Healthy Soil is the Future

Two months ago Bob Taylor of the STRI wrote an article based on limited trials data. This suggested that using bacterial and fungal additives as part of a maintenance programme, to re-establish natural growth processes on substantially sterile greens, would not work.

The trials and article were based upon a common misconception that a single microbial product can be a magic cure-all that will produce fantastic results, like a new improved fertiliser. This is wrong.

Given the different physical and chemical make up of greens and tees from club to club single site trials for a single product are very unreliable guides.

Adopting a biological approach means reintroducing, as far as possible, normal plant growth processes that have evolved over millions of years.

In this quick look at what goes on underground I will try and set out what happens in the soil and how natural processes can be used to produce better playing surfaces. My comments are based upon a large number of academic studies and our own research and observations at Symbio, gathered through collaborative research with local universities and practical experience of applying these techniques to hundreds of golf courses over the last eleven years.

Apart from commercially sensitive information concerning specific microbes nearly all the data is published on the internet.

Grasslands are part of a major food web, which stretches from man above ground to the smallest microbe in the soil below ground. There are probably thousands of mechanisms to ensure growth continues in times of stress to stop these chains breaking down to prevent mass starvation through the entire food web.

Since the 1920's when inorganic fertilisers were introduced which override natural nutrient uptake sports turf soil has been prone to excessive fungal disease, dry patch, thatch build up and black layer.

Excessive fertilisers, fungicides, water and iron damage the soil food chains, blocking recycling, natural growth and disease suppression. More chemicals are introduced to treat more symptoms and the soil can become less and less fertile until it becomes too toxic to support healthy grass growth.

LET'S LOOK AT HOW TO SOLVE THE UNDERLYING PROBLEMS.

Plants photosynthesise taking energy from the sun, carbon from the air, and nutrients from the soil producing carbohydrates, proteins and fats. In grasses, about 50% of this energy goes into top growth, to feed the above ground food chain and 50% goes back into the soil via the roots and exudates to feed the underground, mostly invisible, food chain (Figure 2).

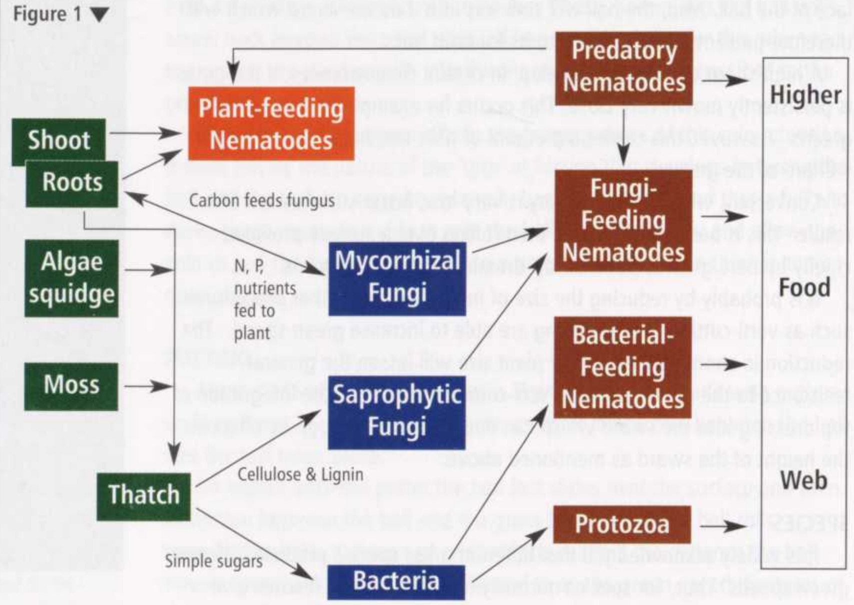
OUT OF SIGHT

Out of sight used to be out of mind, but by using molecular analysis and scanning electron microscopes that allow identification of individual bacteria, fungi and other organisms, we can now start to understand how natural processes work on a golf green and how to use them to our advantage.

THE SOIL FOOD WEB (Figure 1)

Food underground comes from exudates from plant roots, in the form of proteins and carbohydrates, which includes sugars and starches. Sugars are the main food for bacteria. (Figure 2).

Figure 1 ▼



The Soil Food Web in Sports Turf Soils - by Soil Foodweb inc. ™

When grass dies (i.e becomes thatch) it is full of cellulose and lignin. These are the tough structural materials that give grass the strength to resist bending and trampling. You only have to look at a dead tree to know this is the favourite food of fungi which convert dead grass, leaves and twigs to humus - the nutrient store and foundation for future plant growth.

Bacteria and fungi form the foundation of the whole food chain. The good (saprophytic) microbes only live on dead matter. There are about 20,000 enumerated soil bacteria and 15,000 fungi, of these, most greenkeepers know only the few disease - causing (pathogenic) fungi which live on live plants, by name.

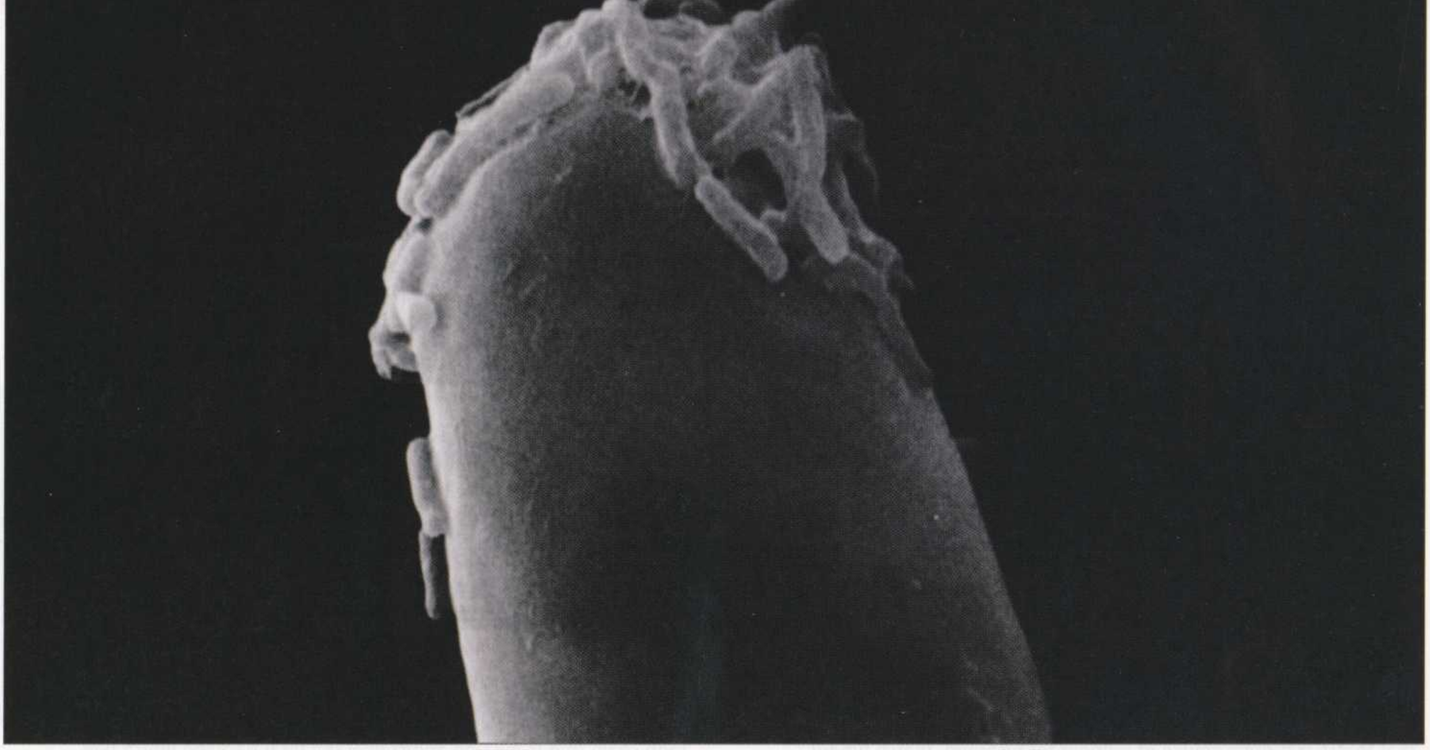
Certain fungi known as Mycorrhizae form extremely close associations with the roots, actually growing inside them. The plant provides these fungi with carbohydrates (sugars) and in return the mycorrhizae use their hyphae to suck up phosphate, nitrate, trace elements and water and feed them to the plant, effectively giving the plant a vastly extended root system. This is a two way dependant partnership and both partners rely extensively on the other for survival.

It must be said that very little is known about how all these bacteria and fungi interact but we do know how they fit into the food chain.

In a gram of healthy soil you may find about a billion bacteria weighing about 100 μg and a similar weight of fungal biomass, only half of each may be active but for fescue and bent grass growth it is important to have

Martin Ward, of Symbio, looks at some of the progress which has been made by the bio-tech industry in recent years.

Figure 2 ▶



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approximately equal bacterial and fungal biomass.

A few bacteria fix nitrogen from the atmosphere; others take it from recycled nutrient in the soil. Locked up in a bacterial cell or fungal hyphae nitrogen is not available to the plant. To release nutrient the microbes have to die or be eaten by the next stage of the food chain comprising protozoa and nematodes. There may be 10,000 protozoa in a gram of soil but only a few hundred nematodes. Some nematodes can be seen with a magnifying glass.

Protozoa and nematodes eat the bacteria and fungi, they use the carbon to grow and excrete excess nitrogen as ammonium, which feeds the grass when converted to nitrate by nitrifying bacteria in the presence of oxygen

There are two other types of nematode, root - eating and predatory. Root - eating you know about but they are kept in check by the predatory nematodes which eat all nematodes, These in turn are eaten by small worms which create small spaces in the soil leaving little tunnels full of excrement (ammonium) for roots to grow into and feed on and so the chain expands up to moles and other burrowing animals. For golf course purposes we try to stop the food chain at non-casting worms but up to that point all aspects of the chain are necessary for natural healthy grass growth.

Working together all these microbes and organisms ensure a constant supply of nutrient for the plant, avoiding the boom and bust of the fertiliser cycle, they protect the grass from disease, because if the grass dies the whole food chain is compromised and they recycle dead grass back into usable nutrient.

WHY ARE GOLF GREENS STERILE?

Dumping a tonne or more of inorganic fertiliser (salts) per hectare per year means that the plant is swimming in a sea of food. The plant does not need its associations with microbes to live, which coupled with the fact that bacteria like sugars, not salts, the use of fungicides, excess water and compaction which deprives the microbes of oxygen, the removal of animals which replenish the microbes via excrement and near daily cutting mean that large parts of the food chain cannot survive.

We often find that golf greens have less than 1% of the microbial biomass of healthy soil and that the total fungal biomass is much less than that of the bacteria, though as we shall see fungi are extremely important to your greens management programme.

You can now see the reason for adding bacteria, fungi and selected food sources is to re-establish the primary links in the soil food chains.

HOW DOES THIS HELP THE GREENKEEPER?

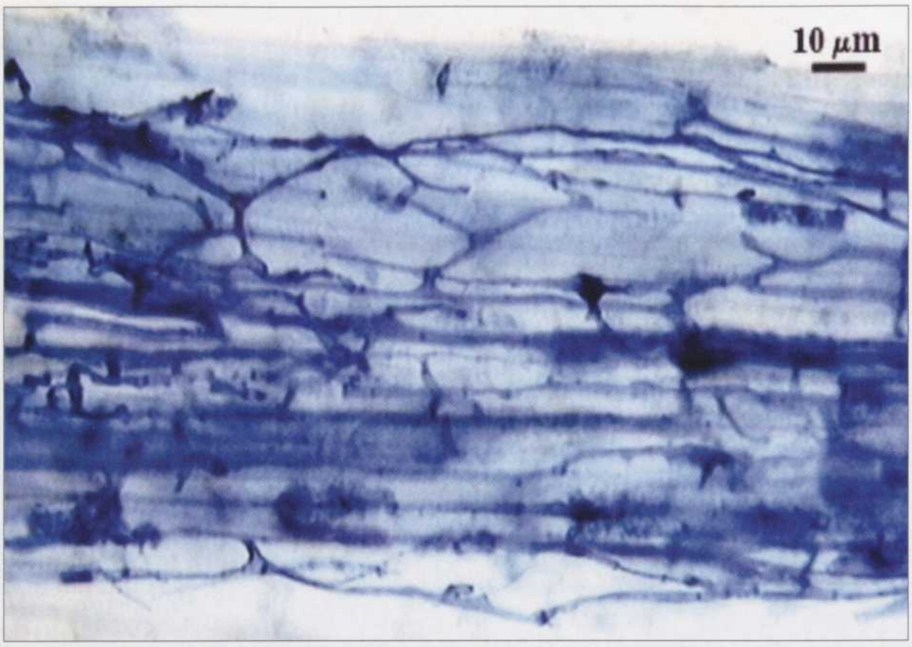
DISEASE MANAGEMENT

There are of course specific remedies for each disease as they metabolise in different ways but in general, diseases occur on sports turf because fungal pathogens, which cull weak plants as part of natural selection, have a lot of weak grass to attack and very few of the natural defence mechanisms to stop them.

If all the grass dies we all starve, so nature has worked out some clever tricks to keep the plant and food chain alive. Figure 3 is a root covered in mycorrhizal and other fungi which shows blue in the picture, you can hardly see the root for fungi. It effectively forms a barrier against any disease-causing organism that wants to penetrate the root.

The good fungi and bacteria also get to any freely available nutrient first and out-compete the pathogens, this is called competitive exclusion. A third way that some soil microbes keep their host plant alive is to produce toxins active against disease causing organisms.- Finally in times of stress and food shortage some microbes will eat other microbes,

Strengthening the sward and replacing the defence mechanisms has to be an essential part of any IPM programme.



◀ Figure 3

THATCH AND DRY PATCH MANAGEMENT

A hectare of greens with 4cm of thatch has about 400 m3 of dead organic matter that is full of excellent nutrients diluted with top dressing. Current wisdom is to hollow core or rip it out and replace it with – top dressing plus dead organic matter full of excellent nutrients. Weird or what?

The simple solution is to convert thatch into humus as it is formed, releasing the locked-up nutrient thus providing a building block for future plant growth that holds moisture and increases cation exchange capacity. To do this you need fungi that eat cellulose and lignin.

Other advantages of microbially activating and degrading thatch are that thatch is a great source of nutrient for fusarium, thatch fungus, basidiomycetes (The fungi that causes dry patch) and other nutrient loving fungal diseases. If the thatch is already full of beneficial fungi the pathogens cannot get a seat at the table so they cannot grow.

Percolation rates increase giving faster play after rain and as we shall see, thatch degradation helps reduce pH and promote the growth of bent and fescues.

Aeration is needed of course, as it would be for a 400 m3 compost heap, but generally once the process has started, weekly or fortnightly aeration with needle tines or a sarrel roller that does not upset the playing surface are all that is needed for thatch reduction. This is in addition to the aeration needed to address deeper compaction and drainage problems.

FINE GRASS PROMOTION

We do not exactly understand the mechanisms involved, and there is very little published research but we have seen the following reactions so often that it is worth mentioning here.

If you analyse soil supporting poa annua greens you find a bacterial biomass about 10 x greater that fungal biomass but soil that supports old established fescue and bent grasses has a nearly equal amount of fungal and bacterial biomass. Most greenkeepers report a sudden sustained increase in Agrostis tennuis grasses when they start to degrade thatch in situ, i.e. when the fungal population increases. Research has shown that Poa annua does not associate as well with mycorrhizae as perennial grasses which gives all fine grasses an advantage on mycorrhizal greens but additionally, the combination of increased thatch reduction and reduced fungicide application during the growing season combine to substantially increase the colonisation of bent and even fescues. The common theme is that fungal biomass has to increase and pH in the thatch layer reduce as humus and humic acids are formed by biological thatch degradation.

HOW DO I GET MY SOIL TO WORK?

Key parameters that will stop a healthy soil food chain forming are excessive chemical residues in the soil, and a greens committee that won't let you aerate.

If you do not suffer either of these impediments you should work with a company or agronomist that can advise how to build up each part of the food chain that is missing and supply the total package which will probably vary year to year as the soil quality improves.

You will join the fortunate band that already benefit from having their soil working 24 hours a day to produce an excellent playing surface and contribute to maintaining the natural features of our fantastic heathland, links and downland courses.

My thanks go to the professors and researchers at the universities of Oregon, Surrey and London for information contained and to Soilfoodweb Inc for the electron micrograph pictures, the technical team at Symbio and especially to the greenkeepers who have helped us with their time, feedback and advice in developing this technology.

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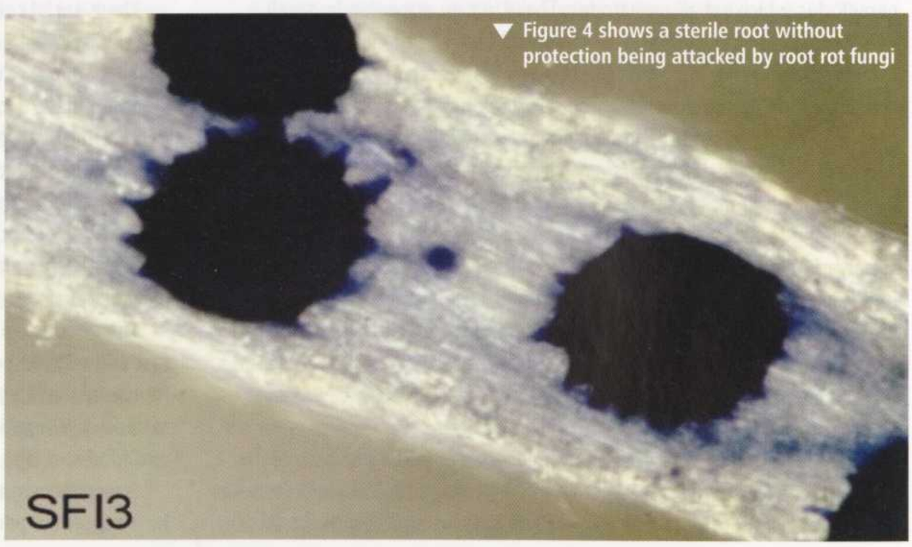

▼ Figure 4 shows a sterile root without protection being attacked by root rot fungi