FRACTAL ANALYSIS AS AN USEFUL METHOD IN AMPELOGRAPHY

Servilia Oancea ¹

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Plant vegetation architecture can be quantified by a range of methods. Fractal analysis provides a novel approach for quantifying the geometric structure of individual plants, leaves and roots. The shape of the leave is the most important morphologic characteristic for Vitis. The leaves can be whole or divided into lobes delimited by sinuses; the different shapes and sizes of the sinuses determine the specific characteristics of the grape varieties. We studied three varieties from table grapes and three for wine grapes. Fractal dimension for the table grape varieties has smaller values than for the wine varieties.

1. INTRODUCTION

To better understand how crops intercept light, the complexity of plant structure needs to be characterized. The structure of plant vegetation and its geometric elements and objects combined with the total amount of leaf area determine the distribution of light within these plants. Plant vegetation architecture can be quantified by a range of methods. There exists no mathematical procedure to describe plant vegetation architecture completely, and improved methods are needed [1, 2]. Thus there is a need for a method that would allow for initial assessment of the complexity of a leaf and facilitate the selection of the best method of shape description of a given object. Contrary to regular shapes with integer dimensions in classical geometry, fractals are not regular and may have an integer or non-integer dimension. Fractal analysis provides a novel approach for quantifying the geometric structure of individual plants, leaves and roots. Fern leaf is the familiar example in this domain. A quantitative approach of the size and shape of fern leaves has never been formulated [3]. The study about fern leaves showed that the shapes and fronds have fractal properties and fern fronds differ from one species to another. Studies on the form of leaves for different kinds of plants were reported [4, 5]. Morphological leaf characters and quantitative measurements of anatomical elements of the leaf, i.e. angles, area, teeth number, petiole length, have been extensively utilized in ampelographic research. It is thus important to define good shape measures that can be effectively applied to leaf shapes, so they can be compared and analyzed by meaningful and objective criteria. The shape

¹ University of Agricultural Sciences and Veterinary Medicine, Iasi, Romania
of the leave is the most important morphologic characteristic for Vitis. The leaves can be whole or divided into lobes delimited by sinuses; the different shapes and sizes of the sinuses determine the specific characteristics of the grape varieties. A set of five categories of leaves - orbicular, reniform, cordiform, cuneiform and tronconic were determined based on some calculated ratios and codes [6]. Stefano Mancuso [7] determined the fractal dimension of the grapevine leaves belonging to different genotypes with the hope to be useful in the field of ampelography. His study was carried out with 12 genotypes collected from the grapevine. Mancuso used the Box-Counting Method to determine the fractal dimension of the leave contour from these genotypes and he found that these leaves have sly similarity and fractal dimensions of 1.204 for *Sangiovese Casentino* and 1.499 for *Piccolo Precoce*.

The objective of this study is to determine the fractal dimension for complex structures of table grape and wine varieties leaves.

2. MATERIALS AND METHODS

We studied three varieties of table grapes: Muscat Perla de Csaba, Aromat de Iasi and Milcov and three for wine: Cabernet Sauvignon Feteasca neagra and Tamaioasa romaneasca. The leaves of these genotypes were collected from the ampelographic collection of the Faculty of Horticulture from the University of Agricultural Sciences and Veterinary Medicine, Iasi. Afterwards they were pressed and scanned. In Figure 1 an image of a scanned leave from Muscat Perla deCsaba is given and in Figure 2 that of a leave from Cabernet Sauvignon prepared with Paint in order to determine the fractal dimension.

![Fig. 1: Muscat Perla de Csaba.](Image)

![Fig. 2: Cabernet Sauvignon.](Image)

To determine the fractal dimensions the modified box-counting method (BCM) was used. HarFA soft (Institute of Physical and Applied Chemistry, Brno University of Technology, Czech Republic) was utilized to study microscopic images of epidermal cell. In HarFA a modification of traditional Box Counting Method is used. With this modification three fractal dimensions are obtained, which characterize properties of black plane DB, black-white border of black object DBW (and this information is the most interesting) and properties of white background DW. The fractal dimension is the slope of the straight line „Black&White” [8].
3. RESULTS AND DISCUSSIONS

The fractal dimension for the leaf from figure 1 is given in figure 3 and for the leaf from figure 2 it is given in figure 4.

**Fig. 3:** Fractal dimension for Muscat Perla de Csaba.

**Fig. 4:** Fractal dimension for Cabernet Sauvignon.

Our results for the other leaves are given in the table 1. From this table we can see that the fractal dimension for the table grape varieties has smaller values than for the wine.
varieties. Student’s test allows us to observe a very significant difference between the fractal dimensions for the leaves of the table grape varieties and the leaves of the wine varieties (p=0.000699). The leaves of the table grape varieties don’t have accentuated lobes because these varieties usually come from Asia where the solar radiation is high and doesn’t necessarily have to reach the leaves that are the closest to the ground. The other three varieties, wine varieties, come from Europe where the solar radiation is lower, so the radiation needs to penetrate through the sinuses in order for the grapes to accumulate higher quantities of sugar.

Table 1: The fractal dimension for table grape leaves varieties.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Fractal dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscat Perla de Csaba</td>
<td>1,1322</td>
</tr>
<tr>
<td>Aromat de Iasi</td>
<td>1,1436</td>
</tr>
<tr>
<td>Milcov</td>
<td>1,1586</td>
</tr>
<tr>
<td>Cabernet Sauvignon</td>
<td>1,2498</td>
</tr>
<tr>
<td>Feteasca Neagra</td>
<td>1,2278</td>
</tr>
<tr>
<td>Tamaioasa Romaneasca</td>
<td>1,2454</td>
</tr>
</tbody>
</table>

4. CONCLUSION

Our results showed the differences between the two types of leaves – table grapes and wine grapes. The fractal dimension of the table grape varieties is significantly different from the one of the wine grape varieties. The wine grape leaves need to have a more complex shape in order for the solar radiation to penetrate deeper through the sinuses so that the fruit can accumulate higher quantities of sugar. Consequently, this study emphasizes the usefulness of fractal analysis in ampelography.

REFERENCES