STUDY OF THE CORRELATIONS BETWEEN SOIL PHYSICAL, CHEMICAL PROPERTIES AND THE NUMBER OF MICROORGANISMS IN OAK FOREST SOIL

Oneț Aurelia *

*University of Oradea-Faculty of Environmental Protection cristyonet@yahoo.com

Abstract

The correlations between soil microbe and soil physical and chemical properties were studied. The research was done in 2013 on the haplic luvisol. The soil samples were collected from an oak forest from Bihor County, Romania. Total number of aerobic mesophilic heterotrophs, Actinomycetes, fungi, Azotobacter and nitrifying bacteria was determined using the dilution method. The monitored physical and chemical properties of the soil samples were: moisture content (Ur, %), hydrolytic acidity (Acid., me/100 g soil), organic matter content (humus, %) nitric nitrogen (NO_3-N, ppm), ammonium nitrogen (N-NH_4, ppm), organic carbon C% and total N%. Pearson's correlation coefficients were conducted on the soil physical and chemical properties as well on the microbial properties analysed to determine how these variables were interrelated. The microbial communities were strongly correlated with the soil physical and chemical properties.

Keywords: correlations, microorganisms, soil properties, oak forest.

INTRODUCTION

Most soils are classified on the basis of their chemical and physical properties. The reason for this is that a soil chemical and physical property are more readily defined and measured than their microbiological properties. In this context we must give more attention to soil microbiological properties because of their important relationship to crop production, plant and animal health, environmental quality and food safety and quality.

Also, many studies have reported that the soil physical and chemical properties are known to influence the abundance and quality of soil microorganisms and the relationship between soil properties and soil microbiota across large spatial scales and different land-use type.

Also was investigated that after accounting for heterogeneity resulting from large scale differences among sampling locations, soil properties still explain significant proportions of variation in soil microflora.

The distribution of microorganisms in forest soils is mostly determined by vegetation and soil chemical characteristics. For example, the study conducted by Hackl, E. (2004), compared the bacterial communities on six forests under different pine and oak vegetation.

The results shown that Gram-positive bacteria communities, especially *Actinomycetes*, were more abundant under conifer forests than

under oak coverage. These results suggest that bacterial communities are adaptive to the soil chemistry.

Relatively less information is available on the relationships between soil physical, chemical properties and counts of microorganisms in oak forest soils. The present work aims to study the microbiological activity of the haplic luvisol from an oak forest and the relationships between the microorganisms abundance and the soil chemistry.

MATERIAL AND METHODS

The study was conducted in a field sites located at 30 kilometers from Oradea, Bihor County, Romania. This field has the same soil type (haplic luvisol) and the studied oak forest spreads over an area of 203,2 acres. The soil samples were taken from the experimental plots in the year 2013, in spring and autumn season.

In March the oaks were still not foliaged, during the October the trees already were after leaf-fall. The soil samples were collected from the top soil (0-20 cm), and each one was consisting of 5 individual, randomly collected subsamples.

The collected soils were sieved through a 2 mm mesh screen to remove plant roots, rocks, and macrofauna. After sieving, soil samples were analyzed to characterize their physical, chemical and microbiological properties.

Physical and chemical properties of the soil samples were determined as follows: moisture content (Ur,%) using gravimetrically method by oven-drying fresh soil at 105^0C, hydrolytic acidity (Acid., me/100 g soil) was determined by Kappen procedure, pH in 1:2:5 soil water suspension by pH-meter, organic matter content (humus, %) by using Walkley-Black method, nitric nitrogen (NO_3-N, ppm) determination by colorimetric method and ammonium nitrogen (N-NH_4, ppm) with Nessler reagent. The method used for organic C% determination was wet oxidation method and dosage titration and for the total N% Kjeldahl method.

The quantitative variation of three ecophysiological bacterial groups have been studied: aerobic mesophilic heterotrophs, heterotrophic fungi and nitrogen fixing bacteria *Azotobacter*.

The soil samples (10 g) were suspended in 90 ml distilled water. Dilutions (of 10^{-6}) were prepared from the soil samples using distilled water and these were dispersed with a top drive shaker for 5 min.

Plate count method was used to estimate total number of aerobic mesophilic heterotrophs on a solid nutrient medium containing meat extract (Atlas, 2004), total number of culturable fungi on Sabouraud Agar and total number of *Azotobacter* on Ashby's glucose agar.

After incubation the counts obtained were multiplied by the dilution factor to obtain the number of colony forming unit per gramme of soil.

RESULTS AND DISCUSSION

The average values of the physical and chemical properties of the studied haplic luvisol as well of the bacterial counts are presented in the following tables (1, 2).

Table 1

Physical and chemical properties of the haplic luvisol

Season	Moisture content (%)	Hydrolytic acidity (me/100 g soil)	pH	Organic matter content (%)	nitric nitrogen (NO_3-N ppm)	ammonium nitrogen (N-NH_4, ppm)	Organic C%	Total N%
Spring	18.5	3.36	6.15	4.83	5.2	8.9	2.80	0.228
Autumn	17.97	3.9	5.90	6.54	3.2	12	3.79	0.330

Table 2

Principal groups of microorganisms present in the haplic luvisol

(CFU g^{-1} dry soil)

Season	Aerobic mesophilic heterotrophs	*Actinomycetes*	Fungi	*Azotobacter*	Nitrifiyng bacteria
Spring	$34{,}68x10^6$	$16{,}38x10^6$	$1{,}92x10^6$	235	630
Autumn	$36{,}8x10^6$	$17{,}38x10^6$	$1{,}29x10^6$	340	560

The correlations between the tested parameters are described in the following. In the spring season, a statistically significant negative strong correlation is present between the number of heterotrophic fungi and the number of nitrogen fixing bacteria (r=-0.986; p=0.014).

The number of fungi is statistically significant strong correlated with acidity (r=0.994; p=0.006) and organic matter content (r=0.992; p=0.008).

A significantly strong correlation is observed between acidity and organic matter (r=0.981; p=0.019) and between organic matter and ammonium nitrogen content (r=0.956; p=0.044). Ammonium nitrogen content is correlated with the total N% content (r=0.974; p=0.026) and the total N% is strong correlated with pH values (r=0.986; p=0.014).

In the autumn season, the number of aerobic mesophilic heterotrophs is significantly strong correlated with the number of fungi (r=0.999; p=0.001) and the total number of heterotrophic fungi is significantly strong correlated with the nitric nitrogen content (r=0.970; p=0.030). Acidity values are significantly strong correlated with the moisture content (r=0.982; p=0.018), organic matter content (r=0.994; p=0.006) and ammonium nitrogen content (r=0.953; p=0.047).

A statistically significant strong correlation is present between the moisture content and organic matter content (r=0.983; p=0.017), ammonium nitrogen content (r=0.973; p=0.027) and organic C% (r=0.975; p=0.025).

Ph values are statistically significant strong correlated with nitric nitrogen content (r=0.959; p=0.041) and organic C% content (r=0.974; p=0.026), organic matter content is statistically strong correlated with ammonium nitrogen content (r=0.979; p=0.021) and total N% content (r=0.965; p=0.035) and significantly strong correlations are observed between the ammonium nitrogen content, organic C% content (r=0.981; p=0.019) and total N% content (r=0.980; p=0.020).

CONCLUSIONS

Based on the correlations between the tested parameters may be evidence that the microorganisms abundance is controlled by the soil chemistry and many soil properties are interrelated one with another.

The incidence of bacteria in soil samples was evidently dependent on the acidity, pH values and moisture content and on the presence of organic matter, organic carbon and total nitrogen content in soil. These parameters are the best predictors of bacterial and fungal community composition.

ACKNOWLEDGEMENT

This paper has been financially supported within the project entitled ***"Horizon 2020 - Doctoral and Postdoctoral Studies: Promoting the National Interest through Excellence, Competitiveness and Responsibility in the Field of Romanian Fundamental and Applied Scientific Research",*** contract number POSDRU/159/1.5/S/140106. This project is co-financed by European Social Fund through Sectoral Operational Programme for Human Resources Development 2007-2013. **Investing in people**

REFERENCES

1. A. Sri Lakshmi, Golla Narasimha, 2012. Production of cellulases by fungal cultures isolated from forest litter soil. Journal Annals of Forest Research, Forest Research and Management Institute ICAS, vol.55, Issue 1, Bucharest, Romania.
2. Alexander, M., 1965. Most probable-number method for microbial populations. In: Black, C.A., Evans, D.D., White, J.L., Ensminger, L.E., Clark, F.E. (eds.), "Methods of Soil Analysis", Ed. Am. Soc. Agron., Madison.
3. Anne le Mellec, Beate Michalzik, 2008. Impact of a pine lappet (Dendrolimus pini) mass outbreak on C and N fluxes to the forest floor and soil microbial properties in a Scots pine forest in Germany. *Canadian Journal of Forest Research*, 38(7): 1829-1841, 10.1139/X08-045.
4. Atlas, R.M., 2004. Handbook of Microbiological Media. 3rd edition. CRC Press, New York.
5. Bhupenda Singh, N.P. Todaria, 2012. Nutrients composition changes in leaves of Quercus semercapifolia at different season and altitudes. Journal Annals of Forest Research, Forest Research and Management Institute ICAS, vol. 55, Issue 2, Bucharest, Romania.
6. Campbell RW, Sloan RJ., 1977. Forest stand responses to defoliation by the gypsy moth. Forest Science Monograph 19: 34.
7. Comerford, B.,2005. Forest Soil. Encyclopedia of Soil Science, Second Edition.
8. Drăgan-Bularda, M., Kiss. S., 1986. Soil Microbiology. Univ. Babeş-Bolyai, Cluj-Napoca.
9. Frostegård Å, Bååth E, Tunlid A, 1993. Shifts in the structure of soil microbial communities in limed forests as revealed by phospholipid fatty acid analysis. Soil Biol Biochem 25:723–730.
10. Gaublomme, E., De Vos B. & Cools, N., 2006. An indicator for Microbial Biodiversity in Forest Soils. INBO. R.2006.40 Instituut voor Natuur- en Bosonderzoek, Brussel.
11. Hackl, E., Zechmeister-Boltenstern, S., Bodrossy, L., and Sessitsch, A., 2004. Comparison of Diversities and Composition of Bacterial Populations Inhabiting Natural Forest Soils. Appl. Enviro. Microbiol. 70(9):5057-5065.
12. Houston D.,1981. Effects of defoliation on trees and stands. Pages 267–281 in Doane CC,McManus MC, eds. The Gypsy Moth: Research toward Integrated Pest Management. Washington (DC): USDA Forest Service. Technical Bulletin 1584.
13. Jens-Konrad Preema et all, 2012. Bacterial community structure and its relationship to soil physico-chemical characteristics in alder stands with different management histories.
14. Johnson,D., and Curtis, D., 2001. Effects of forest management on soil C and N storage:meta analysis. Forest Ecology and Management 140:227-238.
15. Kandeler E., 2007. Physiological and biochemical methods, In: Paul E.A. (ed.): Soil Microbiology. Ecology and Biochemistry, Vol. 3. Academic Press and Elsevier Inc., Burlington: 53–83.
16. Köteles N., Ana Cornelia Pereş, 2010, Air's temperature at surface of the soil (level 0 m), in the area of Oradea City, Analele Universităţii din Oradea, Fascicula Protecţia Mediului, Vol. XV, Anul 15, Editura Universităţii din Oradea, 2010, ISSN 1224-6255, pag. 661-667
17. M.A. Ahangar, G.H. Dar, Z.A. Bhat, 2012. Growth response and nutrient uptake of blue pine (Pinus wallichiana) seedlings inoculated with rhizosphere microorganisms under temperate nursery conditions. Annals of Forest Research, Forest Research and Management Institute ICAS, vol. 55, Issue 2.

18. Pereş Ana Cornelia, 2012, Meteorologie şi climatologie, Editura Universităţii din Oradea, ISBN 978-606-10-0962-6, nr. pag. 253.
19. Perry, D., 1994. Forest Ecosystems. First Edition. The Johns Hopkins University Press. pp 429.
20. Rasche, F., et al, 2010. Seasonality and resource availability control bacterial and archaeal communities in soils of a temperate beech forest. ISME J. 5, 389–402.
21. Ranjan K.B., Santa R.J., Abdul M., 2007. Microbial degradation of organophosphorous pesticide: Chlorpyrifos. The internet Journal of Microbiology, Volume 4 Number 1.
22. Schlesinger, W., 1997. Biogeochemestry: An analysis of global change. Second Edition. Elsevier.
23. Schloter M, et.al., 2003. Indicators for evaluation soil quality. Agriculture Ecosystems and Environmen 98: 255–262.
24. Setiawati T.C., 2014, Correlations between Soil Microbe and Soil Chemical properties in Limestone Mining Area: Case Study at Southern Jember Indonesia, International Conference on Chemical Environment & Biological Science (CEBS-2014), Kuala Lumpur (Malaysia).