FRACTAL DIMENSION OF LEAVES FROM THREE SPECIES OF *SOLANACEAE*

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Fractal analysis has been applied to describe various aspects connected with the complexity of plant morphology. In this work we determined the fractal dimension of leaves from three species of Solanaceae in order to characterize the structure/architecture of the these leaves. Samples for every species (pepper, tomato and eggplants) have been collected from the greenhouse of the University of Agricultural Sciences and Veterinary Medicine from Iasi. The leaves were pressed, scanned and processed with the Corel Photo-Paint 1 in order to use the HarFA soft to determine the fractal dimension. Our results showed that the fractal dimension of these vegetable leaves increases from pepper to tomato. But the fractal dimension is a fractional quantity and it is a direct measure of the relative degree of complexity of the leave. Tomato leaves have multiple sinuses and we suggested that this complexity is related to the necessity of light penetration through the plant. The eggplant leaves have a medium fractal dimension between pepper and tomatoes. This means that this structure assure eggplant needs of light and temperature. From this it follows that tomatoes need a higher complexity to develop by comparison with the other studied species.

Key words*: fractal dimension, self-similarity, leaves*.

Many pattern of nature are irregular and Euclidean geometry cannot describe their form. Thus, fractal analysis has received increasing attention as a number of studies have shown that fractal dimension could be useful for characterizing complex biological structures. Fractal geometry has been applied to describe various aspects connected with the complexity of plant morphology. Studies on the form for different kind of plants were reported in the literature [2], [5-8].

Fern leaf is the familiar example in this domain. A quantitative approach to the size and shape of fern leaves has never been formulated [1]. The study about fern leaves showed that the shapes and fronds have fractal properties and fern fronds differ from one species to another. We also used the fractal analysis to study the plant leaves for different species of trees [3]. The grapevine leaves have irregular shapes and structure and it is thus possible to employ the fractal analysis to characterize them [4].

The fractal dimension is a fractional quantity and it is a direct measure of the relative degree of complexity and roughness of the figure and it can never be greater than the Euclidian dimension of the space where the object is embedded.

The main objective of this study was to evaluate the fractal dimension of leaves from three species of *Solanaceae* in order to characterize the structure/architecture of these leaves.

MATERIAL AND METHOD

Samples for every species, tomatoes (*Lycopersicum esculentum*), pepper (*Capsicum annuum*) and eggplants (*Solanum melongena*) have been collected from the greenhouse of the University of Agricultural Sciences and Veterinary Medicine from Iasi. The leaves were pressed, scanned and processed with the Corel Photo-Paint 1 in order to use the HarFA soft to determine the fractal dimension.

In HarFA from the Institute of Physical and Applied Chemistry, Brno University of Technology, Czech Republic, the modified box-counting method (BCM) method was used. By this modification we obtain three fractal dimensions, which characterise 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" [9].

This method is, in our opinion, very easy to use and more accurate and can be applied in biology.

RESULTS AND DISCUSSION

The fractal dimensions for pepper, eggplant and tomato plants are given in *figures 1, 2 and 3*.

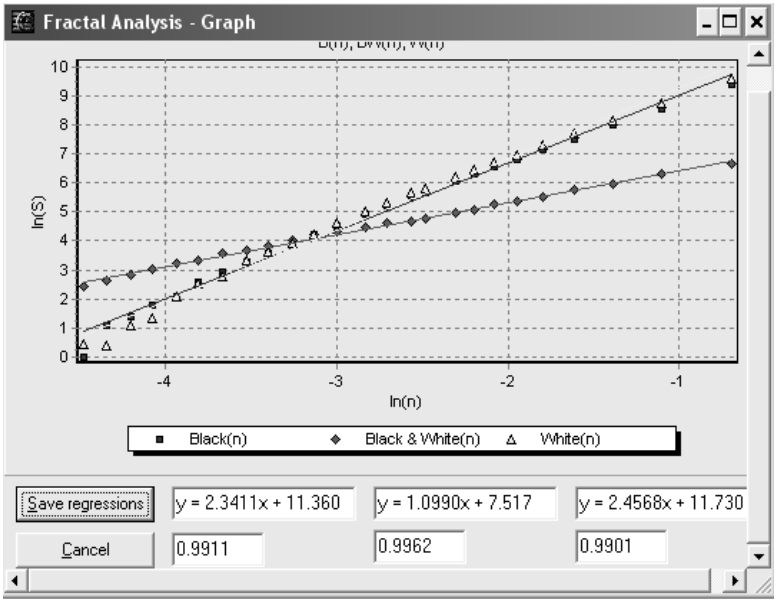

Figure 1 **Fractal dimension of pepper leave**

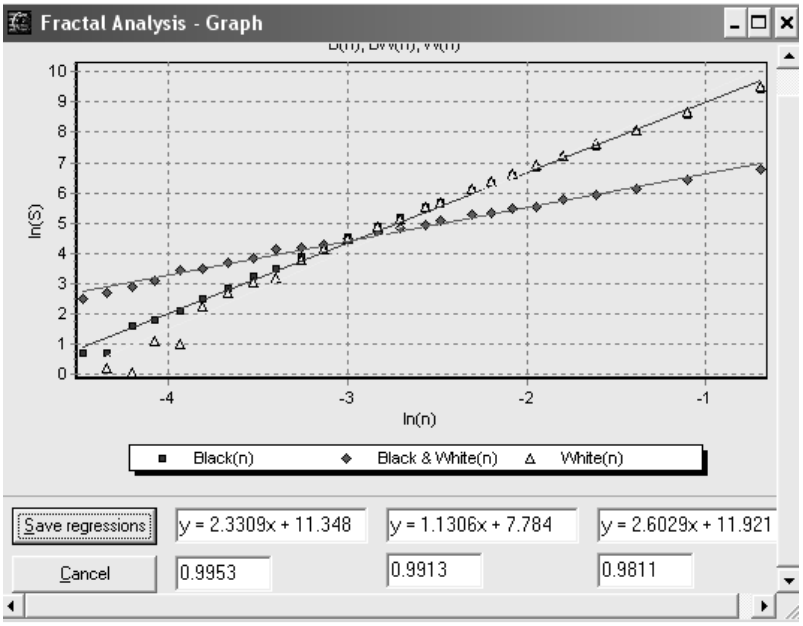

Figure 2 **Fractal dimension of eggplant leave**

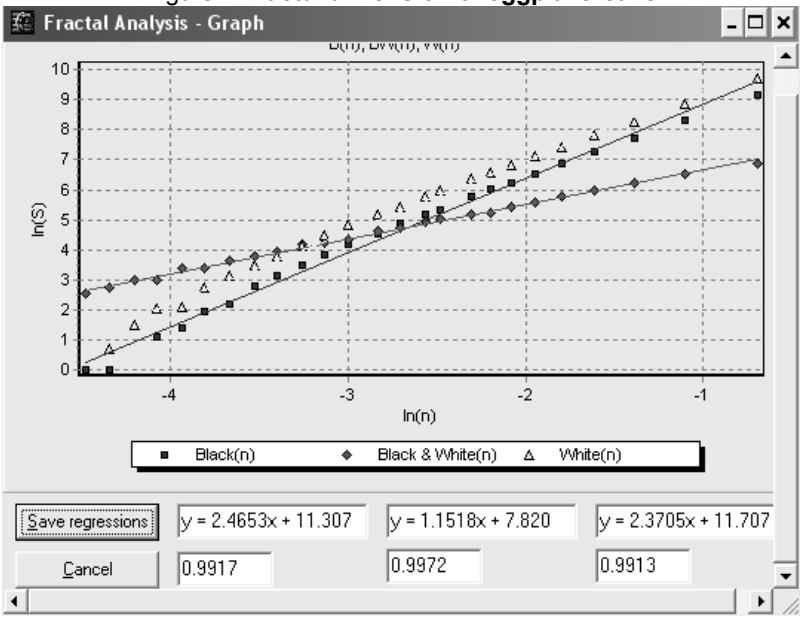

Figure 3 **Fractal dimension of tomato leave**

Our results showed that the fractal dimension increases from 1.099 for pepper leave to 1.1306 for eggplant leave and to 1.1518 and for tomato leave.

These values follow a straight line as *figure 4* shows.

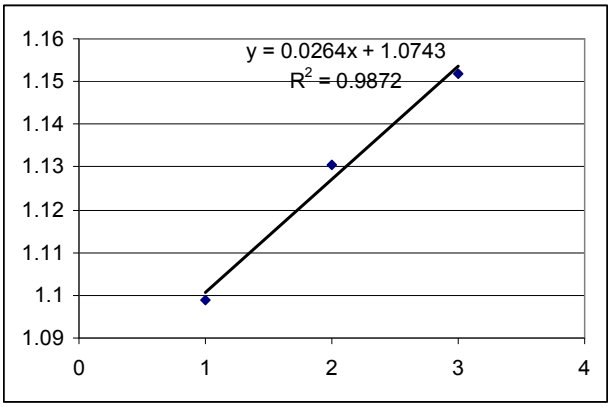

Figure 4 **The fractal dimension of the studied plant leaves**

CONCLUSIONS

In this paper we pointed out the importance of concept of fractal structure in characterization of plant leaves. Tomato leaves have multiple sinuses and we suggested that this complexity is related to the necessity of light penetration through the plant. The eggplant leaves have a medium fractal dimension between pepper and tomatoes. This means that this structure assures eggplant needs of light and temperature. From this it follows that tomatoes need a higher complexity to develop by comparison with the other studied species.

BIBLIOGRAPHY

1. Campbell, R.D., *1996 - Describing the shape of fern leaves: a fractal geometrical approach,* Acta Biotheoretica ,44, p. 119-126.
2. Corbit, J.D., Garbary, D.J., 1995 - *Fractal dimension as a quantitative measure of complexity in plant development,* Proceedings of the Royal Society of London Series b-Biological Sciences, 262 (1363), p. 1-6.
3. Creanga, I., Oancea, Servilia, Tudorie, M., Creanga D., Bara I., 2002 - *Oak leaves fractality*, Int. J.of Chaos Theory and Application, 7(1-2) , p. 85-90.
4. Mancuso, S., 1999 - *Fractal geometry-based image analysis of grapevine leaves using the box counting algorithm*, VITIS, 38 (3), p. 97-100.
5. Nonnenmacher, T.F., Losa, G.A., Weibel, E.R., 1993 - *Fractals in Biology and Medicine,* Boston, USA.
6. Oancea, Servilia, 2006 - *Analiza fractala. Aplicatii in stiintele naturii*, Editura PIM, Iaşi.
7. Oliveira, Plotze R., Falvo, M., Padua, J.G., Bernacci, L.C., Carneiro, Vieira L., Oliveira, G.C.X., Bruno, O.M., 2005 **-** *Leaf shape analysis using multiscale Minkowski fractal dimension, a new morphometric method; a study with Passiflora* (*Passifloraceae*), Canadian J. of Botany, 83 (3), p. 287-301.
8. Valdez-Cepeda, R.D., Blanco-Macias, F., *2002 - Fractal geometry of daughter young cladodes of Opuntia ficus-indica (cactaceae)*, Acta Horticulturae, 581, p. 169-175.
9. Zmeškal, O, Veselý, M, Nežádal, M, Buchníček, M., 2001 - *Fractal Analysis of Image Structures*, HarFA - Harmonic and Fractal Image Analysis, p. 3 – 5.