Journal of Young Scientist, Volume VIII, 2021
ISSN 2344 - 1283; ISSN CD-ROM 2344 - 1291; ISSN Online 2344 - 1305; ISSN-L 2344 – 1283

THE ROLE OF THE SOIL MICROBIOTA IN PROVIDING ECOSYSTEM SERVICES

Roxana Oana NICULAE, Dănuț Constantin NICULA

Scientific Coordinator: Assoc. Prof. Biotech. PhD Irina GREBENIȘAN

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania, Phone: +4021.318.25.64, Fax: + 4021.318.25.67

Corresponding author email: oananiculae04@gmail.com

Abstract

Ecosystem services are the many and varied benefits that people freely gain from the natural environment and the proper functioning of ecosystems. Such ecosystems include, for example, agroecosystems, urban ecosystems, forest ecosystems, pasture ecosystems and aquatic ecosystems, etc. Collectively, these benefits are known as ecosystem services.
In this paper we wanted to highlight the very close link between the relationships of soil microorganisms, soil microbiota and the optimal functioning of agroecosystems, which is reflected in the rich harvest obtained in both households presented as case studies.
Due to the systems of good agricultural practices which are respected in both households presented in the case study, the functioning of agroecosystems is optimal and this is reflected both in soil health - expressed as biodiversity and the functioning of microorganisms and in plant health.

***Key words**: ecosystem services, soil microbiota.*

INTRODUCTION

Ecosystem services concept - ecosystems have potential to supply a range of services that are of fundamental importance to human well-being, health, livelihoods, and survival (Costanza et al., 1997; Millennium Ecosystem Assessment (MEA), 2005; TEEB Synthesis, 2010). Different ways of defining ecosystem service have been developed so far – they can be described as the benefits that people obtain from ecosystems (MEA, 2005) or as the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010). More recent publications define the ecosystem services (ES) as contributions of ecosystem structure and function (in combination with other inputs) to human well-being (Burkhard et al., 2012; Burkhard B. & Maes J. Eds., 2017). Ecosystem services, outputs, conditions, or processes of natural systems that directly or indirectly benefit humans or enhance social welfare. Ecosystem services can benefit people in many ways, either directly or as inputs into the production of other goods and services. For example, the pollination of crops provided by bees and other organisms contributes to food production and is thus considered an ecosystem service (Johnston, 2018).
Aislabie and Deslippe discussed the roles of microbes in the ecosystem services provided by soils to humans. The diversity of microbes in soil is enormous and they drive many soil services. They examined the functional, metabolic, and phylogenetic diversity of soil bacteria, archaea, and fungi. The roles of these soil microbes are highlighted in the cycling of major biological elements (C, N, P), in the recycling of wastes, and the detoxification of environmental pollutants. Microbes play a pivotal role in the cycling of nitrogen; they exclusively mediate nitrogen fixation, denitrification, and nitrification. They also discussed recent theoretical advances in understanding of ecosystem processes that were made possible through explicit consideration of the roles of soil microbes (Aislabie and Deslippe, 2013).
Soil is considered as one of the most competent ecosystems for subsistence of microorganisms. Soil microbial community structure and activity depend largely on structure and status of soil habitat. Diverse heterotrophic microbial communities in soil along with their complex

web of interaction facilitate the cycling of micro- and macro-nutrients in soil ecosystem. The demand of sustained plant productivity is achieved through managing soil fertility. The dynamic relationships between different components, living or nonliving, of agroecosystem control the richness of plants or crops. In turn, soil organic matter is influenced by the inputs from plants and also their chemistry makes each ecosystem somewhat unique in its microbial community. Though the role of soil microbiome is widely known, we still have limited understanding of its complexity. Thus, understanding the microbial diversity will enhance our ability of increasing agricultural production (Baliyarsingh et al., 2017).

The soil consists of a plethora of both biotic and abiotic matter and provides the medium for plant growth, habitat for microorganism, which plays an important role in maintaining and contributing to the ecosystem service. The soil microbial community is an important component as they are involved in organic matter decomposition, nutrient cycles, and soil health. Likewise, enzymes in soil are also known for substantial role in energy transfer, catalyzing reactions necessary for all life processes, and also used as indicator of soil health. Soil microbes and enzyme are co-dependent with one another enhancing soil fertility by increasing the nutrient availability for plant growth. For instance, microbes like bacteria, fungi, and algae form association with soil rhizosphere like plant growth-promoting rhizobacteria which regulate plant growth by producing hormones and protect plant from disease-causing pathogen. (Jamir et al., 2019)

In this paper we wanted to highlight the very close link between the relationships of soil microorganisms, soil microbiota and the optimal functioning of agroecosystems, which is reflected in the rich harvest obtained in both households presented as case studies.

Due to the systems of good agricultural practices that are observed in both households presented in the case study, the functioning of agroecosystems is optimal and this is reflected both in soil health - expressed as biodiversity and the functioning of microorganisms and in plant health.

MATERIALS AND METHODS

Chemical analysis of soil samples

For the analysis of soil samples from the two households in the case study we used the colorimetric and turbidimetric qualitative analysis kit from Hanna Instruments pH. Soil can be acid, neutral, or alkaline. Each plant has a range of pH in which it thrives and most plants prefer conditions near the neutral mark (pH 5.5-7.5). There are however plants that prefer acid or alkaline environments. The solubility of the nutrients, that is the ability of the plants to absorb them, depends largely on their pH value. The soil microbiological activity is also pH dependent. Most bacteria, especially those putting nutrients at the plants' disposition, prefer moderately acid or slightly alkaline conditions. The pH level hence influences the fertility of the soil.

Nitrogen (N). Nitrogen is an indispensable element for the growth of vegetation and is a key factor in fertilization. A correct quantity of Nitrogen allows a healthy growth of the entire structure and in particular creates a thriving and greener plant. An excess of Nitrogen on the other hand, weakens the plant's resistance creating an unbalanced relationship between the green parts and the stems and trunk.

Phosphorus (P). Phosphorus contributes to the formation of buds, roots and blooming as well as lignification. A lack of phosphorus results in a stifling of plant.

Potassium (K). Potassium plays an important role in how much water is absorbed by the roots and the regulation of cellular activity. In addition, Potassium makes plants more resistant to disease and yields a positive effect on the color and fragrance in flowers.

Test procedure

Reading the Color-Card The pH, phosphorus (P2O5), and nitrogen (NO3) tests use colorimetric methods of testing. The color developed corresponds to the soil fertility. To figure out the fertility, the color which appears must then be compared against the Color-card. To match the color, hold the tube containing the test solution approximately 2 cm away from the color-card. Stand with a light source behind the card and match the test tube color to that of the Color-card to read: Trace, Low, Medium or

High. If the color of the test tube falls between two standard colors, e.g. between Medium and High, the test result is then Medium-High. Eight different readings are possible, Trace, Trace-Low, Low, Low-Medium, Medium, Medium High, High, and very-High.

The potassium (K2O) test utilizes a turbidimetric method. To obtain the test results, rest the tube against the Color-card over the reading area. Stand with the light source behind your back. Start at Trace, look through the tube, and go to Low, Medium or High until you see the white line in the middle of the reading area of the Color-card. The test result is obtained in Trace, Low, Medium or High.

Performing the test

General Extraction Procedure

Add the following to a clean Berzelius jar:

Field soil: 1.5 cup of soil and 8 cups of water

Garden soil: 1 cup of soil and 8 cups of water

Greenhouse soil: 1 cup of soil and 16 cups of water For best results, use bottled or distilled water. Stir or shake gently for at least one minute and make sure that all the soil is moistened. Allow to stand until the soil settles (from 30 minutes to 24 hours depending on the soil texture). The clearer the extract becomes, the better the results, however, a little cloudiness will not affect the accuracy of the test.

Nitrogen (NO3) test. Use the pipette to transfer 2.5 mL of the clear general soil extract (above) to a clean test tube. Add the content of one packet of HI 3895N-0 Nitrogen reagent to the tube, replace the cap and shake well for 30 seconds to dissolve the reagent. Allow the tube to stand for 30 seconds, match the pink color with the Nitrogen color-card.

Phosphorus (P2O5) test. Use the pipette to transfer 2.5 mL of the clear general soil extract (see above) to a clean test tube. Add the contents of one packet of HI 3895P-0 Phosphorus reagent to the tube, replace the cap and shake well for 30 seconds to dissolve the reagent. Match the blue color against the Phosphorus color-card for the P concentration.

Potassium (K2O) test. Use the pipette to add 0.5 mL of the clear general soil extract (above) to a clean test tube. Fill the tube to the lower graduation mark (2.5 mL) with water. Add the content of one packet of HI 3895K-0 Potassium reagent to the tube, replace the cap and shake well for 30 seconds to dissolve the reagent. Match the test tube against the Potassium reading-card.

Fertilizers used as inputs for household vegetable crops

Fertilizers used as inputs are manure from cattle - compost used as maceration or diluted with water, or as such, wood ash, eggshells and nettle maceration

Nettle macerate

One kg of nettles to 10 liters of water, then leave to soak for a week, then put a liter of macerated to 9 liters of water and water the plants at the root or sprinkle with foliar applications.

RESULTS AND DISCUSSIONS

The in situ and in vivo experiments were performed in two households, one of the Nicula family from Aldești village, Golești commune, Vâlcea county and the other of the Niculae family from Crivăț village, Crivăț commune, Călărași county, and the in vitro experiments were performed in the laboratory of Ecology and Microbiology within the Faculty of Land Improvements and Environmental Engineering of the University of Agronomic Sciences and Veterinary Medicine Bucharest, which is equipped with the apparatus, equipment and reagent kits necessary to perform microbiological, ecological, biochemical and biophysical determinations.

Microbiological analysis of soil samples

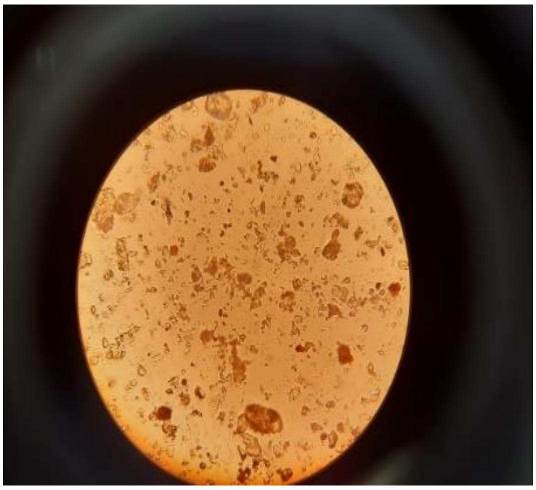


Figure 1. Microscopic image of the soil sample highlights the presence of bacteria, protozoa and yeast in

addition to soil particles used as fertilizer based on microorganisms

Figure 2. Microscopic image of the soil sample highlights the presence of bacteria, yeasts and fungi used as fertilizer based on microorganisms

Figure 3. Microscopic image of the soil sample highlights the presence of bacteria, yeast and fungi used as fertilizer based on microorganisms

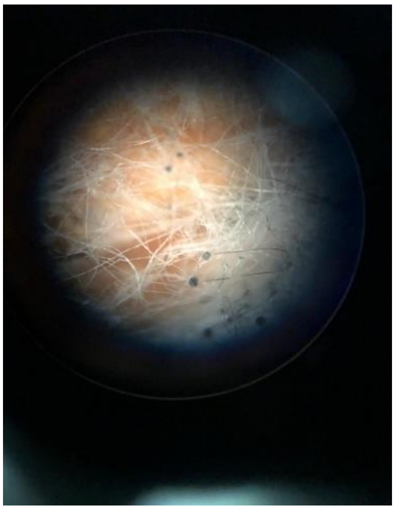
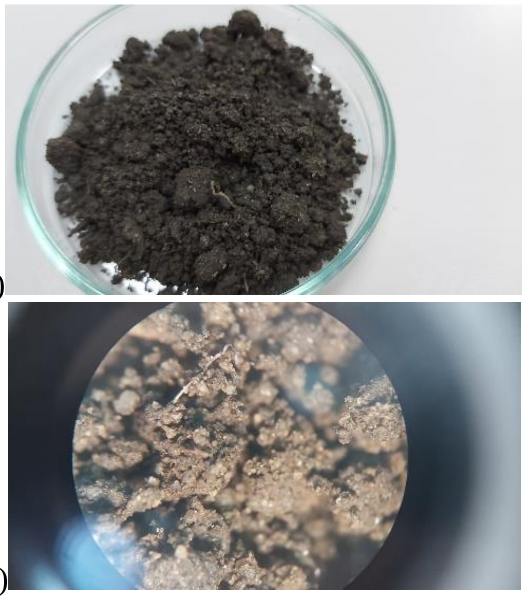


Figure 4. Stereomicroscopic image of the soil sample highlights the presence of hyphae and fruiting bodies - conidiophores of edaphic fungi

Results of chemical qualitative analyzes of soil samples

a)



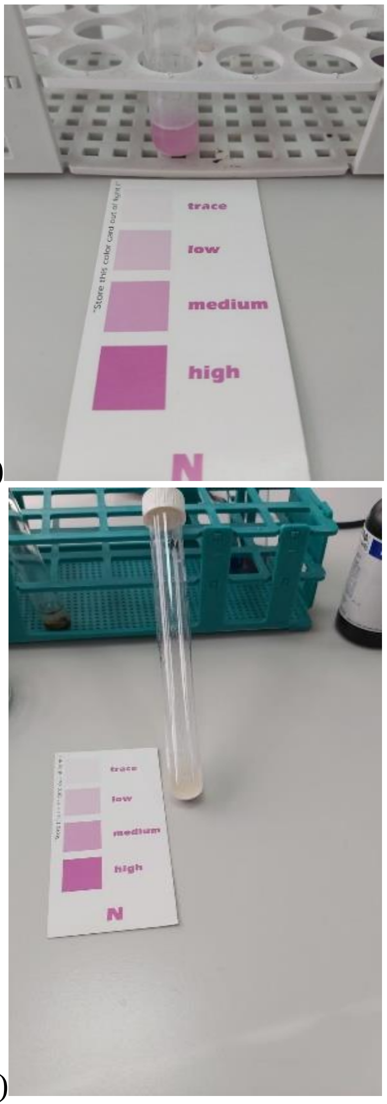
b)

Figure 5. Soil samples a) macro b) stereomicroscopic

Figure 6. Oana Roxana Niculae during the qualitative determinations at the soil samples in the laboratory

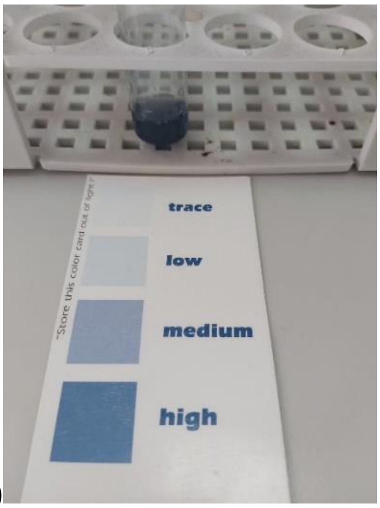
Figure 7. Hanna Instruments N, P, K analysis kit for soil sample analysis

a)

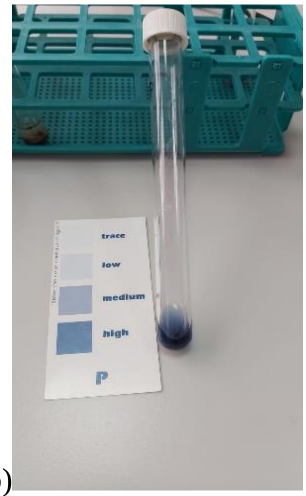


b)

Figure 8. Results of chemical qualitative analyzes of soil samples - nitrogen (N)
a) soil sample from the Nicula family household, 2020
b) soil sample from the Niculae family household, 2021

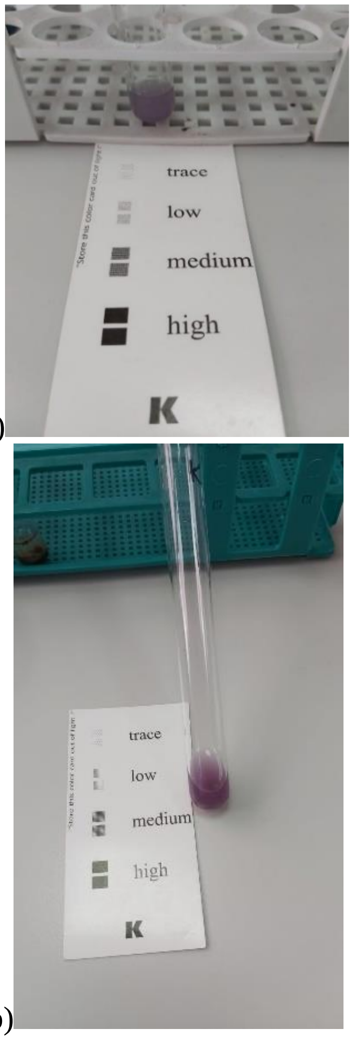


a)



b)

Figure 9. Results of chemical qualitative analyzes of soil samples - phosphorus (P)
a) soil sample from the Nicula family household, 2020
b) soil sample from the Niculae family household, 2021



a)

b)

Figure 10. Results of chemical qualitative analyzes of soil samples - potassium (K - Kalium)
a) soil sample from the Nicula family household, 2020
b) soil sample from the Niculae family household, 2021

Results of electrochemical analysis of soil samples

Figure 11. Results of electrochemical analysis of soil samples from the Nicula family household, 2020
- pH determined with WTW laboratory pH meter

Fertilizers used as inputs for household vegetable crops


a)


b)

Figure 12. Organic fertilizers used in the household – cow compost and wood ash

Establishment of vegetable crops in the protected area - greenhouse and in the field, 2020, the household of the Nicula family


a)


b)

Figure 13. Onion and pepper crops


a)


b)

Figure 14. Cucumber and tomato crops in the solarium


a)
b)

Figure 15. Cucumber and pepper crops


a)
b)

Figure 16. Cucumbers, tomatoes and cabbage seedlings in the solarium


a)
b)

Figure 17. Tomatoes in the solarium

Establishment of vegetable crops in the protected area - greenhouse and in the field, 2021, the household of the Niculae family

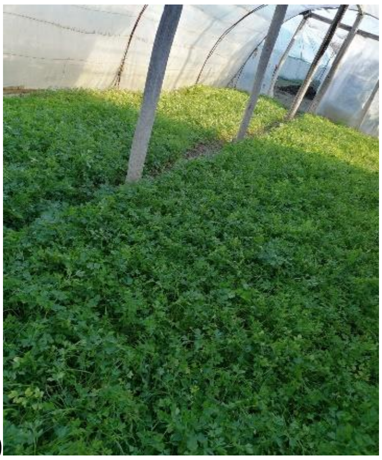

a)
b)

Figure 18. Land preparation for planting a) tomato culture b) radish culture

a) 

b) 

Figure 19. Alveoli with tomato seedlings in the greenhouse

a) 

b) 

Figure 20. Parsley, radish, lettuce and onion crops in the solarium

Figure 21. Cultivation of radishes in the greenhouse

CONCLUSIONS

The delivery of ecosystem goods and services depends on the structure and functioning of ecosystems, which are affected by (global) environmental changes and the effects of land management on soil biota. In order to understand and finally be able to manipulate the relationships between soil biota and the provision of ecosystem goods and services, the usefulness of the concept of "functional groups" of soil biota is limited.

Functional groups are usually defined only at a trophic level (eg fungal feeders), and the relationship between such groups and the functioning of the ecosystem is not simple. There is evidence that the type, range and relative abundance of functional traits of organisms and species in biotic communities exercise control over different ecosystem functions, which means that there are multiple associations between ecosystem traits and services at different trophic levels.

From a functional ecological perspective based on features, existing agro-ecosystems can be analyzed in terms of sustained delivery of ecosystem goods and services. Such analyzes will be helpful in designing resource-efficient agro-ecosystems and agricultural landscapes. A number of entry points for the biological management of such systems are available for the sustainable production of ecosystem goods services.

From the microbiological analyzes to the soil samples performed in the laboratory experiments we obtained the following results:

- Very high diversity of microorganisms in soil samples from households of the Nicula family located in Aldești village, Golești commune in Vâlcea county and Niculae in Crivăț village, Crivăț commune, Călărași county highlighted by microscopes from the laboratory of Ecology and Microbiology to the University of Agronomic Sciences and Veterinary Medicine of Bucharest through the usual microbiological techniques shows that the soil is healthy and this is reflected in the quality vegetable products that families obtain, sustainably capitalizing on the resources of agroecosystems.

From the potentiometric analyzes at the soil samples we obtained the following results:

- The pH of the analyzed soil samples had a value of approximately 6.65 pH units, which means that the soil reaction is weakly acidic to neutral, an optimal value for the development of microorganisms and plants.

From the physico-chemical analyzes to the soil samples performed in the experiments we obtained the following results:

- to determine the nitrogen in the soil, a pink compound with a medium concentration is obtained, the color being directly proportional to the amount of nitrogen in the soil sample in the case of this qualitative chemical analysis, performed using the Hanna Instruments kit for determining nitrogen in the soil;
- for the determination of phosphorus in the soil, a blue compound with a high concentration is obtained, the color being directly proportional to the amount of phosphorus in the soil sample, in the case of this qualitative chemical analysis, performed using the Hanna Instruments kit for determining phosphorus in the soil;

- to determine the potassium in the soil, a blue compound with a high turbidity is obtained, the turbidity being directly proportional to the amount of potassium in the soil sample in the case of this nephelometric analysis, performed using the Hanna Instruments kit to determine potassium in the soil.

REFERENCES

Aislabie J., Deslippe J., 2013, Soil microbes and their contribution to soil services, Environmental Science, https://www.semanticscholar.org/paper/Soil-microbes-and-their-contribution-to-soil-Aislabie-Deslippe/d1acb08b9b1902a795ced9d5fa0448b219da90ac?p2df

Baliyarsingh B., Nayak S.K., Mishra B.B., 2017, Soil Microbial Diversity: An Ecophysiological Study and Role in Plant Productivity. In: Adhya T., Mishra B., Annapurna K., Verma D., Kumar U. (eds) Advances in Soil Microbiology: Recent Trends and Future Prospects. Microorganisms for Sustainability, vol 4. Springer, Singapore. https://doi.org/10.1007/978-981-10-7380-9_1

Burkhard B., de Groot R., Costanza R., Seppelt R., Jørgensen S.E., Potschin M., 2012, Solutions for sustaining natural capital and ecosystem services. Ecological Indicators 21: p. 1–6.

Burkhard B,, Maes J., (Eds.) 2017, Mapping Ecosystem Services. Pensoft Publishers, Sofia, 374 pp. Available at: http://ab.pensoft.net/articles.php?id=12837 https://ab.pensoft.net/articles.php?id=12837

Costanza R., D'Arge R., de Groot R.S., Farber S., Grasso M., Hannon B., Limburg K., Naeem S., O'Neill R.V., Paruelo J., Raskin R.G., Sutton P., van den Belt M., 1997, The value of world's ecosystem services and natural capital, Nature 387: p. 253- 260

Jamir E., Kangabam R.D., Borah K., Tamuly A., Deka Boruah H.P., Silla Y., 2019, Role of Soil Microbiome and Enzyme Activities in Plant Growth Nutrition and Ecological Restoration of Soil Health. In: Kumar A., Sharma S. (eds) Microbes and Enzymes in Soil Health and Bioremediation. Microorganisms for Sustainability, vol 16. Springer, Singapore. https://doi.org/10.1007/978-981-13-9117-0_5

Johnston R.J., 2018, "Ecosystem services" .*Encyclopedia Britannica*, https://www.britannica.com/science/ecosystem-services.

Wall D.V., Bardgett R.D., Behan-Pelletier V., Herrick J.E., Hefin Jones T., Ritz K., Six J., Strong D., van der Putten W., 2012, Soil Ecology and Ecosystem Services. https://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199575923.001.0001/acprof-9780199575923;

***https://www.millenniumassessment.org/en/index.html

***http://teebweb.org/publications/teeb-for/research-and-academia/