SCIENCE of the

by Dr RICHARD GIBBS

Soil science is one of those subjects that either interests people or it doesn't, yet if you think about it, most of the problems that are likely to be experienced on a golf course are related in some way with what goes on *under* the turf. Drainage, compaction, turf nutrition and irrigation are all extremely topical areas for discussion and all come under the umbrella of soil science in some form. Sand greens are promoted as the answer to all our problems of poor drainage and playing quality, yet how much detail is used to explain that these greens are also artificial creations for which the physical, chemical and biological characteristics associated with 'traditional' soils simply do not apply.

In short, I believe that many greenkeepers experience only the bad side of soil science, ie. once it has caused a problem. Unfortunately, many will be in the almost permanent position of battling against the undesirable side of soil science (eg. compaction, poor drainage, drought) simply because the increase in traffic over the last few years has put constraints on the soil that did not exist in the past. In contrast, new courses that are currently being built should be constructed with many principles of soil science firmly embedded in the specifications if the project as a whole is to succeed. Therefore the greenkeepers of these new courses theoretically should not experience the same degree of difficulty experienced by greenkeepers of many older courses. I say theoretically because this all hinges on soil science being very much part of the golf education scene.

SOILS AND CONSTRUCTION

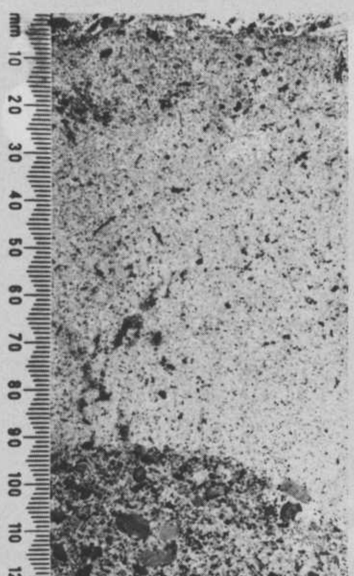

Figure 1: A cross section of a poorly built sand carpet construction. Soil has been pushed over clean gravel in a slit drain beneath the sand carpet (see arrow) destroying the vital drainage connection of the slit drain with the sand carpet

In my time as a research scientist and soils consultant and more recently as a turfgrass and soils lecturer at Lancashire College of Agriculture and Horticulture, I am often amazed at how so many principles of soil science continue to be ignored, particularly when the whole approach to construction is tackled from a civil engineering angle. Take for example the photograph opposite. This shows a cross-section of a sand carpet construction where approximately 100mm of medium-fine sand was placed over existing topsoil which has been intensively slit drained. What you should see is a layer of medium-fine sand overlying a blinding layer of course sand (which there is), overlying a layer of clean gravel in the slit drain (which there isn't).

What happened was that a layer of soil (marked by the arrow) was pushed over the gravel in the slit drain during construction so that there is now no direct drainage connection. The consequence of this action was a complete failure of the system to remove surface water during the winter period, such that the whole construction had to be re-drained with new sand-gravel slits after only one season of use. This sort of example gives sand constructions (of which the picture is only one type) a bad name.

SAND AND PEAT

Another area that gives sand constructions a bad name happens nearer the surface. When using sand as a construction or maintenance medium, provided that the correct type of sand is used, it is true to assume that problems of poor drainage and aeration can be overcome. However, solving the primary problem of drainage creates other difficulties relating to water storage and nutrition. Adding an organic amendment (usually peat), which helps overcome water and nutrition shortfalls, is regularly carried out and indeed again it is true that an increase in water holding capacity is achieved in classic 'law of diminishing returns' fashion through the addition of peat to sand. However, adding peat to pure sand or even to a sand/soil mix is in my view a misguided horticultural legacy, particularly when the peat is incorporated only in the surface of the construction. Consider the origins of peat – it accumulates in cold, wet, often high up places where anaerobic conditions prevail and organic matter decomposition is severely retarded – and yet here we are adding the material to a growing medium with no biological activity whatsoever and suddenly expecting the rootzone to drain, to provide water and nutrients, to provide an acceptable level of aeration and to absorb the impact of golfer's feet – all within a few months of being created.

What often happens to the peat is that with time it separates out into a discrete layer within the construction, becomes buried by sequential top-dressings and finally turns into an anaerobic layer impeding both drainage and aeration.

There are those who believe that if the right type of soil is mixed with an appropriate proportion of very carefully specified sand, then this mix has many physical advantages over a sand/peat mix (see Jim Arthur's comments in May 1991 issue of Greenkeeper International). I would generally agree with this view, although I do not hold the view at all that 'fen soil' is the only soil capable of providing this ideal concoction of physical properties, with the use of local top soil being virtually always out of the question for greens constructions. In my view, golf courses should attempt to reflect the nature and properties of their indigenous soils and this should not involve the huge expense of carting large quantities of soil from one end of the country to the other.

ANAEROBIC ROOTZONE

Whilst at Aberystwyth I made a study of a sand construction which had gone anaerobic due to the addition of peat as an organic amendment at the surface. The study showed that the total amount of organic matter in the peat/sand layer (0-20 mm) was very closely related to the redox* potential of the same layer. What was also particularly interesting was that it was possible to show that the amount of roots growing beneath the anaerobic zone decreased the more anaerobic the peat/sand layer became. We are generally quite accustomed to a *physical* barrier reducing root growth at depth, but a *chemical* barrier can also have serious consequences. **The lower the redox value, the more anaerobic the soil – it can even become negative.*

BLACK LAYER

Furthermore, the same sort of problem can occur with time even when organic matter has not been deliberately added during the construction phase. We are very fortunate at Myerscough to possess some of the oldest constructed sand greens in the country and it is only now that some of the undesirable side effects of certain sand greens are coming to light. Many of you may have come across the dreaded black layer, something which develops particularly in sand constructions as a result of a change in the chemical nature of the rootzone. It may develop in more traditional greens as well, except perhaps we just don't see it.

What is this mysterious black layer? Originally I had assumed that it always represented an anaerobic layer of peat that had become buried by sequential top dressings. Indeed one of the conditions for a black layer to develop is that a source of organic matter must be present to act as food supply for anaerobic bacteria. However, in this particular sand green at Myerscough, which was constructed in 1980, a black layer has developed where the organic matter source comes not from peat but from a natural build-up of organic matter from decaying grass roots and stems, better known to us all as thatch (see photograph on Page 17). This build-up of thatch has occurred under anaerobic conditions for two reasons: first, the green was sown with a creeping bentgrass (a turfgrass still causing much controversy) which is well known to be a voracious thatch producer and it has not been particularly well controlled on this green over the years; second, this sand green is a classic example of where the principles of soil science have been ignored – not, I hasten to add, through the fault of the college staff, but because the manufacturers of this particular system (for which there is a patent) insisted on a certain type of sand, which by today's standards would be totally inappropriate. The result of using this sand has been that the

SOIL

A black layer in a pure sand green. This layer has developed because conditions in the green are anaerobic for long periods, due to inappropriate choice of sand and deficiencies in maintenance. This is formed by metallic sulphides (e.g. iron sulphide) which are created under intensely anaerobic conditions by sulphur-reducing bacteria. These intense anaerobic conditions are sufficient to kill turfgrass roots

green continues to hold water in the rootzone despite allowing water to pass freely into the drains.

BLACK LAYER CHEMISTRY

With the help of Dr Bill Adams of the Soil Science Unit, University College of Wales, I have been very interested in examining the chemical nature of the black layer. His preliminary tests have given quite startling results – the black layer has a pH of two units lower than the pH of the original sand and iron sulphide is present, which gives the layer its colour (see below). Iron sulphide is formed from hydrogen sulphide, which is a gas produced under severe and prolonged anaerobic (reducing) conditions and which is toxic to turfgrass roots. No wonder all the sand falls out when the hole is changed – there are no roots to bind the sand together below a depth of 50mm!

In fact, under these anaerobic conditions much of the iron is present in its reduced ferrous state and this reacts with the hydrogen sulphide to form the black ferrous sulphide. Ferrous iron (which is highly mobile in the soil) can be oxidised fairly easily to ferric hydroxide (essentially rust) which has precipitated out immediately below the black layer where conditions are more aerobic and where there is no concentrated organic matter source for anaerobic conditions to develop. It is quite common to find a thin film of ferric hydroxide lining the holes created by hollow tine corers, since these holes are point sources where air has been introduced into the rootzone. This whole sequence of events, which I have described in very simplistic form, is a process which occurs as a natural part of soil development in wet or marshy soils and is well known to soil scientists. What is interesting is that we have seen the same process occur in a very short time in a constructed soil profile.

DEVELOPMENT OF BLACK LAYER

One reason why the black layer may have developed so quickly may be due to the regular use of ammonium sulphate and iron sulphate, both of which are acidifying fertilisers and which favour chemical reduction in anaerobic soils, in addition to providing sources of soluble iron and sulphur. We need further evidence of the importance of these sources. Certainly, detrimental consequences are not inevitable with their use and at the moment I would not hesitate to continue using both types of fertiliser.

To summarise, there is a complex chemistry occurring beneath the surface of golf greens, including some which we consider to represent the ideal free-draining growing medium. Development of the black layer is an extreme example of deterioration brought about through lack of adequate mechanical maintenance to improve aeration and prevent accumulation of organic residues. Problems in maintenance are often – as at Myerscough – compounded by errors in design specifications. Finally, I would finish by stressing that soil science is important to the greenkeeper and you are in the extremely fortunate and rare position of regularly being able to inspect the soil in your greens every time you change a hole – something which happens in no other sport. Make the most of this opportunity.

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He acknowledges with gratitude the provision of analytical data on black layer by Dr Bill Adams and the assistance with redox and peat measurements from Dr David Lance of Land Use Consultants, Devon.