PLANT-SOIL INTERRELATIONSHIP, FACTOR OF EVOLUTION FOR BACTERIAL POPULATIONS

MARINEL PAŞCA [1], LUMINIŢA COJOCARIU [1], MARINEL HORABLAGA [1], DESPINA-MARIA BORDEAN [1], MĂRIOARA NICOLETA FILIMON [2], ROXANA POPESCU [3], AURUŢA DARLEA [1], AURICA BREICA BOROZAN [1]

1 Banat`s University of Agricultural Sciences and Veterinary Medicine
300645 Timisoara, 119 Aradului Way
2 West University of Timisoara, 300223 Timisoara, 4 Blvd. V. Parvan, Romania;
3 „Victor Babes" University of Medicine and Pharmacy
300041 Timisoara, 2 Eftimie Murgu Plaza
borozan_a@yahoo.com

ABSTRACT
The rhizosphere is influenced by the region, soil and plant roots. The area that is not influenced by plant roots has been named edaphosphere. Plant roots release a wide range of compounds in the rhizosphere, which create unique micro-environments for the microorganisms present in the soil. By its root exudates, species *Vicia sativa* contributes to an increase in the bacterial density (fact proven by comparison with the control variant), to the improvement of the fertility of the soil (moderately gleyic eutric cambisol) on which it is cultivated and to plant growth. Even there are similarities between the rhizospheric area (culture medium: soil extract), control variants, and respectively edaphosphere (culture medium: soil extract) and rhizospherical bacteria isolated on Topping medium, small differences have been noticed

Keywords: root exudates, *Vicia sativa*, rhizosphere, edaphosphere, Topping nutritive environment, soil extract

INTRODUCTION

It was discovered over a century ago that, through their roots, plants can change their environment, creating the so-called rhizosphere effect.

Although roots can release large quantities of inorganic C, which can affect directly the biogeochemistry of the soil (CHENG ET AL., 1993; HINSINGER ET AL., 2001; HINSINGER ET AL., 2009), they also produce organic carbon, which leads to dramatic changes in the biology of soils but also in the physical and chemical characteristics of soils. In a larger sense, this organic C released is often called rhizodeposit (JONES ET AL., 2004).

Root secretions contain: reductive sugars, amino acids, amides, organic acids and phenolic acids (CURL AND TRUELOVE, 1986; GRAYSTONE ET AL, 1996).

The organic acids identified in the rhizosphere play an important part in the formation of the bacterial population in the soil, therefore they can have a significant impact on plant growth (SHENGJING ET AL., 2011).

The rhizosphere represents a unique biological niche of the soil, being under direct influence of the plant roots, with abundant saprophytic microflora, which decomposes organic matter, lignocelluloses and chitin (LECHEVALIER, 1989B; LYNCH, 1990 A; LYNCH, 1990 B; LYNCH AND WHIPPS, 1991).

The rhizosphere effect is large in the case of the bacterial segment, as compared to the impact on actinomycetes and fungi. Gram negative non-sporogenous species of bacteria dominate the rhizosphere. The number of bacteria in the rhizosphere may vary between 10^8-10^9/g soil. The most frequently met genera are *Arthrobacter*, *Pseudomonas*, *Agrobacterium, Azotobacter, Mycobacterium, Alcaligenes, Micrococcus, Flavobacter, Alcaligenes, Cellulomonas* and others.

Generally, microbiological activities are positively correlated to the concentration of soluble carbon produced by the root and microbial micromass. The potential of microorganisms to react to plant root secretions suggest a certain degree of co-evolution between the plants and the microorganisms that inhabit the rhizosphere (NANNIPIERI ET AL., 2008).

According to GARBEVA ET AL. (2004), the bacteria influenced by the root plants are selected directly in relation to the dimension and distribution of the particles of a certain soil, the pH, the physical and chemical characteristics, by creating a specific habitat.

The same authors present another way in which the bacteria are selected, namely indirectly, by the exudates of the macroflora represented by plant roots. Plant roots have a strong influence on the availability of C and N through the exudates in the rhizosphere (KORANDA ET AL., 2011).

For the purpose of this paper, the studies have been focused on the bacterial populations in the edaphosphere and rhizosphere, where the direct influence of root exudates of *Vicia sativa* can be seen, but also the impact of the pH, humidity and K in the soil. The research is still in progress, in order for us to observe the benefits that can be obtained from including the legume *Vicia sativa* in rotation.

MATERIAL AND METHOD

The soil under study is moderately gleyic eutric cambisol found in Banat area and cultivated with a vetch species (*Vicia sativa*). The depth for sampling soil was between 0 and 20 cm.

In order to observe the density of the bacterial populations in the rhizosphere we harvested 10 vetch plants, together with the corresponding soil on a distance of 2.5 mm. Later we took 10 soil samples from the edaphosphere, as well as a control variant.

The samples were processed in the laboratory. We isolated the bacteria using the method of suspensions and dilutions, on two culture media: soil extract and Topping. Bacterial cultures were incubated at a temperature of 28 ºC for 48 hours (STEFANIC, 2006).

Statistical analysis

The data were statistically analyzed using a statistical package MVSP 3.1.

We are grateful to WEBOMATIK RO SRL for permission to use statistical package MVSP 3.1. and technical assistance.

RESULTS AND DISCUSSIONS

The experimental values obtained after 48 hours of incubation are graphically represented below in *Figure 1*. Significant increases of CFU /g soil, as compared to the control variant, can be noticed especially in the edaphosphere, on both media, followed by the rhizosphere of *Vicia sativa* species (*Figure 1*). An important factor that influences the bacterial population in the rhizosphere is soil type (KOWALCHUK ET AL., 2000). Microbial populations in the rhizosphere benefit from a continuous source of carbon produced by the root of the plant, the result being the increase in the density of the microbial population and a distinct structure of the same population (BOWEN AND ROVIRA, 1991).

The exudates produced by the roots of plants select and influence the development of bacteria and fungi in their vicinity (GRAYSTONE ET AL., 1996; YANG AND CROWLEY, 2000; WHIPPS, 2001).

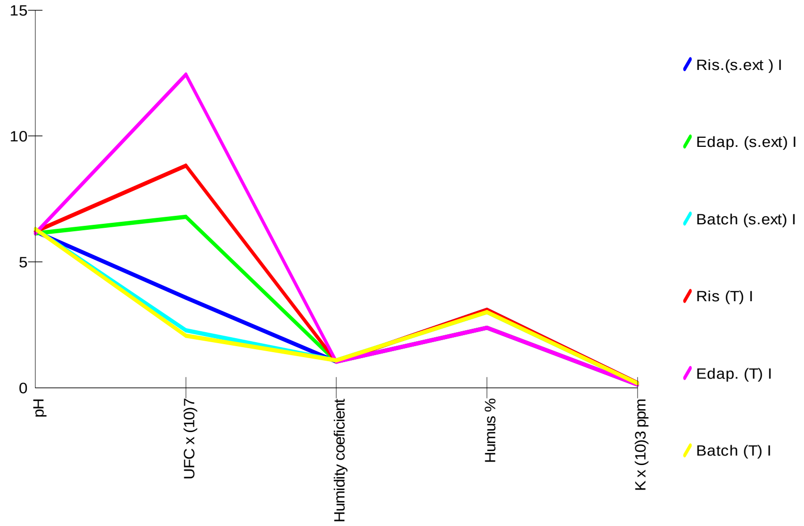

Figure 1. CFU/g soil in relation to some factors present in the biotope

Ris (s.ext) I – rhizosphere (soil extract); Edap (s.ext) I – edaphosphere (soil extract); Batch (s.ext) I – Batch (soil extract); Ris (T) I – rhizosphere (Topping); Edap (T) I – edaphosphere (Topping); Batch (Topping) I – Batch (Topping);

The marking of this increase is realized by a descending plateau in the case of the bacterial segment on soil extract from the rhizosphere (*Figure 2*).

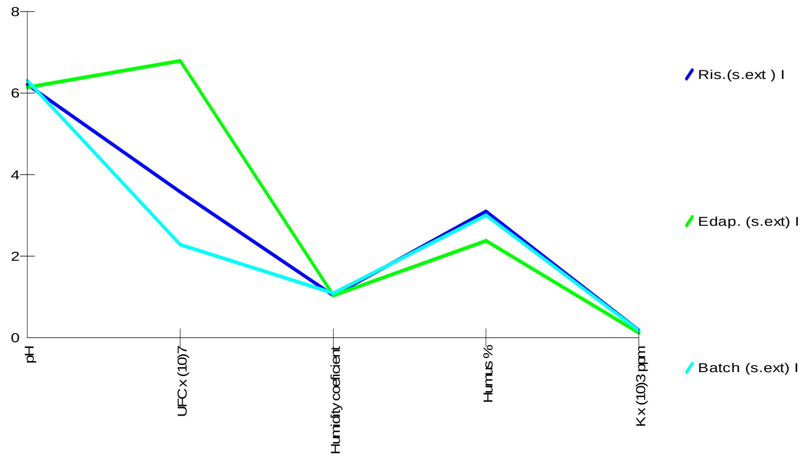

Figure 2. CFU /g soil on soil extract

Of the two culture media used in our research, Topping gave better results. Humus has a limited impact on bacteria in rhizosphere, edaphosphere and the control variant, as shown by our studies, in both types of culture media. Although soil humidity has a direct impact on microbial activity and the degradation capacity of organic matter, it is not clear whether the presence of plants modifies these effects by rhizosphere processes (FEIKE AND WEIXIN, 2007).

The present research has found that the influence of humidity and potassium is insignificant.

By cluster analysis we found that the edaphospheric area (Topping culture medium) differs significantly from the other areas. There is similarity between the rhizospheric area (culture medium: soil extract) and the control variants, and respectively edaphosphere (culture medium: soil extract) and rhizospherical bacteria isolated on Topping medium, although small differences have been noticed even in these situations (*Figure 3*).

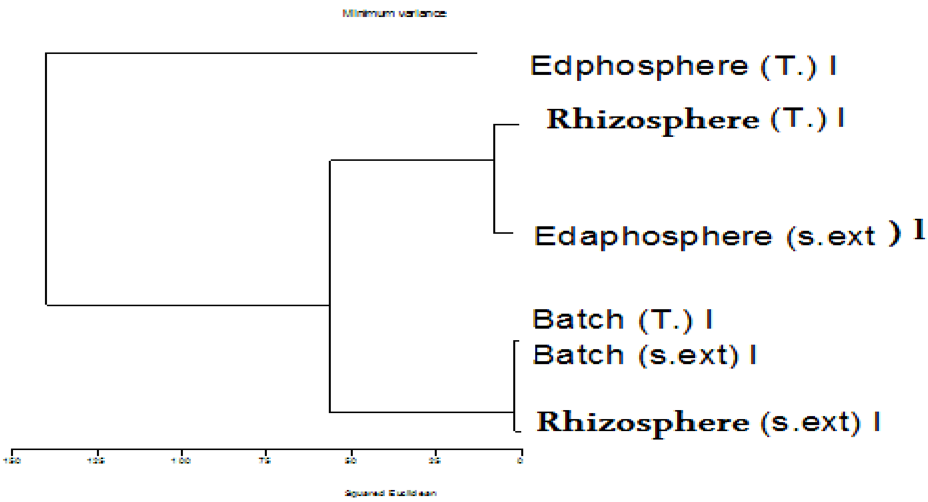

Figure 3. Cluster analysis of bacterial development in the three areas of the soil

By analysing the main components we found an insignificant influence of the humidity coefficient and of the pH, only on the control variants of both experimental media. Humus and potassium have connections only in the rhizosphere (*Figure 4*).

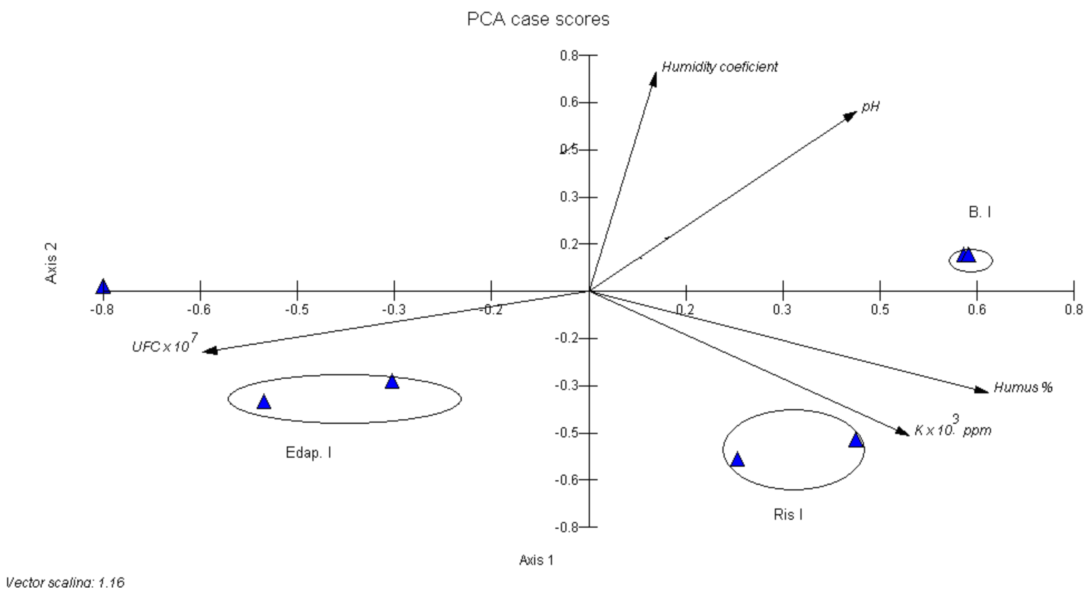

Figure 4. Main component analysis

CONCLUSIONS

Due to the rhizosphere effect of the legume species under research, the bacterial populations have improved in numbers as compared to the control variants.

The humus and the potassium contents have limited impact on CFU/g soil, in the rhizosphere of the above-mentioned forage legume. The humidity coefficient and the pH have an insignificant influence on this component of the soil.

The area where significant increases in the bacterial microflora take place is the edaphosphere.

"In vitro", the best results were obtained on Topping medium, as compared to soil extract medium.

REFERENCES

BOWEN GD., ROVIRA AD. (1991): The rhizosphere, the hidden half of the hidden half. In: Waisel Y., Eshel A., Kafkafi U, eds. Plant roots, the hidden half. New York: Marcel Dekker, 641-69.

CHENG W., COLEMAN D. C., CARROLL C. R. AND HOFFMAN C. A. (1993): In situ measurement of root respiration and soluble carbon concentrations in the rhizosphere. Soil Biology & Biochemistry 25, 1189-I 196.

CURL EA., TRULOVE B. (1986): The rhizosphere. Berlin: Springer-Verlag.

FEIKE A. DIJKSTRA, WEIXIN CHENG (2007): Moisture modulates rhizosphere effects on C decomposition in two different soil types. Soil Biology and Biochemistry, 39, 9, 2007, 2264-2274.

JONES DL, HODGE A., KUZYAKOV Y. (2004): Plant and mycorrhizal regulation of rhizodeposition. New Phytol 163:459–480.

LECHEVALIER M. (1989B): Actinomycetes in agriculture and forestry. In: Goodfellow, M., Williams, S.T. and Williams, M.M. (eds), Actinomycetes in Biotechnology. Academic Press, London, UK, pp. 327–358.

LYNCH, J.M. (1990A): Microbial metabolites. In: Lynch J.M. (ed) The Rhizosphere, John Wiley, Chichester, pp177-206.

LYNCH, J.M. (1990B): Introduction: some consequences of microbial rhizosphere competence for plant and soil. In The Rhizosphere. Lynch, J.M. (ed.). Chichester, UK: Wiley and Sons, pp. 1–10.

LYNCH, J.M., WHIPPS, J.M. (1991): Substrate flow in the rhizosphere. In The Rhizosphere and Plant Growth. Kleister, D.L. and Cregan, P.B. (eds). Dordrecht, the Netherlands: Kluwer Academic Publishers, pp. 15–25.

KORANDA M., SCHNECKER J., KAISER CHRISTINA, FUCHSLUEGER LUCIA, KITZLER BARBARA, STANGE C. F., SESSITSCH ANGELA, ZECHMEISTER-B. SOPHIE, RICHTER A., (2011): Microbial processes and community composition in the rhizosphere of European beech – The influence of plant C exudates. Soil Biology and Biochemistry, 43, 3, 551-558.

GARBEVA, P., VEEN, J.A.V., ELSAS, J.D.V. (2004): Microbial diversity in soil: selection of microbial populations by plant and soil type and implications for disease suppressiveness. Annual Review of Phytopathology 42, 243–270.

GRAYSTONE S.J., VAUGHAN D., JONES D. (1996): Rhizosphere carbon flow in trees in comparison with annual plants: The importance of root exudation and its impact on microbial activity and nutrient availability; Applied Soil Ecology 5, 29-56.

KOWALCHUK, G.A., STIENSTRA, A.W., HIELING, G.H.J., STEPHEN, J.R.,WOLDENDORF, J.W. (2000): Changes in the community structure of ammonia-oxidizing bacteria during secondary succession of calcareous grasslands. Environmental Microbiology 2, 99–110.

HINSINGER PHILIPPE , BENGOUGH A. GLYN , VETTERLEIN DORIS, IAIN YOUNG M. (2009): Rhizosphere: biophysics, biogeochemistry and ecological relevance. Plant and Soil, 321, 1-2, 117-152.

HINSINGER P., FERNANDES BARROS ON., BENEDETTI MF. NOACK Y, CALLOT G. (2001): Plant-induced weathering of a basaltic rock: experimental evidence. Geochim Cosmochim Acta 65:137–152.

NANNIPIERI P. , ASCHER J. , CECCHERINI M. T. , LANDI L. , PIETRAMELLARA G. , RENELLA G. AND VALORI (2008): Effects of Root Exudates in Microbial Diversity and Activity in Rhizosphere Soils; Molecular Mechanisms of Plant and Microbe Coexistence. Soil Biology, 15, III, 339-365, DOI: 10.1007/978-3-540-75575-3_14.

SHENGJING SHI, ALAN E. RICHARDSON, MAUREEN O'CALLAGHAN, KRISTEN M. DEANGELIS, EIRIAN E. JONES, ALISON STEWART, MARY K. FIRESTONE, LEO M. CONDRON (2011): Effects of selected root exudate components on soil bacterial communities, FEMS Microbiology Ecology, 77, 3, 600–610.

STEFANIC GH. (2006): Metode de analiza a solului (biologica, enzimatica si chimica). Probleme de agrofitotehnie teoretica si aplicata. Institutul de cercetare-dezvoltare agricola Fundulea, XXVIII, 5-25.

YANG, C.H., CROWLEY, D.E. (2000): Rhizosphere microbial community structure in relation to root location and plant iron nutritional status. Applied and Environmental Microbiology 66, 345–351.

WHIPPS, J. (2001): Microbial interactions and biocontrol in the rhizosphere. J. Exper Bot 52: 487–511.