FRACTAL ANALYSIS OF CORN ROOT CHANGE UNDER ANIONIC CLAYS ACTION

ANALIZA FRACTALĂ A MODIFICĂRII RĂDĂCINII DE PORUMB SUB ACȚIUNEA ARGILELOR ANIONICE

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Abstract. *The fractal analysis is a useful method to characterize the structure of branching trees, root of plants, leaves, membrane surface of cells. The main objective of this study was to evaluate the impact of the treatment with LDH on growth of corn roots, using fractal analysis. In order to evaluate the change on root plants we determined the fractal dimension for untreated and treated corn plant roots. Seeds of corn were put into Petri dishes on double filter paper together with suspensions from anionic clay and they were kept here for five days. The germinated seeds were planted in soil where they continued to growth. After four weeks the root plants have been collected and the fractal analysis was performed. Our results demonstrated that the fractal structure of corn roots changed after the treatment with LDHs. We suggest that these anionic clays increased plant capacity to develop complex roots.*
Key words: fractal structure, root architecture, LDH

Rezumat. *Analiza fractală este o metoda uzuală de caracterizare a ramurilor copacilor, a ramificațiilor rădăcinilor plantelor, a frumzelor, a suprafaței membranelor celulare etc. Obiectivul principal al acestei lucrări este de a evalua impactul tratamentului cu LDH în creşterea rădăcinilor plantelor de porumb, folosind analiza fractala. Pentru a evalua modificările rădăcinilor plantelor, am determinat dimensiunea fractală a plantelor tratate şi a celor netratate. Semințele de porumb (Zea mais) au fost puse la germinat în sticle Petri pe hârtie de filtru dublă şi cu suspensie de argilă anionică unde au fost ținute cinci zile. Semințele germinate au fost plantate apoi în sol unde au continuat să crească. După patru saptamâni au fost colectate rădăcinile şi s-a efectuat analiza fractală. Rezultatele arată că rădăcinile plantelor s-au modificat după tratamentul cu LDH prin comparație cu martorul. Noi sugerăm că aceste argile anionice cresc capacitatea plantelor de a dezvolta rădăcini complexe.*
Cuvinte cheie: structura fractală, arhitectura rădăcinii, LDH

INTRODUCTION

The shape of objects has been described using Euclidean geometry. Many biological objects like leaves, roots, cells or sub cellular organelles display irregular shapes and discontinuous morphogenetic pattern in connection with their functional diversity and seem impossible to describe them rigorously or quantitatively using Euclidean geometry. G.B. West (West G.B. et al., 1999)

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showed that the existence of fractal-like network endows life with an additional fourth spatial dimension. Natural selection has tended to maximize both metabolic capacity, by maximizing the scaling of exchange surface areas, and internal efficiency, by minimizing the scaling of transport distances and times.

The complexity of the plant roots has been studied by many researchers but there are few results due the influence of the rizosphere heterogeneity (Akasaka Y. et al.,1998; Berntson G.M., 1994; Campbell R.D., 1996; Eshel A., 1998; Melniciuc Puică N. et al., 2006; Nielsen K.L. et al., 1997; Oancea S., 2006; Puzon K. A. M., 2005). Root growth is related to the consumption of water and nutrients of plants and it directly take the effect of environmental change. By exploring different spatial niches, plants with contrasting root architecture may reduce the extent of competition among neighboring root systems. Root complexity has been difficult to comprehend using simple Euclidean methods. The main objective of this study was to evaluate the impact of the treatment with LDH on growth of corn roots, using fractal analysis.

MATERIAL AND METHOD

To study the effect of anionic clays on root growth, two kinds of clays have been prepared and we sorted the following variants:

- 1 – control;
- 2 - MgAlLDH+sodium paranitrophenolate.

The experiments were conducted in the Biophysics Department Laboratory of the University of Agronomy from Iasi. As a biological material we used corn (*Zea mays*), the most widely used cereal in our country. 50 seeds of corn were put into Petri dishes on double filter paper together with 5 mL treatment solution (a suspension that contains 0.5g of clay and 50mL bidistilled water). Here the seeds were kept in dark at the optimal temperature (23^0C) for 5 days. After that the germinated seed were planted in soil in the our laboratory where they developed for two months. For analysis the plants were extracted from the soil, washed and the root were cut from the shoot. Then we make many photos of the root with a Canon camera.

Fig. 1 – The corn roots

These photos were prepared with the PHOTO-PAINT 1 in order to use the HarFA soft to determine the fractal dimension.

There are many other methods to determine the fractal dimension (Box Counting method, Yardstick method, Mass-Dimension Method, Perimeter–Area Method, Slit-Island Method, Asymptotic fractal formulas etc.).

In HarFA is used a modification of traditional Box Counting method. By this modification on 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" (Zmeškal O. et al., 2001)

RESULTS AND DISCUSSIONS

The diagrams of the fractal dimensions for the four roots from the figure 1 are given in figures 2-5

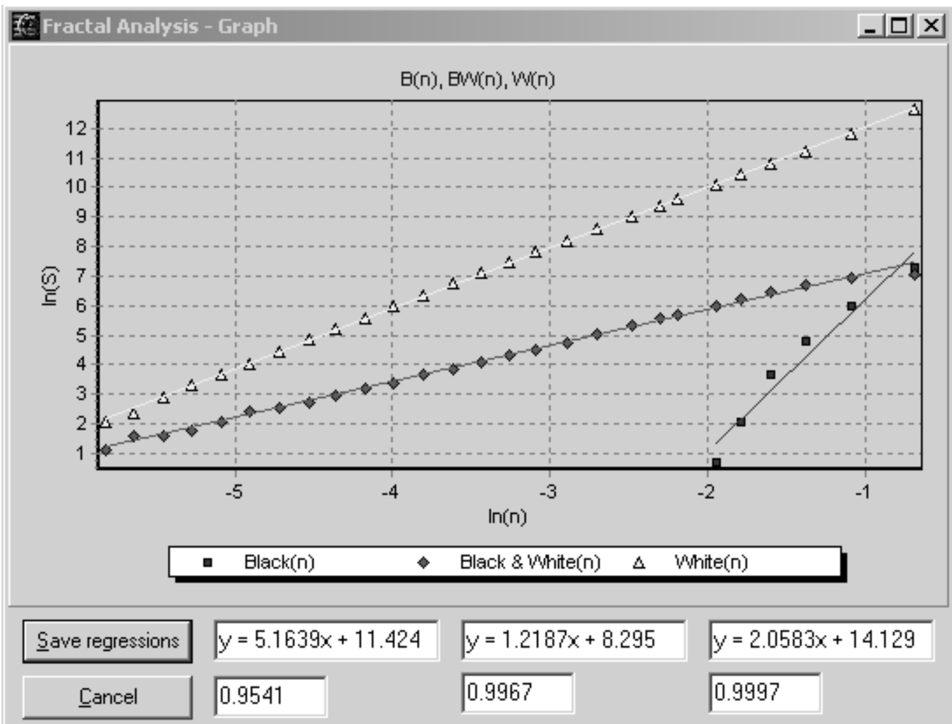

Fig. 2 – The fractal dimension for control root

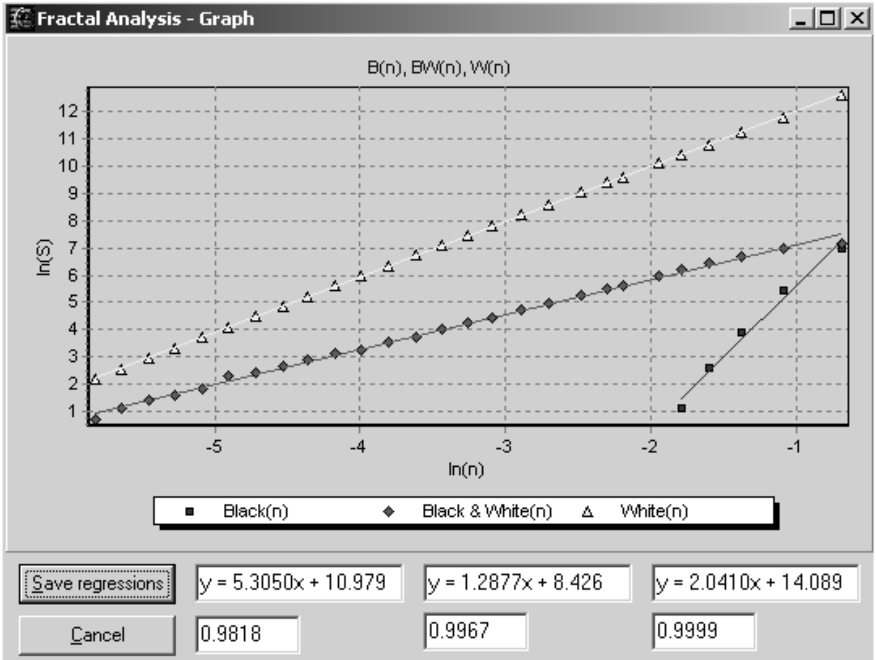

Fig. 3 – The fractal dimension for control root

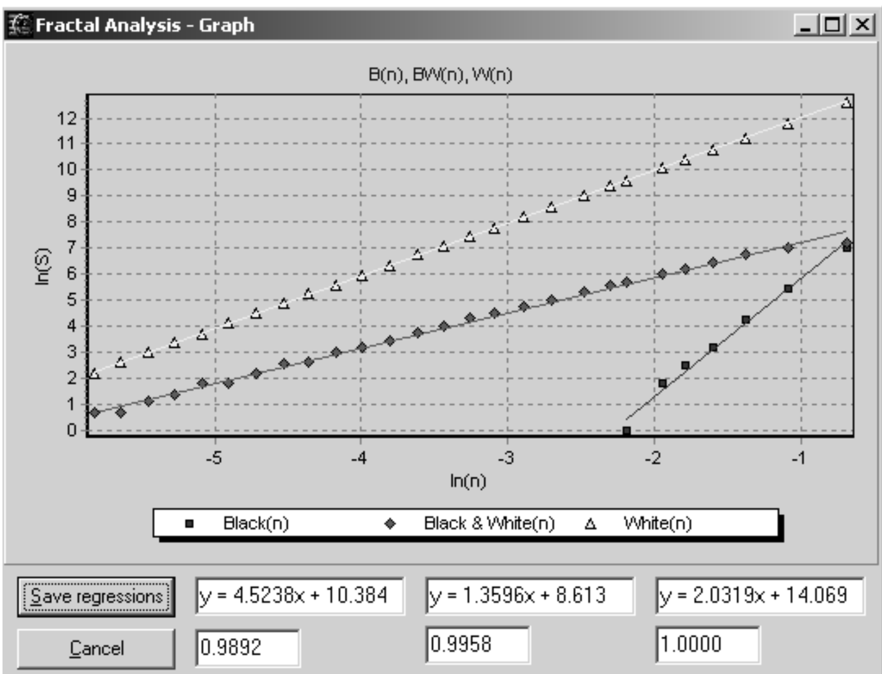

Fig. 4 – The fractal dimension for treated corn root

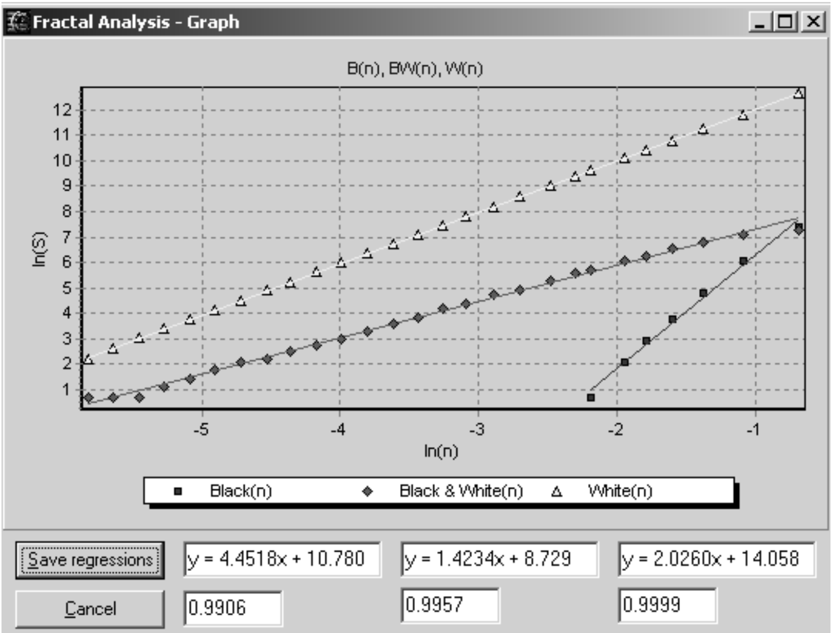

Fig. 5 – The fractal dimension for treated corn root

The above diagrams showed that the fractal dimension increases from 1.2187 (in the case of the control corn roots) to 1.4234 (in the case of the treatment with MgAlLDH+sodium paranitrophenolate).

For five roots of the control plants and the treated plants, the mean fractal dimensions are given in figure 6.

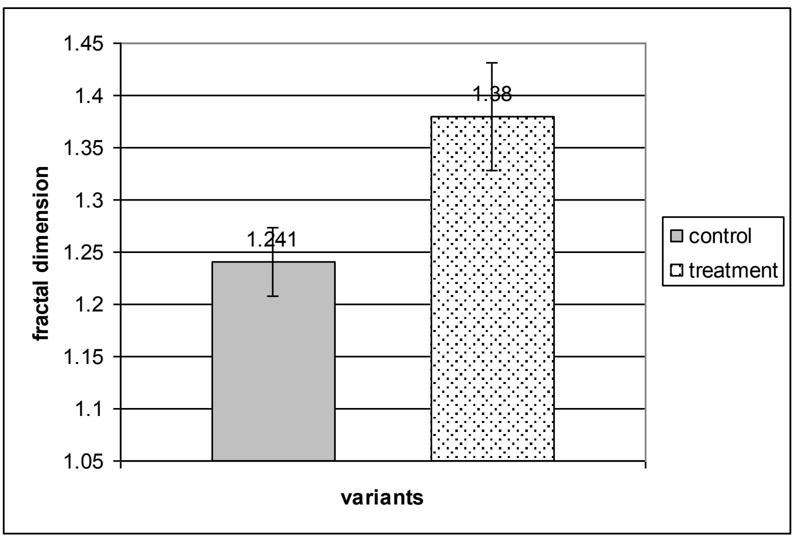

Fig.6 – The fractal dimension for corn root after anionic clay treatments. Error bars are confidence intervals (n=5) (Oancea S., 2007)

From figure 6 we can see that the errors bars don't overlap; this means a highly significant difference exists between fractal dimension from control and treated roots. These results showed that the treatment of the corn plant with this anionic clay increases the fractal dimension of the roots.

CONCLUSIONS

1. In this work we pointed out the importance of concept of fractal structure in physiological characterization of root architecture. Due the fact that the fractal dimension is a direct measure of the relative degree of complexity of the figure, we can conclude that this chemical compound influences the root architecture and this clay contributes to the increase of the root contribution to the water transport in plant and plant development.

2. We determined the planar fractal dimension (2D) of the roots, with the aid of the above mentioned photos, but for better results we must use the 3D fractal dimension and connect it with the morphological changes in root system.

REFERENCES

1. **Akasaka Y., Mii M., Daimon H., 1998 -** *Morphological alterations and root nodule formation in Agrobacterium rhizogenas-mediated transgenic hairy roots of peanut* (*Arachis hypogaea L.*). Annals of Botany, 81 (2), 355-362
2. **Berntson G.M., 1994** - *Root systems and fractals: how reliable are calculations of fractal dimensions*. Annals of Botany, 73 (3), 281-284
3. **Campbell R.D., 1996 -** *Describing the shape of fern leaves: a fractal geometrical approach.* Acta Biotheoretica 44, 119-126
4. **Eshel A., 1998 -** *On the fractal dimensions of a root system*. Plant Cell and Environment, 21 (2), 247-251
5. **Melniciuc Puică N., Oancea S., Dorohoi D.O, 2006** - *Fractal analysis as investigation method in old organic support.* Romanian Journal of Biophysics, 16(2), 135-140
6. **Nielsen K.L., Lynch J.P., Weiss H.N., 1997 -** *Fractal geometry of bean root systems: Correlations between spatial and fractal dimension*. American Journal of Botany, 84 (1), 26-33
7. **Oancea Servilia**, **2006 -** *Fractal analysis of the root architecture for tomato plants treated with cadmium.* Lucrari stiintifice, USAMV Iasi, *seria* Agronomie, vol. 49, 246-250
8. **Oancea Servilia, 2007** - *Ghid de prelucrare rapidă a datelor experimentale*. Editura Performantica, Iasi
9. **Puzon K. A. M**., **2005 -** *Mathematical Analysis of Root Growth in Gamma-irradiated Cashew (Anacardium occidentale L.) and Mangosteen (Garcinia mangostana L.) Using Fractals*. Nature and Science, 3(1), 59-64
10. **West G.B., Brown J.H., Enquist B.J., 1999 -** *The fourth dimension of life: fractal geometry and allometric scaling of organisms*. Science, 284(5420), 1999, 1677-9
11. **Zmeškal O., Veselý M., Nežádal M., Buchníček M., 2001 -** *Fractal Analysis of Image Structures*. HarFA - Harmonic and Fractal Image Analysis, 3 – 5