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SPATIAL VARIATION OF PHYSICAL CLAY AND ORGANIC CARBON IN THE COMPLEX OF CINNAMON FOREST SOILS (CHROMIC LUVISOLS) AND THEIR SUITABILITY FOR CULTIVATION OF VINES

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Abstract

Object of this study are lands in the village Balabanchevo, municipality Sungurlare, Bulgaria. The main soil type in the region is Chromic luvisols with soil profile differentiated to different degree. In the current work is studied the spatial variation of soil organic matter and physical clay content, depending on the topographical location and the degree of erosion.
Studied soils are characterized by two main processes that determine the their particle size distribution - lessivage, causing accumulation of clay in subsoil and surface erosion, which is responsible for removal of relatively sandy upper layers and remaining of clayey subsurface horizons on the top.
In this research is determined particle size distribution in three depths - 0-25, 25-50 and 50-75 cm and the content organic carbon in the surface horizons.
Differences in clay content determined in the three studied depths are substantial and statistically significant.
Differences between sampling points in respect toorganic matter content are insignificant. Relatively high levels of humus content is detected only in a small part of investigated area, where are distributed relatively dark colored soils with expressed meadow soil formation process, and in the northern and the southern parts, where to some extent more strongly is retained humus formation effect of the natural vegetation.

Key words: *Chromic luvisols, geospatialization, organic carbon, physical clay.*

INTRODUCTION

In topsoil, the ideal soil structure is formed by predominantly crub-like aggregates, best formed when organic matter is naturally high (> 2% organic carbon content) and well humified (Greenland et al. 1975). The role of organic matter is less significant in the subsoil where the soil texture and the exchangeable cations are more important (Bronick and Lal, 2005).
Soils rich in organic matter are generally high in available nutrients.
Soil texture is an important consideration in variety and rootstock selection due to its effect on vine growth and potential nematode and/ or phylloxera damage. Soil texture largely influences vine growth due to its effects on water holding capacity and nutrient availability. Generally, finer-textured soils have a higher water holding capacity and higher native fertility thereby producing vines of higher growth potential as compared to sandy soils (McKenry and Christensen, 1998). Clay soils can fix potassium in soil, thereby decreasing the availability of this nutrient to the plant. Particle size distribution however is an absolute limitation when the content of physical clay is less than 10% or more than 70%.
Present study is a part of soil amelioration survey of derelicted, because of their low natural fertility terrains in the hilly Central Eastern part of Bulgaria. The task we set ourselves is to be defined the boundaries of soil heterogeneity in relation to organic carbon content and particle size distribution of soil.

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 it is established particle size distribution in the three depths by pipette method (Trendafilov and Popova, 2007) and organic carbon content according to ISO 14235:1998.

Soil morphology. Within the boundaries of studied area are established two soil types:

Cinnamon forest soils (Chromic luvisols)

Chromic luvisols, within the terrain are shallow, moderate to severe eroded. Parent material is hard, silicate, presented of highly weathered granite, metamorphites of granite and paleovolcans. Weathering crust is shallow and most often its depth does not exceed 10-15cm. The morphology of soil profile is typical for the cinnamon forest soils (Chromic luvisols) in the region. The surface horizon is elluvial pale, highly washed in respect of bases. Its depth ranges from 0 to about 15-18 cm. Subsoil is represented by metamorphic illuvial yellow-reddish coloured horizon with depth up to 40-50 cm, with heavy texture and compacted significantly.

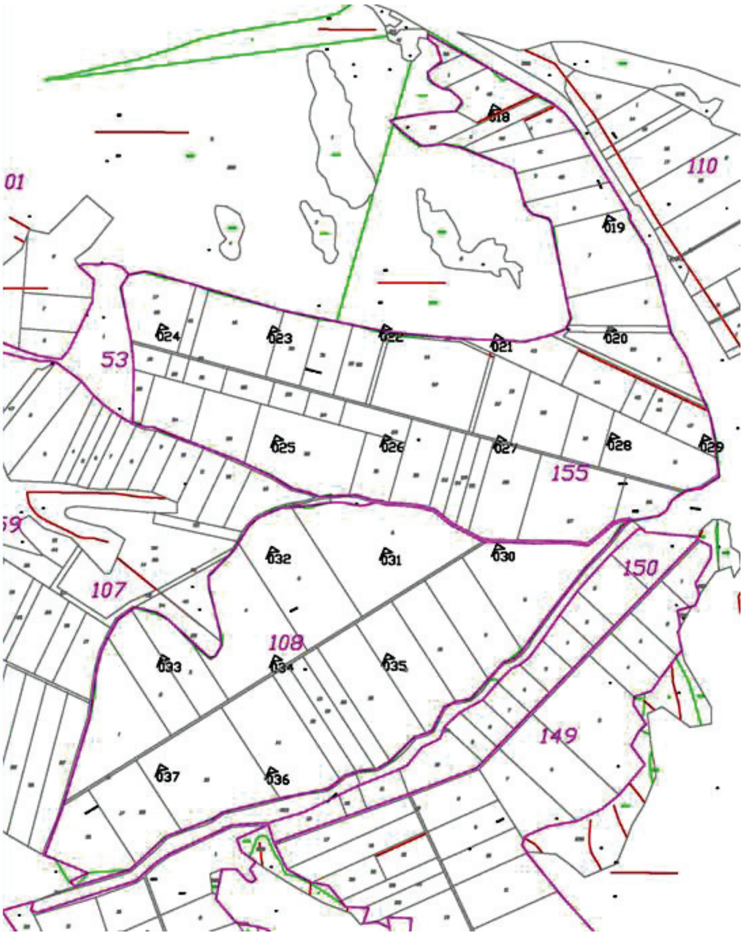

Figure 1. Situation and location of sampling points in parcels 108 and 155

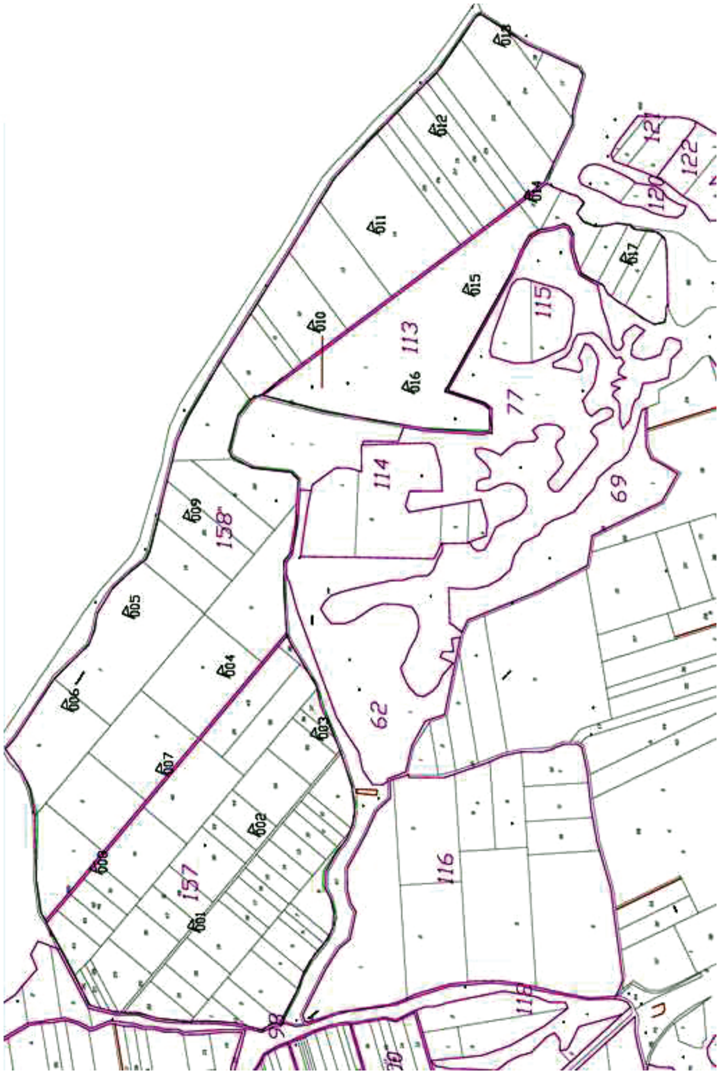

Figure 2. Situation and location of sampling points in parcels 157, 158 and 113

Most shallow profiles are established in the higher parts of the terrain where the soil is very severe eroded and on the surface is established the transitional, illuvial-metamorphic horizon. In some parts of the terrain with limited area on the surface is established the bottom 1/3 of the illuvial horizon which is skeleton with materials from the horizon C.

The structure of surface horizon is highly powdered and in the illuvial-metamorphic horizon-lumpy-prismatic, dappled with non-carbonate skeletal material whose granulometry is characterized by rock fragments with sizes in the range of 10 to 50 mm. In the zone of most active accumulation of clay in the illuvial horizon is established strong surface gleization, presented of stains, dots and concretions of manganese and iron oxides.

Severe eroded leached cinnamon forest soils, shallow

The depth of the humus horizon is between 10 and 20 cm. In some parts of the terrain which have limited area humus layer is completely reduced, as a result of sheet erosion. Total depth of the soil profile is 50-60 cm. The deeper layers of the soil profile are highly skeletal. The skeletal part turns into shallow weathering crust.

Shallow leached cinnamon forest soils have limited availability for cultivation of vines. These soils may be included within the vineyard with its peripheral parts of the distribution in order not to be disturbed the overall plan of the plantation.

RESULTS AND DISCUSSIONS

Soil texture

As stated above, mechanical structure is an important feature of the suitability of soil for wine growing and in a narrower meaning-for the choice of rootstock.

Studied soils are characterized by two main processes that determine the their particle size distribution-lessivage, causing an accumulation of clay in subsoil and surface erosion, which is responsible for removal of relatively sandy upper layers and remaining of clayey subsurface horizons on the top. In cases where the soil profile is relatively shallow and undeveloped in its lower part are established significant percentage of skeletal fractions-stone, sand and gravel.

The type, size and distribution of skeletal fractions within the soil profile are not significant limitation of the soil suitability for wine growing.

The overall impression given by the obtained results for particle size distribution is that soils are relatively clayey. Average content of physical clay is 55.5%, with no substantial differences in parcels. Relatively the lowest clay content is found in parcel 108-average 47.73%, while the highest – in parcels 157 (64.6%) and 113 (63.8%). Differences between the parcels, in terms of content of clay are insignificant.

From Figure 3 can be seen that the increase in content of physical clay, i.e. the presence of accumulated clay in subsoil is typical for parcels 155, 157 and 158, while in the other this trend is not clear. Differences in clay content for the three studied depths are substantial and statistically significant.

Interpretation of the data indicates that if during the preliminary preparation terrain the tillage is performed at a depth of 70-75 cm, the average content of clay in this layer will be less than 60%, which is generally favorable for the development of root system of all known and used in practice vine rootstocks. If the tillage in made at depth of 75 cm. with turning and homogenization of the layer, average content of clay over 60% will be established in 60% of the area of all terrains.

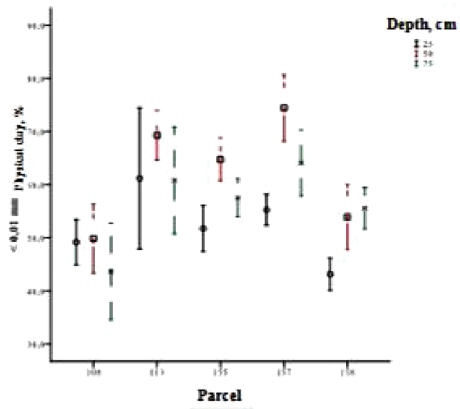

Figure 3. Changes in content of physical clay in parcels and depths, with intervals of variation

In cases when the ploughing is made in the upper 50 cm, the sections in which the plough layer will contain over 60% clay, will increase to 75% from the whole area.

The reason is that the soil composition in the deepest layer is very skeletal, which is a favorable opportunity to enrich the root active horizon with skeletal fractions.

Described average clay content, visible in raw form in Table 1 and displayed graphically in Figure 3 does not actually reveal that in this case, behind the averages is hidden a large variation of clay content in different samples from the field.

Data for the frequency distribution Figure 4 of the content of physical clay presented separately in depths of investigation (in the rows on the chart) and parcels (columns in the chart) shows that values of physical clay greater than 60% are highly unlikely in the surface horizons of parcels 108, 157 and 158, but in other parcels the variance of values higher than 60% physical clay is significant.

In deeper horizons up to 50 cm is more probably clay content to be established above 60% rather than below this value, while horizons with depth 50-75 cm take an intermediate position.

From the viewpoint of above analysis we can conclude that in the parcels 108 and 113 is necessary to use of rootstocks which are resistant to high clay content in the soil, such as SO4, or rootstock hybrids close to it. In other parcels this is not so decisive condition.

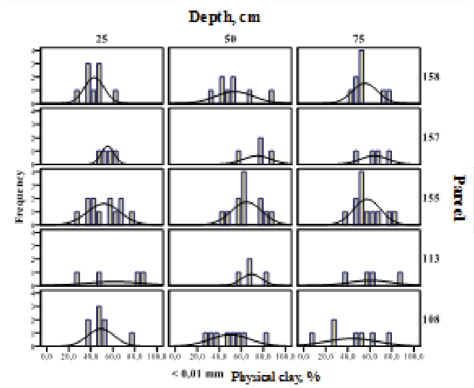

Figure 4. Frequency distribution of physical clay fraction in parcels and depths

According to particle size distribution the studied soils are classified [1] as follows:

In the surface horizons more common texture classes are heavy loam (35.1% of the total area), followed by medium loam (32.4%). In these sections physical clay content is up to 60% of the mass of soil and that is favorable for the development of vine roots, without significant limitations. Clayey variations at this depth are established in 13.5% of cases of investigation.

At a depth of 25-50 cm medium loam are established only in 16.7% of the cases of investigation, while heavy loam-in 36.1%. Clayey varieties are found in over 1/3 of the cases, i.e. in practice they are the most widespread in all study sites.

At a depth of 50-75 cm the most widespread are heavy loam soils with physical clay content from 45 to 60%, i.e. the clay content is in the range that is suitable for the vines grafted on appropriate rootstocks.

Shallow, leached cinnamon forest soils established within the terrain, can be used if the soil profile depth is more than 60 cm. It is appropriate in this area, soils not to be deep ploughed. As a primary tillage there can be applied meliorative deep loosening.

In the total sample, characterizing the whole surveyed area and through the whole depth of plough layer (unless it is more shallower than 75 cm) is more probably to be established clay content up to 60%, as the terrains in which it is higher will be an exception.

The spatial distribution ofphysical clay content in 0-75 cm layer in investigated parcels is presented in Figure 5 and Figure 6

Textural classes are defined according to classification developed by Kachinskii (1965).

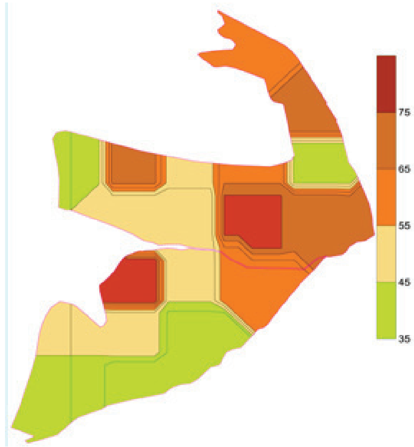

Figure 5. Spatial distribution of physical clay content in 0-75 cm layer in parcels 108 and 155

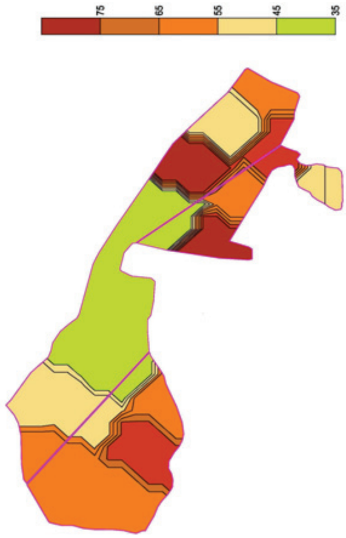

Figure 6. Spatial distribution of physical clay content in 0-75 cm layer on parcels 157, 158 and 113

During the survey there are established processes of present hydromorphism. This gives reason to predict unfavourable water and air regime in highly compressed subsoil horizons, which will occur after the entry of the vineyard into the fruit-bearing period (3-5 years after the pre-planting tillage).

This necessitates performing of periodic subsoiling of the soil with single ax subsoiler in period of 3-4 years. When performing this tillage, should be followed the technological requirements for optimum soil moisture at the time of subsoiling-moisture 50-65% of field capacity.

Soil organic matter content

Average humus content (Figure 7) expressed as organic carbon is low-1.22% for the whole area of investigation. The differences between parcels in terms of organic matter content are insignificant, except parcel 113 in which humus is only 0,85%-significantly lower than in the other investigated parcels and far below the average for the whole studied area.

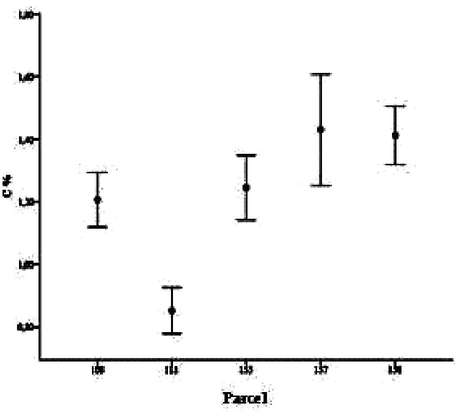

Figure 7. Average content and intervals of variation of organic carbon content in the surface horizon in the investigated parcels

Average content of humus in the parcel 108 is 1,22 ± 0,09%, and in 155-1,24 ± 0,1%. A higher content of humus in parcel 155 is due to the presence of soils with meadow process of soil formation in which humus is higher. Most frequently established humus content in both parcels in contour 1 is 1.2%, as in parcels 155 and 158 are determined values above 1.8%, but as an exception. (Figure 8).

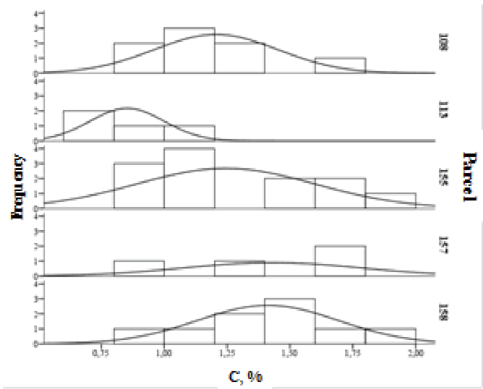

Figure 8. Frequency distribution of organic matter content

Figure 9 and Figure 10 shows the spatial distribution of humus content in the area of studied parcels. It is seen that relatively higher values of humus content are established only in a small part of parcel 155, where are distributed relatively dark colored soils with well expressed meadow soil formation, and in the northern and the southern parts of both parcels where to some extent more strongly is retained humus formation effect of the natural vegetation.

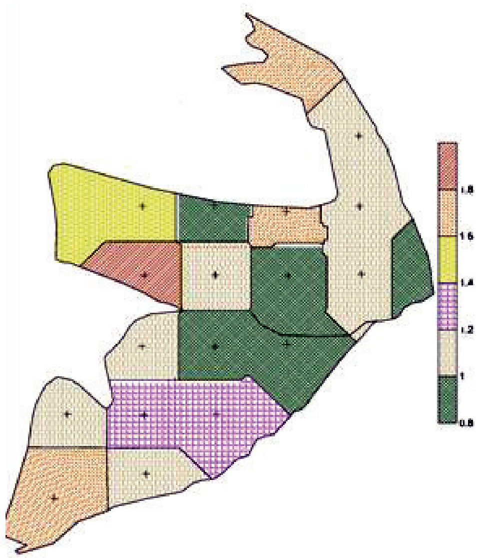

Figure 9. Spatial distribution of soil organic matter content in parcels 108 and 155

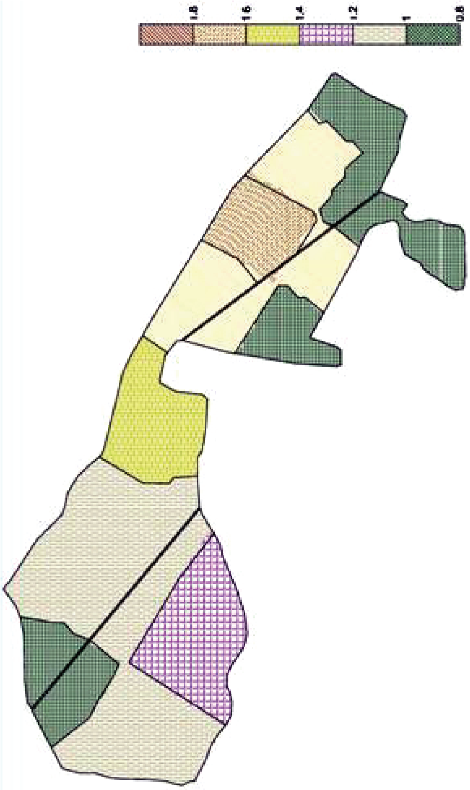

Figure 10. Spatial distribution of soil organic matter content in parcels 113, 157, 158

CONCLUSIONS

Described regularities in the distribution of physical clay and total data for particle size distribution of studied soils shows that, although values are very most favorable for the development of vine this indicator is not a significant limitation. Negative effects of high values of this parameter can be overcame by application of appropriate tillage and use of appropriate rootstocks.

Soil organic matter content, despite of its low levels is not a limitation for the suitability of land for vine growing, but it determines relatively weak vigor and requires application of less vigorous trainings.

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