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Research Article

Evaluation of plant growth by using fractal analysis method

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Abstract

Sufficient evidence has been collected that alternative biological and ecological processes may occur in individual plant specimens that dwell in environmentally equivalent habitats. Environmental stress triggers individual, specimen-specific adaptive response. The article shows the ability of using fractal analysis to examine the growth and transpiration parameters of plants.

Keywords: Fractal analysis, plant transpiration, plant growth, plant biomass, neutral theory, morphological, physiological parameters.

Introduction

In recent years, numerous information has accumulated that alternative neutralistic biological and ecological processes can be realized in ecologically equivalent environmental conditions (Aleksandrova V.V et al., 2020; Aleksandrova V.V.et al., 2017; Aleksandrova V.V. et al., 2019; Volkov I.M. et al., 2018; Ivanov V.B. et al., 2016; Ivanov V.B. et al., 2021; Ivanov V.B. et al., 2021; Caniego F.J. et al., 2005; Mavletova C.M.V. et al., 2017; Mandelbrot B.B., 1982). One of the most generalized concept of the stochastic appearance of self-similar structures is fractal analysis (Andreson A.N. et al., 1995; Shirley B.W., 2002; Gelashvili D.B. et al., 2013; Levkova A.N. & Ivanov V.B. 2017; Martin M.A. et al., 2005; Usmanov I.Y. et al., 2019). There are data that the physiological and biochemical indicators of plants in natural habitats can be fractal in nature (Ivanov V.B. et al., 2018; Ivanov V.B. et al., 2019; Karagacheva T.V. et al., 2017; Usmanov I.Y. et al., 2017; Usmanov I.Y. et al., 2016; Usmanov I.Y. et al., 2020; Usmanov I.Y. et al., 2019; Usmanov I.Y. et al., 2019; Usmanov I.Y. et al., 2019; Usmanov I.Y. et al., 2020; Usmanov I.Y. et al., 2019; Scherbakov A.V. et al., 2021; Shcherbakov A.V. et al., 2021). However, it remains an open question whether the picture of the indices demonstrated by plants in stable laboratory conditions will have a fractal nature or plants in stable conditions will behave so similarly that they will make the principle of fractal logic inapplicable in relation to the dynamics of their indicators. The study of the mechanisms by which plants compensate for the deficiency of mineral nutrition elements seemed to us the most interesting from this point of view. Firstly, the deficiency of mineral nutrition elements is one of the most common stresses in plants in nature. It is known that on poor soils the content of some elements of mineral nutrition may be hundreds of times lower than what plants need. Secondly, in order to survive against the background of such a serious and ubiquitous stress on plants, it was necessary to create a perfect and, one might even say, sophisticated system of various alternative compensatory mechanisms. This system in plants consists of three parts connected by such complex metabolic relationships that one can speak of their conditional independence from each other. The first is the work of ion pumps in the absorption zone, primary and secondary active transport, closely related to the processes of root respiration, as well as the release of root exudates. The second is the variety of growth processes - an increase in the size of the root system and the area of its contact with the rhizosphere. And the third is the complicated system of regulation of the intensity of transpiration. That is why, in our opinion, this system of mechanisms for overcoming deficiency is very convenient for testing the applicability of the principles of neutralism and fractality to plants. At the same time, the main interest was in monitoring and comparing individual plant indicators.

Materials and Methods

The objects were 2 week *Zea mays sprouts*, which were grown on the Hoagland-Arnon nutrient medium. The first 6 days of the plant were grown on a full mixture and from 7 to 12 days the plants were transferred to a deficit of elements of mineral nutrition. In the course of the experiment, individual indicators of growth in length, mass, and intensity of transpiration were recorded. Fractal analysis was performed according to the method proposed by Gelashvili (Gelashvili D.B. et al., 2013).

Results and Discussion

It was found that the growth of biomass in all seedlings had a similar dynamics. This was reflected in the fact that between all individual indices of RGR (mg/mg) there were fixed significant correlation links. The correlation coefficient varied from 0.64 to 0.79. In this case, the remaining individual indices (increase in length and intensity of transpiration) had a relatively independent dynamics. In this case, the correlation relations between the parameters then appeared and disappeared. All this indicates that in the transition to a deficit, the achievement of the same magnitude of biomass increment by individual plants is possible by including various physiological mechanisms-growth or transpiration. Thus, plants really turned out to be able to achieve the same goal through the inclusion of all available alternative mechanisms in the most varied ratios, while the ratio in the intensity of the mechanisms launched by plants can change daily.

Such a complex nature of the picture of daily individual indicators of plants was the reason for checking it for compliance with indicators of fractal logic. As a result it was established that both before and after the transition to a deficit and the pattern of observed growth weight and transpiration indicators is an object of a fractal nature.

Conclusions

Thus, there are prerequisites to consider the growth and transpiration processes of plants, not from the standpoint of rigid determinism, but from the standpoint of neutralist concepts. Previously, different authors in various modifications of unified neutral theory showed a weak (statistically insignificant) dependence of various biological processes on environmental conditions. This justifies our attempt to apply neutralist approaches to the analysis of massives not only of data on secondary plant metabolism but also of events of the basic plant metabolism. Moreover, the degree of variability and neutrality of plant indicators, in our opinion, should be determined by indicators of their habitat. It is based on the following principle: any adaptation requires resources from the plant, therefore, under stress, plants launch as many defense mechanisms as they can afford in terms of their resource supplying. Therefore, the stronger the stress, the more unfavorable the living conditions of plants, the less plants will be able to demonstrate polyvariance in the work of individual alternative neutral survival mechanisms and the more they will become similar to each other. As a result, the number of correlations between the morphophysiological parameters of plants will increase significantly. In general, the picture of individual plant indicators will shift towards greater regularity, which can be successfully determined by fractal analysis. This method allows any array of individual indicators of various objects to be checked for self-similarity and for the presence of properties inherent in objects of a regular nature. The main idea is that the more stressed plants are, the more the picture of their individual indicators will demonstrate the properties of an object of a regular nature.

This method as a kind of mathematical analysis of plants has the following advantages. Firstly, it allows you to work with any morphological or physiological parameters of plants. Secondly, you can use both regularly recorded indicators (transpiration rate, concentration of metabolites) and indicators of a cumulative nature that form over the years (mass, linear dimensions). Thirdly, to evaluate the results, it does not matter, how much the morphological and physiological parameters are actually related to each other; only the general variability of individual values is important. The lower it is, the more stress plants experience. Fourth, this method is applicable to any plant species in any habitat. The data array for conducting a correct analysis is small - 10 plant indicators and 10 individual values of each of them. Fifth, this method, due to its features, can be widely used in applied ecology and ecophysiology. It is suitable both for screening the state of individual plant species in various habitats, and for long-term monitoring of the state of individual species in certain pre-selected areas. The latter is especially relevant for territories experiencing technogenic stress in connection with the economic activity of mankind.

References

Aleksandrova V.V., Ivanov V.B., Vojtova V.A. (2020). Assessment Of The Level Of Stress Load On The Plants Of The High Bogs Of Western Siberia By The Method Of Fractal Analysis. *Sib J Life Sci Agric* **12:** 71-78. https//doi.org/10.12731/2658-6649-2020-12-1-71-78

Aleksandrova V.V., Ivanov V.B., Vojtova V.A. (2020). Analysis of the correlation between the results of toxicological experiments and the pH level of the water. *Sib J Life Sci Agri* **12:** 71-78.

Aleksandrova V.V., Loginov D.N., Vojtova V.A. (2017). Correlation Analysis Of Migration Of Anthropogenic Pollutants In Bottom Sediments By The Method Of Chemical Analysis. *In world Sci Discov* **9:** 4-2.

Aleksandrova V.V., Levkova A.N., Ivanova A.V. (2019). Analysis And Forecast Of Migration Of Chemicals In Surface Water And Bottom Sediments Of Small Rivers. *Sib J Life Sci Agric* **11:** 12-20.

Andreson A.N., McBrantey A.B. (1995). Soil Aggregates as mass fractals. Australian J. Soil Research **33:** 757-772.

Shirley B.W.(2002). Biosynthesis of flavonoids and effects of stress. *Curr Opin Plant Biol* **5:** 218–223.

Volkov I.M., Ryakhin M.S., Belousov S.N., Aleksandrova V.V., Ivanov V.B. (2018). Ensuring environmental safety of project solution within a license holder's block through the best available technologies. *Oil Ind* **2:** 109–112. https//doi.org/10.24887/0028-2448-2018-2-109-112

Gelashvili D.B., Iudin D.I., Rosenberg G.S., Yakimov V.N., Solntsev L.A. (2013). Fractals and multifractals in bioecology. *Nizhny Novgorod Nizhny Novgorod Univ* 370.

Ivanov V.B., Scherbakov A.V. (2021). Assessment of the level of stress on plants of Western Siberian raised bogs by the method of fractal analysis. *Sib J Life Sci Agric* **13:** 4. https//doi.org/10.12731/2658-6649-2021-13-4-224-237.

Ivanov V.B., Fedorenko L.Z., Ivanova L.G. (2018). Assessment of seasonal dynamics of surface water quality according to the fertility criterion Ceriodaphnia affinis. *In World Sci Discov* **10:** 38-45.

Ivanov V.B., Aleksandrova V.V., Usmanov I.Y., Yumagulova E.R., Chibricov O.V., Ivanov V.B., Shcherbakov A.V. (2016) . Comparative evaluation of migrating anthropogenic impurities in ecosystem in the middle Ob region through bioindication and Chemical analysis *Vegetos Int J Plant Res* **29:** 43-86

Ivanov V.B., Shcherbakov A.V. (2021). Enzymes of flavonoid biosynthesis as a reason for the polyvariant nature of their accumulation. *Mod Phytomorphology* **15:** 47-52.

Ivanov V.B., Shcherbakov A.V., Usmanov I.Yu. (2021). Bifurcations and neutrality in the biosynthesis of plant flavonoids. *Mod Phytomorphology* **15:** 39-42.

Ivanov V.B., Shcherbakov A.V., Conhar I.G., Ivanova A.V., Usmanov I.Y. (2019). Using the principles of fractal analysis for description of plant flavonids metabolism. *Int J Adv Biotechnol Res* **10:** 456-464.

Karagacheva T.V., Ivanov V.B. (2017). Protease activity of microorganisms in soils polluted with produced waters. *Nizhnevartovsk NVGU Publ House*. 41-43.

Caniego F.J., Espejo R., Martin M.A., San Jose F. (2005). Multifractal scaling of soil spatial variability. *Ecol* Model **182:** 291-303.

Levkova A.N., Ivanov V.B. (2017). Ecological and chemical analysis of the state of bottom sediments of small rivers in the Nizhnevartovsk region in the zone of influence of the oil industry. *Nizhnevartovsk NVGU Publ House* 355-360.

Mavletova C. M.V., Shcherbakov A.V., Ivanov V.B., Yumagulova E.R., Usmanov I.Y. (2017). Pulsating Mosaic of Soil Parameters in the Southern Trans-Urals *Bull Nizhnevartovsk State Univ* **4:** 124-133.

Mandelbrot B.B. (1982). The fractal geometry of nature. New York. *Freeman* 468.

Martin M.A., Pachepsky Y.A., Perfect E. (2005). Scaling, fractals and diversity in soils and ecohidrology. *Ecol Model* **182:** 217-220.

Usmanov I.Y., Yumagulova E.R., Aleksandrova V.V., Ivanov S.P., Shcherbakov A.V., Ivanov V.B., Gonchar I.G. (2019). Fractal analysis of flavonoids in complex chemical compositions in extracts of Chamaedaphne calyculata (L.) Moench (ericaceae) in oligotrophic swamps of Western Siberia. *Mod Phytomorphology* **13:** 35-40.

Usmanov I.Y., Yumagulova E.R., Ivanov V.B., Aleksandrova V.V., Ivanov N.A., Schaichmetova R.I., Scherbakov A.V., Mavletova-Chistuakova M.V. (2017). Physiological Barriers for Adventitious Species Invasion in Oligotroph Ecosystems of the Middle Ob Area. *Vegetos Int J Plant Res* **30:** 81-85. https//doi.org/10.5958/2229-4473.2017.00195.1

Usmanov I.Y., Yumagulova E.R., Ovechkina E.S., Ivanov V.B., Aleksandrova V.V., Ivanov N.A., Shcherbakov A.B. (2016). Fractal Analysis of MorphoPhysiological Parameters of Oxycoccus Palustris Pers in Oligotrophic Swamps of Western Siberia. *Vegetos Int J Plant Res* **29:** 1-3. https//doi.org/10.5958/2229-4473.2016.00002.1

Usmanov I.Y., Shcherbakov A.V., Ivanov V., Ivanov S., Gonchar I. (2020). Use of fractal analysis principles when describing flavonoids variety of the south trans-urals plants. *Mod Phytomorphology* **14:** 13-19.

Usmanov I.Y., Ivanov V.B., Abdrakhimova G.S., Shcherbakov A.V., Yumagulova E.R., Aleksandrova V.V. (2019). Fractal Analysis of Flavonoids in Composition HPLC-Fingerprint Extracts of Oxycoccus palustris Pers. (*ERICACEAE*) in Oligotrophic Swamps of Western Siberia. *Int J Adv Biotechnol Res* **10:** 369-376.

Usmanov I.Y., Shcherbakov A.V., Yumagulova E.R., Ivanov V.B. (2019). Signs of neutrality in the formation of spectra of flavonoids in natural cenopopulations. In the collection: Ecology and evolution: new horizons proceedings of the International Symposium dedicated to the 100th anniversary of Academician S.S. Schwartz. Institute of Plant and Animal Ecology UrO RAN 288-289.

Usmanov I.Y., Yumagulova E.R., Aleksandrova V.V., Gonchar I.G., Shcherbakov A.V., Ivanov V.B. (2019). Complexes of Chamaedaphne calyculata (L.) Moench flavonoids in oligotrophic bogs of the Middle Ob River. Bull. Nizhnevartovsk State Univ **2:** 59-71.

Usmanov I.Y., Ivanov V., Shcherbakov A. (2020). System for ecological regulation of the biosynthesis of flavonoids as a strange attractor. *Mod phytomorphology* **14:** 77-84.

Usmanov I.Yu., Shcherbakov A.V., Ivanov V.B., Yumagulova E.R. (2019). Fractal analysis of flavonoid biosynthesis system. *Kazan Kazan Univ* Press 446.

Scherbakov A.V., Ivanov V.B., Ivanova A.V., Usmanov I.Y. (2021). The Equifinal Achievement of the Total Antioxidant Activity of Flavonoids by Plants in Various Habitats. *IOP Conf Ser Earth Environ* Sci **670.** https//doi.org/10.1088/1755-1315/670/1/012018

Shcherbakov A.V., Aleksandrova V.V., Egorova V.I., Ivanov V.B. (2021). A program for assessing the level of stress load on plants of raised bogs in Western Siberia by the method of fractal analysis. *Mod Phytomorphology* **15:** 86-91.