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METHODOLOGY FOR COMPLEX AMELIORATIVE EFFECT ON THE ACID-ALKALINE BALANCES IN THE SOILS

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Abstract

For several years have developed and tested specific methods for soil sampling and interpretation of the results regarding the assessment of soil heterogeneity in the vineyard terroir. The heterogeneity of the soil in terms of the indicators characterizing the harmful acidity in the soil must be taken into account not only in the area horizontally, but also in the vertical direction - i.e. the change in the depth of the soil profile. The role of acid-alkaline balance due to the structure of soil acidity is a complex soil component of the terroir. In terms of its relative influence, it is comparable to the importance of the chemical composition of the soil as it determines the dynamics of its components in the soil-plant system.

Key words: *acid-alkaline balance, liming model, soil sampling model.*

INTRODUCTION

The productivity and fertility of the soil when it is part of the vineyard terroir should be considered in a different way compared to that one used for determination the suitability and fertility of all other crops. The world's viticultural terroirs are built on low-yielding lands. The main thing in the formation of a good and perspective terroir is that high productivity is not necessarily pursued, but it is important that the soil cover has a very high degree of equality not only in terms of acidity, but also the geological basis and natural hydrology of the terrain.
In order to neutralize the harmful acidity and to cover the cost levels in the calcium balance and ultimately to increase the yield, a balance rate must be calculated, leading not to complete neutralization of the permanent sorption positions, but to reduction of the toxic action of mobile aluminum, hydrogen and manganese (Almaliev, 2020).
In Bulgaria, the leveling of the geological and hydrological conditions of the terrain can rarely be observed, as there are large vineyards in which there is a high diversity in terms of soil, topographic, geological and hydrological conditions within one and same vineyards.
From this point of view, our work is an attempt to parameterize the existing heterogeneity in our country in terms of location.
For several years, we have developed and tested specific methods for soil sampling and interpretation of the results regarding the assessment of soil heterogeneity in vineyard terroir.
Vineyards have been shown to vary spatially in terms of soil, vine nutrition (Bramley, 2001; Davenport and Bramley, 2007; Reynolds and Hakimi Rezaei, 2014a), vegetative growth (Baldy et al., 1996; Bramley et al., 2011), yield, and fruit composition (Bramley, 2001; Reynolds et al., 2007; Bramley et al., 2011).
Precision viticulture techniques including global positioning systems (GPS) and geographic information systems (GIS) have become powerful tools to study vineyard terroir (Reynolds et al., 2007) and variability (Bramley and Hamilton, 2004; Bramley, 2005) while keeping key environmental factors constant. Other studies that have utilized precision viticulture to explain interactions between soil characteristics and vine growth and/or fruit composition.
Bramley (2001) found that soil texture had an impact on yield in Australian vineyards. Areas within the vineyard that had higher percentage of clay contained lower yielding vines. Strong spatial and temporal distribution patterns were found within vineyards for many nutrients in various tissue types of vines in Coonawarra vineyards (Davenport and Bramley, 2007).
The aim of the presented publication was to describe methodically - step by step how to approach the melioration of acid soils in order to neutralize the acid-alkaline balance.

MATERIALS AND METHODS

The study was conducted on terrain occupied by old vineyard on strongly acidic eroded Eutric regosols. Due to the strong development of the processes erosion and acidity, the vineyard should be uprooted and replanted. The task of the melioration study was to equalize the terrain in terms of acidity. When surveying terrains with heterogeneous soils, we used different soil sampling methods, including for the same terrain we collected soil samples in different ways so that we could determine which of them is the most representative to describe the terrain most accurately. The most representative was soil sampling method in a square grid in accordance with modern GIS systems. Based on this, in the course of the present study we adopted a model for soil sampling, in which each of the samples is taken from the field using a soil probe, and the sampling points are located within the field in a square grid, regardless of the boundaries of soil differences and topography of the terrain.

Four sections, which have different degrees of erosion, were inspected. The soil sampling was taken at two depths 0-25 and 25-50 cm.

After standard preparation, the soil samples were analyzed to establish the following parameters: pH, potentiometric in KCl (Arinushkina, 1970); easily mobile exchangeable Al^{3+} and H^{+}, titrimetric according to (Sokolov, 1939); easily mobile exchange Mn^{2+} in extract with 1 m KCl, as the preparation of the extract was carried out according to the Laboratory system for liming (Palaveev and Totev, 1970a), (LSVPT-64), and the determination of Mn^{2+} in the extract by AAS (BDS11047, 1995); easily mobile exchange Ca^{2+} and Mg^{2+}, complexometric by the method of Mazaeva, Neugodova and Khovanskaya (Palaveev and Totev, 1970b), the integrating index V3% and the lime rate was calculated.

RESULTS AND DISCUSSIONS

There are very few scientific publications in Bulgaria about the mathematical apparatus of geostatistics and its application for characterization of the variables in the environmental and precision agriculture. Heterogeneity is rarely used and is often ignored due to lack of appropriate technology or lack of time and knowledge to work with it, especially in technological processes in our agriculture.

The main question is how to quantify it. Soil sampling from the study area is difficult and expensive, and it is often necessary to judge the condition of the entire study area by one sample, which is obviously extremely inaccurate. Geostatistics solves this problem by giving us the variation in the places from which no samples were taken as evaluates the error that is being handled (Kutev, 2013).

In the last two decades, the method has received wide acclaim and has been applied to analyze and map data from various fields such as agriculture, fisheries, geology, hydrology, climatology, oil industry, remote sensing, soil science. Geostatistics entered the field of precision farming in the 1990s with the development of technologies such as Yield monitors, Global Positioning System (GPS), Remote Sensing (RS), and Variable rate technologies (VRT) and Geographic Information Systems (GIS) (Sahoo, 2014).

Soil sampling is the first step in generating field-specific information to make lime and fertilizer decisions. Selecting an appropriate sampling strategy ensures that the soil in a field is collected in a manner that produces the most accurate and reliable soil test results. Because soils in agricultural fields can vary significantly, use a sampling strategy that best captures that variation. Proper sampling is particularly important when a site-specific management approach is embraced.

Modern technologies including GPS (Global Positioning System), GIS (Geographic Information Systems), FMIS (Farm Management Information Systems), and Variable Rate Technology (VRT) allow producers to manage soils and amendments with greater precision. Site-specific soil sampling provides the foundation for many lime and fertilizer decisions enabled by these technologies. Site-specific soil sampling is the basis for:

- identifying the spatial distribution of nutrient deficiency and sufficiency within fields;
- increasing lime and fertilizer use efficiency by variably distributing lime, nutrients, and

other amendments based on the spatial distribution of soil properties and crop requirements;
• minimizing potential for nutrient loss from fields by overapplication;
• optimizing production through the targeted use of agricultural amendments.

To best utilize site-specific soil sampling, you need a clear understanding of the benefits and limitations of each sampling strategy, as well as knowledge surrounding the tools and process used to develop the sampling plans.

This publication provides a methodological approach to assist in the selection and development of soil sampling strategies, based on:

1. Describes how to position the sampling points.
2. The method of soil sampling is described - separately for each depth, and not by mixing them.
3. Because the work is methodical, and in order to be clearer, the values and spatial location of the individual points are shown only on the horizon A. Scilicet from now on, each depth selection is approached in this way (as in horizon A).
4. Using this approach, the color indicators of the different indicators characterizing the acid-base balance, as well as the integrating indicator V3 in the different parts of the terrain are very well depicted.
5. The decision taken in the development of norms of demand needs is fully consistent with the design and sequence described in this study, namely to create a buffer background-which is absolutely mandatory when considering and interpreting values only from single receivables, here in this case horizon A, and in most cases from practice as an average sample of all horizons.

The outlines of the terrain, which are on a cadastral map, are presented in Figure 1. The terrain is developed in the northwest-southeast direction.

Figure 1. Boundaries of the terrain on a cadastral map

The logic is that the survey grid should be in the same direction. Figure 2 shows how we built the soil sampling grid and how it lies on real terrain.

Figure 2. Soil sampling grid

Each side of the square is 90 m in size. The intersected points of each square indicate the place from which a single soil sample should be taken with a probe at two depths 0-25 and 25-50 cm (Figure 3). These points are stored in the GPS memory, each of which is numbered, and this number corresponds to the number of the laboratory sample. Samples from different depths are not mixed but are indicated as A and B. The subject of our study is only the data of the samples at a depth of 0-25 cm (A-horizon).

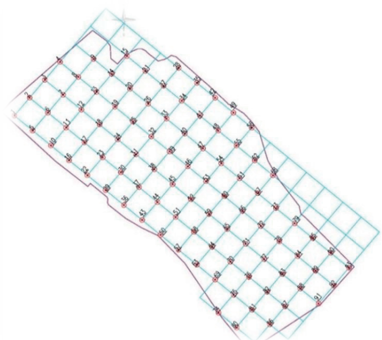

Figure 3. GPS soil sampling points

Table 1 presents the results of analyzes of some of the soil samples as showing the laboratory numbers, each number corresponding to a specific point with UTM coordinates. The following columns show the pH values, the indicators of harmful acidity (Al^{3+}, H^{+} and Mn^{2+}) and their antagonists (Ca^{2+} and Mg^{2+}), the integrating indicator (V_3) and the lime rate (NN).

The obtained values of all indicators are plotted on the map. Figure 4 shows the pH values. The most acidic areas (in red) were in the northwestern parts of the terrain, and in the southeast the acidity was not so widespread. The very acidic spots in the examination area became very clear. A spot of well-defined acidity is noticed in the south-eastern part, which was very different from the neighboring sections, these were points 83-84 and 88. If this had occurred in only one sample, then according to the methodology would have condensed the soil sampling grid in smaller squares around this point to determine if it was an analytical error or accidentally a small area of acidic soil that was found during the sampling with the probe. However, this acidity was found in three adjacent samples, it is considered as correct.

Table 1. Results of laboratory analyzes

No.	ox (UTM)	oy (UTM)	pH	Al meq/100	H meq/100	Mn meq/100	Ca meq/100	Mg meq/100	V3 %	NN kg/da
1	428522	4591963	3.94	1.14	0.08	0.45	4.84	1.70	79.7	300
2	428554	4592001	3.95	1.27	0.08	0.41	3.60	1.90	75.8	500
3	428588	4592039	3.95	1.28	0.09	0.57	3.95	2.25	76.2	500
4	428619	4592078	3.94	1.02	0.07	0.58	4.98	1.85	80.4	300
5	428563	4591930	3.97	0.82	0.05	0.52	5.22	1.65	83.2	200
6	428596	4591970	3.92	0.79	0.05	0.54	3.44	1.70	78.8	300
7	428625	4592006	3.95	1.12	0.07	0.38	4.50	2.00	80.5	300
8	428653	4592043	4.02	1.08	0.07	0.39	4.02	1.95	79.5	300
9	428692	4592082	3.96	0.72	0.05	0.37	4.24	1.65	83.8	200
10	428605	4591898	3.98	0.86	0.06	0.47	3.98	2.05	81.3	300
11	428634	4591938	4.04	1.25	0.08	0.40	4.04	1.70	76.8	500
12	428664	4591978	3.93	1.01	0.07	0.48	4.27	1.60	79.0	300
13	428693	4592009	4.04	0.87	0.06	0.33	4.61	1.80	83.6	200
16	428637	4591865	3.99	1.21	0.08	0.38	4.34	2.10	79.4	300
17	428672	4591902	4.01	1.19	0.08	0.45	4.29	1.95	78.4	300
18	428702	4591939	3.97	1.09	0.07	0.56	3.69	2.20	77.4	300
22	428672	4591837	3.98	0.99	0.07	0.36	4.89	2.00	82.9	200
23	428706	4591872	3.99	1.11	0.07	0.57	4.90	2.00	79.8	300

Figures 5, 6 and 7 show the content and spatial distribution of the different soil sampling points, respectively: exchangeable aluminum, manganese, calcium and magnesium in different parts of the terrain, as in a color scale, the values are displayed on the side.

Figure 8 shows the soil saturation degree with bases in different parts of the terrain, as a result of which the lime necessity of the soil was determined.

Despite the low pH found in relatively large areas, the strong lime demand is limited in very small areas. In principle, sections with less than 90% should be limed, but the solution is to lime all sections below 95% to create a buffer background.

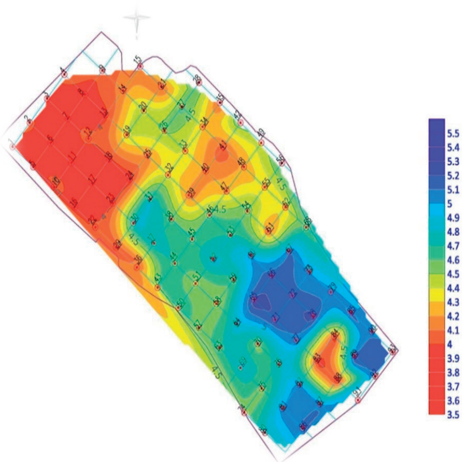

Figure 4. Spatial pH distribution

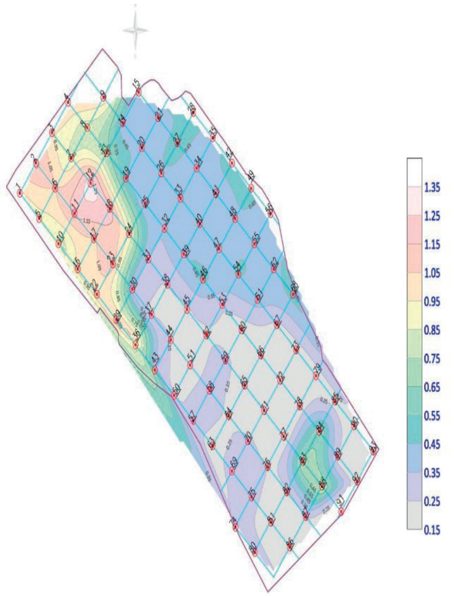

Figure 5. Spatial distribution of exchange aluminum

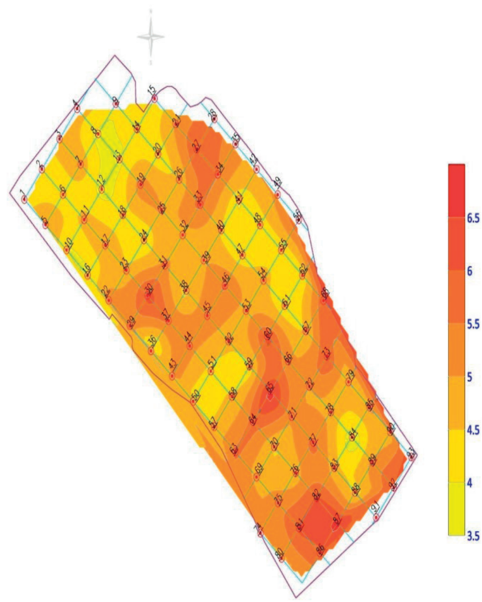

Figure 7. Spatial distribution of exchange calcium and magnesium

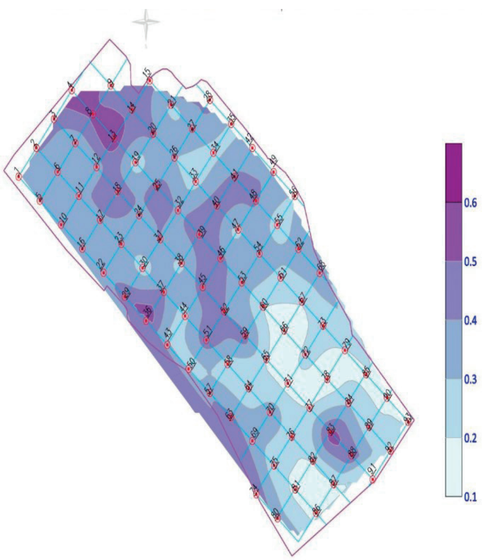

Figure 6. Spatial distribution of exchange manganese

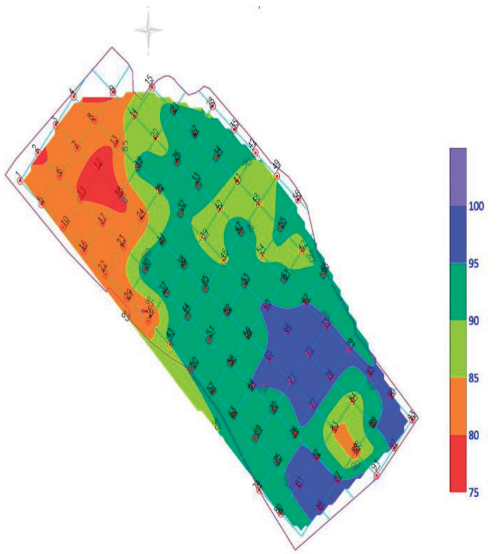

Figure 8. Spatial distribution of the soil saturation degree with bases

In order to achieve equalization of the acidity indicators in the whole area, it is necessary to lime as shown in Figure 9. However, as the different lime necessity sections are outlined, they are not convenient and not efficient for the movement of machines and therefore the solution is to develop a model in approximately the same contours, but already as meliorative areas - Figure 10.

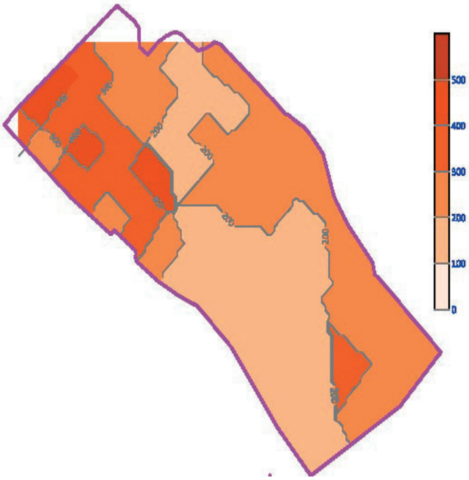

Figure 9. Distribution of the areas of lime necessity

Then the terrain would look like this. Here the contours are twisted so that it can be seen better. The machine will move from left to right and will apply a different amount of ameliorant for each of the already outlined rectangular chemical meliorative subareas. The interrupted line indicates the track of the machine, and the solid line indicates the boundaries of the individual areas and reflects the rate of ameliorant that must be applied for each sector.

Figure 10. Model of meliorative plots

CONCLUSIONS

The described method is part of a methodology for complex meliorative effect on the acid-alkaline balance of soils that have the potential of viticulture terroirs, but are characterized by two main disadvantages:

- Contain harmful acidity to the main crops, expressed by the degree of constant sorption positions in the soil with easily mobile exchange bases.
- Characterized by a high degree of heterogeneity in terms of genesis, composition and properties and particularly in terms of acidity.

The heterogeneity of the soil in terms of the indicators characterizing the harmful acidity in the soil must be taken into account not only in the area horizontally, but also in the vertical direction - i.e. the change in the depth of the soil profile. The role of acid-base balance due to the structure of soil acidity is a complex soil component of the terroir. In terms of its relative significance, it is comparable to the importance of the chemical composition of the soil as it determines the dynamics of its components in the soil-plant system.

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