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VINEYARD MICROREGIONING IN KRAMOLIN (SUHINDOL AREA, BULGARIA) BY GIS

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Abstract

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Suhindol area is famous for its red wine grape varieties and is one of the approved areas for growing the variety Gamza.

GIS (Geographical Information Systems) were used for vineyard microregioning in this area. Climate parameters were identified by simulation optimization. An analysis of suitable soils for vineyard growing was made based on the existing soil map of the area.

The optimal conditions for the development of each vine variety were identified for each microregion, using preliminary defined limiting conditions. Three microregions were outlined for the production of good quality dry red wine and table grapes. Specific varieties and suitable vine rootstocks were defined, depending on the soil and climatic parameters.

Key words: Geographic Information System (GIS), regioning, microregioning, soils, climate, vine varieties, vine rootstocks

Introduction

The territory of Suhindol Municipality belongs to the Pre-Balkan physical and geographical region, characterized with low elevations. The average height above sea level is 300-400 m. The highest location within the boundaries of the municipality is Suhindol Peak with 482 m.a.s.l. The relief is complex, diverse and rugged – plain, hilly and semi-mountainous with prevalence of hilly terrains. The surrounding hills are composed of limestone of different composition, namely, compact, coquinoid to marlstone known as the Urgonian-Barremian type. The region is open to the north-east along the waterlogged basin of Rossitsa river. The lowest areas on this territory are along the Valley of Rossitsa River at 130-150 m.a.s.l. The high parts are located on karst limestone rocks while river deposits (alluvium) prevail in the terrace of Rossitsa River.

The continental climate is softened by "Alexander Stamboliiski" Dam, the semi-mountainous terrain, rugged relief and forest nature of the land.

The climate in this area is favorable for the

development of viticulture and growing high quality grapes.

It is characteristic for the Middle (or Hillock) region of the Danube undulating valley, which is part of the moderately continental European climatic area. It is characterized with a hot and comparatively dry summer and cold winter. The average annual air temperature in this area is 11°C. The coldest month is January with an average monthly temperature of +1.2°C and the warmest – July with an average of +21.8°C. The total air temperature during vegetation, measured by the Suhindol Meteorological Station, was 3700.3° and the length of the vegetation period – 218 days.

The annual precipitation was within 530 - 650 mm.

Sunlight period during vegetation was 1806 hours, of which 745 hours during active vegetation (April-June), 650 during grain filling (July-August) and 411 during grape ripening (September-October).

The area of Suhindol, which encompasses the territory of Suhindol, Kramolin, Koevtsi, Byala Cherkva and Byala Reka, belongs to the Northern viticultural region. Viticulture and wine production have been a major occupation in this area for centuries, therefore, it was among the first to be approved for the production of vine seedlings, viticulture and wine production. The first Cooperative of Viticulture and Enology was established here in 1909.

This is a large area and the study was carried out only on the territory of Kramolin village, known for one of the best Gamza wines.

A database for GIS was compiled for the purpose of viticultural microregioning that accounted for the complex influence of all important factors in the development of vine varieties as well as decreased and facilitated the process of microregioning (Arnaudova and Popov, 2010).

The project required to combine data on the geographic location and microclimatic characteristics of the studied area and present them as digital matrices. The suitable mathematical methods used as well as the relational languages for deriving and processing of the necessary information gave the opportunity to perform a multi-factorial analysis when selecting information (Arnaudova, 2008).

The purpose of the present project was to outline the microregions on the territory of Kramolin (Suhindol area) by means of GIS.

Material and Methods

The materials and methods of data processing were described in detail in previous publications (Arnaudova, 2008; Arnaudova and Popov, 2010) and included the following:

Preparation of materials and data for GIS

Graphic information

- digital cadastre map and map of reclaimed property in the studied area. The digital model format was ZEM, CAD. Information source: the Geodesy, Cartography and Cadastre Agency;
- digital large-scale soil map of the area 1:10 000. The soil maps reflected in detail the boundaries between the separate soil types within the frames of a single study. Information sources: The Soil Resources Agency and the Institute of Soil Science "Nikola Pushkarov";
- topographical maps in a scale 1:25 000 and digital elevation matrices (DEM);

Attributable information

• soil diversity – physical and chemical parameters;

• relief – inclination, exposure and slope length;

• biological requirements of grape varieties, grown for different purposes, to climate and soil.

Mathematical processing of data:

- regression analysis was used to derive mathematical models of the polynomial type

I and II. The insignificant coefficients were evaluated by Student's criterion (Mitkov and Minkov, 1993);

- the evaluation of total vegetation air temperature in °C allowed to derive the regression correlation between exposure and the calculated total vegetation air temperature in °C (Arnaudova, 2008).

Solving an optimization assignment

The mathematical formalization of the assignment to select a site for vine varieties was made under the following prerequisites:

- Identification of microclimate parameters of the studied territory in compliance with the conditions for yield formation and grape quality, depending on the relief and landscape characteristics;
- Complete evaluation of the effect of accompanying factors on site selection for the specific variety and identification of the direction of grape production: average annual temperature, minimum and maximum temperature by month and other factors, affecting grape growing and its quality;
- The identification of land boundaries with the suitable climate for a certain grape variety was followed by a study of the opportunity to ensure the optimum conditions for vineyard development. An analysis of suitable soils and microrelief was made, taking into consideration the limitations. This stage allowed for flexibility in site selection for a specific variety.

Application of GIS

- *Development of Triangulated Irregular Networks* (TIN) for relief surface, temperature distribution, slopes and exposure;
- *Combining layers* with different information allowed for applications, necessary for vine varieties' microregioning – map of reclaimed property, soil map and topographic map, etc.;
- Development of *thematic maps* that represented cross-sections of the common map by a certain type of graphic or attributable information.
- *Relational languages*

Results

Natural conditions

Climatic

The relief of the territory of Kramolin is diverse and complex – plain to hilly with 250-450 m.a.s.l. and inclinations of 1 to 12° with diverse exposure, most often to the south, north and east. The northern part, which has a higher above-sea level, has a plain to hilly relief with an inclination of 1 – 6°. The correlation (T_{sum} = 3813 - 0.308*H, R^2 = 0.94 at significance of α = 0.95 and validity limits of 60<H<450) showed that the distribution of the total air temperature (°C) during the vegetative period was within 3652-3742°, depending on the above-sea level and influence of exposure during its formation. The annual precipitation was 537-700 mm and the total precipitation for the period September-October – 25.7-29.9 mm.

Soil

Part of the territory of the Suhindol area is within the North Bulgarian forest steppe zone and part in the semi-mountainous zone. The prevailing soil diversity in this location is as follows: medium-leached Chernozems (Haplic Chernozems) (6362 da), low-clay Rendzins (Rendzic Leptosols) (3200 da), alluvial-deluvial and deluvial soils (Eutric Fluvisols) (1314 da), dark-grey forest soils (Luvic Faeozems) and light-grey forest soils (Leptic Leptosols) that occupy large areas but are not suitable for viticulture. The soils in the plough layer are heavy sandy-clay and light-clay by mechanical composition with physical clay content of 45 to 64 %.

Identification of viticultural microregions

The obtained climatic data and analysis of

Table 1
Characteristics of soil diversity in the first microregion by FAO (2006)

Description (in Teoharov, 2004, FAO 2006)	Clay in plough layer, %	pH in H_2O	Humus, %	Humus, cm	Strength, cm	Depth of $CaCO_3$	Inclination, º	Area, da
Calcaric Chernozems	59.1	8	2.5	40	70	from the surface	3-6	235.6
Haplic Chernozems	59.1	7	2.7	55	110	90	1-6	2017.7
Haplic Chernozems	57.4	6.8	2.7	35	80	60	1-6	3255.5
Haplic Chernozems	59.7	7	2.2	35	80	90	0-3	1089.3
								6598.1

Table 2
Characteristics of soil diversity in the second microregion by FAO (2006)

Description (Teoharov, 2004, FAO 2006)	Clay in plough layer, %	pH in H_2O	Humus, %	Humus, cm	Strength, cm	Depth of $CaCO_3$	Inclination, º	Area, da
Eutric Fluvisols	52.1	6.8	3.1	85	180	100	1-3	581.7
Eutric Fluvisols	55.3	7.2	3.2	125	160	90	1-3	732.3
								1314

Table 3
Characteristics of soil diversity in the third microregion by FAO (2006)

Description by FAO	Clay in plough layer, %	pH in H_2O	Humus, %	Humus, cm	Strength, cm	Depth of $CaCO_3$	Inclination, º	Area, da
Rendzic Leptosols	43	8	2.5	40	50	from the surface	6-12	3199.8

soils, participating in the evaluation of their suitability for growing different vine varieties (Tables 1, 2 and 3), allowed for the following limitation conditions:

• **red wines**

- total vegetation temperature – 3600-3900°C;
- annual precipitation – 600-700 mm;
- precipitation for September and October – 110 mm;
- mechanical composition of the plough layer with physical clay content of 30-45%;
- humus content in percentage 2-3 %;
- soil reaction according to pH – from slightly acid to slightly alkaline and alkaline;
- soil strength over 50 cm and effect of the soil-forming rock.

• **table grapes**

- total vegetation temperature – 3600-3900°C;
- annual precipitation – 600-700 mm;
- precipitation for September and October – 110 mm;
- mechanical composition of the plough layer

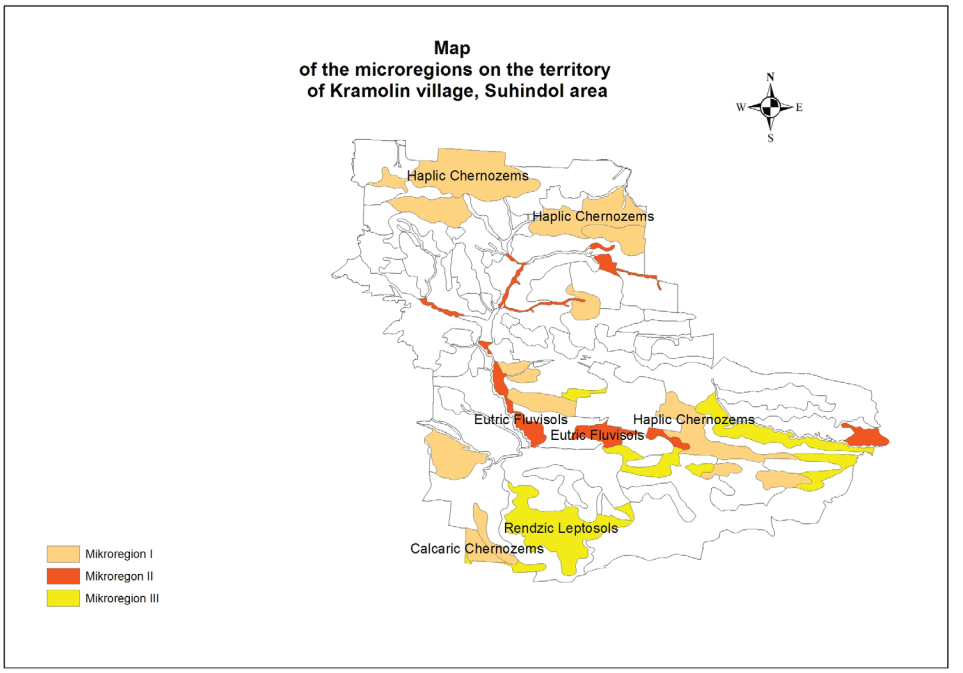

Fig. 1. Microregion map of the territory of Kramolin village

with physical clay content of 20-45 %;

- humus content in percentage – 3- 4 %;
- soil reaction according to pH – from slightly acid to slightly alkaline and alkaline;
- soil strength over 50 cm and effect of the soil-forming rock.

The climatic, soil and relief data for the Suhindol area lead to the identification of three microregions with different soil diversity and total vegetative temperature (Figure 1).

The first microregion – encompasses the plain and hilly territories in the central and northern part with an area of 6598.1 da.

Orography and above-sea level: The suitable terrains in this area have a small inclination and were 400-500 m.a.s.l.

Climatic conditions: The total air temperature sum during the vegetation period was 3660-3680°, the annual precipitation sum – 655-690 mm and the precipitation in September-October – 25.7-26.7 mm.

- *Inclination* – 1-3°, 3-6º;
- *Exposure* - diverse;
- *Subsoil water level* – 10 m;

Soil conditions – soil diversity is represented by medium-leached and carbonate Chernozems (Table 1). In terms of physical clay content they are light-clay (57-59%). Soil profile depth is 70-110 cm. Humus content is 2.2-2.7 % and humus horizon depth reaches 35-55 cm.

Suitable varieties and rootstocks: varieties – **red wine varieties** – Merlot, Pinot Noir, Bouquet, Evmolpia, Plovdiv Malaga; rootstocks – Chasselas x Berlandieri 41 B, Berlandieri x Riparia SO4; **table varieties** – Super Early Bolgar, Armira, Black Pearl, Pleven, Lyubimets, Mechta, Dunav, Ryahovo, Blyan, Breeze, Katya, Elitsa, Svilena, Lazur; rootstocks – Rupestris do Lot, Berlandieri x Riparia SO4.

The second microregion encompasses the southern slopes in the hilly parts of the territory with an area of 1314 da.

Orography and above-sea level: The terrains are located at 300-370 m.a.s.l.

Climatic conditions: The total air temperature during the vegetative period was 3680-3700°; annual precipitation was 615-655 mm and precipitation in September – October – 25.7-26.7 mm.

- *Inclination* – 1-3º;
- *Exposure* – diverse;
- *Subsoil water level* – 10 m;

Soil conditions – soil diversity comprises alluvial-deluvial and deluvial-meadow soils (Table 2). Soils are light-clay by physical clay content (52-55%). Soil profile depth is 160-180 cm. Humus content is 3.1-3.2 % and the depth of humus horizon reaches 85-125 cm.

Suitable varieties and rootstock: varieties – **table** – Bolgar, Italia, Muscat D'hamburg, Alphonse-lavallée, Palieri, Chaush, Queen of the Vineyard, Super Early Bolgar, Armira, Black Pearl, Pleven, Lyubimets, Mechta, Dunav, Ryahovo, Blyan, Breeze, Katya, Elitsa, Svilena and Lazur; rootstocks – Rupestris do Lot, Berlandieri x Riparia SO4.

The third microregion – encompasses the southern parts of the territory with an area of 3200 da.

Orography and above-sea level: This area has the lowest above-sea level – 200-300 m.

Climatic conditions: The total air temperature during vegetation was 3700-3740°, total annual precipitation – 537.1-615 mm and precipitation in September-October – 27.8-29.8 mm.

Inclination – 6-12º;

Exposure – southeast;

Subsoil water level – 10 m;

Soil conditions – soil diversity is represented by Rendzins (humus-carbonate) (Table 3). Soils are characterized as heavy sandy-clay by physical clay content (43 %). Soil profile depth is 50 cm. Humus content of soil is 2.5 % and humus horizon depth – up to 40 cm.

Suitable varieties and rootstocks: varieties – **red wine** – Gamza, Cabernet Sauvignon, Merlot, Pinot Noir, Bouquet, Evmolpia, Plovdiv Malaga, Ruen, Thracian Glory; rootstocks – Chasselas x Berlandieri 41 B, Ferkal; **table** – Bolgar, Italia, Muscat D'hamburg, Alphonse-lavallée, Palieri, Chaush, Super Early Bolgar, Armira, Black Pearl, Pleven, Lyubimets, Mechta, Dunav, Ryahovo, Blyan, Breeze, Katya, Elitsa, Svilena, Lazur; rootstocks – Ferkal, Berlandieri x Rupestris 110 Richter.

Discussion

The complex research on the climatic and soil conditions and factors on the territory of Kramolin (Suhindol area) resulted in the identification of a single temperature zone with a total temperature of 3652-3742° during vegetation that is suitable for growing both red wine and table vine varieties with different periods of grape ripening – from the earliest to the latest. The following parameters were established – average duration of the vegetative period (218 days) and average monthly temperature of the warmest month – July – (+21.8ºC) that were fully agreeable for the normal vine development and good grape ripening of the varieties, proposed to be grown in all three microregions.

The annual precipitation sum was within 537 – 700 mm, i.e. fully satisfactory for the water requirements of the wine vine varieties. The most common and suitable soil diversity was identified as well – medium-leached Chernozems (Haplic Chernozems) (6362 da), light-clay Rendzins (Rendzic Leptosols) (3200 da), alluvial-deluvial and deluvial soils (Eutric Fluvisols) (1314 da).

Chernozem soils (Haplic Chernozems, Calcaric Chernozems) in the First Microregion are light-clay (57.4-59.7% clay content), which is a prerequisite for heavier red wines. This requires a more specific vinification technology and longer maturity. The outlined microregions on the territory of Kramolin gave a full description of the soil and climatic conditions and a possibility to identify the viticultural

regions. The developed models will help farmers to decide how to use their land and select the suitable varieties.

The microregioning project on the territory of Kramolin in 1997 identified four microregions (Popov et al., 1997). The inspection of the terrain at that time lead to the study of the soil diversity, suitable for vineyards, including white wine varieties.

Due to the fact that the above-mentioned soil diversity (deluvial-coluvial soils – carbonate, medium and heavy sandy clay; Rendzins – medium sandy clay) were not mapped on the soil map, used for the present study, they were not included in the microregioning process.

Conclusion

The complex study of the climatic and soil conditions and factors lead to the optimized identification of the microclimatic parameters of the studied territory and complete evaluation of the effects of accompanying factors as well as the climatic zones and soils, most suitable for vineyards.

The application of GIS outlined the boundaries of three microregions on the territory of Kramolin (Suhindol area).

The data on the climate and soil diversity allow for the selection of suitable varieties for good quality dry red wines and table grapes to be grown in the three microregions. Suitable rootstocks were proposed based on the data about soil carbonate content.

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