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DIFFERENTIATION OF FERTILIZATION RATES WITH PHOSPHORUS AND POTASSIUM BASED ON GEOSPATIAL DATA FOR THEIR RESERVES IN SOIL

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Abstract

Generally the stockpiling fertilization with phosphorus and potassium is applied before planting of perennial crops and requires introducing of high fertilization rates, calculated on the basis of the soil reserves and forecasted balance of the element for a long period. Opportunities for correction of stockpile fertilizer rates after planting of perennials are very limited, taking into account the technological limitations of incorportation of fertilizers to the depth of active root layer.This requires precise calculation of fertilizer rates, depending on the heterogeneity of the soil even before planting.
Present work is an attempt for approximation of balanced stockpiling rates with phosphorus and potassium to the actual needs of plants of fertilization on the whole area of the plantation. It is used nearest neighbour method, combined with soil sampling in graticule conformed to the configuration of the area. The optimal density of the graticule is established experimentally by prior reconnaissance soil sampling and defining the function of the spatial heterogeneity expressed as variogram. Obtained on the first approximation results are generalized to the threshold of economically significant sensitivity to corresponding nutrient, and then are outlined sub-areas for differentiated fertilization.
The advantages of the nearest neighbour method in the proposed model for geospatialization is that, its application provides an outlining of sub-areas for diferentiated fertilization with proper configuration which is suitable for service by fertilizer technique.

Key words: *geospatialization, fertilization, phosphorus, potassium.*

INTRODUCTION

Compared with other perennial crops vine consumes relatively economical mineral forms of major nutrients in the soil and has well expressed adaptability to different levels of mineral nutrition (Enikov and Benevski, 1984).
Some differentiation in terms of rate of nutrients absorption is established between the different varieties, cultivation directions, and variety-rootstock combinations (Delas, 1992; Lambert et. al., 2008).
By pre-planting fertilization with high doses of phosphorus and potassium fertilizers the soil is accumulated with major nutritional elements in quantities that are sufficient to ensure normal growth and development of perennial crops up to the third-fourth year (sometimes longer). From the potassium fertilizers most commonly used is potassium sulphate and from phosphorus-triple superphosphate. The use of more quick-acting fertilizer is not recommended because they can be leached easily into deeper soil layers. Due to the very low mobility of compounds in potassium sulphate and superphosphate, these fertilizers are retained in the zone of their introduction for a long period of time. On one hand, this feature may have a negative effect, because if these fertilizers are not incorporated in sufficient depth in soil, they can not be assimilated by the vine roots. From another hand, however their low mobility in soil, ensures their long-term action which is of great importance to all perennial crops (Valcheva et. al., 2012).
The doses used for stockpiling fertilization must be calculated the most precisely, because the opportunities for their correction after establishing the vineyard are very limited from a technological standpoint. Fertilizer rates must be calculated based on the soil reserves, the forecasted balance of the element for a long period, and according to the heterogeneity of the soil even before planting.
Present work is an attempt for approximation of balanced stockpiling rates with phosphorus and

potassium to the actual needs of plants of fertilization on the whole area of the plantation.

MATERIALS AND METHODS

During the current research we accepted a model for collecting of soil samples in which each sample is taken from the terrain with soil probe as the sampling points are situated in square grid, regardless of the borders of soil types and local terrain topography. We studied two sections-parcels 108 and 155 (Figure 1), which have complex topography and parcels 113, 157 and 158 (Figure 2), where the terrain is relatively leveled and with slightly rough and monotonous relief. Parcels 108 and 151, and parcels 113, 157 and 158 are adjacent and form two contoures. In both sites we take individual soil samples from three depths – 0-25, 25-50 and 50-75 cm for each point (position of sampling points is marked in Figure 1 and Figure 2). The location of points was previously mapped and coordinates were entered into the Global Positioning System-GARMIN, allowing to determine the location of each point to an accuracy of 1m.

After standard preparation of soil samples are established available forms of phosphorus and potassium in soil, according to GOST 26209-91.

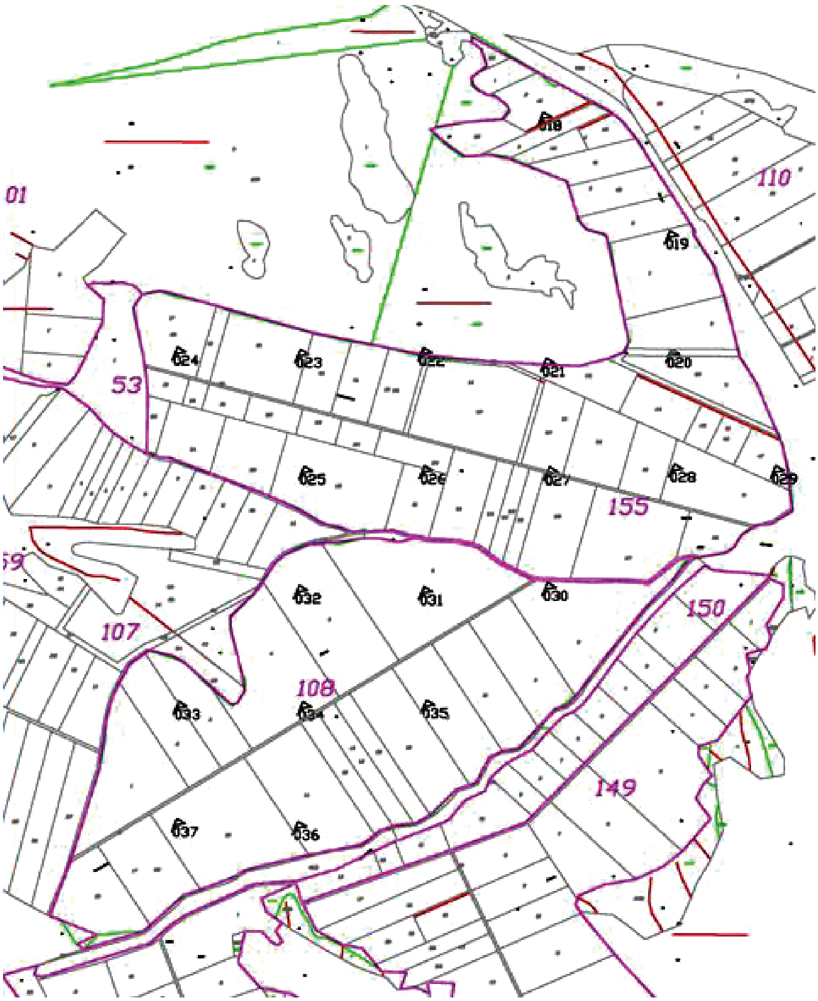

Figure 1. Situation and location of sampling points in parcels 108 and 155

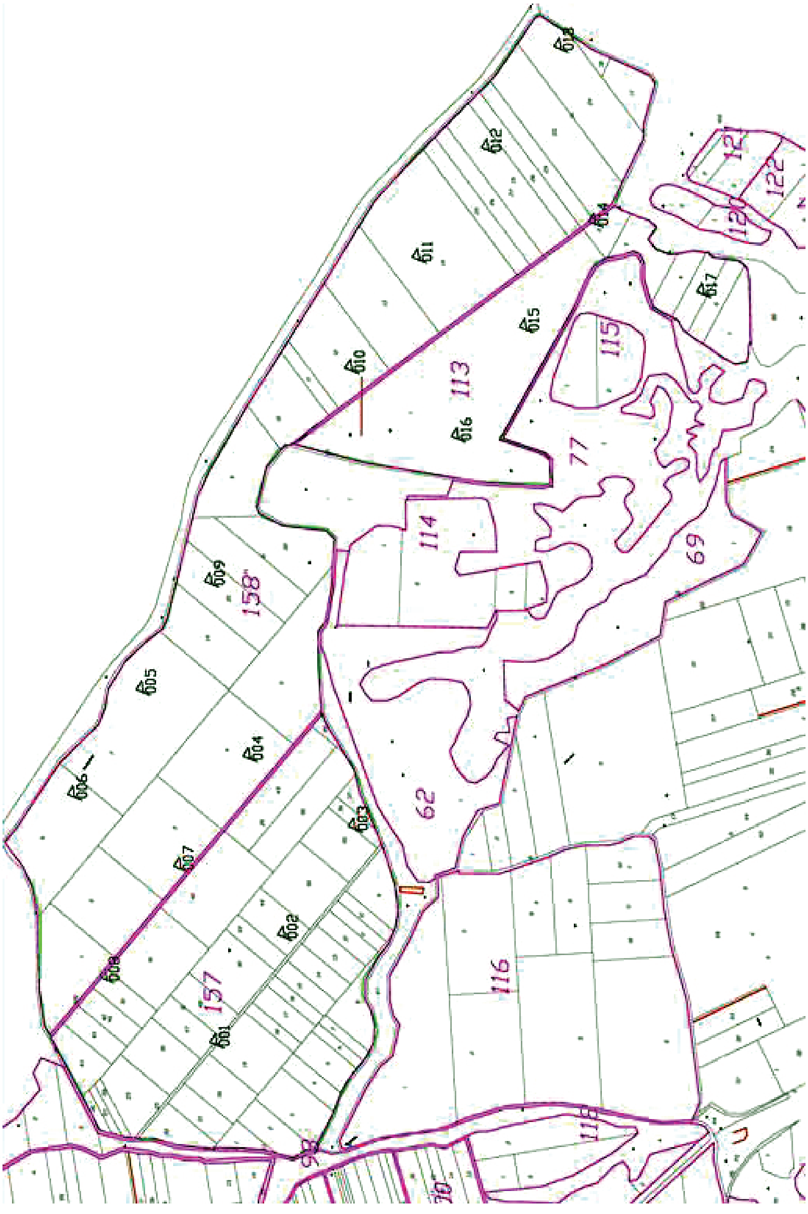

Figure 2. Situation and location of sampling points in parcels 157, 158 and 113

RESULTS AND DISCUSSIONS

Content of available phosphorus

Average content of assimilable phosphorus determined in acetate-lactate extract is low (4.03 mg P_2O_5/100g soil) and this is the overall conclusion which should be made for the whole investigated area. The lowest is phosphorus content within the boundaries of parcels 113, 155 and 158-under 4 mg P_2O_5/100g soil. As can be seen from Figure 3 and Figure 4 zones with relatively higher phosphorous content are established only in contour, delineated by the borders of parcels 108 and 155, while in the other content of this element is very low, according to standards for reserves of phosphorus in the classification tables for the method of 'Egner-Riem'.

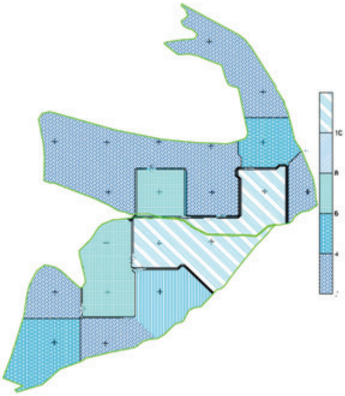

Figure 3. Spatial distribution of available phosphorus ($mg\ P_2O_5/100g$ soil) content in soil in parcels 108 and 155

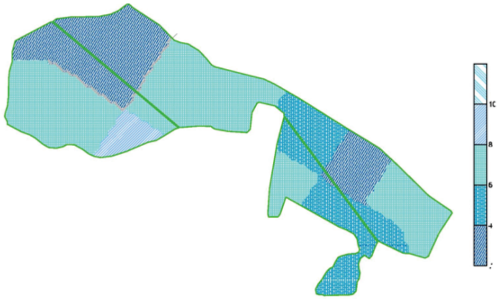

Figure 4. Spatial distribution of available phosphorus (mg P2O5/100g soil) content in soil in parcels 113, 157 and 158

Content of available potassium

Usually soils in Bulgaria are well stocked with potassium, but in this case studied areas are an exception. Average content of assimilable potassium, total for observed terrains is 13.79 $mg\ K_2O/100g$ soil, which is much below the standards for reserves of this nutrient. Obtained data require an application of stockpiling fertilization with potassium fertilizers. Stockpiling potassium fertilization will be differentiated by norms for some parts of the parcels.

The obtained results for reserves of phosphorus and potassium in soil give a reason to develop differentiated rates of stockpiling fertilization with these nutrients, which from agrochemical and economic viewpoint is appropriate for studied areas. For this purpose is used the method of Nearest neighbor, combined with soil sampling in graticule.

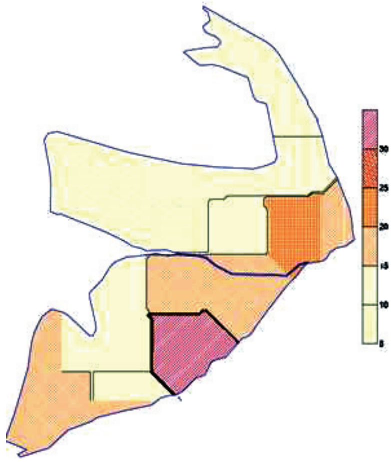

Figure 5. Spatial distribution of available potassium content ($mg\ K_2O/100g$ soil) in soil in parcels 108 and 155

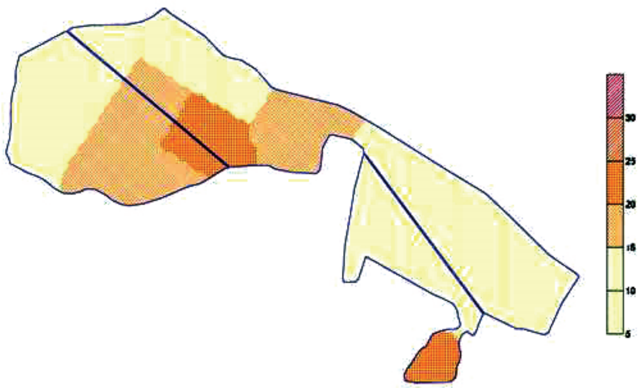

Figure 6. Spatial distribution of available potassium content ($mg\ K_2O/100g$ soil) in soil in parcels 113, 157 and 158

Statistical data processing

For the extrapolation of the data for reserves of nutrients on the principle from point to two dimensional space of field surface is used the method of Nearest Neighbor. Previously is randomized in space the position of points for investigation and is set the density of graticule corresponding with the technological significance of obtained thereby sub-parcels.

The randomized soil sampling formulated an algorithm in which areas have parallel sides. Sampling points are presented as three-dimensional vectors, the two of dimensions are meter coordinates x and y, and evaluated factors (in this case, stocks of the soil of phosphorus and potassium) play the role of vector on the axis 0z in three-dimensional space. Theoretically it is possible both parameters-reserves of phosphorus and reserves of potassium to be unite in a common algorithm with the coordinates of points, but then can not be achieved clear visualization and respectively mapping of the results.

In the accepted model the boundaries of representativeness of the sampling point forms a set of points with discrete distribution on axes 0x and 0y and with constant value on 0z. Extrapolation error is estimated by the method of fuzzy boundaries.

The presence of fuzzy boundaries obtained during the mapping of the algorithm generally should be an indicator for thickening of graticule of samples on the terrain. In this case it is avoided because by definition we have adopted the smallest technological size of areas.

Fertilization

Depending on the content of available phosphorus and potassium in the soil and after statistical analysis of data by the method of Nearest neighbor is developed a model for differentiated fertilization of investigated area. Obtained on the first approximation results are generalized to the threshold of economically significant sensitivity to corresponding nutrient, and then are outlined sub-parcels for differentiated fertilization.

For stockpiling phosphorus fertilization is used triple superphosphate and for potassium fertilization-potassium sulphate.

The area of sub-parcels for phosphorus fertilization, the rate of fertilization and the required amount of triple superphosphate are shown in Figure 7, Figure 8, and Table 1.

The area of sub-parcels for potassium fertilization, the rate of fertilization and the required amount of potassium sulphate are shown in Figure 9, Figure 10, and Table 2.

Phosphorus and potassium fertilizers are applied separately, after cleaning the weeds from the terrain. In order to achieve better homogenization of phosphate fertilizers with soil, it is recommended calculated in Table 1 fertilizer rates to be divided in two and to be applied twice. After fertilization, the area is ploughed at 15 cm in order to achieve better mixing of fertilizer with the soil. First three years after establishment of vineyard phosphorus and potassium fertilizers are not applied. During vegetation of vine is recommended to perform three or four times foliar fertilization with appropriate fertilizers, containing micronutrients and amino acids. Spraying of fertilizers can be combined with the performance of vineyard crop protection.

Table 1. Rate of fertilization (kgP_2O_5/ha) and required amount triple superphosphate (t)

Sub-parcel, №	Parcel, №	Area of subparcel (ha)	Rate of stockpiling fertilization with phosphorus (kg P_2O_5/ha)	Rate of TSP (t/ha)	Required amount TSP (t)
1	155	33.486	528.8	1.15	38.50
2	108 155	18.038	377.1	0.82	14.80
3	108	25.973	485.2	1050	27.30
4	157 158	13.688	548.0	1.19	16.30
5	157 158	27.913	477.8	1.04	29.00
6	113 158	20.237	521.1	1.13	22.90
7	158	6.741	485.6	1.05	7.10
Total:		146.075			155.90

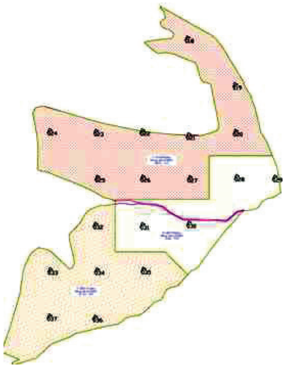

Figure 7. Distribution of area of parcels 108 and 155 into sub-parcels for phosphorus fertilization

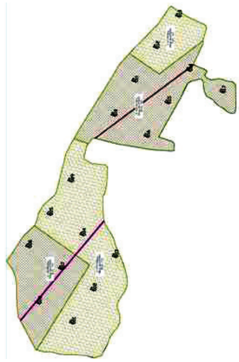

Figure 8. Distribution of area of parcels 113, 157 and 158 into sub-parcels for phosphorus fertilization

Table 2. Rate of fertilization (kgK_2O/ha) and required amount potassium sulphate (t)

Sub-parcel, №	Parcel, №	Area of subparcel (ha)	Rate of stockpiling fertilization with potassium (kg K_2O/ha)	Rate of Potassium sulfate (t/ha)	Required amount Potassium sulfate (t)
1	155	33.225	344.5	0.69	22.90
2	108 155	21.410	140.8	0.28	6.00
3	108	14.511	246.1	0.49	7.10
4	108	2.176	353.0	0.71	1.50
5	108	6.174	197.8	0.40	2.50
6	157 158	12.521	305.3	0.61	7.60
7	157	6.456	256.8	0.51	3.30
8	157 158	12.473	134.9	0.27	3.40
9	158	4.161	98.6	0.20	0.80
10	158	5.989	172.0	0.34	2.00
11	158	5.282	330.9	0.66	3.50
12	113 158	10.242	242.9	0.49	5.00
13	113 158	9.364	324.1	0.65	6.10
14	113	2.092	111.5	0.22	0.50
Total:		146.075			72.20

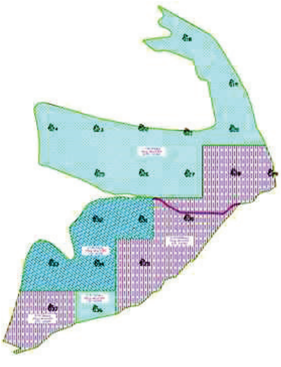

Figure 9. Distribution of area of parcels 108 and 155 into sub-parcels for potassium fertilization

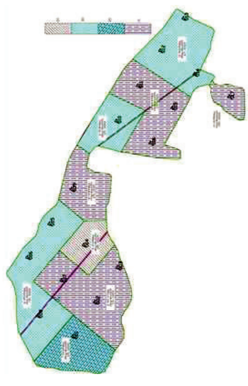

Figure 10. Distribution of area of parcels 113, 157 and 158 into sub-parcels for potassium fertilization

Phosphorus and potassium fertilizers are applied separately, after cleaning the weeds from the terrain. In order to achieve better homogenization of phosphate fertilizers with soil, it is recommended calculated in Table 1 fertilizer rates to be divided in two and to be applied twice. After fertilization, the area is ploughed at 15 cm in order to achieve better mixing of fertilizer with the soil. First three years after establishment of vineyard phosphorus and potassium fertilizers are not applied. During vegetation of vine is recommended to perform three or four times foliar fertilization with appropriate fertilizers, containing micronutrients and amino acids. Spraying of fertilizers can be combined with the performance of vineyard crop protection.

CONCLUSIONS

Advantages of this statistical method in the proposed model for geospatialization are that as a result of its application it is possible to outline sub-parcels for differentiated fertilization, with a proper from technological standpoint configuration.

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