Marvels and Mysteries of Mycorrhizae

By Brenda Frick, Ph.D., P.Ag.

Mycorrhizae are fungi that only live in union with plants. Both the fungus and the plant benefit from their relationship. The plant provides sugars to the fungus. The fungus provides a variety of services to the plant[1]. The potential value of these biological services is an exciting prospect for organic and low input farmers.

In natural systems, a lack of nutrients often limits plant growth. Plants supplement their nutrient needs through mycorrhizae. Researchers suggest that approximately 80 percent of plants and as many as 170 species of fungus may be involved in mycorrhizal associations[2]. Mycorrhizae are common in every natural environment[2].

Many crops support mycorrhizae. Legumes are especially prone to mycorrhizal association. Cereals generally are mycorrhizal, though different varieties have different levels of association[2]. Some crops, such as canola, are non-mycorrhizal. These crops can severely reduce mycorrhizae populations, and delay their development in crops that follow the non-mycorrhizal crops in rotation[2].

Many common agricultural practices such as tillage and the use of chemical fertilizers may substantially reduce the number and the types of mycorrhizal associations. These practices can change the communities of fungi, further reducing the benefits of mycorrhizal associations to the plants involved[3]. Mycorrhizae are especially limited in high phosphorus soils[2].

In organically managed soils, phosphorus levels are often reduced[4], so greater effects of mycorrhizae may be seen, especially where efforts are made to reduce tillage. A higher dependence on legumes for nitrogen and the use of cover crops to build organic matter in organic systems also benefit the mycorrhizae.

In a study of organic and conventional systems[5] more crop roots were associated with mycorrhizae in the organic plots. Soils managed organically were able to initiate mycorrhizal associations more readily. Much of the difference was related to the level of soluble phosphorus in the soil.

What benefits might mycorrhizae bring? Unfortunately, research on mycorrhizae in crop production on the prairies is very limited. Evidence from other species and regions suggests exciting potential. The mycorrhizal fungus grows as a vast web of tiny filaments in the plant roots and in the surrounding soil. The fungal threads, called mycelium (or mycelia in the plural), "explore" a much larger area than the plant roots alone could. When the mycorrhizae encounter limited resources, like water, phosphorus or micronutrients, they can pass them on to their associated plant[2]. Mycorrhizae can increase phosphorus uptake, and plant access to other soil nutrients such as ammonium, potassium, calcium, iron, copper, manganese, zinc and nickel[3].

Drought resistance and heat tolerance are other benefits attributed to mycorrhizae[6]. Some of this effect may be due to hormonal changes that the mycorrhizae cause in the plant. These allow the plant to maintain a better water balance under drought conditions[7]. Changes in the soil can also influence drought tolerance. Some mycorrhizae produce a sticky substance that cements small soil particles together into stable aggregates. The cement like substance holds water, which is a direct benefit in parched soils, and also acts to reduce soil erosion by water[8]. Soils are able to store more carbon when mycorrhizae are active[2].

Mycorrhizal associations may change a plant's relationships with its community. Other microbes in the soil may be more beneficial to plants with mycorrhizal associations[9]. Mycorrhizae can increase the ability of nitrogen fixing bacteria to promote growth in legumes, and of other growth promoting bacteria in other plants. Mycorrhizae may reduce infection by bacteria and fungi that cause plant diseases[10]. There is evidence for some trees, that association with mycorrhizae helps them resist insect attacks[11]. Other trees were able to gain nitrogen from mycorrhizae that infected living soil insects[12].

Plant to plant relationships can also be altered. Mycorrhizae can act as a bridge between two plants that allows phosphorus to move from a "donor" plant through mycorrhizae to a "receiver" plant[13]. Relationships can change between weeds and crops[3]. Mycorrhizae can inhibit plants that are not mycorrhizal - plants such as lamb's-quarters, pigweeds, wild mustard, and wild buckwheat. They may also inhibit the growth of non-mycorrhizal crops such as mustard, canola, quinoa, buckwheat or amaranth[14].

One researcher claimed that mycorrhizae can change the "functioning of weed communities so that the net effect of weeds becomes more beneficial" [3]. This may happen if weeds promote the growth of mycorrhizae that later colonize the crop. This could be why some crops grow better following some weed communities[3].

There are many challenges in working with mycorrhizae. Research is limited in part because the fungi are difficult to identify and culture[2]. Currently, we do not understand the full balance of benefits and risks. As one researcher stated, "When you are dealing with soil, it really is a big black box; it is so difficult to figure out what is going on down there." [15] Never-the-less, it seems that research in this area has great potential.

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