Getting to the ROOT of the problem

Dr Alan Gange of Royal Holloway, University of London explains how soil dwelling microorganisms may help in the fight against annual meadow grass.

In terms of living biomass, the majority of most plants is hidden beneath the soil surface in the form of roots. Grass plants are no exception and in some cases, 70% of the total plant weight may be below ground. However, it is a mistake to think that a root system is just plant material. On the outer surface of the root live countless thousands of bacteria. These survive on chemicals exuded by the root and they are thought to play an important role in maintaining healthy growth There is evidence that these bacteria also protect the root against disease-causing fungi.

A group of 'friendly fungi' also live in intimate associations with grass roots. The scientific name of these is arbuscular mycorrhizal fungi (AMF). The fungi grow in soil and when they encounter a root, they enter the host cells. Inside these they form a number of different structures, most notably highly branched microscopic arbuscules, from whence they are named. The arbuscules are sites of nutrient exchange and the association benefits both partners; the fungi donate nitrates and phosphates to the plant, in return for a supply of carbon.

It is a fact that fungicides which are applied to golf turf in order to control pathogenic fungi may harm the mycorrhiza too. In our experiments at Royal Holloway, we use a fungicide to reduce mycorrhizal abundance in natural grasslands, and thereby demonstrate their benefit to plants. However, a survey of pesticide usage on Britain's golf clubs, conducted by the Ministry of Agriculture and ourselves, has found that this chemical is the second most widely applied pesticide on greens.

Mycorrhizas in golf greens

A well-respected text book has stated that mycorrhizas can be detrimental to golf turf, because if the flow of carbon to the fungus exceeds the benefit derived from enhanced nutrient uptake, then the fungus becomes parasitic. In theory this is true, but there is virtually no evidence to support this suggestion and the nutrient status of golf green soils makes it a highly improbable scenario. Instead I believe that AMF may be of great benefit to greenkeepers in the battle to reduce or even eliminate Annual Meadow Grass (Poa annua) growth.

It is an odd fact that Poa does not form a mycorrhiza, while bent grasses (Agrostis) and fescues (Festuca) form a very strong one. In other words, bents and fescues seem to derive great benefit from the mycorrhiza, while Poa does not. Until recently, it was thought that this benefit was entirely manifest in increased growth, because of the enhanced nutrient uptake. However, recent work has shown that mycorrhizal plants may show greater resistance to insect pests and diseases which attack shoots or roots, than do non-mycorrhizal conspecifics. In addition, because some plants do not form a mycorrhizat the balance of competition between them and other species which do form the association can depend on the level of the fungus in the soil.

In natural grasslands, by which I mean no added fertiliser or pesticide and grazed by rabbits, the infection levels of the roots of Agrostis capil1aris and Festuca rubra were 81% and 76% respectively. In the greens of a nearby golf course, the average values for all 18 greens were 1.6% for Agrostis and 4% for Festuca. On a second course, we failed to detect AMF in 11 of the 18 greens Furthermore, on this second course we have recently completed bacterial counts of the soil. In the natural grassland, the average value was about 7 x 107 bacterial cells per gram of dry soil.

In the golf green this was 4 000 times lower and in two greens, we could not detect bacteria. It therefore appears that the microbiological constituents of plant root systems in golf greens are much lower than one would normally expect. I think this may highlight a potential problem with bacterial amendment treatments which have recently become available. If one applies bacteria and increases their numbers to something approaching "normal", then this is likely to have more effect than if one starts from a baseline of zero. Clearly, as both mycorrhizas and bacteria can protect roots against disease-causing fungi, grass plants in golf greens are going to be more susceptible than those in unmanaged turf. There is a vicious circle here which somehow we need to break: Grass is attacked by disease, fungicide is applied, this kills the beneficial microorganisms as well as the pathogens, hence the plant loses its natural protection, so it is more susceptible to disease etc.

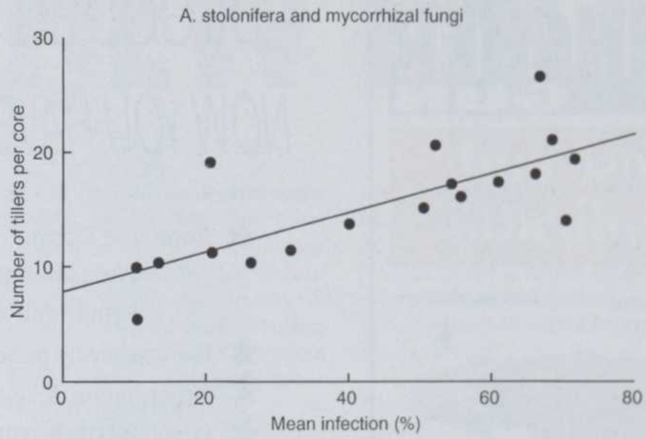

Figure 1

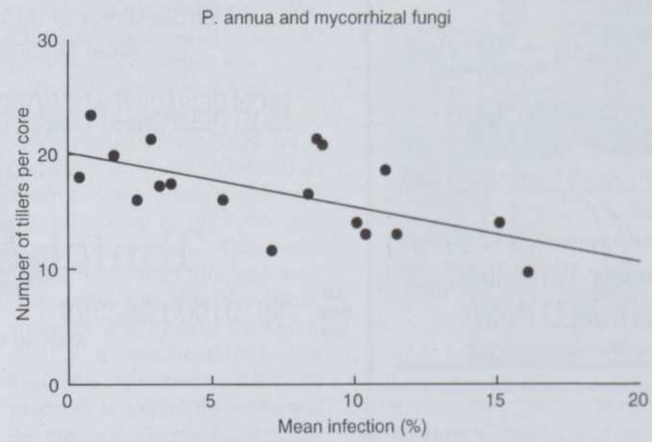

Figure 2

In my studies of AMF and grass abundance I have found that there is a relationship between the amount of mycorrhiza in the soil and the abundance of Poa and Agrostis. I sampled from two areas on the 18 greens of one course – the green itself, which had received fungicide application over a number of years, and the collar which had not. There was a striking difference in the amount of AMF fungi in the two areas. In the green, the bent grass had 5% of the root system infected with the fungus, while in the collar it had 30% infection. Furthermore, if one plotted the amounts of the two grass species on graphs against the abundance of fungus in the soil, then areas with high fungal abundance also had high Agrostis (Fig. 1) but low Poa abundance (Fig. 2).

My reasoning for these results is as follows. When bent grass has a reasonable level of AMF infection, it benefits from enhanced nutrient uptake, and is therefore a stronger plant, more able to withstand the intense management regime of cutting, trampling etc. Without the fungus, it is weaker and more prone to disease and loss from the green. Once the bent grass plant dies, it cannot be replaced naturally, because golf green soil does not contain its seeds. However, most green soils contain large amounts of Poa seed, which germinates and grows rapidly to fill the gaps left by the bent grass. Even if the green is overseeded with bent, this will not alleviate the problem, because of the continual regeneration of Poa. The lack of bacteria also contributes to the problem, because recent studies have shown that the functioning of the mycorrhiza is enhanced and more efficient when the bacteria are present. Therefore, in golf greens, one has the opposite situation to that in natural grasslands; the annual grass is the strongest competitor because unlike the perennials, it does not suffer from a lack of its microbiological helpers. It can dominate the greens, at the expense of bents and fescues.

The root of the problem

I believe that a way to combat the growth of Annual Meadow Grass on golf greens is to target research on the bents and fescues. If we could replace their natural root microorganisms then we may be able to slowly reverse the competitive balance between the annual and perennial grasses.

The elimination of Poa from golf greens must be a slow process, so that the game can continue to be played.

The easy solution would be to shut every green with Poa, spray with an appropriate herbicide, and reopen six months later. Not a very sensible idea, I think!

Clearly, there are a great many issues which we need to address before this approach can be implemented. I believe that this is an exciting and important area of work which needs pursuing with funded research. There are potential advantages for not only the golf industry, but for manufacturers of pesticides and fertilisers as well. Of critical importance is the need to find out whether there are fungicides which are less deadly to AMF and bacteria than others. Furthermore, we need to set up experiments in which the relations between microorganisms and the various management methods employed on greens are determined.

When we have this information, we will be able to look at ways of replacing the fungi and bacteria in greens and then sustaining their levels. In this way we will really be getting to the root of the problems which many greenkeepers face.