10.7251/AGSY1303841S

ASSESSMENT OF THE SOIL SUITABILITY OF ZELINA VINEYARD AREA FOR GROVING GRAPES

Mario SRAKA, Ivana MAMIC

University of Zagreb, Faculty of Agriculture, Croatia
(Corresponding author: msraka@agr.hr)

Abstract

Zelina vineyard area belongs to, according to winegrowing regionalization, north-western part of the Croatian winegrowing, sub region Prigorje-Bilogora, and is important wine growing region in Croatia. Even though there are various possibilities of using land for the purpose of this study attention is focused only on assessment the suitability of the land in Zelina vineyard area for the cultivation for grape growing. Evaluation of soil suitability for Zelina vineyard area was carried out according to the modified FAO method (Brinkman R., Smith, A.I., 1973, Vidaček, Ž., 1976).
In the area of Zelina vineyard 14 pedosystematic units from the division of automorphic and hydromorphic soils were determined. Zelina vineyard area has a total of 31,9 ha of soil suitable for viniculture (class P-1), soil with moderately suitability (class P-2) occupy 3180,8 ha of surface, soil with restricted suitability (class P-3) occupy 1287,0 ha of surface, while permanently unsuitable soils (class N-2) occupy 508,5 hectares of surface. There are no temporarily unsuitable soils (class N-2).
According to the degree of suitability and possibility of usage the most suitable soils for viniculture are eutric brown soil on marl and rendzina on marl and soft limestone with southern, south-western and south-eastern exposure, and on altitude of 150-400 m. The dominant constraints for other units are related to frost, exposure and inclination of the terrain and the some properties of soil. The study shows the hydro and agro melioration measures necessary to implement for individual units of soils to improve their use value.
Keywords: land evaluation, Zelina vineyard area, land reclamation

Introduction

The Republic of Croatia has about 32,485 ha of vineyards (Statistical Year Book, 2012), which represents approximately 2.4% of the used agricultural land. Due to the variety of environmental conditions for growing grapes Croatia is divided regionalization of vineyard areas in the two regions - continental Croatia and littoral Croatia. Zelina vineyard is one of the continental Croatian viticulture region, subregion Prigorje-Bilogora, and it is known for producing quality wines, as well as the festival exhibition of continental Croatian wines – St. Ivan Zelina, which is one of the largest and most important in Croatia.
Grapevine is a longtime culture which for its growth and development needs to the specific requirements in environmental growing conditions - primarily climate and topography. Soil as a third important factor in viticulture, also significantly affects on the quality and quantity of grape production, but it may be different emergency technological measures to adjust the cultivation of grapes. The evaluation and assessment of land for dedicated purposes we can distinguish two types of constraints, namely: limits in space or external characteristics of land (climate, relief) and limitations in the soil or inland properties of solum. Therefore, the main objective of this study was to determine the types and characteristics of soils Zelina vineyards, and evaluate their produced characteristics for viticulture, under certain conditions, relief and climate.

Materials and methods

For this study it have been used pedological and other existing data which are the property of Soil Science Department and the Central Agricultural Library of Faculty of Agriculture, University of Zagreb. Analysis of climatic features of Zelina vineyard according to the National Weather Service, the weather stations Zelina and Križevci, and includes precipitation, temperature, number of days with frost and insolation for period from 1981 to - 2010th. Systematics of soil was determined according to the current classification of soils (Skoric et al., 1986), and the distribution of soil according Basic soil map of Croatian scale 1:50.000 sections Zagreb 2 and Ptuj 4. Physical and chemical properties of soils are described according to data from previous field and laboratory studies, which are attached to the expositors of soil map. Evaluation of soil suitability classes in the Zelinski vineyard area, taking into account the type and intensity of limitations to their intensive use for viniculture, is in accordance with the modified criteria for soil evaluation (FAO, 1976; Vidaček Ž., 1976).

Results and discussion

Geographical position

Zelina vineyard is situated on the north-eastern part of Zagreb County and bordered by the hills of Medvednica, Kalnik and Papuk and the rivers of Sava and Drava and covers hilly landscape of Bilogora.

Climatic features

Climate is usually the determining factor of growing grapes in vineyard production. Generally it can be said that the climate of Zelina vineyards is a temperate continental, and according to value of Lang rain factor (81.9) has a humid characteristics. The average annual rainfall (period 1981-2010) is 909.6 mm, with a large annual variation of 594.6 mm to 1290.7 mm. During the active growing season grapevine (IV-IX month) average fall 516.4 mm, while the outside of the growing season (X-III month) 393.2 mm. Since the minimum rainfall for growing vines is 300-400 mm, and the optimal amounts is 650-850 mm (Licul R., Premužic D., 1974), precipitation is not a limiting factor for growing grapes in this area. The average annual air temperature (period 1981-2010) is 11.1°C, with the annual variation of 9.7°C to 12.3°C. According to thermal markings it is a moderately warm climate. The average air temperature during the active growing season is 17.7^0C, the coldest month is January with an average temperature of -0.3°C, while the monthly mean temperature of the warmest month - July is 21.5°C. Mean daily temperature above 10°C (effective active temperature) occur in April and cease during October. The grapevine is long day plant, and the required about 1500 to 2500 hours of insolation for successful cultivation. Since the average annual value of insolation in the area of Zelina vineyards is 2006.3 hours, here vinegrape is situated in the optimal conditions for development. The highest average insolation in July (295.4), and lowest in December (49.0). In the area of Zelina vineyards there are great variations in the number of frost days, so that in some years during the vegetation period are not recorded frosts, until years when during the vegetation was recorded up to 32 days of frost.

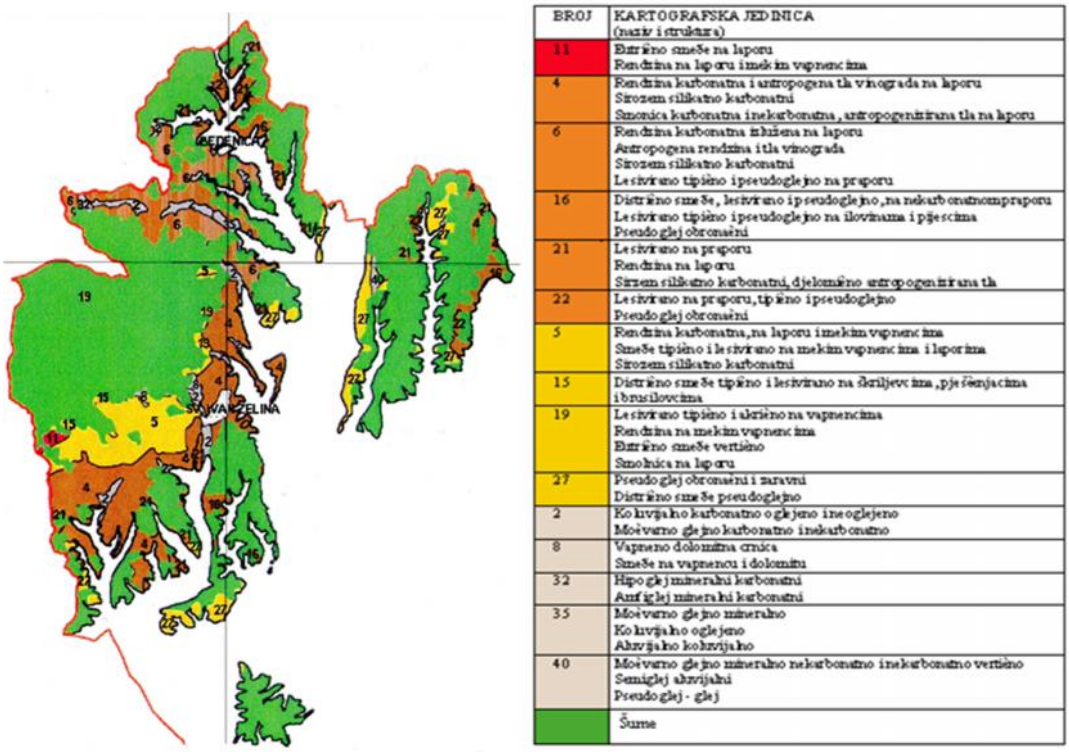
Relief

The relief of a region characterized by the shape and position of the earth’s surface into space. Zelina vineyard is surrounded by the north side position of mountain chain Zagrebačka gora and Kalnik, which lowered to the south are more or less and make the combination of hills and hillock at whose slopes are located vineyards. The positions of vineyards Zelina descend quite uniformly to the south, southeast and east. At these almost the proper deployed ribs eastern part of Zagrebačka gora on mild and sometimes steeper slopes are vineyards on the eastern, southern and western exposures, and inclination of the slopes is quite mild. Therefore this is a vineyard in terms of orographic very suitable for growing grapes. A characteristic of these slopes and hills that always

reduces altitude above sea level going from north to south and from west to east, and the vineyards are located at an altitude of 150 m to 400 m (Čmelik Z. et al., 2008).

Soil

According to the Basic soil map of Croatian scale 1:50 000, section Zagreb 2 and Ptuj 4 in the area of Zelina vineyards found 15 soil mapping units from the division of automorphic and hydromorphic soils, whose spatial distribution is shown on soil map scale of 1:100 000, figure 1. It was found 10 types of soil from automorphic division (rhegosol, colluvial soil, calcomelanosol, rendzina, vertisol, distric cambisol, eutric cambisol, calcocambisol, luvisol and rigosol) and four types of soils from hydromorphic division (pseudogley, pseudogley-gley, humofluvisol and eugley). Basic physical and chemical properties of certain types of soil are described according to the results of previous field and laboratory studies, and are found in expositors of Basic soil map sections Zagreb 2 and Ptuj 4.



BROJ	KARTOGRAFSKA JEDINICA (nazivi strukture)
11	Eutrično smeđe na laporu Rendzina na laporu i mekim vapnencima
4	Rendzina karbonatna i antropogena tla vinograda na laporu Sirozem silikatno karbonatni Smonica karbonatna inekarbonatna, antropogenizirana tla na laporu
6	Rendzina karbonatna ilimerizirana na laporu Antropogena rendzina i tla vinograda Sirozem silikatno karbonatni Lesivirano tipično i pseudoglejno na praporu
16	Distrično smeđe, lesivirano i pseudoglejno, na nekarbonatnompraporu Lesivirano tipično i pseudoglejno na ilovinama i pijescima Pseudoglej obronačni
21	Lesivirano na praporu Rendzina na laporu Sirozem silikatno karbonatni, djelomično antropogenizirana tla
22	Lesivirano na praporu, tipično i pseudoglejno Pseudoglej obronačni
5	Rendzina karbonatna, na laporu imekim vapnencima Smeđe tipično i lesivirano na mekim vapnencima i laporima Sirozem silikatno karbonatni
15	Distrično smeđe tipično i lesivirano na škriljevcima, pješčenjacima i brusilovcima
19	Lesivirano tipično i akrično na vapnencima Rendzina na mekim vapnencima Eutrično smeđe vertično Smonica na laporu
27	Pseudoglej obronačni i zaravni Distrično smeđe pseudoglejno
2	Kolovijalno karbonatno oglejeno ineoglejeno Močvarno glejno karbonatno inekarbonatno
8	Vapneno dolomitna crnica Smeđe na vapnencu i dolomitu
32	Hipoglej mineralni karbonatni Amfiglej mineralni karbonatni
35	Močvarno glejno mineralno Kolovijalno oglejeno Aluvijalno kolovijalno
40	Močvarno glejno mineralno nekarbonatno inekarbonatno vertično Semiglej aluvijalni Pseudoglej - glej
	Šume

Figure 1: Soil Map of Zelina vineyards area, scale 1:100.000 with a legend

Evaluation of agruicultural land for vineyards

Concept and evaluation criteria

Land as an object of evaluation includes physical space - climate, relief, soil, geology, hydrosphere, vegetation, and the results of past and present human activities (drainage and irrigation, terracing, deep tillage, fertilization etc.), to the extent of their impact on benefits and features dedicated using (modified according to FAO, 1976, Vidaček, Ž., 1976).

Evaluation of land suitability Zelina vineyards for viticulture is primarily qualitative and based on relevant soil properties and qualities and/or limitations of systematic soil units. Classification structure consists of orders, classes and subclasses suitabilities for viticulture. Orders determine the suitability (P) or unsuitability (N) of soil for viticulture; classes determine suitability degree: P-1 good or suitable soil for viticulture without major restrictions, P-2 moderately suitable soil for viticulture with individual limitations and P-3 limited suitable soil for viticulture with a number of serious limitations.

Class N-1 temporarily unsuitable soils for viticulture that require radically arranging and class N-2 permanently unsuitable soils for viticulture because their arrangement is not possible or not economically justified. Subclasses of soil suitability and unsuitability determine the types and intensity of limitations, which are shown in table 1

Table 1: Types of restrictions with the intensity and the criteria used in the evaluation of land suitability for vineyards

Landforms (r) r1 = narrow stream valleys r2 = narrow river valleys r3 = closed depression r4 = plains r5 = hills r6 = mountain	**Terrain inclination (n)** n1 = 0-1% flat n2 = 1-3% almost flat n3 = 3-8% gentle slopes n4 = 8-16 moderate slopes n5 =16-30% moderately steep slopes n6 > 30% stepp slopes
Ekological depth of soil (du) du1 = very shallow 0-15 cm du2 = shallow 15-30 cm du3 = medium deep 30-60 cm du4 = deep 60-120 cm du5 = very deep >120 cm **Climate (k)** - frost, fog	**Drinage (dr)** dr1 = very weakk dr2 = wea dr3 = incomplete dr4 = moderately good dr5 = good dr6 = slightly excessively dr7 = excessively
Soil acidity (a) a1 = very acid < 4,5 a2 = acid 4,6-5,5 a3 = weakly acid 5,6-6,5 a4 = neutral 6,6-7,2 a5 = basic > 7,2	**Humus content (hu), %** hu1 = very low < 1% hu2 = low 1-3 % hu3 = moderate 3-5 % hu4 = high 5-10% hu5 = very high > 10%
Actively lime (vp), % vp1 = little < 5 vp2 = moderately 5-15 vp3 = much >15	**Soil water regime** mv = periodic water deficiency in the soil vv = periodic excess water in the soil v = stagnant surface waters pv = flood waters V = high level of underground water
Supply of physiologically active phosphorus, mg P_2O_5/100 g of soil (fv) fv1 = poor < 12 fv2 = moderately 13-20 fv3 = good 21-30 fv4 = very good >30	**Supply of physiologically active potassium, mg K_2O/100 g of soil (kv)** kv1 = poor < 20 kv2 = moderately 21-35 kv3 = good 36-50 kv4 = very good >50

Results of the assessment and present land suitability

Table 2 shows the results of evaluation of the suitability of agricultural land Zelina vineyards for growing vines respecting the data of the soil properties, relief and climate. Based on identified limitations were determined mapping units of soils of different suitability for viticulture production (Figure 2): P-1 class (mapping unit 11) is very good suitability - area of 31,9 ha, P-2 class (mapping units 4, 6, 16, 21 , 22) moderate suitability - area of 3180,8 ha, P-3 classes (mapping units 5, 15, 19, 27) limited suitability - area of 1287,0 ha and N-2 class (mapping units 2, 8, 32, 35, 40) permanently unsuitable soils - area 508,5 ha.

Table 2. Suitability of agricultural land of Zelina vineyards for viticulture

Number	SOIL MAPPING UNITS (name and structure)	AREA ha	SUITABILITY CLASSES	THE DOMINANT LIMITATIONS
11	Eutric cambisol on marl Rendzina on marl and soft limestones	31,9	**P-1**	fv1, kv1, n4
4	Rendzina calcareous and vitisols on marl Rhegosol siliceous-calcareous Vertisol calcareous and noncalcareous, rigosols on marl	1422,2		n5, du3, vp2-3
6	Rendzina calcareous on marl Antropogenic rendzina and vitisols Rhegosol siliceous-calcareous Luvisol typical and pseudogleyic on loess	1011,1		n5, du3, vp2, hu2
16	Distric cambisol, luvic and pseudogleyic, on noncalcareous loess Luvisol typical and pseudogleyic on loams and sand Pseudogley on slope	213,1	**P-2**	k, fv1, kv1, n4
21	Luvisol on loess Rendzina on marl Rhegosol siliceous-calcareous, partly antropogenic soils	387,2		k, fv1, kv1, n4
22	Luvisol on loess, typical and pseudogleyic Pseudogley on slope	147,2		k, fv1, kv1, n4
5	Rendzina on marl and soft limestones, calcareous Calcocambisol on soft limestones and marl, typical and luvic Rhegosol siliceous-calcareous	633,4		n5, du2-3, vp3
15	Distric cambisol on shists, sandstones and phyllites, typical and luvic	26,5		a1, r6
19	Luvisol typical and akric on limeston Rendzina on soft limestones Eutric cambisol, vertic Vertisol on marl	69,7	**P-3**	r6, du3-4
27	Pseudogley on slopes and plain Distric cambisol, pseudogleyic	557,4		dr2, vv
2	Colluvial soil, calcareous, gleyic and nongleyic Eugley, calcareous and noncalcareous	346,6		r1, vv, k
8	Calcomelanosol Calcocambisol	45,7		du1, r6
32	Eugley, hypogleyic, mineral, calcareous Eugley, amphigleyic, mineral, calcareous	20,9	**N-2**	r4, k, vv
35	Eugley mineral Colluvial soil, gleyic Alluvial-colluvial soil	46,9		r4, k, vv
40	Eugley mineral, noncacareous and vertic Humofluvisol alluvial Pseudogley - gley	48,4		vv, k, r4

Recommendations for land reclamation

Soils without major limitations for viticulture (P-1 class) are eutric cambisol, and rendzina on marl and soft limestone up to 16% slope. The main measure for their reclamation is ameliorative fertilization. Moderately suitable soil (P-2 class) are rhegosol, rendzina, anthropogenic vertisol, distric cambisol, luvisol and pseudogley on slope up to 30% slope. The main measures for land reclamation are ameliorative fertilization, humization, deep tillage and contour tillage. Soils with larger limits for growing vines (P-3 classes) are rhegosol, rendzina, vertisol, eutric and distric cambisol, calcocambisol, luvisol and pseudogley up to 30% slope. The main measures for their regulation are ameliorative fertilization, humization, deep tillage and contour tillage, terracing, drainage, calcification. Temporarily unsuitable soils for growing grapes (N-1 class) does not have, because are all used for vineyards. Permanently unsuitable soils for viticulture (N-2 class) are colluvial soil gleyic and nongleyic, eugley, calcomelanosol, very shallow calcocambisol and

pseudogley-gley. In addition to climate and topography, the main limiting factor for viticulture are periodic excess water and shallow depth of soil.

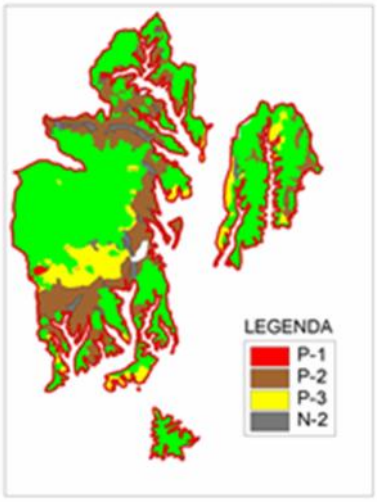


Figure 2.: Map of suitability of agricultural land of Zelina vineyards area for viticulture

Conclusions

Area of Zelina vineyard is pedological very heterogeneous. It was found 14 different types of soil, that differ mutually in their features. Total there 4499.7 ha of soils that have different degree of suitability to viticulture (class P-1 to P-3) and 508.5 ha unsuitable soils for viticulture (class N-2). The main limiting factors for the viniculture in this area are climate (fog and frost), relief (exposure and inclination) and the soil properties (ecological depth, drainage, moisture regime, soil reaction, humus content, active lime and supply of physiologically active nutrients). For a successful intensive viniculture is necessary to carry out the following hydro and/or agrotechnical measures, individually or in combination: drainage, deep tillage, calcification, humization, ameliorative fertilization. The relief can be corrected by contour tillage or terracing.

Bibliography

FAO (1976). A framework for land evaluation. Soil Bull. No. 32, FAO, Rome and ILRI, Wageningen. Publ. No. 22

Čmelik Z. et al. (2008). Regionalization of fruit growing and viticulture production in Zagreb County, Zagreb

Licul R., Premužic D. (1974.). Practical viticulture and enology, Nakladni zavod Znanje, Zagreb

OPK – Basic Soil Map of Croatia scale 1:50.000, sections Zagreb 2 and Ptuj 4 with corresponding expositors. Archive of the Soil Science Department, Faculty of Agriculture, Zagreb

Statistical Year Book of the Republic of Croatia (2012)

Škorić A. (1986). Genesis, development and taxonomy of soil. Faculty of agriculture, University of Zagreb

Vidaček Ž. (1976). Contribution to the application some classifications of soil/land in specific soil investigations on the example of the middle flow of the river Plitvica. Masters thesis. Faculty of agriculture, University of Zagreb