Mycorrhizae and Turfgrass

Biological tool improves establishment, growth, disease and drought resistance of golf turf grasses
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Myco-what?

Ten years ago the mention of mycorrhizal fungi to a golf superintendent might have met with a blank stare. Today's managers are much more knowledgeable regarding the benefits of mycorrhizae. Research studies have shown us all how these specialized fungi can improve fertilizer utilization, rooting depth, the speed of establishment, disease and drought resistance of turf. The golf industry and golf managers take their responsibility for managing the game and the environment seriously. New tools, such as the use of beneficial mycorrhizal fungi, allow golf managers to improve the condition of both turf and soil

Golf course management is a balance between the speed of play, golfer's desire to see perfectly manicured turf grass and the ecological concerns of frequent chemical and water use. Golf courses do not operate in a vacuum but are part of a watershed. The selection of fertilizers, pesticides and water are important not only to the "look" of the course but to the surrounding environment as well. Golf course managers have a new tool in their belt that utilizes nature's own way for growing plants and conserving resources. Golf course managers can use a group of beneficial soil organisms, the mycorrhizal fungi, to improve the health and vigor of their turf grass.

What mycorrhizae are

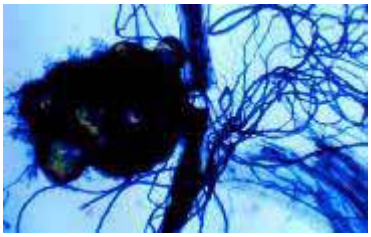

Figure 1

Glomus mosseae spores (left) colonized root (center) and hyphae (right)

Figure 2

Arbuscule within root where mycorrhizal fungus and grass root exchange food and nutrients.(Curtesy of M. Brumett)

Most grass species in their undisturbed natural environments form a beneficial association with mycorrhizal fungi. The resulting structure is called a mycorrhiza, or literally "fungus-root". Although several types of mycorrhizal fungi form mycorrhizae with plants, the largest group, -endomycorrhiza or also called arbuscular mycorrhizae form with most grass species. Mycorrhizal fungi are present in soil as spores, as hyphae in soil (filaments) or as colonized roots **(Figure 1).** Hyphae of mycorrhizae penetrate into and between the outer cells of the root. Inside the root the fungus forms special coiled hyphae (arbuscules) **(Figure 2)** that provide increased surface area for exchanges of food to the fungus and nutrients for the grass.

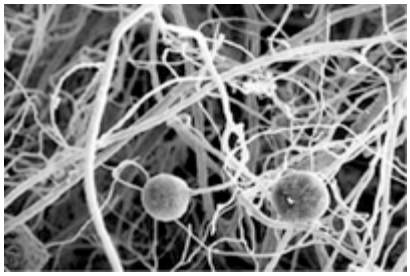

Figure 3

The abundance of hyphae attachedto colonized turf grass roots greatly expand the level of nutrients.(Curtesy of B. Auge)

The mycorrhizal fungi once established on the turf root system radiate out from the roots to form a dense network of filaments **(Figure 3)**. These filaments form an extensive system of hyphae that grow into the surrounding soil and provide a variety of benefits for the grass plant. This network of filaments obtains 15 major macro and micro nutrients and water and transport these materials back to the turf root system. Mycorrhizae are especially important for uptake of nutrients that do not readily move through the soil such as phosphorous and many of the micro-nutrients. The elaborate network of hyphae beneath the soil surface greatly increases the potential of the root system to absorb nutrients and water. Conserving and incorporating fertility and water directly into the target turf grass is a goal of golf management professionals and minimizes off site and groundwater movement of fertilizer that is not utilized. The network also binds soil particles together, improves soilporosity and the movement of air and water within the soil.

Where mycorrhizae are

Soils in natural settings are full of beneficial soil organisms including mycorrhizal fungi. Research indicates, however, many common practices can degrade the mycorrhiza-forming potential of soil. Construction practices, tillage, removal of topsoil, site preparation, heavy use of pesticides and chemical fertilizer, compaction, and leaving soils bare are some of the activities that can reduce or eliminate these beneficial soil fungi (Amaranthus et al. 1996; Doer et al. 1984; Dumroese et al. 1998). In many man-made landscapes we have reduced or eliminated healthy diverse populations of mycorrhizal fungi. **(Figure 4)**

Figure 4

Golf Course under construction near Las Vegas, Nevada.

Putting greens constructed according to U.S. Golf association standards lack mycorrhizal fungi at the time of sowing and mycorrhizal populations are slow to increase in the green (Koske et al. 1997). All important turf grass species can form a specialized symbiotic (mutually beneficial) relationship with mycorrhizal fungi. Unfortunately, modern golf construction practices often reduce or eliminate these beneficial organisms). New mycorrhizal products designed for the golf industry are now returning these ancient allies of grass back to golf course soils.

Show me the data

Mycorrhizae are, by far, the most researched aspect of soil biology. Over 48 thousand studies of the mycorrhizal relationship with plants are available in the literature.

Figure 5

Mycorrhizae inoculated bentgrass (left) and control (right) grown in sandy substrate with low fertility.

Studies have shown that grass species in the family Poaceae benefit greatly from mycorrhizal colonization in terms of growth and nutrient acquisition (Gemma and Koske 1989; Sylvia and Burks 1988; Hall et al 1984)**(Figure 5 & 6)**. Warm-season grasses such as bermuda grass with coarse root systems are very dependent upon mycorrhiza for sustained growth (Hetrick et al 1988; 1990). Recent data indicates that cool-season, finer rooted bentgrass species also form abundant mycorrhiza and benefit from the relationship, especially where the phosphorous levels are not too high (Gemma et al. 1995; Gemma et al 1997; Koske et al 1997). It is also well documented that inoculation of grasses with mycorrhizal fungi in soil with low phosphorous concentrations can produce greater shoot and root biomass (Hall et al 1984; Petrovic 1984; Hetrick et al. 1986; 1988).

Recent findings of improved turf grass establishment, root growth, fertilizer utilization, cover percentage, drought, nematode and disease resistance has golf course managers including mycorrhizal inoculations in their construction and maintenance practices. Golf course greens incur environmental stresses caused by compaction, frequent mowing, and artificial sandy substrates lacking nutrient and water holding capacities. Mycorrhizae can benefit many plants and results are often very apparent in situations where environmental stress is high.

Water, water everywhere?

Attention has focused on water conservation as water becomes a more expensive and environmentally sensitive component of golf course management. Research studies have shown that mycorrhizae can enhance the ability of grasses to avoid water stress (Koske et al 1995; Auge et al. 1995; Allen et. al. 1991). Recent studies from the Journal of Turfgrass Science indicate that creeping bentgrass inoculated with the mycorrhizal fungus *Glomus intraradices* tolerated drought conditions significantly longer than non-mycorrhizal turf (Gemma et al. 1997). Mycorrhizal inoculated turf also recovered more quickly from wilting than non-mycorrhizal turf. Mycorrhizal turf maintained significantly higher (avg. 29% more) chlorophyll concentrations than non mycorrhizal turf during drought events. Other research studies indicate that greater chlorophyll content and enhanced photosynthate production can lead to increased drought resistance. Mycorrhizal inoculations can be a useful tool to managers because sand/peat putting greens dry out quickly and creeping bentgrass is intolerant of drought and difficult to maintain under summer conditions.

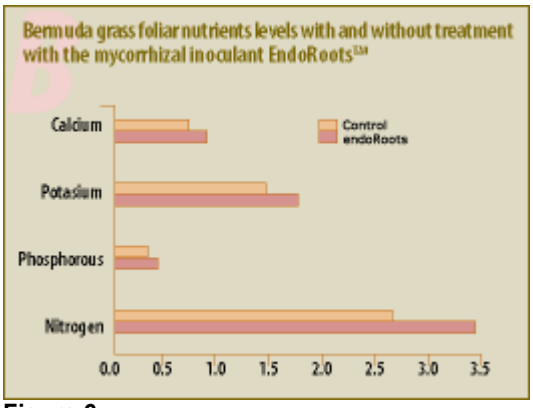

Figure 6

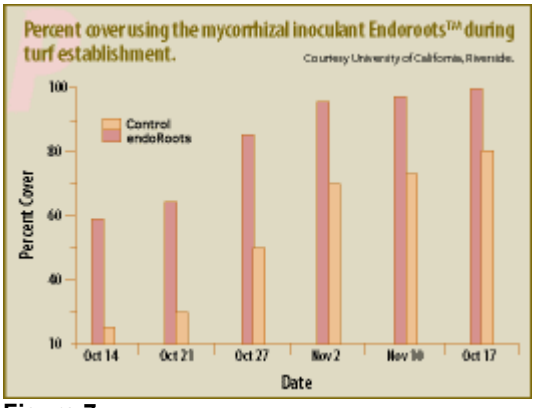

Figure 7

Faster grow-in

Research (Gemma et al, 1997; Green et al. in preparation) indicates that mycorrhizal inoculation at the time of sowing can increase the rate of establishment by turfgrass species**.** The early establishment of turfgrass in sand/peat medium has received the attention of managers where early

playability can have a significant economic payback. In recent trials in Oregon and California, mycorrhizal inoculants at the time of sowing doubled the percent grass cover in the early establishment period.**(Figure 7, 8, 9).**

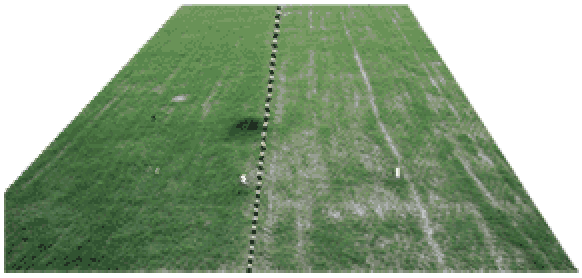

Figure 8
Creeping Bentgrass cover with mycorrhizal inoculation with endoroots (left) and cover in control area (right). (Courtesy if Robert Green PhD Research Argonomist, University of California)

Figure 9
Bermuda grass cover with mycorrhizae inoculation using Glomus intraradices spores (right) and non inoculated control (left).

Resistance to disease and nematodes.

Root pathogenic fungi and parasitic nematodes can be acute problems for golf course managers. Research indicates that the mycorrhizal relationship can improve grasses resistance to the negative effects of these organisms (Newsham et al. 1995; Little and Maun 1996; Thompson and Wildermuth 1989, Linderman 1994). Mycorrhizal fungi improve the plants resistance to soil born diseases in several ways for a wide range of host species (Allen 1991; Linderman 1994). The literature of recent years, indicates that mycorrhizal control of plant diseases may be strongly influenced by enhanced nutrition. Other factors might also play a role, such as less availability of resources for the pathogens, physical changes in roots and root tissues, chemical changes of root and plant tissues, reduction of environmental stresses, and increased concentrations of other beneficial soil organisms around roots.

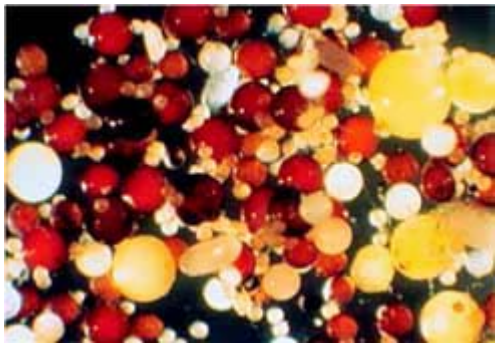

Figure 10
Spores from a variety of Glomus mycorrhizal species.

Some specific mycorrhizal fungi like Glomus mosseae **(Figure 10)** and Glomus intraradices are particularly effective in preventing fusarium, pythium, and phytophora infections (St-Arnauld et al 1995; Sitaramaiah and Sikora 1981; Baghel and Bhatti 1990))

Root infections by pathogenic nematodes are generally less severe on mycorrhizal plants than on non mycorrhizal plants, but the responses may vary, and the mechanisms involved are being studied (Linderman 1992). Symptoms of nematode infection are generally reduced, and often, nematode populations themselves are reduced (Hussey and Roncadori 1978; 1982). One reasonable proposed mechanism is the improvement in turf grass vigor as a result of the mycorrhiza relationship masks yield losses caused by nematode infection. Also, changes in root exudates by mycorrhizae may change the attractiveness of roots to nematode pathogens. Increased production of inhibitory substances by mycorrhizae may additionally affect nematode population and survival. Research has demonstrated mycorrhizal fungal species Glomus mosseae and Glomus intraradices can help control the negative impacts of parasitic nematodes (Pinochet et al. 1993; Calvert et al. 1993; Zambolim and Schenck 1983; Chou and Schmitthenner 1974).

When do I use mycorrhiza?

Sand/peat medium incorporated during construction of golf greens is generally devoid of mycorrhizal inoculum (Gemma et al 1997) and is a prime candidate for achieving the benefits of the mycorrhizal relationship. Mycorrhizal inoculum can be incorporated during construction and aerification. Mycorrhizal propagules are then incorporated into the rooting zone where they will be effectively utilized.

Figure 11

Mycorrhizal inoculum should be incorporated both spring and fall for several years until healthy populations of mycorrhizae are established. Mycorrhizal colonization assessments are simple tests now available at many soil testing laboratories. Incorporating mycorrhizal inoculum during aerification is an appropriate way of developing a mycorrhizal network in the soil even for greens not inoculated during construction **(Figure 11)**

Use diverse species of mycorrhizal fungi

Natural areas generally contain an array of mycorrhizal fungal species. The proportions and abundance of mycorrhizal species often declines following any disturbance. Not all mycorrhizal fungi have the same capacities and tolerances. Because of the wide variety of soil, climatic, and biotic conditions characterizing golf environments, it is improbable that a single mycorrhizal fungus could benefit all turf grasses and adapt to all conditions. For example, the types and activities of mycorrhizal fungi associated with grasses are often different than those associated with woody plants. Mycorrhizal fungi have differing abilities to produce antibiotics that retard soil pathogens. Likewise, some mycorrhizal fungi are better at producing enzymes that facilitate mineral uptake such as phosphorous and iron. Still other mycorrhizal fungi can access organic forms of nitrogen. Selecting mycorrhizal products that contain several mycorrhizal species likely provides a range of benefits to the plant not found with only one species. **(Figure 12)**

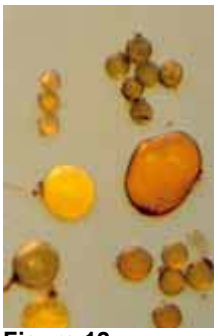

Figure 12
A diversity of mycorrhizal spores from the genus *Glomus.*

Making a commitment

How often do you think about the impact of your golf course maintenance practices on turf and environmental quality? Annually? Weekly? Daily? If you responded weekly or daily you are probably a person who is interested in organic, environmentally friendly products that will improve turf and soil quality. Mycorrhizal fungi are not new, trendy, genetically engineered organisms. These specialized fungi have been fundamental to the survival and growth of plants for over 400 million years. When you view turf grass at a golf course it is like viewing an ice burg. Between 50 to 80 percent of the energy absorbed by the grasses is allocated below-ground. This energy can be put to work by the manager utilizing specific beneficial soil organisms.

New scientific advancements in the cost effective growing of certain mycorrhizal species beneficial to turf grass are rapidly bringing mycorrhizal products to the golf management marketplace. Mycorrhizae can help lower costs over the long run. Healthy living soil and turf will retain nutrients, build soil structure, reduce stress and suppress disease, thus reducing the frequency and level of certain maintenance activities. Choosing to incorporate mycorrhizal fungi into construction and aerification programs will not only benefit the environment but improves turf cover, rooting, fertilizer utilization, disease and drought resistance. Protecting the environment has never made more sense. Myco-what? This may be a question of the past.

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