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SPATIAL DISTRIBUTION ANALYSIS OF THE ECOLOGICAL FACTORS IN THE AVEREŞTI WINE GROWING CENTRE – HUŞI VINEYARD

L. IRIMIA[1*], C.V. PATRICHE[2]

[1]*University of Agricultural Sciences and Veterinary Medicine, Iaşi*
[2]*Romanian Academy, Iaşi Branch*

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ABSTRACT - The spatial distribution of the ecological factors explain the presence in viticultural areas of "terroirs", which are microzones with particular ecological features, favourable for wine growing, that influence the quality of grapes, as well as the authenticity of wines. The locations of these *terroirs* in the vineyards are usually known, but their ecological evaluation and territory delimiting are difficult to achieve. In this work, we proposed the use of the *Geographic Information System* (GIS), a tool of the informational technologies that allow carrying out complex analyses of the geographic areas. Using GIS, we calculated the spatial distribution of some climatic (temperature, solar radiation, insolation and rainfall) and topographic factors (altitude, slope and slope direction) for the Avereşti Wine Growing Centre and elaborated the thematic maps corresponding to the above-mentioned factors. Their analysis pointed out the presence in the Averesti wine growing area of many "terroirs" with particular ecological features, some of them being favourable for the production of quality white wines, while others, for table and sparkling wines.

Key words: vine, viticultural area, Geographic Information System, climatic maps

Rezumat - Analiza distribuției spațiale a factorilor ecologici în centrul viticol Avereşti – Podgoria Huşi. Distribuția spațială a factorilor ecologici explică existența, în cadrul arealelor viticole, a unităților de "terroir" cu caracteristici ecologice particulare, deosebit de favorabile pentru cultura viței de vie. Acestea îşi pun amprenta asupra calității strugurilor şi conferă vinurilor autenticitate şi tipicitate. Localizarea unităților de "terroir" din podgorii este, în general, cunoscută, însă evaluarea lor ecologică şi delimitarea teritorială sunt dificil de realizat. Prin lucrarea de față se propune folosirea, în acest scop, a Sistemului de Informații Geografice (SIG), instrument al tehnologiilor informaționale care permite analiza complexă a arealelor geografice. Cu ajutorul SIG, s-au calculat distribuția spațială a factorilor climatici (temperatura, radiația solară, insolația reală, precipitațiile) şi orografici (altitudinea, panta terenului, expoziția versanților) pentru centrul viticol Avereşti din podgoria Huşi şi s-au întocmit

* E-mail: liviuirimia2005@yahoo.fr

hărțile tematice corespunzătoare factorilor menționați. Analiza acestora a evidențiat existența mai multor unități de "terroir" cu caracteristici ecoclimatice particulare, unele dintre ele favorabile pentru producerea vinurilor albe de calitate, iar altele, mai sărace în resurse heliotermice, sunt doar pentru producerea vinurilor de masă şi a vinurilor materie primă pentru spumante.

Cuvinte cheie: viță de vie, areal viticol, Sisteme Informaționale Geografice, hărți climatice

INTRODUCTION

The overproduction and aggressive competition on wine market constrain the farmers to adopt some measures for increasing the economic efficiency of their vineyards. One of these measures is to limit vine areas to the most favourable zones that provide quality productions and confer authenticity to wines. Nowadays, the favourable conditions of vine areas are evaluated according to the condition of plantations and to the quality of grapes, which are relative criteria that may lead to wrong decisions. The option is the detailed ecological classification of vine areas, which can be achieved by means of the *Geographic Information System* (GIS), a tool of the informational technologies that, by combining graphics and information, allows the complex analysis of the geographical areas. The GIS processed information is represented by satellite images, orthophotoplans, topographic maps, climatic maps and any other kind of information used for analysing a geographic area (Patriche, 2003, ESRI 2009).

Because of the multiple analysis opportunities it offers, the *Geographic Information System* is used in viticulture for the management of vine patrimony, the ecological assessment of viticultural areas and for getting necessary information for practising the precision viticulture (Jones et al., 2004; Pythoud, 2004; Ingensand et al., 2008; Irimia et al., 2009; Martinovich et al., 2003; Dainelli et al., 2005)[*].

MATERIALS AND METHODS

In this study, the used satellite images presented the Averesti Hilltop and the adjacent sloping coasts, where the studied vine area is located. Based on these images, a digital elevation model (DEM) (SRTM – USGS, 2004) was created, which was subsequently re-sampled from the original 90 m to 10 m resolution, through the bilinear interpolation, for an accurate reproduction of the land area (USGS, 2004). DEM was used for showing the slopes and their exposure. The spatial distribution of air temperature (*average annual temperature and average temperature in the hottest month – July)* and the average annual rainfall were calculated using DEM, through the statistical regression analysis. The characteristics of the radiation

[*] **Irimia L., 2006 -** *Influența tăierilor cu elemente scurte de rod asupra potențialului vegetativ şi de producție la soiurile de viță de vie pentru struguri de vin, din centrul viticol Avereşti-podgoria Huşi (Influence of cuttings with short fruit bearing elements on the vegetative and production potential in wine grape varieties from the Avereşti Wine Growing Centre, Huşi Vineyard).* PhD Thesis, USAMV Iaşi

(global radiation and duration of solar shining) were obtained, too, by using DEM, at two stages: derivation of irradiation parameters, ignoring the nebulosity and their correction, using the solar shining (Patriche, 2003; Patriche, 2006).

The marked area, of 600 ha, represents the vine plantations grown in 2007. The studied area was divided in 8 microzones ("*terroirs"*) with particular ecological features: Buneşti, Armăşeni, Roşiori, Avereşti, Arsura, Pribeasca and Pîhneşti (*Figure 1*).

Fig.1 - The *terroirs* of the Avereşti Wine Growing Centre (satelite image):
1. Buneşti; 2. Pribeasca; 3. Arsura; 4. Pîhneşti; 5. Avereşti-Plopi; 6. Avereşti-Deal; 7. Roşiori; 8. Armăşeni

RESULTS AND DISCUSSION

Orographic factors. The vineyard is located in a hilly area, typical of the central part of the Moldavian Plateau. The Avereşti Hilltop is the relief element that dominates the entire relief of the area and is situated at the separation point of Crasna and Lohan hills from the Buneşti Hill.

Height. The vine plantations are located on the highest sector of the entire area. The planted area covers two distinctive subunits: a taller one, in the northern part and a lower one, in the southern part (*Figure 2*). At the northern limit of the planted area (Buneşti *Terroir*), the maximum elevation is of 338 m, while at the southern limit (Avereşti *Terroir*) it is of 257 m. The relief height in the planted area is not very significant (81 m), but it exerts a certain influence on the climate, knowing that the thermal gradient is 0.65°C for 100 m (Patriche, 2003).

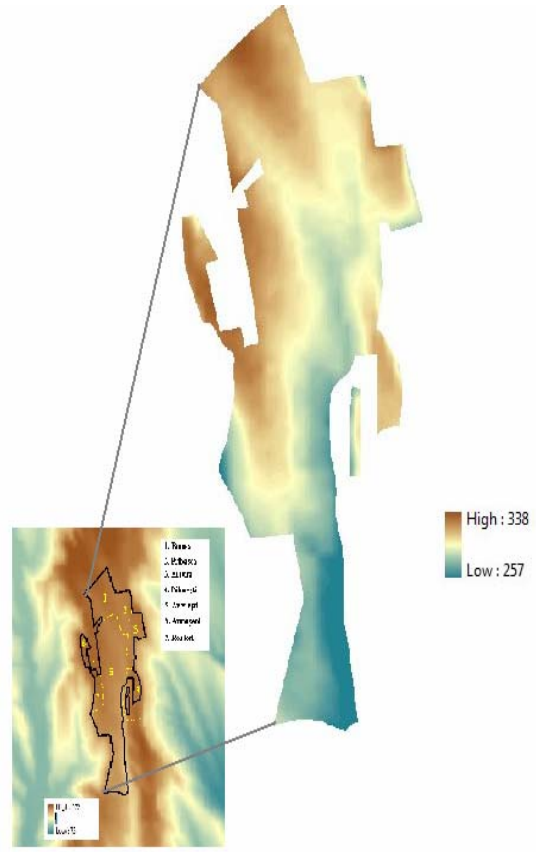

Fig. 2 - The elevation map, Avereşti Wine-Growing Centre

The slopes in the planted area are relatively uniform: 65% of the plantations are located on flat fields (0 – 5 % slope) and 32.1%, on moderate slopes (5–15% slope), which are the most favourable for wine-growing (*Figure 3*). At the eastern limit of the area (Arsura and Pîhneşti *terroirs*), the map pointed out sloping areas with high inclination of 20 – 25%, corresponding in the field to advanced erosion (*Figure 4*).

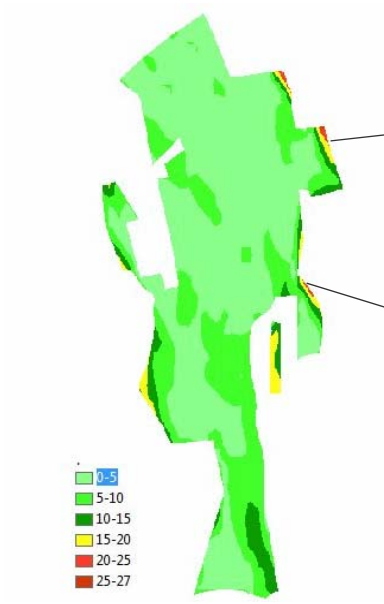

Fig. 3 -The slope map, Avereşti Wine Growing Centre

Fig. 4 - Advanced erosion corresponding to slope areas from the eastern limit

The slope exposure. For the highest part of the viticultural area, the slope exposure is favourable for wine growing: 9.9% of slopes from the planted area have southern exposure, 25.3% have south-eastern to south-western exposure and 42.82% have eastern exposure (*Figure 5*).

The most favourable areas for wine growing are the southern exposure areas, because they have recorded the highest solar radiation and insolation values. They are located on the Lohan Valley (Buneşti and Pribeasca *terroirs*). Increasing the image resolution, the slope exposure can be studied even for the plot area. Such an analysis was carried out for the Buneşti *terroir*, settled at the northern limit of the vine area (*Figure 6*).

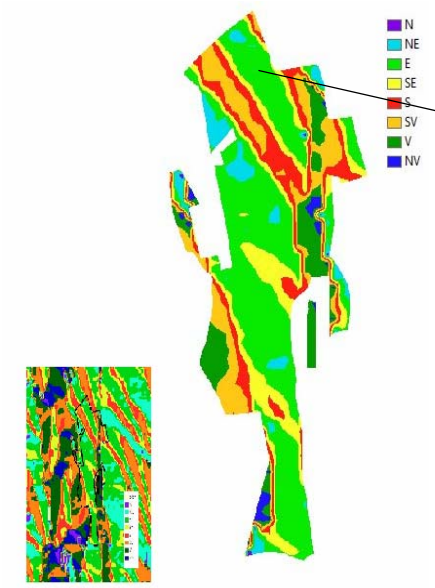

Fig. 5 - The slope direction map, Avereşti Wine Growing Centre

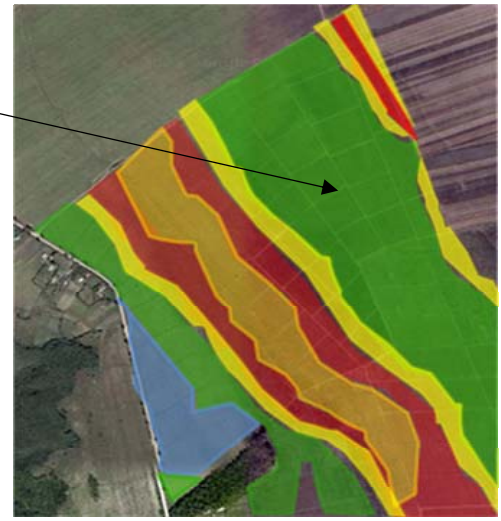

Fig. 6 – Slope exposure for Buneşti *terroir*

Variation of climatic factors. Determinations were carried out on *solar radiation, solar insolation, average annual temperature, average temperature of the hottest month (July) and annual rainfalls.* The maps representing the distribution of solar and thermal factors were elaborated using DEM and a combination of point data sets for estimating the annual climate variables (Patriche, 2006).

Average annual temperature. The temperature map (*Figure 7*) has shown that the Avereşti Wine Growing Centre is situated in the coldest part of the entire region, with average annual temperatures of +8.34…+8.83°C, which were below the minimum thermal threshold (9°C), for the efficient grape growing (Oşlobeanu et al., 1991; Patriche, 2006). The northern part of the area (Buneşti, Armăşeni and Roşiori *terroirs*) is colder that the southern one. The lower values of the average annual temperature explain the 10 – 14 day delay of the beginning of the growing season, comparatively with Bohotin and Huşi, the neighbouring wine growing centres. These values also explain the high acidity of the wines produced in this area, feature that allows their usage as raw matter for sparkling wines.

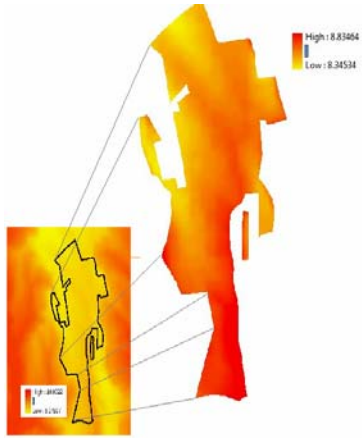

Fig.7 - The spatial distribution of the annual temperature, Avereşti Wine Growing Centre

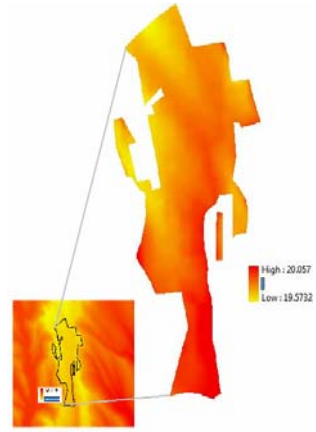

Fig. 8 - The spatial distribution of the hottest month temperature, Avereşti Wine Growing Centre

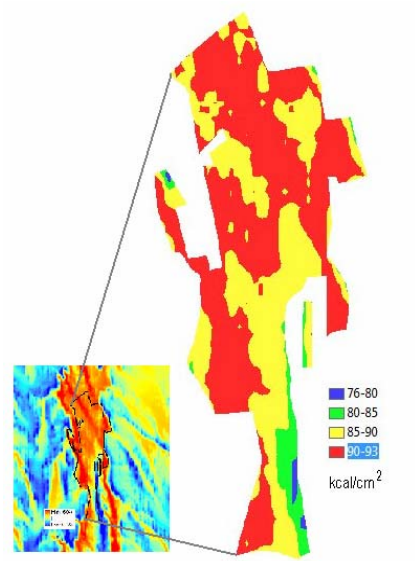

Fig.9 - The spatial distribution of solar radiation, Avereşti Wine Growing Centre

The average temperature of the hottest month (July), an important indicator of the ecological potential of the *terroir* for producing quality wines, varied between 19.5°C in the northern part of the plateau (Buneşti, Armăşeni, Roşiori and Arsura *terroirs*) and 20.05°C in the southern part (Avereşti Plopi *terroir*) (*Figure 8*). According to these values, we concluded that the southern half of the vine area had the ecological potential to produce white quality wines, while the northern colder half could produce only table wines and sparkling wines.

Solar radiation. The amount of solar radiation received by vine during the growing season (1 April-30 September) is shown in *Figure 9*. Vine plantations are located in the area with the highest values of solar radiation from the entire region, compensating the lack of thermal favourable conditions of the local climate. For 55.6% of the planted area, the solar radiation varies between 90 and 93 kcal/cm^2/year, under conditions of the lowest value for wine growing of 80 kcal/cm^2/year. For 39% of the area, the solar radiation is 85 - 90 kcal/cm^2/year.

The comparative study of exposure and solar radiation maps have shown that the abundant solar radiation was recorded on southern exposure slopes, in the northern part of the area (Buneşti, Armăşeni, Roşiori, Arsura and Pîhneşti *terroirs*) and at the southern limit (Avereşti-Plopi *terroirs*).

For checking the accuracy of data given by the radiation map, we carried out a particular analysis for the Avereşti-Plopi *terroir,* situated at the southern limit of the vine area. We noticed the followings (*Figure 10*):

- In the area with the greatest values of solar radiation, 90 – 93 kcal/cm^2, the density (vines/ha) of plantations was normal and, according to our field data, there was found high quality production every year;

- In the area with mean values of solar radiation, 85 – 90 kcal/cm^2, plantations had a high percentage of missing vines, which were destroyed by frost, and recent clearings were made;

- In the area with limitative (80 – 85 kcal/cm^2) and restrictive values of radiations (76 – 80 kcal/cm^2) for wine growing, vine plantations were cleared since the ’80, a few years after their establishment, because they were destroyed by frost.

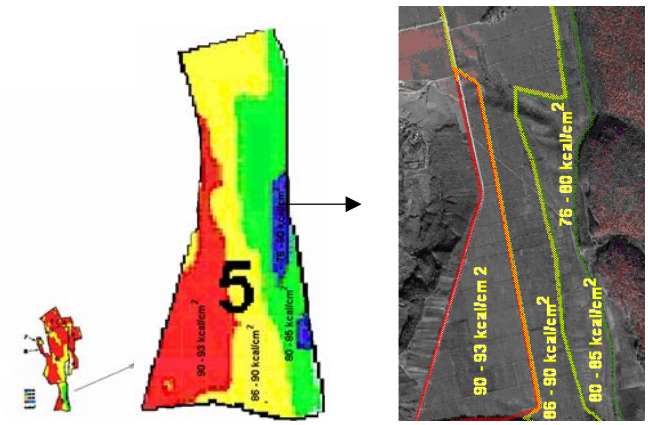

Fig. 10 - Comparison between the spatial distribution of solar radiation and present condition of vine plantations from the Avereşti – Plopi *terroir*

Solar insolation. For more than 89% of the planted area, the useful insolation (1 April - 30 September) varied between 1600 and 1773 hours/year, while the lowest demand for wine growing was 1200 hours/year. The highest values of useful insolation (1700-1773 hours/year) were recorded on the slopes with southern and eastern exposure of the Buneşti, Armăşeni, Roşiori, Arsura and Avereşti Plopi *terroirs* (*Figure 11*). The comparison with satellite images has shown that the microzones with lower values of insolation matched with the ones in which plantations were frequently affected by frosts.

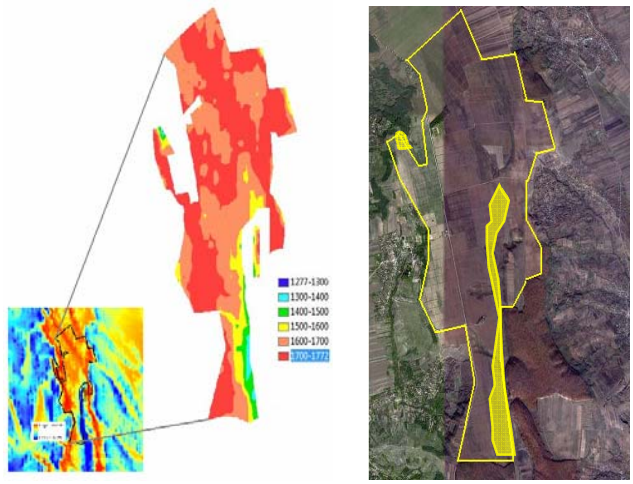

Fig. 11 - The spatial distribution of solar insolation (1 April – 30 September), Avereşti Wine Growing Centre

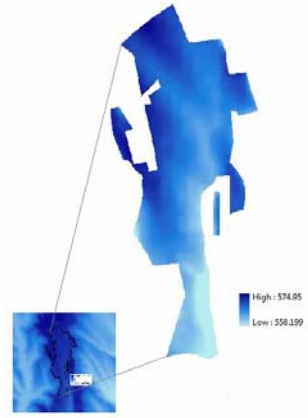

Fig. 12 - Rainfall map, Avereşti Wine Growing Centre

Average annual rainfalls vary between 558.1 and 574.9 mm/year and have a rather homogeneous distribution in the studied area (*Figure 12*). The highest values were recorded in the northern part of the area (Buneşti, Armăşeni, Roşiori and Arsura *terroirs*), while the lowest ones, in the southern part (Avereşti – Plopi *terroir*). In years lacking rainfall, water stress might appear in the sloping areas from the southern part of the vine area (Avereşti-Plopi *terroir*).

CONCLUSIONS

The Geographic Information System (GIS) allows an accurate study of the spatial distribution of ecological factors from vine planted areas.

The knowledge of the spatial distribution of ecological factors gives the necessary data for assessing the suitability of different viticultural areas (vineyards and wine growing centres) and even of small areas (farms and plots).

Data regarding the values and spatial distribution of thermal and solar factors (*temperature, solar*

radiation and insolation) are useful for selecting the grapevine varieties and locating them in the most suitable areas.

REFERENCES

ESRI, 2009 - *ESRI - GIS and Mapping Software, http://www.esri.com*

Jones G.V., Nelson P., Snead N., 2004 - *Modelling Viticultural Landscapes: A GIS Analysis of the Terroir Potential in the Umpqua Valley of Oregon.* GeoScience Canada, 31(4):167-178

Pythoud K., 2004 - *Etude des terroirs viticoles vaudois. 3. Modélisation des paramètres climatiques*, Revue suisse Vitic. Arboric. Hortic., *36*, 10-14

Ingensand J., Golay F., Caloz R., Pythoud K., 2008 - *Evaluating the usability of Web-GIS for wine-cultivation*, Cybergeo, European Journal of Geography

Irimia L.*, Patriche C.V., Țârdea C., 2009* *– Utilizarea GIS pentru studiul variației locale a factorilor ecologici din centrul viticol Avereşti – podgoria Huşi (GIS used for the study of local variation of ecological factors from the Avereşti Wine Growing Centre, Huşi Vineyard).* Lucrări Ştiiţifice UŞAMV Iaşi, Seria Horticultură, vol. 1 (52), 509-514

Martinovich L., Winkler P., Iván Gy., Doroszlai T., Kiss M., 2003 – *GIS support for the vineyard register of the Hungarian Ministry of Agriculture and Rural Development*, EFITA Conference, Debrecen, Hungary

Dainelli N., Conese C., Rapi B., Romani M., 2005 - *Integration of GIS and RS techniques for canopy variability evaluation in vineyards,* COST 718 – New technologies for agrometeorological model applications, CNR Research Area – Polo Scientifico di Sesto Fiorentino

Oşlobeanu M., Macici M., Magdalena Georgescu, Stoian V., 1991 – *Zonarea soiurilor de viță de vie în România (Vine variety zoning in Romania)*. Edit. Ceres, Bucureşti

Patriche C.V., 2003 – *Evaluarea biofizică şi tehnică a terenurilor agricole (Biophysical and technical evaluation of farming lands)*, Edit. Terra Nostra, Iaşi, 185 - 234

Patriche C.V., 2006 – *Modélisation de quelques variables agro-climatiques*, Actes du Colloque International: „Observation et analyse des territoires ruraux", Simona Niculescu (editor), Edit. Sedcom Libris, Iasi, 102-120

Țârdea C., Dejeu L., 1995 – *Viticultura (Wine Growing)*. Edit. Didactică şi Pedagogică, Bucureşti

USGS, 2004 – *Shuttle Radar Topography Mission*, 3 ArcSecond (90m), scene: SRTM_u2_n182e028, filled finished-B, Global Land Cover Facility (www.landcover.org), University of Maryland, College Park, Maryland