Cotswold Seeds Ltd
The Cotswold Business Village
Moreton in Marsh,
Gloucestershire GL56 0JQ

The Secret Life of Mycorrhizal Fungi - What Is it And How Does it Work?

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Fungi are very diverse and fascinating organisms. They are ubiquitous and come in all sorts of shapes, forms and specialties. Some are known for their negative impacts on crop yields[1] but fungi can also be very beneficial for multiple reasons which we will further investigate in this article. In this article, we will dive deeper into the wonderful world of a diverse group of fungi, namely mycorrhizal fungi.

Mycorrhizal fungi – what's that?

The terminology of mycorrhiza is derived from the old Greek words for 'fungus' and 'roots', hence, the name exactly describes where these fungi are found – in the soil, in association with the roots of plants[2]. Mycorrhizal fungi form **symbiotic** relationships with approximately 80–90% of the land plants[3]. Symbiotic means that both plants and fungi benefit from this type of interaction. The fungi play a crucial role in nutrient cycling by providing plants with soil nutrients, and in return fungi receive carbohydrates that the plant assimilated through photosynthesis for their growth and reproduction[4]. Mycorrhizal fungi develop **mycelia** which are extensive soil webs of long, filamentous and branching structures, so called **hyphae**[4]. The mycelium can actually be seen as an extension of the plant roots, enabling extra nutrient and water uptake.

Two general mycorrhizal types can be distinguished – one group that surrounds plant root tips and do not infiltrate into the plant cells, and another group that penetrates and develops inside plant root cells[2]. Of this latter group, **arbuscular mycorrhizal (AM) fungi** constitute a very important group of fungi that grow inside plant cells as they are the most widespread fungi and 200,000 plant species host them[4,5]. These plant species include, amongst others, herbs, grasses and many other crops[5].

How are plant-fungi partnerships established?

Okay, so we know that mycorrhizal fungi and plants form a tight partnership. But the question remains: how do they find each other, and how do they establish these interactions?

Well, it all starts with fungal spores which are found in the soil. They start germinating into hyphae and explore the soil to search for fine plant roots[2]. Plants excrete compounds in the proximity of the roots which can be detected by fungi, these are so called **root exudates**[2]. This way, the fungus knows where the roots are. However, while the fungus explores the soil, it also releases **fungal exudates**

which are in turn detected by the plant and trigger processes inside the root cells[2]. As a result, the plant knows a fungus is approaching and prepares for the symbiotic interaction.

After the chemical acquaintance, a physical encounter occurs. When the fungi finds a good location on the root, they develop a swollen hyphae, known as a **hyphopodium**[2]. The hyphopodium then protrudes into the outer layer of the plant cell wall. New genes are expressed in the outer root cells, and result in the production of an AM-specific structure that is essential for successful penetration, the so-called **prepenetration apparatus** (PPA)[2,6]. The fungal hyphae can grow through this structure when it penetrates the root cell[6]. Subsequently, the fungi starts branching and forms **arbuscules** (Figure 1), filling most of the plant cell. Arbuscules are actually the core of the symbiosis – this is where the nutrient exchange occurs[2].

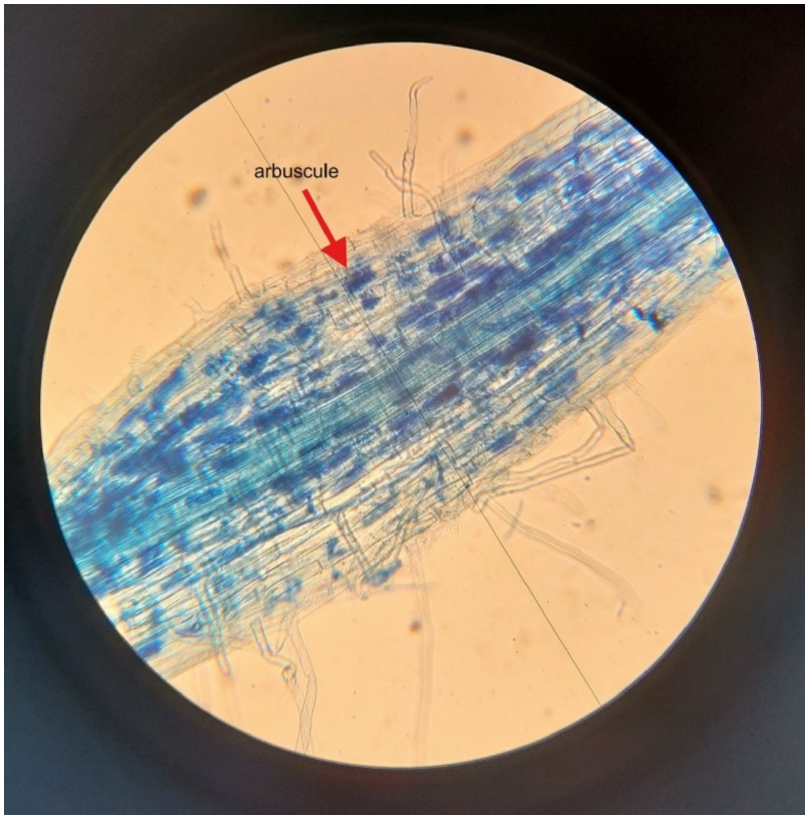

Figure 1. Photo through microscope of a fine maize root colonised by arbuscular mycorrhizal fungi. Arbuscules are clearly visible as the "cloudy", dark blue structures. Nutrient exchange occurs through the arbuscules. © Ellen Baekelmans (2022)

What can you do to maintain or improve AM fungal colonisation in your field?

First of all, AM fungi need living plants for their survival and reproduction as they depend on the sugars that are provided by plants. Therefore, the use of **cover crops** is a great solution to maintain the AM fungi in the field[8,11]. Secondly, **tillage** practices physically disturb the fungal mycelium. To maintain the fungal networks, tillage should be reduced[8,12]. Furthermore, reduction of **artificial fertiliser inputs** may also be beneficial for AM fungi[13]. When plants are offered an easily accessible source of nutrients – as from artificial fertilisers – they no longer see the benefit of providing sugars to the AM fungi. As a result, the fungal abundances decrease and fungal benefits and ecosystem services are lost. Lastly, avoid the use of **pesticides** and especially fungicides and nematicides as they kill all living fungi in the soil, including AM fungi[9].

In summary

AM fungi contribute to sustainable agriculture by decreasing the demand of artificial fertiliser inputs,

increasing soil health and increasing crop performance. You should view AM fungal networks as an extension of the plant roots, therefore one should try to maintain and enhance plant-mycorrhizal associations to improve crop performance and ecosystem services, which ultimately leads to more sustainable farming systems.

1. Fisher, M. C. et al. Emerging fungal threats to animal, plant and ecosystem health. Nature vol. 484 186–194 Preprint at https://doi.org/10.1038/nature10947 (2012).

2. Bonfante, P. & Genre, A. Mechanisms underlying beneficial plant - Fungus interactions in mycorrhizal symbiosis. Nature Communications vol. 1 Preprint at https://doi.org/10.1038/ncomms1046 (2010).

3. Martin, F. M. & van der Heijden, M. G. A. The mycorrhizal symbiosis: research frontiers in genomics, ecology, and agricultural application. New Phytologist vol. 242 1486–1506 Preprint at https://doi.org/10.1111/nph.19541 (2024).

4. Smith, S. E. & Read, D. Mycorrhizal Symbiosis. (Academic Press, London, 2008).

5. van der Heijden, M. G. A., Martin, F. M., Selosse, M. A. & Sanders, I. R. Mycorrhizal ecology and evolution: The past, the present, and the future. New Phytologist vol. 205 1406–1423 Preprint at https://doi.org/10.1111/nph.13288 (2015).

6. Genre, A., Chabaud, M., Timmers, T., Bonfante, P. & Barker, D. G. Arbuscular mycorrhizal fungi elicit a novel intracellular apparatus in Medicago truncatula root epidermal cells before infection. Plant Cell 17, 3489–3499 (2005).

7. Parihar, M., Rakshit, A., Adholeya, A. & Chen, Y. Arbuscular Mycorrhizal Fungi in Sustainable Agriculture: Nutrient and Crop Management. (2024).

8. Sosa-Hernández, M. A., Leifheit, E. F., Ingraffia, R. & Rillig, M. C. Subsoil arbuscular mycorrhizal fungi for sustainability and climate-smart agriculture: A solution right under our feet? Frontiers in Microbiology vol. 10 Preprint at https://doi.org/10.3389/fmicb.2019.00744 (2019).

9. Herath, B. M. et al. Applications of Arbuscular Mycorrhizal Fungi for Sustainable Agricultural Systems. in Arbuscular Mycorrhizal Fungi and Higher Plants 319–340 (Springer Nature Singapore, 2024). doi:10.1007/978-981-99-8220-2_14.

10. Messa, V. R. & Savioli, M. R. Improving sustainable agriculture with arbuscular mycorrhizae. Rhizosphere 19, (2021).

11. Schaefer, D. A., Gui, H., Mortimer, P. E. & Xu, J. Arbuscular Mycorrhiza and Sustainable Agriculture. Circular Agricultural Systems 1, 1–7 (2021).

12. Peng, Z. et al. Mycorrhizal effects on crop yield and soil ecosystem functions in a long-term tillage and fertilisation experiment. New Phytologist 242, 1798–1813 (2024).

13. Thakur, M., Ramawat, N., Anli, M., Ray, J. G. & George, N. P. Nutrition and Sustainable Diets, a section of the journal Frontiers in Sustainable Food Systems The inevitability of arbuscular mycorrhiza for sustainability in organic agriculture-A critical review. (2023).

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