Annals of the Academy of Romanian Scientists
Series Agriculture, Silviculture and Veterinary Medicine Sciences
Online ISSN 2344 – 2085 Volume **11**, Number **2/2022**

THE EVOLUTION OF MYCORISIAN FUNG AS SYMBIOTIC PARTNERS

Marina DRAGOTA[1], Stefana JURCOANE [2]

The article analyzes the evolution of mycorrhizal fungi, which served as symbiotic partners in association with plants, more precisely with their root system. The advantage brought by the existence of mycorrhizal symbioses for plant nutrition, highlighted the influence this association has on plant growth and development. The existence of mycorrhizal fungi was demonstrated approximately 400 million years ago, the first discoveries being the fossils of Aglaophyton major plants that showed traces of arbuscules, these being considered edifying transfer structures for the vesicular-arbuscular endomycorrhizal type. Mycorrhizae are present in mature ecosystems, ecosystems that present a cyclical and unitary evolution of the components between the biotic and abiotic unit, at which point the mycorrhizal associations have the role of regulating the assimilation of food resources for the plants with which they are associated. In this association, hyphae play an important role in the nutrient cycle, having the function of stopping losses from the ecosystem

Keywords: biotechnology, mycorizae, wheat, roots
DOI https://doi.org/10.56082/annalsarsciagr.2022.2.69

1. Introduction

Fungi interact with nitrogen-fixing bacteria found in the soil. Colonization with vesicular-arbuscular fungi favorably affects the populations of nitrogen-fixing bacteria in the rhizosphere of the plant that colonizes it; and the growth and development of the plant colonized by both organisms is greatly stimulated. The hypothesis that the mycorrhizae are independent at any moment, compared to the physiological state of the host plant, is difficult to accept. Following an experiment carried out by [1], with hormones synthesized by different bacterial colonies (Azotobacter, Rhizobium, Pseudomonas), it was found that the formation of mycorrhizal associations is positively influenced by treatments on the host roots [8]. Among the hormones used in the experimentation stage, auxins are distinguished by the influence they have on the formation of roots and on the relaxation of cell walls; gibberellins act on the formation of leaves and roots, and cytokinins are involved in the basic processes of plant growth.

[1]PhD. student University of Agronomic Sciences and Veterinary Medicine in Bucharest, (e-mail: marina.dragota@yahoo.com)
[2]Prof. PhD. University of Agronomic Sciences and Veterinary Medicine in Bucharest, (e-mail: stefana.jurcoane@biotehgen.eu)

In mycorrhizal symbioses, the main benefit for the host plant is the progressive assimilation of immobile nutrients, especially nitrogen. The vesicular-arbuscular relationships increase the assimilation of nitrogen in the tissues of the host plant, as a result of hyphae competition for mineralized organic nitrogen. The most important role is to minimize the inputs of chemical fertilizers from the farm management system, optimizing the nutrition cycles - with a minimum negative ecological impact - ensuring increased productions [6]. That is why these fungi must be seen as an indispensable component of any sustainable agricultural system.

The importance of mycorrhiza for the plant is not limited to the absorption of water and nutrients from the soil. Symbiotic plants are often more competitive and more tolerant to environmental stress than those without mycorrhizae. Here we can give an example of osmotic stress, mycorrhizae make plants more resistant to cold weather (below 15 degrees).

Arbuscular mycorrhizal fungi colonize the roots of most monocotyledons and dicotyledons despite their different root architecture and cell patterning. Key Result Large lateral roots are preferentially colonized, and fine lateral roots are immune to arbuscular mycorrhizal colonization. Fungal preference for large lateral roots also occurred in sym mutants that block colonization of the root beyond rhizodermal penetration.

Mycorrhiza is a form of symbiosis between fungi and plants, more precisely a fungus comes into contact with plant roots. After studying the fungus-plant relationship, especially the connection with the root system of the plant, a considerable capacity of them to deliver nutrients to the plant was observed [6]. Thus, it is desired to replace inorganic fertilizers in the technologies of cultivating cereals in an intensive system. The need to fertilize crops and the principles of a rational fertilization are summarized in the fertilization plan, which represents the tool for control and management of fertilizers. The fertilization plan is based on a foundation made up of the combination of the following parameters: the rotation, the genetic production potential of the crop, the availability of the soil nutrient reserve, the water resource and the dose of applied fertilizers. The dose of applied fertilizers is the result obtained from the calculation of the system made up of three equations: the genetic production potential of the crop, the availability of the soil nutrient reserve and the water resource. The basic fertilization is done with organic fertilizers and/or complex chemical fertilizers that provide the plants with the necessary nutrients, which they need for the desaturation of the vegetative cycle with a satisfactory result. The role of the Glomus intraradices fungus is to form mycorrhiza, so that the absorption of macronutrients from the soil is intensive [4]. The experiment of absorption of macronutrients from the soil was carried out in relation to the wheat plates. The system designed to highlight the benefits brought by mycorrhiza was constituted by sowing wheat in a chemically unfertilized soil. The need for food is provided by the connection made between the root system of the plant and the extraradical hyphae of the fungus.

2. Materials and methods

The soil taken into analysis from the geographical area of Muntenia, Romanian Plain, more precisely Berceni commune, Ilfov county is located within the physical body 150 noted as soil profile P1. The soil profile P1 framed as argic cherniosome presents a profile of the type Amp-Am-AB-Bt-Ck, being formed by loessoid deposits. The groundwater is located at a depth of over 5m. The soil was formed by an illuviation process of the clay from the upper horizon.

Experimental work was carried out both on the field of the experimental field and in the collaborating laboratories of Agricola Berceni SRL. It was used to multiply the Glomus intraradices fungus, on a nutrient broth type solid culture medium. After Multiplication, they were stabilized in suitable solutions, later arriving on the sample land cultivated with the wheat host plant.

In the experimental field, two experimental wheat plots were established. One plot was cultivated as a control, while the second plot was cultivated and treated with mycorrhizae. For the establishment of the wheat culture, the technology according to this culture was executed, without producing a rebate from any operation. The abiotic factors that have an impact on mycorrhiza were studied.

The light. The energy source of the symbiont fungus is in the plant and depends directly on the way it carries out its photosynthesis process and on its ability to translocate the products of photosynthesis to the root (Varma, 2008) [7]. The lack of the light source produces a restriction for the development of the fungus, so its evolutionary process is slowed down, sporulation no longer occurs, and the expansion of the mycelium in the soil and in the root is reduced.

Temperature. From the point of view of the processes of spore germination, root penetration by hyphae and their proliferation inside the cortical cells, temperature can be a factor with a limiting effect (Gavito et al., 2005)[2] soil pH.

The efficiency of the fungus-plant association is determined by the adaptability of the fungal partner to a certain soil pH level. The pH affects both spore germination and their development. The relationship between soil pH and the effects of mycorrhizae depends on the host species, the type of soil, the forms of phosphorus and the species of fungi involved Salinity.

In the case of high salinity, a decrease in the production of propagation structures (propagules) and in the colonization of vesicular-arbuscular fungi was observed (Pfeiffer and Bloss, 1988)[5].

A well-developed root system means a good capacity for the absorption of nutrients from the soil followed by the sustained development of the aerial part of the plant, the increase of the vegetative mass and the final increase of the quality of the harvested vegetables. The addition of phytohormonal solutions can add to the growth of the plant.

In most types of mycorrhizae, the movement of carbohydrates, produced during photosynthesis, is done from the host plant (autotrophic partner) to the symbiotic fungus (heterotrophic partner). In the case of absorption of nutrients from the soil, the transfer has an inverse direction, from the fungus to the host plant [3].
The contribution of vesicular-arbuscular fungi to the assimilation of nutrients is the absorption of nutrients (especially phosphorus) from the soil, with the help of extraradicular hyphae - especially from those parts of the soil to which the plant did not have access. The hyphae of the fungus act similarly to the absorbent hairs on the root of the plant.

After comparing the diameter of the absorbent hairs (5-20 μm) with that of the mushroom hyphae (3-7 μm), the absorbent hairs would gain the cause, but comparing the length and density of the mushroom hyphae with that of the absorbent hairs - the fungus would be, because it exceeds the possibilities of expansion of the plant by 10 to 100 times more.

3. Results and Discussions

The results obtained in the wheat cultivation technology of the Glossa, Arnold and Apache varieties, from a quantitative and qualitative point of view refer to the quantitative production and quality indices such as total protein content, gluten content and moisture.

The experiments were carried out on the land for the cultivation of experimental crops owned by SC AGRICOLĂ BERCENI SRL.

Two experimental variants of fertilizing treatment were established for each variety and lots were cultivated for each work variant.

3.1 . The influence of treatments on gluten content

The applied treatments of fertilization on the experimental variants have influenced in a different way each variety.

Therefore, the gluten content in the production carried out by each cultivar is different in g% in case of Glossa, Arnold and Apache as shown in Table 1.

Table 1. The influence of treatments on the gluten content by experimental variant- the fertilizing treatments (Production differences-gluten content, g%)

Nr. crt.	Repetiţii	Var. martor (g %)		Var. 1 (g %)		Var. 2 (g %)	
1.Glosa	1.1	24.02	24.06	29.01	29.03	28.02	27.97
	1.2	24.05		28.98		27.98	
	1.3	24.1		29.1		27.91	
2.Apache	2.1	22.97	22.99	27.41	27.32	26.8	26.91
	2.2	23.01		26.98		27.02	
	2.3	22.99		27.56		26.91	
3.Arnold	3.1	32.01	32.07	38.92	38.94	38.74	38.83
	3.2	32.11		39.01		38.95	
	3.3	32.09		38.89		38.81	

3.2 Differences regarding gluten content among the wheat varieties

According to the parameters for classifying wheat in the bakery category, the gluten content must be over 28% of high-quality baking flour, over 26% of regular baking flour and over 22% of regular baking flour to which improvers are added.

After the experimental nutritional treatments, the obtained production fell into the group of over 28%, i.e. obtaining flours for baking of superior quality.

Gluten is a colloidal gel that contains a quantity of water of about 200-250% compared to the U.S. The dry substance of gluten consists of 75-90% gluten proteins (gliadin, glutenin) and 25-10% aglutenic substances (lipids 2-4 %; albumins and globulins 3-4%; carbohydrates 8-10%, mineral substances 0.7%).

The production differences among the wheat varieties regarding gluten content are illustrated in Fig.1.

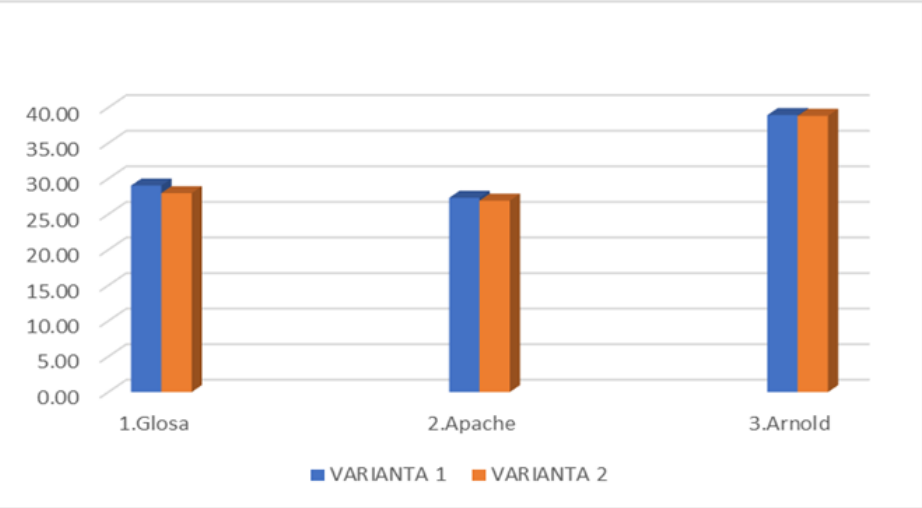

Fig. 1. Production differences in gluten content among the studied wheat varieties

3.3. The principles of rational fertilization

The need to fertilize crops and the principles of rational fertilization are summarized in the fertilization plan, which represents the control and management tool for fertilizers.

The fertilization plan is based on a foundation made up of the combination of the following parameters: crop rotation, the genetic production potential of the crop, the availability of the soil nutrient reserve, the water resource and the dose of applied fertilizers.

The dose of applied fertilizers is the result obtained from the calculation of the system made up of three equations: the genetic production potential of the crop, the availability of the soil nutrient reserve and the water resource. Basic fertilization is carried out with organic fertilizers and complex chemical fertilizers that provide the plants with the necessary nutrients, which they need for the desaturation of the vegetative cycle with a satisfactory result.

The expected productions for sustainable agriculture cannot be based on the nutrients provided by the environment. Fertilization technology is based on two classes of nutrients: macroelements and microelements, both showing the same degree of importance in obtaining a sustainable production. The macronutrient class has 3 major nutrients and the micronutrient class consists of 6 major elements, which plants need to go through a healthy vegetative cycle. The terminology of macroelements and microelements, respectively, does not represent the nutritional importance to the plant, but strictly the quantities needed for a plant to produce the maximum. Both macroelements and microelements are equally important, being key elements in the biochemical processes carried out in the plant growth cycle. Macroelements are N (nitrogen), P (phosphorus), K (potassium), and microelements are Ca (Calcium), Mg (Magnesium), S (Sulfur), Fe (Iron), Mn (Manganese) and Zn (Zinc), adding another series of microelements: Ni (Nickel), Mo (Molybdenum), Co (Cobalt), Cu (Copper), B (Boron), etc. which plants need in relatively small quantities, but which are essential to life. These elements are part of the composition of many enzymes that catalyze biochemical processes.

Obtaining good productions depends on the genetic quality of the crops but also on the quality of the soil. That is why in this paper the quality of the soil was studied through the prism of the availability of the stored nutrients, the applied dose of chemical fertilizers in the Triticum culture and the production obtained according to: the genetic production potential of the crop, the availability of the soil nutrient reserve, the water resource and dose of applied fertilizers. The quality of the production is studied from the point of view of protein and gluten assimilation, the parameters that include the wheat harvest in the bakery classes

Conclusions

(1). There is a major benefit in terms of nutrient transport for plants. In most types of mycorrhizae, the movement of carbohydrates, produced during photosynthesis, is from the host plant (the autotrophic partner) to the symbiont fungus (the heterotrophic partner).

(2). In the case of absorption of nutrients from the soil, the transfer has a reverse direction, from the fungus to the host plant [3]. The contribution of vesicular-arbuscular fungi to the assimilation of nutrients is the absorption of nutrients (especially phosphorus) from the soil, with the help of extraradicular hyphae - especially from those portions of the soil to which the plant did not have access.

(3).The hyphae of the fungus act similarly to the absorbent peripheries on the plant root; after comparing the diameter of the absorbent hairs (5-20 µm) with that of the hyphae of the fungus (3-7 µm), the absorbent hairs would have an advantage, but comparing the length and density of the hyphae of the fungus with that of the absorbent hairs - the fungus would have an advantage , because it exceeds the expansion possibilities of the plant by 10 to 100 times more.

(4). After the experimental nutritional treatments, the obtained production fell into the group of over 28%, i.e. obtaining flours for baking of superior quality.

Acknowledgements

The work of **Dragota Marina Alina** was supported by the project "PROINVENT", Contract no. 62487/03.06.2022 - POCU/993/6/13 - Code 153299, financed by The Human Capital Operational Programme 2014–2020 (POCU), Romania.

R E F E R E N C E S

[1] Azcon, R., Marina, A.D. and Barea, J.M. Comparative role of phosphate in soil or inside the host on the formation and effects of endomycorrhiza. Plant and Soil, 49:561-567 (1978).

[2] Gavito, M.E., Olsson, P.A., Rouhier, H., Medina-Penafiel, A., Jakobsen, I., Bago, A., Azcon-Aguilar, C. Temperature constraints on the growth and functioning of root organ cultures with arbuscular mycorrhizal fungi, New Pathologist, (2005).

[3] Jacobsen, D. Gill size of tricopteran larvae and oxygen supply in streams along a 4,000m gradient of altitude. Journal of the North American Benthological Society (2000).

[4] Morton, J.B., Benny, G.L. Revised classification of arbuscular mycorrhizal fungi (Zygomycetes): a new order, Glomales, two new suborders.Glomineae and Gigasporineae, and two new families. Acaulosporaceae, with an emendation of Glomaceae, Biology, Micotaxon. (1990).

[5] Pfeiffer, C.M., Bloos, H.E. Growth and nutrition of guayule (Parthenium argentatum) in a saline soil as influenced by vesicular arbuscular mycorrhizae and phosphorus fertilization. New Phitol. 108(3): 315-321 (1988).

[6] Smith, F.A., Smith, S.E. Mutualism and parasitism: diversity in function and structure in the arbuscular mycorrhizal symbiosis. Academic Press LTD Elsevier Science LTD (1996).

[7] Varma, A., (ed), Mycorrhiza: State of the Art, Genetics and Molecular Biology, Eco-Function, Biotechnology, Eco-Physiology, Structure and Systematics, 3rd Ed. Springer, Heidelberg.797 pp. 36. (2008)

[8] Wang, B., Qiu, Y. L. Phylogenetic distribution and evolution of mycorrhizae in land plants. Mycorrhiza 16(5): 299-363 (2006).