Mycorrhiza: A Water Management Strategy for Turf

Regardless of the environmental conditions, the objective of lawn maintenance is to obtain and keep a dense turf, homogeneous with an intense color, and free of diseases. There are many challenges to overcome in order to achieve this goal: water is scarce or of poor quality, containing salt or other pollutants, fertilizer applications need to be limited to prevent further pollution, and the use of plant protection products does not always offer the desired result. In present days, turf management is often linked with a kind of vicious circle in which most applications - irrigation, fertilizers, plant protection – create further grass quality problems, and are making necessary more corrective treatments. The purpose of this article is to demonstrate that mycorrhiza offers an opportunity to break this vicious cycle and to create conditions for the maintenance of a high quality turf at favorable economic terms.

In the arid and semiarid areas of the Mediterranean Basin, water use for watering lawns is an on-going concern. In many cases access to water is limited, or it is necessary to use recycled wastewater containing salts and pollutants. Furthermore, the costs of maintaining a lawn are very high when considering the full cost of water and of the energy used to pump it. In Andalusia, Spain, the construction and the operations of golf courses are now regulated under Decree 43/2008. It requires, among other things, a water conservation plan with concrete and validated measures. Similar regulations are in place in other regions, or are expected to be enacted soon.

MYCOSYM is a company dedicated to developing biological solutions based on mycorrhiza, a symbiotic relationship between a plant and a fungus. This relationship is beneficial as the fungus receives carbon and energy resulting from the photosynthesis of the plant and, in turn, the plant receives water and nutrients that the fungus accesses beyond the zone of influence of the roots. This symbiosis has evolved very early in plant evolution, so the phenomenon "mycorrhiza" is rather the rule than the exception.

In scientific studies and in practical applications, it has well been demonstrated that a lawn treated with MYCOSYM's products to establish a mycorrhiza has a better appearance and vigor, tolerates without any damage irrigation reduction of up to 50%, recovers from damages due to extreme situations (e.g. until near the point of permanent wilt), tolerates more water salinity, and has fewer disease symptoms. In addition, users have noticed a higher turf density and less soil compaction on golf greens that were treated with MYCOSYM products.

Mycorrhiza: Symbiosis Between Fungus (myco, μυκό) and Root (rhizo, ριζο)

The roots of mycorrhizal plants are colonized by certain beneficial soil fungi. It is known that growth and development of most plant species cannot be optimal if not in a mycorrhizal state. Over 80% of all plant species form arbuscular mycorrhizae or endomicorrizae, including grass species commonly used for lawn.

Arbuscular mycorrhizal fungal species are ubiquitous and not specific to given plant species. The majority of commercial inoculants are based on *Glomus intraradices*, a species having demonstrated its versatility in colonizing most host plants in various environments.

Once the symbiosis is established, the fungus will grow in the form of hyphea, extend its mycelium into the soil and colonize further roots on its way. The rhizosphere (i.e. the soil volume occupied by the roots and the mycorrhizal fungus) is thus greatly extended and the access to water and nutrients contained in the soil is significantly enhanced. In the soil, the fungus completes its life cycle to produce new spores that can initiate colonization of new roots. Overall, the plant is vitalized with the extensive colonization by the fungus.

Soil Ecological Balance Improves Turf Stress Tolerance.

The importance of mycorrhizae and microbial activity are well known components that contribute to increased efficiency in absorbing nutrients and water, to improve soil fertility, and to promote tolerance to and recovery of the inoculated plants from diseases and abiotic stresses such as drought, salinity, nutrient imbalances, and the presence of contaminants.

Mycorrhizal fungi are frequently found in undisturbed natural soils, contributing to the proper growth of the plants and to biological equilibrium. This equilibrium is often disturbed under agronomic or landscaping conditions and has to be re-established by the application of mycorrhizal products.

It has been reported that root diseases caused by pathogenic microorganisms are most severe in soils with low levels of beneficial microorganisms. Therefore, in soils disturbed by man or artificially created (agricultural land, gardens, green areas, sports, growth substrates, etc.) it is necessary to provide mycorrhizal fungi to achieve a better balanced system.

Benefits of Mycorrhizae.

Root development: formation of new roots is stimulated. The higher density and greater volume of roots results in a more efficient grass plant, better prepared to tolerate stress.

Nutrient use: the spread of the fungus outside the roots and between the roots allows for higher capture of nutrients, beyond their depletion zone, and for their transport to the plant. In addition, hyphae of the fungus have different mechanisms of metabolization and are able to unlock elements with low solubility and low soil mobility. The result is greater efficiency in the use of fertilizers, particularly phosphorus and micronutrients.

Efficient use of water: similar to the case of nutrients, the extended rhizosphere allows for a better access to and transport of the water available in the soil, beyond the root system itself as well as the interstitial water between the roots. This is particularly important when the soil humidity is below the absorbing capacity of the roots. On balance, the plant can survive in a healthier state with less water and recovers better from drought situations.

Disease tolerance: as the plant is mycorrhized it has a lower requirement for plant protection measures against infections by root pathogens, including *Phytophthora spp*., *Pythium spp.*, *Fusarium spp.*, *Thielaviopsis spp.*, *Rhizoctonia spp.*, *Verticillium spp.*, *Alternaria spp.*, *Sclerotium spp..* The same applies to problems caused by nematodes.

Salinity tolerance: mycorrhized plants tolerate conditions of salinity in the soil or in the irrigation water. The fungal system plays a role in osmotic regulation, enabling water absorption at higher salt concentrations.

Tolerance to heavy metals and pollutants: mycorrhizae act as stabilizers for such pollutants, filtering and fixing them in the soil, thus preventing their absorption that would be toxic for the plant. This phenomenon is used in site remediation and lands reclaim; and it also enables also the use of recycled wastewater.

Soil de-compaction: the fungal mycelium is an intense network in the soil that extends within and beyond the root zone, thus improving the soil structure. Furthermore, the hyphae secrete a protein called glomalin that aggregates soil particles without compacting the soil: the mechanical resistance of the lawn will be improved.

Scientific Study.

New technologies are needed to meet the environmental and economical requirements linked to the intense use of water and other inputs in maintaining lawns, e.g. sports fields, golf courses, without scarifying any quality criteria.

To this effect, to confirm its practical experiences, and to corroborate the existing scientific literature on mycorrhiza functionality, in 2008 MYCOSYM has contracted a study to the Department of Agronomy, Institute of Sustainable Agriculture (Spanish National Research Council, CSIC) in Cordoba, Spain. This scientific study aimed at measuring the tolerance to water stress of a grass inoculated with a MYCOSYM product..

Hydric Stress Tolerance of Mycorrhized Grass.

Availability and quality of water for irrigation is the main limiting factor in the sustainable maintenance of sports and amenity lawns.

For their growth and to maintain a thermal balance, plants draw water from the ground to evaporate it into the atmosphere. The transpiration rate required at any time depends on, primarily, air temperature and air humidity.

In the case of water deficit, i.e. when there is prolonged or temporary inability of the plant to transport water, wilting symptoms will appear, sometimes becoming irreversible.

Water deficit occurs when the soil humidity remains low, when the transpiration rate is high, or when there is excessive resistance to water flow in the roots.

Working Principle: Actual conditions of a golf green were simulated, using Penncross (*Agrostis stolonifera* L.) in a well-drained sandy substrate, maintaining transpiration conditions under control. During testing, water deficit was caused by reductions of 20, 40, 60 and 80% of the optimal field capacity, which had been determined as being 15% soil humidity content.

Results: For any soil humidity content (from saturation to water deficit), the mycorrhized grass shows a higher transpiration rate than an untreated one. (Figure 1).

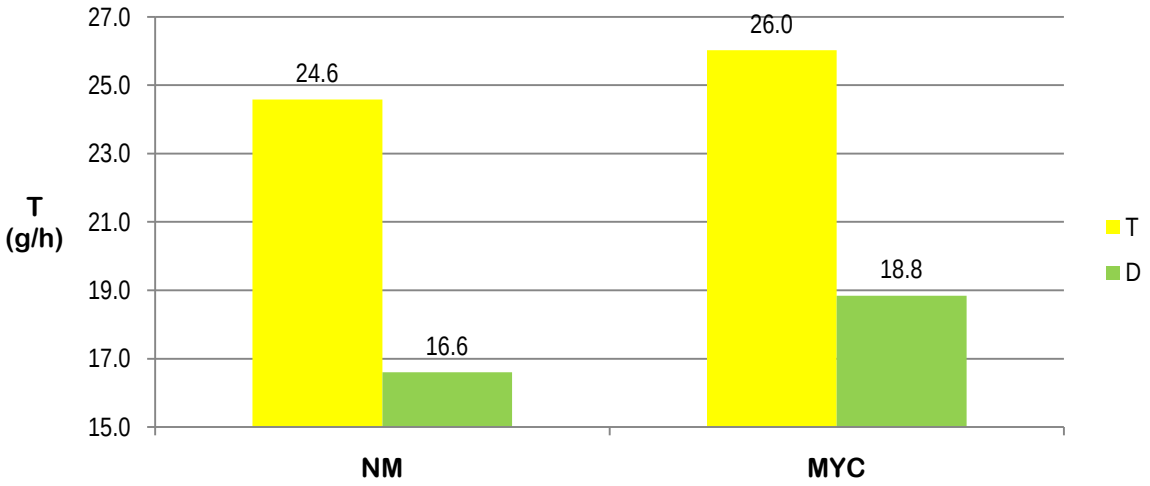

Figure 1. Average transpiration rate of mycorrhized *Agrostis stolonifera* (MYC) and not mycorrhized (NM) in a sandy soil, at high humidity (T) , or at water shortage levels (D).

Actually, the increased transpiration capacity is relevant when the amount of available water in soil is a limiting factor, i.e, near the permanent wilting point, when the quantity of available water is so low that the damage by water stress in the plant will be irreversible. This occurs at a humidity of around 7% in a sandy soil. (Figure 2).

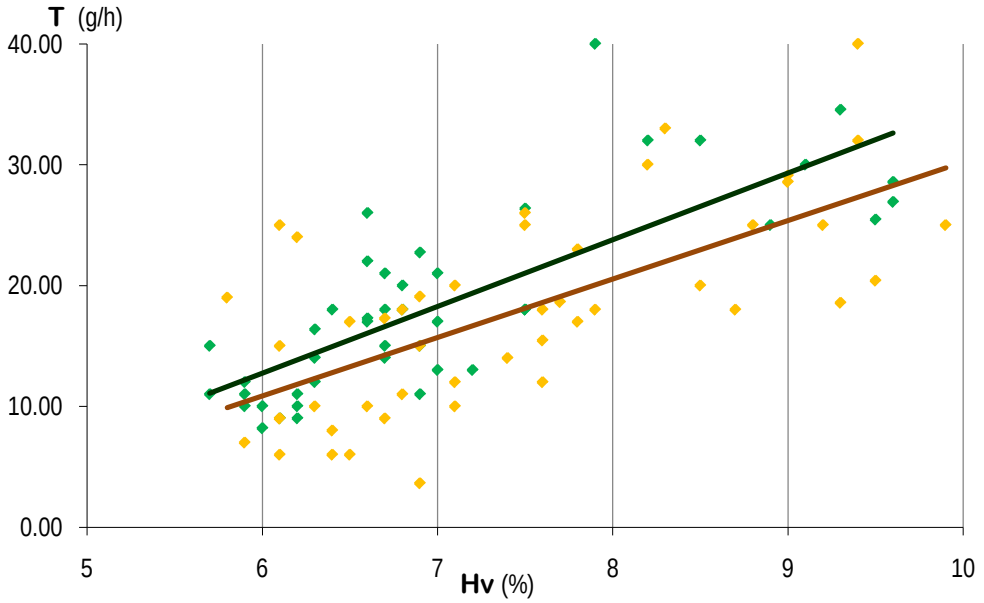

Figure 2. Transpiration rates of a mycorrhized grass (green dots, MYC) and of a non-mycorrhized one (yellow dots, NM), in function of soil humidity. The range below 10% humidity is relevant since it is generally considered as suboptimal for a sandy soil.

Under all testing conditions the mycorrhized grass had a higher rate of transpiration than non-mycorrhized grass, down to a water deficit of 40% as compared to a normal field water capacity.

Observations on the increased capacity of transpiration of a fertilized grass were consistently confirmed by a surface leaf temperature decrease of up to 1 ºC. As transpiration is the mechanism by which plants dissipate heat, a lower temperature is an indication of a higher transpiration rate.

In the above ground growth of the grass itself, no significant differences were observed between mycorrhized and non-mycorrhized grass (Figure 3, left). However the root shape was clearly different, mycorrhized plants having a longer and finer aspect. (Figure 3, right).

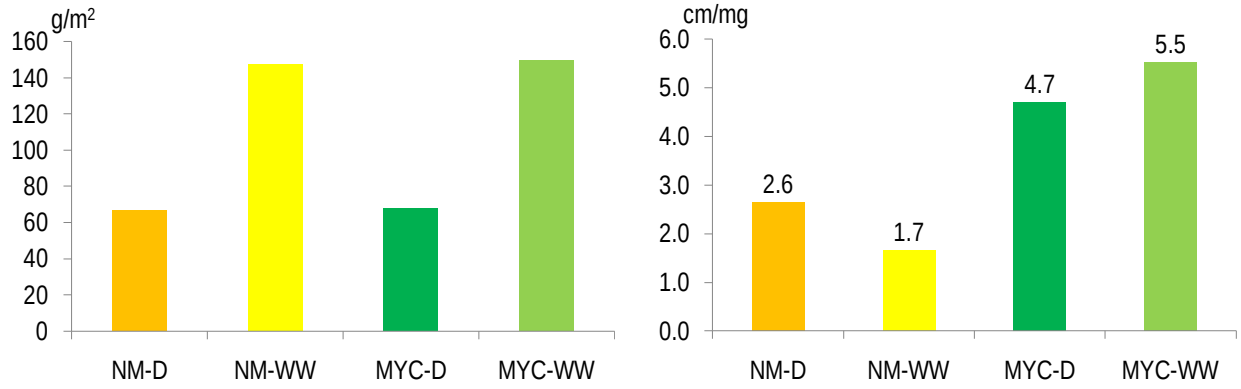

Figure 3. Growth as a function of irrigation and of mycorrhiza.
[NM: non-mycorrhized, MYC: mycorrhized; WW: well watered; D: deficit irrigation].
Left: above ground growth, leaf fresh weight/m², Right: root structure, specific root length.

Conclusion: Mycorrhiza = Water Management System.

This study at the Spanish National Research Council showed that mycorrhizae improve the hydric status of turf by increasing its ability to use the available water in the soil, even at such low amounts that adverse effects would normally occur.

It is suggested that the mechanism underlying this effect is the lower resistance to the flow of water that a mycorrhized root presents, as compared to a non-mycorrhized one. The ability to transport water from the soil into the atmosphere even if the amount of available water is not readily accessible prevents the grass to reach its permanent wilting point, or displaces this point to lower soil humidity levels.

A more efficient irrigation regime can be applied. Management strategies could be (1) longer periods between irrigations, i.e. waiting to reach a point of lower soil humidity before watering again, or (2) decreasing the amount of water applied during each watering, or a combination of the two.

On balance, less water will be used over the whole season without sacrificing any of the quality criteria set for a professional lawn.

Mycorrhizal fungi application in lawn.

Benefits derived from a well mycorrhized plant have been published since many years. However, its use in agriculture, gardening and landscaping has not been extensive because of the lack of availability of standard products in industrial quantities.

MYCOSYM has developed an efficient production system that now makes possible the application of mycorrhizal inoculants at large scale.

At seeding

Aireation

At sodding

DryJect Machine

Dose: 15 g/m^2 = 150 Kg/ha

When new lawns are prepared, the product MYCOSYM® Herba, specially adapted to grasses, will be broadcasted at a dose of at least 15 g/m^2, and incorporated into the soil at a depth of 2-5 cm before sowing or before the placement of turf patches or rolls.

For established lawns, the application will take place at the same time that aeration maintenance is performed. After having perforated the lawn and removed the plugs the product is broadcasted at a rate of at least 15 g/m2, and distributed into the holes together with the refilling sand.

The minimum recommended dose is sufficient to achieve comprehensive mycorrhiza colonization under normal conditions. Higher doses will provide a higher initial population of the fungus and promote a faster and more intense mycorrhiza establishment.

To allow a proper establishment of the mycorrhiza it is advisable to fertilize only slightly (in particular, keeping phosphorus levels well below 30 ppm), and to avoid the use of systemic fungicides during the first weeks after application.

Spores of mycorrhizal fungi have a size that hinders their migration into the soil, making it necessary to apply the inoculantss in the vicinity of the roots. Therefore, it is not advisable to apply them through the irrigation system.

MYCOSYM products contain only mycorrhizal fungi, they are safe for humans and for the environment. Products are listed for their use in organic agriculture by the Swiss Research Institute of Organic Agriculture FiBL.

Apply once as an investment.

Once the mycorrhiza is established, it will last for several years, without any need for recurring inoculation.

As significantly less water and less fertilizer will be consumed, the need for disease control measures will also be reduced. Mycorrhiza is an indispensable technology in the sustainable management of a golf course.

For a one-time investment, annual benefits will be drawn in the form of reduced expenses for water, energy, fertilizers and plant protection products. The return on this investment is clearly favorable and is completed by the satisfaction of managing a lawn in a responsible and sustainable manner.

Testimonials and Applications Results in Golf Courses.

Golf courses using the mycorrhiza technology are committed pioneers, seizing the opportunity to excel in environmental management with modern methods. So far, and due to their high value, greens have been treated in many golf courses. However the benefits arising from mycorrhiza can also be drawn when applying on fairways.

Picture 1: Real Club de Golf de Sotogrande, Spain. Root structure differences
(left: control, right: treated by MYCOSYM)
These differences enabled a faster and better recovery of the lawn treated by MYCOSYM after an episode of water stress: two days without water after having already reduced watering by 20%.

Picture 2: La Cala Golf, Spain:
25% water reduction already achieved, reduced compaction, elimination of the use of humidifiers.

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Picture 3: Club de Golf El Zaudín, Seville, Spain: a totally disturbed green with disease symptoms and helpless aspect could be recovered by mycorrhiza treatment at aeration. After more than three years this green remains in perfect conditions. Subsequently all greens of this course were treated, resulting in water consumption reduction by 25%, and significant lower use of fertilizers and fungicides.

Picture 4: Vale do Lobo Golf, Portugal:
Application with the DryJect machine during the aeration procedure.
Mycorrhiza improved the grass with a larger root system; the user noticed a reduced fertilizers and fungicides consumption.

Frequently Asked Questions

What precautions must be taken for a successful application?

It should be borne in mind that mycorrhiza is formed by a fungus inoculating the plant. Therefore, fungicide may interfere with the mycorrhiza establishment. Avoid the use of systemic fungicides for 2-3 weeks after application. Once the mycorrhiza is established no more adverse effect is expected. In any case the use of contact fungicides is not restricted.

It is known that too high concentrations of nutrients, in particular phosphorus, may inhibit the initiation of the mycorrhiza formation. Also, taking into account the efficiency improvement in absorbing nutrients provided by the mycorrhizal association, it is advisable to reduce the fertilizer level in general. Particularly phosphorus should be reduced drastically and stay at a level way below 30 ppm.

What about recurring applications?

MYCOSYM® Herba does not need to be applied in a recurrent manner, as fertilizers or pesticides do. The mycorrhiza effects last many years, depending on crop management and provided that no adverse conditions are created.

How results of tests under controlled conditions can be translated to field conditions?

The testing model has been chosen to closely reflect actual conditions. Without doubt water reduction potential of more than 40% can be attained. In the field, many variables cannot be controlled as well as in the laboratory. For practical purposes, it is recommended to begin the water reduction after the proper mycorrhiza establishment in small rates of 5-10% each week up to attain the maximal limit.

When is the best application time of MYCOSYM Herba?

Any time is right, although in spring and autumn the mycorrhiza will establish itself faster because of the high biological activity during these seasons. This timing also coincides with the aeration treatment that is usually made once or twice a year.

How long does it take for a lawn to be in a full mycorrhizal state?

This will depend mainly on a correct application and on the activity of the plant. Under normal conditions it takes between 2 and 4 months. To see if a lawn is mycorrhized, root samples can be dyed and observed under the microscope.

Is it an environmentally friendly product?

Yes! Mycorrhiza is a natural symbiotic phenomenon that can be observed in all soils. The MYCOSYM products do not contain GMOs (Genetically Modified Organisms) and are not derived from any GMO. MYCOSYM's aim is to make available high quality mycorrrhizal inoculums in large quantities.