AGRICULTURAL LANDS SPATIAL VARIABILITY EVALUATION BASED ON AGROCHEMICAL INDICES FOR DIFFERENTIATED FERTILIZATION MANAGEMENT

Radu BERTICI*, Daniel DICU*, Mihai HERBEI**, Florin SALA***

Banat University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara, *Environmental Engineering, **Remote Sensing and GIS, ***Soil Science and Plant Nutrition, Timisoara, 300645, Romania

Emails: berticiradu@gmail.com; dicudaniel@gmail.com; mihai_herbei@yahoo.com; florin_sala@usab-tm.ro

Corresponding author: florin_sala@usab-tm.ro

Abstract

The study evaluated soil fertility based on specific agrochemical indices, in order to characterize the spatial variability of the agricultural land studied, and for differentiated fertilizers management. The agricultural land under study is located in the area of Tormac, Timis County, Romania. The soil is of the stagno-gleyc preluvosol type, medium loam-clay. Soil reaction (pH), humus content (H%), phosphorus content (P, ppm), and potassium content (K, ppm) were analysed. The values of the degree of saturation in bases (V%) and the nitrogen index (NI) were determined. The pH values varied between 5.40-6.84 ± 0.09, and the degree of saturation in the bases (V%), registered a variation in close correlation with the pH, in the range 51.81-89.02 ± 2.41%. Nitrogen index (NI) registered values between 1.21-2.63±0.08%. Phosphorus content (P) had values between 21.83-111.60 ± 4.88 ppm, and potassium content (K) recorded values between 115.00-341.0 ± 11.97 ppm. There were low values of the coefficient of variation in the case of soil reaction (CV_pH = 7.4868) and high values in the case of phosphorus content (CV_P = 44.186). The other agrochemical indices studied had intermediate values in terms of coefficient of variation (CV_V = 16.8066; CV_PI = 22.0252; CV_K = 27.3909). Principal Component Analysis facilitated the obtaining of the samples distribution diagram, in relation to the studied agrochemical indices, according to which PC1 explained 87.845% of the variance, and PC2 explained 10.218% of the variance.

Key words: agricultural land, fertilizer management, soil fertility, spatial variability

INTRODUCTION

Agricultural land is the main means of production in agriculture [5], and soil is the basic resource through which plants are grown [33], [32].

In conventional agriculture, the soil represents the nutritional media of plants and also through the soil way nutrients are provided for plant growth and development [9], [2].

Soil is characterized by physical, chemical and biological properties, which can be assessed on the basis of specific indices, and in relation to their value is defined and assessed fertility of soil and agricultural land productivity [19], [29].

Soil fertility is a natural trait, supplemented and sustained by man through a series of inputs with a role in the agricultural production process [36], [1].

The spatial distribution of soil properties is uneven, so there is some spatial variability in agricultural land fertility, relative to different influencing factors [35], [12], [3], [16].

Knowing the spatial variability of agricultural land is important for optimizing fertilization and soil improvement works, in order to obtain profitable production and efficiency of agricultural technologies [18], [34], [15], [30].

Different methods and models of analysis are used for the evaluation of agricultural lands, in order to sustainably manage soil resources and agricultural practices [7], [27], [21], [23].

Some methods of soil evaluation are based on chemical analyzes of soil samples, while others estimate the soil indirectly, by imaging analysis of the vegetation cover, as an expression of soil conditions but also of technological influences [10], [13], [17], [31].

Differentiated management of soil resources and agricultural crops, in relation to their
spatial variability, is important in order to optimize agricultural technologies, especially crops fertilization [24], [26], [25], [18], [20], [30].

The purpose of these works, of differentiated fertilization, is to ensure nutrients for agricultural crops in relation to soil supply and production planning, in terms of their quantity and quality [4], [28], [14].

The present study evaluated the soil fertility within an agricultural area, in order to assess the spatial variability of agricultural land for its differentiated fertilization.

MATERIALS AND METHODS

The study aimed to evaluate an agricultural land with an area of approx. 120 ha, in the area of Tormac locality, Timiș County, Romania, regarding the spatial variability of soil fertility. The graphical representation of the reference area, in which the studied agricultural land is framed, is presented in Figure 1, based on the ArcGIS v.10.6 software [8].

Agrochemical indices defining soil fertility were analyzed, such as soil reaction (pH), humus content (H,%), phosphorus content (P, ppm) and potassium content (K, ppm) [6]. The degree of saturation in bases (V,%) was calculated, as a proportionality relationship with the pH. The nitrogen index (NI,%) was calculated in relation to V and H.

The analytical data set of agrochemical indices was analyzed in terms of statistical safety and the presence of variance, through the ANOVA test.

The degree of correlation between the studied agrochemical indices was evaluated and also the interdependence relations and the statistical safety conditions between certain indices were analyzed.

The degree of variability for each agrochemical index was assessed based on the coefficient of variation (CV) and by Diversity profile, as graphical analysis [11].

Fig. 1. The location area of the agricultural land under study, Tormac locality, Timis County, Romania. Source: Original figure, created with ArcGIS software.
The analysis and expression of the analyzed surface by quality classes, in relation to each agrochemical index analyzed, was done by percentage reporting (%), with representative graphical distribution.

PCA analysis was used to obtain the distribution diagram of the soil samples in relation to the agrochemical indices (as biplot). Also, in the PCA analysis, the presence of the variance in the analytical data set was explained as a percentage, by PC1 and PC2.

Cluster analysis was used to evaluate the grouping of samples based on Euclidean distances, in relation to the degree of similarity for the values of the agrochemical indices studied.

RESULTS AND DISCUSSIONS

From the analysis of the soil samples, for the characterization of the studied agricultural land, and by calculations, resulted the values of agrochemical indices with reference to soil reaction (pH), degree of saturation in bases (V, %), nitrogen index (NI, %), phosphorus content (P, ppm) and potassium (K, ppm), (Table 1).

The pH values varied between 5.40-6.84 ± 0.09, and the degree of saturation in the bases (V, %), registered a variation in close correlation with the pH, in the range 51.81-89.02 ± 2.41%.

The nitrogen index (NI) registered values between 1.21-2.63%. The phosphorus content had values between P = 21.83-111.60 ± 4.88 ppm, and the potassium content recorded values between K = 115.00-341.0 ± 11.97 ppm.

The ANOVA - Single factor test confirmed the presence of variance in the data set, as well as the data safety (for Alpha = 0.001; F > Fcrit, p < 0.001).

From the analysis of the values of the studied agrochemical indices, in relation to the intervals and limits of significance and classification [22], different distributions levels were found, which shows a spatial variation of the studied agricultural land.

In terms of soil reaction, 8.34% of the agricultural analyzed surface has a neutral pH, 20.83% of the land surface has a weakly acid reaction, and 70.83% of the land surface has a moderately acid reaction (Figure 2).

In relation to the degree of saturation in bases (V), 20.83% of the studied agricultural land area has V < 60%, 50.00% of the land area falls within the range of V = 60-80%, and 29.17% of the land has values V > 80% (Figure 3).

The nitrogen index (NI) indicates a part of 41.67% of the surface with low nitrogen supply and 58.33% of the surface with moderate nitrogen supply (Figure 4).
The values of phosphorus content (P, ppm) indicate that 29.17% of the surface has a poor supply of phosphorus, 50.00% of the surface has a phosphorus good supply and respectively 20.83% of the surface has a very good phosphorus supply (Figure 5). Regarding the supply with potassium, 4.17% of the studied land area has a moderate supply with potassium, 45.83% has a good supply, and 50.00% of the surface has a very good supply of potassium (Figure 6).

In the conditions of agricultural use of the studied land, certain balances have been established between agrochemical indices, and from the correlation analysis were
identified very strong positive correlations between pH and V \((r = 0.999)\), between pH and NI \((r = 0.934)\), and between V and NI \((r = 0.937)\). Low correlations were identified between P and pH \((r = 0.601)\), between P and V \((r = 0.608)\) and between P and NI \((r = 0.689)\). Lower levels of correlation were identified between K and studied agrochemical indices (Table 2).

Table 2. Correlation table between the studied agrochemical indices

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>V</th>
<th>NI</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>0.999</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>0.999</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NI</td>
<td>0.934</td>
<td>0.937</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.601</td>
<td>0.608</td>
<td>0.689</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0.412</td>
<td>0.418</td>
<td>0.470</td>
<td>0.526</td>
<td></td>
</tr>
</tbody>
</table>

Source: Original values determined based on analytical data.

The interdependence relationship between the Nitrogen Index (NI) and V was described by equation (1), a polynomial equation of degree 2, in statistical safety conditions \((R^2 = 0.878, p <0.001)\). The graphical distribution of NI values in relation to V are shown in Figure 7.

\[
IN = 0.0001372 x^2 + 0.0135x + 0.2413 \quad (1)
\]

where: IN – Nitrogen Index; x – degree of saturation in bases (V%)

The analysis of the degree of variation of the agrochemical indices values, for the studied agricultural land, was made based on the coefficient of variation (CV). Based on the obtained results, from the analysis of the analytical data set, low values of the coefficient of variation were found in the case of soil reaction \((CV_{pH} = 7.4868)\) and high values in case of phosphorus content \((CV_P = 44.186)\). The other agrochemical indices studied had intermediate values in terms of coefficient of variation \((CV_{NI} = 22.0252; CV_K = 27.3909)\).

The analysis of the degree of variation of the agrochemical indices, for the studied agricultural land, was also evaluated on the basis of Diversity profiles, as a graphical analysis (Figure 8). According to the Diversity profiles, there was a small variation in the case of pH values and a high variation in the case of P values. This shows a high spatial variability in terms of phosphorus content (P), followed, in descending order, by potassium (K), nitrogen index (NI), degree of saturation in bases (V) and soil reaction (pH).

Principal Component Analysis facilitated the obtaining of the sample distribution diagram, in relation to the studied agrochemical indices (Figure 9). PC1 explained 87.845% of the variance, and PC2 explained 10.218% of the variance. At the same time, it was found the
distribution of variants in relation to certain agrochemical indices, depending on the analytical values, which express the state of the agricultural land.

Cluster analysis facilitated the grouping of samples, based on Euclidean distances (Coph.corr. = 0.750), depending on the degree of similarity in relation to the studied agrochemical indices (Figure 10). The high degree of ramifications within the dendrogram, expresses a high degree of variability of the land, in relation to the studied fertility indices.

Two clusters were outlined, with a large number of subclusters each. From the analysis of Similarity and Distance Indices (SDI) values, the highest degree of similarity between the samples (S3-S11) was found, SDI = 3.9644. High levels of similarity were recorded between samples (S5-S1), SDI = 12.146, between samples (S16-S17), SDI = 12.317, between samples (S19-S23), SDI = 15.549, between samples (S6-S16), SDI = 15.567, between samples (S6-S18), SDI = 16.587, between samples (S3-S18), SDI = 16.705, and between samples (S19-S21), SDI = 18.237.
The high degree of spatial variation of the studied agricultural land indicates the need for a differentiated approach, regarding calcareous and fertilizers resources application, in order to ensure optimal plant cultivation conditions. Thus, in relation to pH, 70.83% of the studied surface has a moderate acid pH, and requires attention for correction with calcareous products. In terms of degree of saturation in bases (V%), an indicator for assessing the need to correct acidity, 20.83% of the studied land area requires an immediate correction of soil reaction by aapplication os calcareous resources.

In terms of the degree of nitrogen supply, assessed on the basis of the nitrogen index (NI), it can be estimated that 41.67% of the surface has a low supply and 58.33% a moderate supply of nitrogen. Therefore, in sizing the assortment of nitrogen fertilizers and doses, the level of the supply soil and the agricultural crops will be taken into account, so as to ensure an adequate nutrition of the cultivated plants.

The level of phosphorus supply of the land can be appreciated as moderate for 29.17% of the surface, good supply for 50.00% of the surface and very good supply for 20.83% of the surface. It is recommended to establish the differentiated doses of phosphorus fertilizers, in relation to the state of land supply and the consumption needs of agricultural crops.

In the case of potassium, according to the analytical values 4.17% of the surface is included in average supply, 45.83% in good supply and 50.00% in very good supply. The sizing of potassium fertilizers is recommended to be done in terms of doses in relation to the condition of the land and the needs of crops.

CONCLUSIONS

From the analysis of agrochemical indices, the agricultural land studied has a high spatial variability in terms of phosphorus content (P), followed in decreasing order, by potassium (K), nitrogen index (NI), degree of saturation in bases (V) and soil reaction (pH).

Due to the fact that the differentiated degree of spatial variability of the studied land, in relation to the analyzed agrochemical indices, it is recommended the differentiated approach of fertilization for each nutrient, respectively the application of calcareous resources, in relation to the concrete situation in the field, given by the analyzed samples.

ACKNOWLEDGEMENTS

The authors thanks to the GEOMATICS Research Laboratory, BUASMV "King Michael I of Romania" from Timisoara, for the facility of the software use for this study.

REFERENCES


