as well, because they raised certain particular aspects and difficulties.

Conclusions

The area of agricultural land, pasture category, considered in the study showed a very high variability in terms of the component plots size (80 plots).

Six categories of plot size were generated, and the disproportionate distribution of plots by classification categories showed a very high fragmentation of the land, and a high spatial variability in terms of the plot size.

The evaluated agrochemical indices showed different values in relation to the considered plot size categories (Psc 1 to Psc 6), and a high number of very strong and strong correlations were recorded within the Psc 5 category (25.01 - 50.00 ha). In the PCA analysis, on the average values of the main agrochemical indices (pH, H, P, K), in relation to the Psc categories (Psc 1 to Psc 6), the distribution diagram of the Psc was obtained, where PC1 has confirmed 76.962 % of variance, and PC2 confirmed 18.617 % of variance. Spline models faithfully described the variation of the soil reaction (soil pH) and the humus content (H) in relation to Psc, under statistical safety conditions.

As practical aspects of this study, there are recommendations for periodic analysis of soil quality indices, and differentiated technologies for maintenance and improvement of the land, in relation to agrochemical indices and the biological productivity of the vegetal carpet.

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