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Adjustment of Low Productive Terrains for Establishment of Vineyard Terroir in Bulgaria

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ABSTRACT

The aim of this study was to propose principles technological decisions for adjustment of low productive terrains located in Chernogorovo village and their conversion into specific terroir for growth of wine varieties vineyards. Successively were studied the morphological characteristics of the terrain - mechanical composition and physical properties of the soil, determines were soil reaction, the content of total and alkaline earth carbonates, the content of active calcium, humus content, water-soluble salts, the content of easily absorbable iron, index of chlorine force and the content of nutrient macro elements. Based on the results was found, that within the studied terrain in the part occupied by Chromi-eutric cambisols and Eutric regosols, the terrain was suitable for the establishment and cultivation of vineyards in the direction of high quality red wines. The content of total carbonates and active calcium in Chromi-eutric cambisols did not limit the choice of pad. Can be used seedlings, grafted of pad Berlandieri x Riparia selection Openhaim 4 (SO 4) or other suitable. The area, occupied by Eutric regosols, had higher content of total and active carbonates and it is recommended the use of sustainable pad - Chasla x Berlandieri 41B. The presented study was an attempt to systematize the complex research on the suitability of one complicated terrain in terms of erosive conditions with regard to its suitability for transformation into vineyard terroir.

Keywords: soil properties, vineyard, terroir, wine varieties

INTRODUCTION

The aim of this study was to propose principles technological decisions, projection and adjustment of low productive terrains, located in Chernogorovo village and their conversion into specific terroir for growth of wine varieties vines. The presented study was an attempt to systematize of the complex research on the suitability of one complicated terrain in terms of erosive conditions with regard to its suitability for transformation into vineyard terroir.

MAIN BODY

Object of the study were soils, part of Chernogorovo village, located in Pazardzhik municipality, southern Bulgaria in the central part of the Upper Thracian Plain, north of the Rhodope Mountains. In the course of this study was accepted a model to take soil samples, where each sample was taken from the terrain with a soil probe, as sample points were located within the boundaries of the field in a square grid, regardless of the boundaries of the different soil types and terrain topography. Three divisions were studied – areas 001211, 001214, 001218, which were characterized by complex topography. Samples were taken in three depths 0-25; 25-50 and 50-75 cm. After standard preparation, soil samples were analyzed to establish the indicators: mechanical composition with fotosedimentograf (Trendafilov and Popova, 2007), Bulk density of the soil by paraffin method, Relative density - pycnometrically, Hydrological characteristics of the soil (Trendafilov and Popova, 2007), pH - potentiometric in aqueous extract (Arinushkina, 1970), content of total and alkaline earth carbonates – gas metrically by Scheibler apparatus (Arinushkina, 1970), activate calcium precipitable with $(NH_4)_2C_2O_4$ – Druinnot-Gallet (NO1085/NFX31-106), humus content by method of Turin (Trendafilov and Popova, 2007), water-soluble salts (BDS ISO 11265:2002), content of easily absorbable iron, total nitrogen in the soil (BDS ISO 11261: 2002), mobile forms of phosphorus and potassium (GOST 26209-91/01.07.93).

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RESULTS AND DISCUSSION

The studied object located in Chernogorovo village, Pazardzhik municipality, EKATTE 81089. The study included properties, located in locality "Obleshtenitsa". The total area of the object amounts to 93,7638 ha. In the boundaries of the studied area were found Chromi-eutric cambisols, Gleyi-chromic luvisols, Rankers and Eutric regosols, Figure 1.

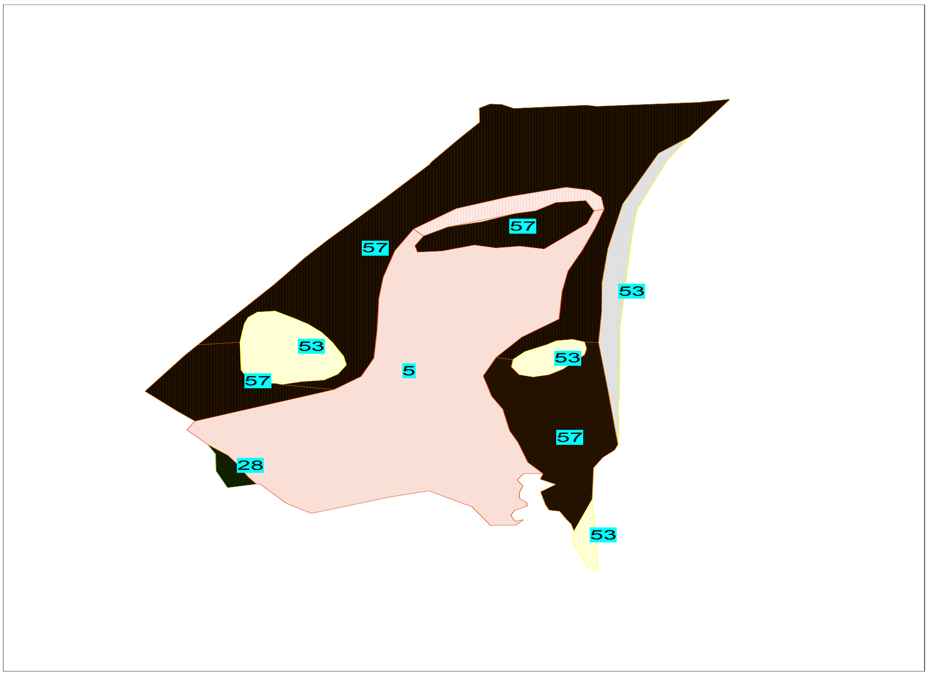

Figure1. *Soil map, dimension 1:15000 - object Chernogorovo, Chromi-eutric cambisols (5), Gleyi-chromic luvisols (28), Rankers (53), Eutric regosols (57).*

Morphology of the soil profile of Chromi-eutric cambisols

Аорн. 0-25 см Dull yellowish Brown (10YR4/3) concise, sandy clay, granular-single grained structure, roots, stones, not effervescence of HCI. Transition – noticeable.

B1 25-50 см Brown, 10YR5/3, dry, thick, clay, blocky-prismatic structure, not effervesce from HCI, Transition - noticeable

BCк Yellowish brown 10YR5/4, dry, thick, clay, blocky structure, effervescence from HCI.

Mechanical composition and physical properties of the soil

The average content of the physical clay in a depth 0-75 cm was 46,3% and increased on the depth of the profile. The mechanical composition in the topsoil horizons was sandy-clay. In the subsoil horizons was sandy clay loam in a depth 25-50 cm and sandy-clay in a depth 50-75 cm . The values of the physical clay shown, that the mechanical composition was not a restriction on the suitability of the soil for growth of vines. The texture coefficient had a value 1,06 and was not a restriction on the suitability of the soil for vineyards.Water properties characterized by indicators specific and bulk density, porosity, field capacity and water reserve. The total porosity of the soil assessed as satisfactory. The field capacity was low – an average value 21,60%. In topsoil horizon the field capacity was higher – 24,95%. The maximum total water reserve for one meter topsoil layer in the terrains with sufficient depth of the profile was 3000 m^3/ha. In the shallow profiles, the maximum water reserve did not exceed 2300 m^3/ha. In the humidity of wilting point in the profiles, whose depth exceeds 1 m contained about 2000 m^3/ha not assimilable water reserve. In the shallow profiles (with depth up to about 75 cm) the volume of the not assimilable water reserve did not exceed 1500 m^3/ha. The estimation of the volume of easily assimilable and total assimilable water reserve in Chromi-eutric cambisols and Eutric regosols shown in Table 2. The average content of physical clay and particles <0,001 mm in the studied depths shown in Table 1.

Table1. *Average values of the physical indicators of Chromi-eutric cambisols by depths*

Soil type	Chromi-eutric cambisols		
Indicators	Depth cm		
	0-25	25-50	50-75
Physical clay % /Particles <0,01mm(%)	46,1	44,1	48,7
Particles <0,001mm(%)	5,0	4,9	5,3
Specific density g/cm3	2,68	2,70	2,71
Bulk density at saturation	1,39	1,45	1,49
Porosity %	48,15	46,27	45,01

Table2. *Water reserve of the soil at different humidity*

Hydrological indicator	Chromi-eutric cambisols	Eutric regosols
Maximum water reserve at saturation m^3/ha	3000	2300
Water reserve at field capacity m^3/ha	2500	1900
Maximum water reserve at wilting point m^3/ha	2000	1500
Easily absorb water reserve m^3/ha	500	400
Total absorb water reserve m^3/ha	1000	800

Soil Reaction

The average value of the indicator pH ($_{H2O}$), found for the whole studied object was 6,53 with a confidence interval 6,22–6,84. The soil reaction of the top horizon was weakly acidic. The average pH values of the soil depth and the intervals of variation, found in the volume of the sample shown in Figure 2. The indicator pH in the topsoil horizon had an average value 6,5 with a confidence interval 5,95–7,05. The soil reaction of the top horizon was weakly acidic. In the depth of the soil pH values increased. The reaction of the subsoil horizons was a neutral. The established pH by the analysis was not a restriction for the growth of the vines. The values of pH, determined in aqueous extracts were within the optimal and allow normal growth of the root system.

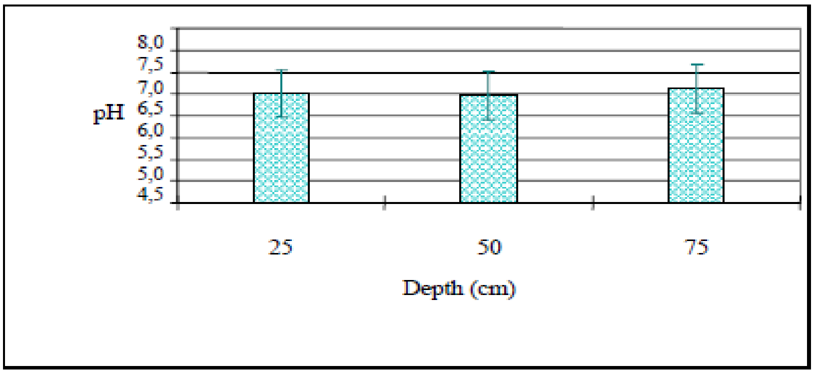

Figure2. *Average pH values on soil depth (Chromi-eutric cambisols)*

Content of Total Alkaline Earth Carbonates

Independently, that the main parent rock was granite and its weathering products and metamorphites on the basis of granite, in some parts of the object was found a carbonate base. Carbonate parent rocks and respectively carbonate subsoil horizons were as stains within the distribution of Chromi-eutric cambisols. The average content of the total alkaline earth carbonates in the depth of the soil profile shown in Figure 3. The content of $CaCO_3$ in the top horizons was average 0,93% and increased in the depth of the profile. In the horizons with a depth 25-50 cm, the average content of $CaCO_3$ was 1,77%, in the depth 50-75 cm - average 4,64% and vary within the confidence interval with an upper limit to 11,06%. The highest value of $CaCO_3$, found for the studied soil diversity within the whole object was 30,35%. Increased content of total alkaline earth carbonates was found in the southern parts of the object and at a depth bigger than 50 cm. The total carbonates, average for the object were 2,40% with a confidence interval 0,15-5,00%.

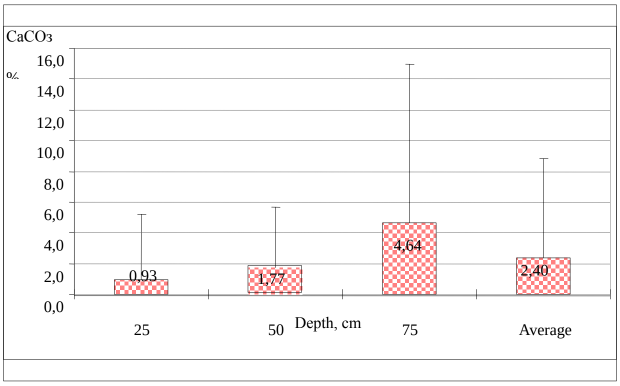

Figure3. *Contents of total alkaline earth carbonates and their distribution in the profile of Chromi-eutric cambisols*

Active calcium content

The average content of active calcium for the area, occupied by Chromi-eutric cambisols was 2,26% and vary in the ranges of confidence interval 1,03–3,49%. The maximum value of the active Ca^{2+}, established within the distribution of the studied soil difference was 7,81%. The average value of the active calcium content for top horizons was 2,49%. The distribution of Ca^{2+} in the depth of the soil profile shown in Figure 4. The figure shown, that the content of the active Ca^{2+} decreases in the depth of the profile. The difference in the values of the indicator was very high.. The content of active calcium in the soil did not limit the choice of pad for planting.

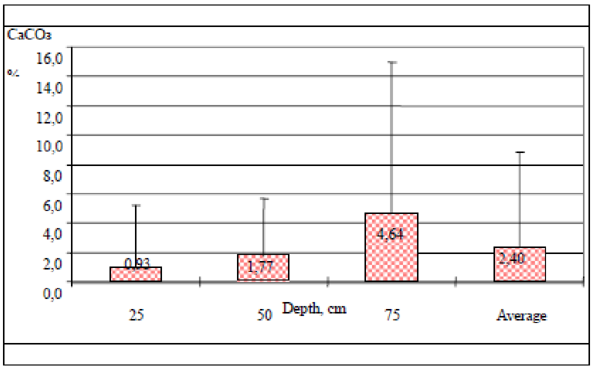

Figure4. *Content of active Ca and distribution in the soil profile*

Humus Content

The humus content for the top horizon of the studied Chromi-eutric cambisols was 1,84% and assessed as low. The humus content decreased to 1,03% in depth 25-50 cm and to 0,49% in depth 50-75 cm. It can be expected, that in the depth of the trench horizon will establish a low humus content – 1,14%, which will vary within the confidence interval 0,90-1,39%. Figure 5 shown the average values of the humus in soil depth. The correspond to the humus total nitrogen content in the studied soil was average 0,11% in the top horizon; 0,06% in a depth 25-50 cm and average 0,08% for the depth of the trench soil layer. The total nitrogen reserve in the layer with depth 0-50cm was 6 t/ha. About 63% of this reserve was in the top 25 cm of the profile.

Content of water-soluble salts

The content of water-soluble salts in the soil was very low and did not exceed the limit of harmfulness (0,25%) and it was not a restriction for the growth of the vine. The data for the average content of water-soluble salts and their distribution in the profile shown in Figure 6.

Content of easily absorbable iron and index of chlorine force

The average value of the content of easily absorbable iron, determinate in extract with ammonium oxalate was 157,27 mg/kg soil for the horizons with depth 0-25 cm; 158,30 mg/kg in layer 25-50 cm and 113,10 mg/kg in depth 50-75 cm. Average for the depth of the trench layer will determine content of easily absorbable iron between 108,12 and 178,59 mg/kg. The data for the content of easily absorbable iron and correspond values of the index of chlorine force shown in Figure 7.

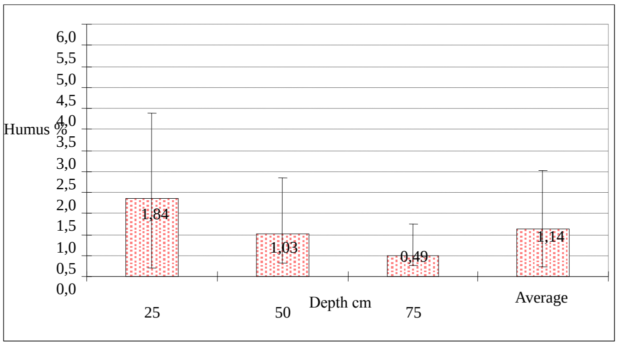

Figure5. *Average humus content (%) and variation of the humus content in the depth of the profile of Chromi-eutric cambisols.*

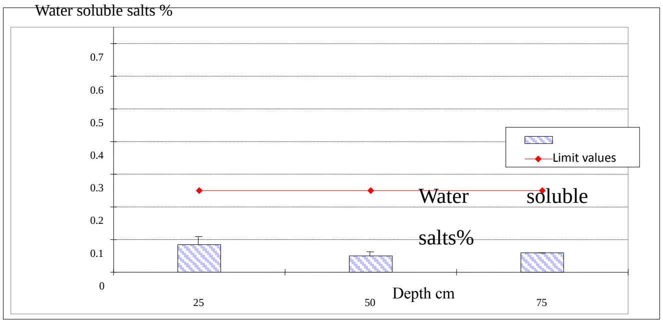

Figure6. *Contents of water-soluble salts and distribution of the salts on the profile of Chromi-eutric cambisols*

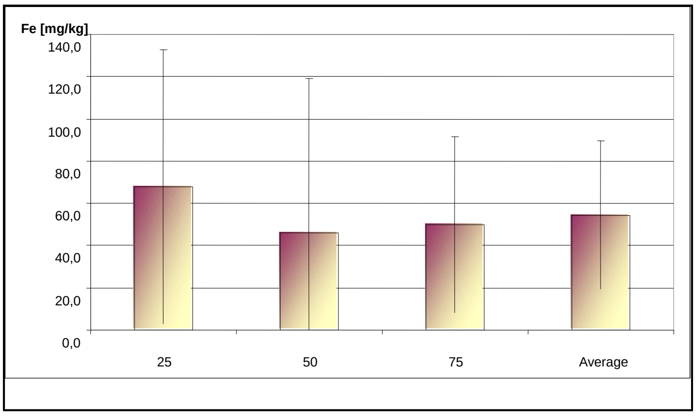

Figure7. *Average content of absorbable iron and its distribution on the profile of Chromi-eutric cambisols*

Content of nutrients macro elements and fertilization rates

The content of total nitrogen in the soil and the content of absorbable phosphorus and potassium shown in Table 3.

The soil was low reserve with total nitrogen and phosphorus and well reserve with absorbable potassium. The data shown in the table for the level of reserve with the main nutrients elements require fertilization with nutrients macro elements with the rates shown in Table 4.

Main phosphorus fertilization was with triple superphosphate. Potassium fertilization was not necessary. The fertilization rates with mineral fertilizers, after the vine fruit-bearing shown in Table 5.

The fertilization rates shown in the table for the current fertilization, previsional for the period of fruit-bearing of the plantation were tentative. The accurate determination of the rates takes place after annually analyzing of soil samples for content of nutrients macro elements in the soil. When planting variety Syrah can be used fertilization rates given for the variety Mavrud.

Table3. *Content of nutrients macro elements*

Total nitrogen content in the soil (mg/kg)	Content of P in the soil (mg/100g)	Content of K in the soil (mg/100g)
47,50	6,30	25,00

Table 4. *Fertilization rates with nutrients macro elements*

Stockpiling fertilization rate P_2O_5 kg/ha	*Fertilization rate with triple superphosphate kg/ha*	*Stockpiling fertilization rate K_2O kg/ha*	*Fertilization rate with potassium sulphate kg/ha*
425	1010	0,0	100

Table5. *Fertilization rates with mineral fertilizers after fruit-bearing*

Variety	Fertilization rate N kg/ha	Fertilization rate P_2O_5, kg/ha	Fertilization rate K_2O, kg/ha
Cabernet	100,5	109,1	30,0
Mavrud	64,9	105,1	50,0
Merlot	51,8	115,6	40,0
Pamid	77,8	82,0	40,0
Riesling	85,7	95,8	40,0

Morphology of the soil profile of Eutric regosols

A 0-25 cm Grayish yellow brown (10YR5/2) dry, concise, sandy clay, granular-single grained structure, roots, stones, not effervescence from HCI. Transition – noticeable.

B1 25-50 cm Yellowish brown, 10YR5/6, dry, thick, clay, blocky-prismatic structure, not effervesce from HCI. Transition – noticeable.

cD Silicate weathering crust

Mechanical composition and physical properties of the soil

The average content of physical clay at a depth 0-75 cm was 37,6%, and decrease in the depth of the profile. The mechanical composition in the top soil horizons was sandy clay. In the subsoil horizons was sandy clay to a depth 25-50 cm and sandy clay at a depth 50-75 cm. The established values of physical clay shown, that the mechanical composition was not a restriction for the suitability of the soil for growth of vines. The texture coefficient had a value 1,00 and was not a restriction on the suitability of the soil for vines. The average content of physical clay and particles <0,001mm at studied depths shown in Table 6.

Table6. *Average values of the physical indicators of Eutric regosols in depths*

Soil type	Eutric regosols		
	Depth cm		
Indicators	0-25	25-50	50-75
Physical clay %/Particles <0,01mm(%)	41,8	41,8	29,9
Particles <0,001mm(%)	4,6	4,6	3,3
Specific density g/cm3	2,69	2,70	2,71
Bulk density at saturation	1,43	1,47	1,50
Porosity %	46,85	45,76	44,75

Soil pH

The average value of the indicator pH ($_{H2O}$), established for whole studied object was 6,22 with a confidence interval 5,62-6,83. The soil reaction of the top soil horizon was acidic. The average pH values of the soil depth and the interval of variation, found in the volume of the sample shown in Figure 8. The indicator pH in the top soil horizon had an average value 6,0 with a confidence interval 4,74-7,34. In the depth of the soil pH value increased. The reaction of subsoil horizons defined as weakly acidic, neutral or weakly alkaline for the profiles in which found total alkaline earth carbonates.

Established in the analysis pH was a minor limit for the growth of the vine. To prevent possible soil acidification in the cultivation process of the vine plantation was necessary to avoid fertilization with ammonium nitrate. Plants need nitrogen provided through fertilization with urea.

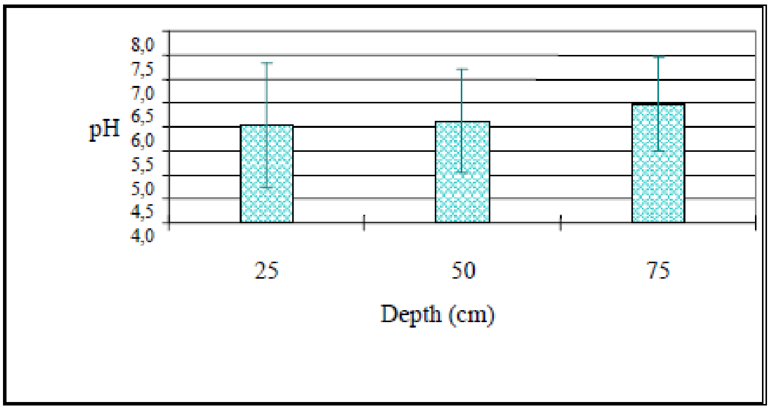

Figure8. *Average pH values on depth of the soil (Eutric regosols)*

Content of total alkaline earth carbonates

Similar to Chromi-eutric cambisols in Eutric regosols the total alkaline earth carbonates were unevenly distributed in the area, occupied by the studied soil diversity. The average content of total alkaline earth carbonates in the depth of the soil profile shown in Figure 9.

The content of $CaCO_3$ in the top horizons was average 1,13% and increased on the depth of the profile. In the horizons with a depth 25-50 cm the average content of $CaCO_3$ was 2,84% and to a depth 50-75 cm - average 7,68% and vary within the confidence interval with an upper limit to 17,29%. The highest value of $CaCO_3$, found for the studied soil diversity within the whole object was 25,71%. The total carbonates, average for the object were 4,04%, with a confidence interval 0,34-8,00%.

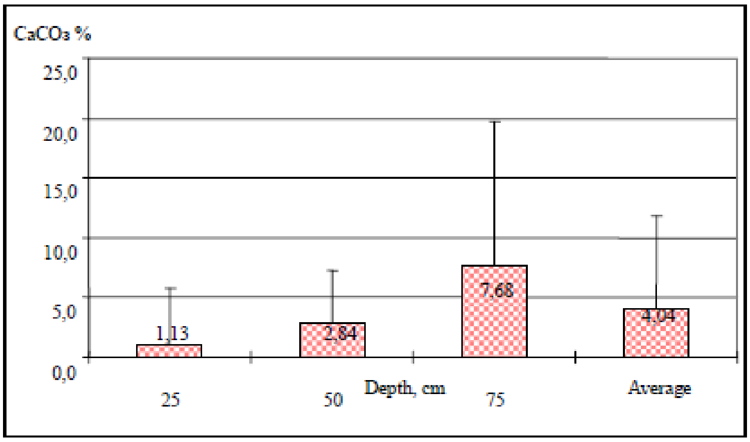

Figure9. *Contents of total alkaline earth carbonates and their distribution in the profile of Eutric regosols*

Active calcium content

The average content of active calcium for the area occupied by Eutric regosols was 4,06% and vary within a confidence interval 1,97-6,14%. The maximum value of the active Ca^{2+}, found within the distribution of the studied soil diversity was 14,72%. The average value of the active calcium content for the top horizons was 3,36%. The distribution of Ca^{2+} in the depth of the soil profile shown in Figure 10. The figure shown, that the content of the active Ca increased in the depth of the profile. The difference in the values of the indicator was very high. The content of active calcium in the soil requires a choice of pad with increased resistance to alkaline earth carbonates and active Ca.

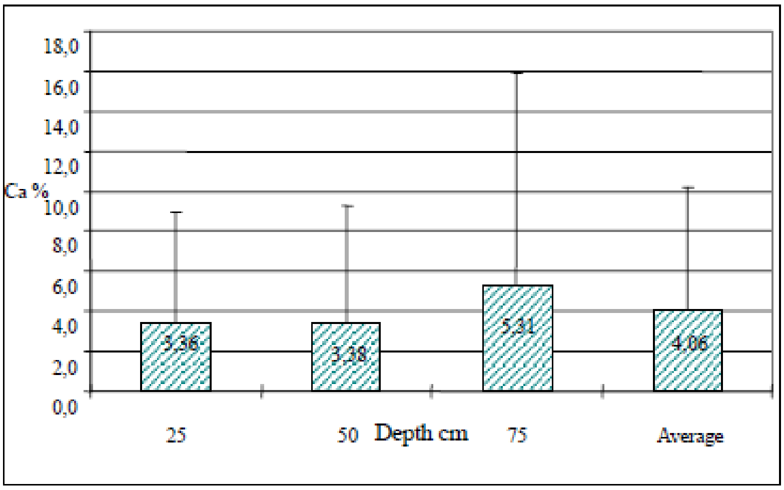

Figure10. *Content of active Ca and distribution in the soil profile*

Humus Content

The humus content of the top horizon of the studied Eutric regosols was 1,27% and assessed as low. Humus content decreased to 0,81% in depth 25-50cm and to 0,38% in depth 50-75 cm.

It can be expected, that in the depth of the trench horizon will be find very low humus content – 0,79%, which will vary within the confidence interval 0,59-1,00%. Figure 11 shown the average values of the humus in soil depth. Correspond to the humus content of total nitrogen in the studied soil was average 0,07% in the top horizon; 0,05% in depth 25-50 cm, and an average 0,06% for the depth of the trench soil layer. The total nitrogen reserve in the layer with depth 0-50cm was 4 t/ha. About 61% of this reserve found in the top 25 cm of the profile.

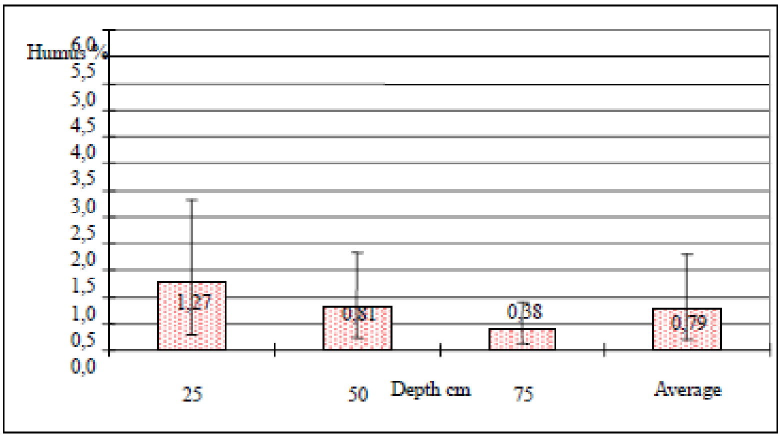

Figure11. *Average humus content (%) and variation of the humus content in the depth of the profile of Eutric regosols*

Content of water-soluble salts

The content of water-soluble salts in the soil was very low and did not exceed the limit of harmfulness (0,25%) and it is not a restriction for the growth of the vine. The data for the average content of water-soluble salts and their distribution in the profile shown in Figure 12.

Content of easily absorbable iron and index of chlorine force

The average value of the content of easily absorbable iron, determinate in extract with ammonium oxalate was 107,80 mg/kg soil for the horizons with a depth 0-25 cm; 160,17 mg/kg in the layer 25-50 cm and 109,22 mg/kg at a depth 50-75 cm.

The data for the content of easily absorbable iron and correspond values of the index of chlorine force shown in Figure 13. Average for the depth of the trench layer will establish an easily absorbable iron content between 82,46 and 171,10 mg/kg.

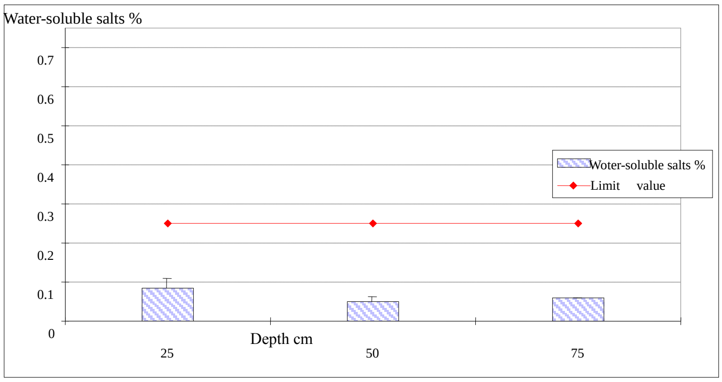

Figure12. *Contents of water-soluble salts and distribution of the salts on the profile of Eutric regosols*

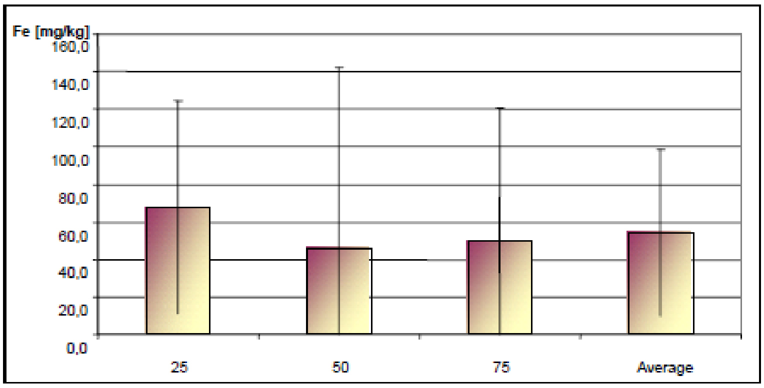

Figure13. *Average content of absorbable iron and its distribution on the profile of Eutric regosols*

Content of nutrients macro elements and fertilization rates

The content of total nitrogen in the soil and the content of absorbable phosphorus and potassium shown in Table 7. The soil was poorly reserve with total nitrogen and phosphorus and well reserve with absorbable potassium.

Table7. *Content of nutrients macro elements*

Total nitrogen content in the soil (mg/kg)	Content of P in the soil (mg/100g)	Content of K in the soil (mg/100g)
44,32	4,80	28,00

Listed in the table data for the level of reserve with the main nutrient elements require the completion of fertilization with nutrients macro elements with the rates shown in Table 8.

Table8. *Fertilization rates with nutrients macro elements*

Stockpiling fertilization rate P_2O_5 kg/ ha	Fertilization rate with triple superphosphate kg/ha	Stockpiling fertilization rate K_2O kg/dka	Fertilization rate with potassium sulphate kg/ha
463	1100	0,0	100

Main phosphorus fertilization was with triple superphosphate. The analyzed soil samples did not show needs of main potassium fertilization. After completion of stockpiling fertilization, phosphorus fertilizers was not applied by the third year. The fertilization rates with mineral fertilizers, after the vine fruit-bearing shown in Table 9.

Table9. *Fertilization rates with mineral fertilizers after fruit-bearing*

Variety	Fertilization rate N kg/ha	Fertilization rate P_2O_5 , kg/ha	Fertilization rate K_2O, kg/ha
Cabernet	103,5	111,3	10,0
Mavrud	67,8	107,2	30,0
Merlot	54,8	117,8	30,0
Pamid	80,8	84,2	30,0
Riesling	88,7	85,4	20,0

The fertilization rates shown in the table for the current fertilization, previsional for the period of fruit-bearing of the plantation were tentative. The accurate determination of the rates takes place after annually analyzing of soil samples for content of nutrients macro elements in the soil. When planting variety Syrah can be used fertilization rates given for the variety Mavrud.

More within the boundaries of the studied object found Rankers and Gleyi-chromic luvisols. Two soil diversity were with unfavorable properties and were unsuitable for growth of vineyards. In Rankers the reason was too shallow profile and in Gleyi-chromic luvisols - unfavorable water regime. The areas of distribution of these soil diversity shown in the soil map of Figure 1, but they were not included in the projected terrains.

CONCLUSIONS

The studied terrain, in the part occupied by Chromi-eutric cambisols (5) and Eutric regosols (57), (Figure 1) was suitable for creation and growth of vine for high quality red wines.

The content of total carbonates and active calcium in Chromi-eutric cambisols did not limit the choice of pad. Can be used seedlings, grafted of pad Berlandieri x Riparia selection Openhaim 4 (SO 4) or other suitable. The area, occupied by Eutric regosols, had higher content of total and active carbonates and it is recommended the use of sustainable pad - Chasla x Berlandieri 41B.

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