Worm Casting

Worms are often regarded as being essential for good drainage and certainly soils with a high worm activity will have a greater overall capacity to absorb water, but under traffic the casts become smeared leaving a fine silty layer of surface material that is capable of holding water for long periods close to saturation. In these circumstances the drainage of worm-worked areas is significantly impaired.

It is not uncommon to achieve improvements in playability and surface conditions when worm control measures have been adopted, thus negating the need for sand top dressings - which no doubt take "the sting" out of heavy worm casting problems.

Some initial results from an American research programme suggest that heavy sand top dressings, applying a 37 mm depth over a single season, have reduced earthworm casting by 58% the following season. Further work is required to determine the longer term effects of sand top dressing on worm casting.

Worm activity is variable throughout the golf course and casting tends to be most prolific on compacted areas of ground. A localised approach to the control of casting will be the most economical to apply.

Member Expectations

At most golf clubs, the expectation of the club membership hopefully ultimately drives the maintenance programme forward. If the course is expected to be playable and presentable through ten to twelve months of the year then the putting surfaces, approaches, tees and fairways must be firm and dry in all but the most extreme conditions.

Whilst drainage systems can be designed to cope with designated rainfall periods, the maintenance of the soil profile and transfer of water to the drainage system is crucial to the provision of satisfactory surfaces.

Sand top dressing may well play an important part in this process, particularly where high drainage design rates are required.

Members will always demand higher standards than those currently provided but reconciling member expectations with the resources and budgets available is the greatest challenge facing most course managers.

Resources and Budgets

It is important to prioritise where resources should be directed. Many clubs would be better served if greater attention were given to the development of better playing conditions within the green complexes, and particularly approaches, rather than embarking upon a fairway top dressing programme.

After all, at least 50% of shots are played on the green, or close by, and it would make little sense to spend a disproportionate percentage of the maintenance budget on areas of the course which, in reality, receive the least amount of play or where traffic may be easily redirected.

If a fairway top dressing programme is deemed appropriate then concentrate on the weakest areas first, such as landing zones, key traffic routes or the wettest fairways.

Availability of Materials

The selection of appropriate materials will be primarily based upon local availability and cost. Representative samples of materials for consideration should be available together with sieve test analyses so that an informed decision can be made based on sound agronomics rather than cost alone. The quality and consistency of supply are important, particularly when large quantities of sand are likely to be used.

Conclusions

So you've been through the assessment process and are satisfied that adequate surface and sub-surface drainage is in place, thatch is under control, compaction is not an issue and worms represent no threat to the playability of the course yet problems remain over surface moisture retention during wet conditions then your fairways are likely to be a candidate for a fairway top dressing programme.

A Rich History

Scott MacCallum meets Gordon McKillop and Anne Wilson, of the STRI, to discuss the Institute's 75th anniversary celebrations.

I've always thought that golf history is great. The game is steeped in it, but it's not so old that we have to rely on archaeological digs and programmes like Time Team turning up an Allan Robertson niblick to make it real.

We can still talk to people who actually saw historic figures like Bobby Jones and Ben Hogan play the game. I'm not that old but even I've seen Bobby Locke and Sam Snead hit a golf ball. I once even shook hands with someone who knew James Braid for heaven's sake. You're not that likely to get that close to a legendary figure in your field if you're a Roman or ancient Greek scholar.

Golf is so much more accessible.

Take 1929 for example. It may have seen the Wall Street Crash but it was a fine year for the game of golf.

The great Walter Hagen won The Open Championship at Muirfield and Bobby Jones, warmed up for his stellar Grand Slam year, by winning the US Open at Winged Foot. There was no Masters in 1929 and it saw only the second ever official Ryder Cup match, at Moortown Golf Club, in Leeds. Great Britain and Ireland won the Cup 7-5.

But it was another event in the north of England, not far from Moortown, that perhaps holds the greatest significance for most of you reading this article. The reason is that in 1929 the STRI, or to be more correct the forerunner to the STRI, the Board of Greenkeeping Research, was founded and began its work at Bingley.

This month the STRI is celebrating its 75th anniversary and doing so in style with an interactive activity day where the staff will demonstrate to guests what they have been up to for the last 75 years and what can be expected in the future. Guests can also get "hands on" with some of the experiments.

Again it highlights how rich, but relatively short, the history is, that current Chief Executive, Dr Gordon McKillop, is only the fifth man to hold the post since 1929. The others being RB Dawson, John Escritt, Peter Hayes and Mike Canaway.

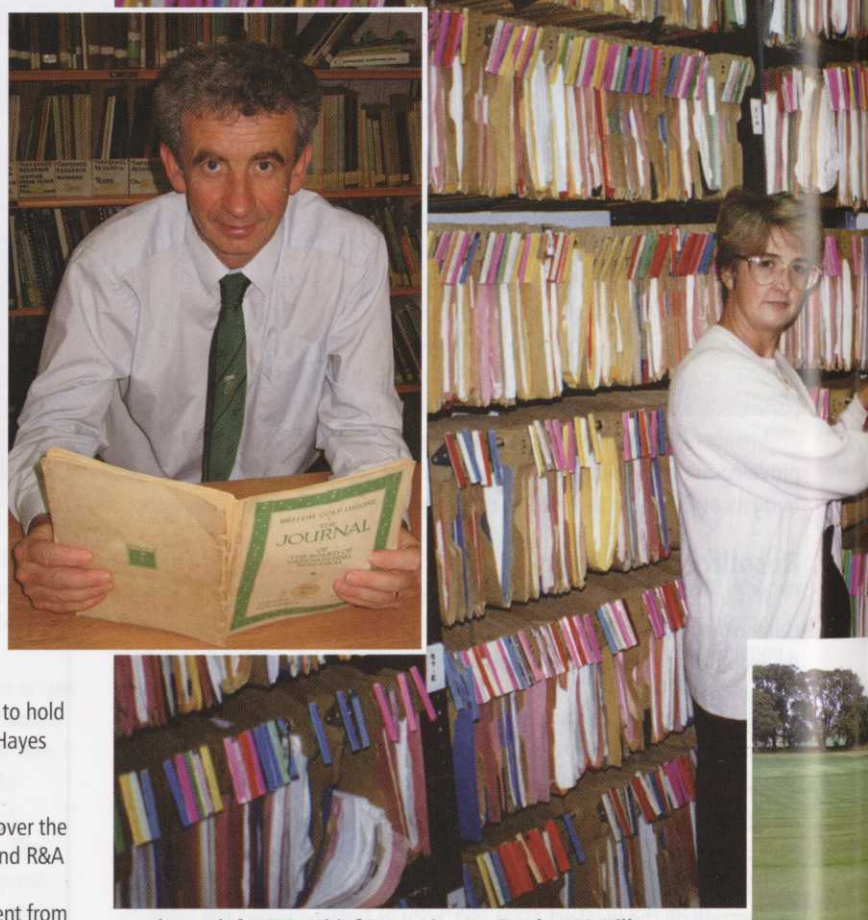
"We are looking forward to welcoming many of the people and organisations who have worked for and been helped by the Institute over the years. In particular we are delighted that our President Lord Griffiths and R&A Chief Executive Peter Dawson will be attending," said Gordon.

The quietly spoken Scot presides over an organisation much different from the one which first open its doors all those years ago.

There was initially a staff of five – two years later it had already gone up to 12 - led by the legendary RB Dawson, whose zeal and enthusiasm laid the foundations for the Institute's success, but the formation of the then Board was the brainchild of two R&A members, Norman Hackett and Percy Clough, who had seen the benefits and improvements to America's golf courses from the recently launched USGA Green Section and who wanted to see something similar in the UK.

"Bingley was chosen as the site of the new Board as both Norman Hackett and Percy Clough lived locally and knew people who offered accommodation and trial sites on the St Ives Estate. The Board was funded by the R&A and the Four Home Unions and the first office was in the original Mansion House of the Estate," explained Anne Wilson, Head of External Affairs, who has studied the Institute's history in preparing a commemorative Bulletin for the 75th Anniversary.

In the early days, while the Board was primarily concerned with work on golf courses it did undertake work for other sports and the Croquet Association was the first non-golfing body to subscribe in 1929, followed by Arsenal Football Club and Skipton Tennis Club the following year. By 1931 the



▲ Above, left: STRI Chief Executive Dr Gordon McKillop.

Bingley was conducting 181 visits a year and 1641 letters were being sent out while that same decade 1400 samples were being sent to the laboratory for testing every year.

It was in 1951 that the Board changed its name to become the Sports Turf Research Institute a move which recognised officially that many more sports than just golf were benefiting for its work.

The main means of communication in the early days was the 'Journal of the Board of Greenkeeping Research' which was also launched in 1929 and that very first issue holds pride of place in the Institute's Library. Priced at five shillings the Journal lists the founding subscribers and also gives an insight into the problems being experienced on golf courses at the time.

"Believed you me nothing changes in terms of what issues were being discussed and it's interesting to read the letters from golf clubs describing the problems they are experiencing,' explained Anne, who was also delighted to discover how many of the original subscribers are still involved with the Institute today.

"However, one of the earliest problems was that there was no fertilisers as such and no dedicated pesticides or weed killers so the mass destruction of

▲ Centre: Anne Wilson, Head of External Affairs. Left: The STRI Trial Fields. Top: The entrance to the STRI offices in Bingley.

weeds and pests was just not possible, while there was only manual or horse drawn machinery. Another issue was that back then there were no grasses bred purely for amenity use and the grasses on golf courses tended to be from agriculture."

Indeed, part of that latter problem was addressed by RB Dawson himself, as he was heavily involved in the development of new grasses. There is actually a grass named after him – the Dawson Red Fescue. The STRI has long since stopped breeding its own grasses preferring to leave that to the seed companies.

The early success of "Bingley" can be judged by the fact that staff numbers grew year on year as the quality of the services offered grew and they became known to an increasing number of golf clubs and sporting bodies. That now stands at 70, including a large team of people who look after the extensive trial sites.

High on that list of services offered by STRI is the agronomy which was based solely out of Bingley, with agronomists making tours of the country before returning to base, until 1992 when Andy Cole became the first regionally based STRI agronomist.

"The main benefit of the original method was that the agronomists all saw each other regularly and were able to share experiences and issues, but now we have the benefit of an agronomist being based in a local area, getting to know the local people and building up relationships and knowledge of the area. It also cuts down on travelling expenses," said Gordon.

There are now 17 agronomists, each of whom operates under the agreed policies of the STRI under the control of Jeff Perris, and they all meet twice a year to discuss agronomic issues as well as more regular meeting with colleagues in their area.

"They also go on joint visits to see how each other works and studies the reports that each other writes," explained Gordon.

The Institute also has its own golf course architecture department led by Jonathan Tucker; a construction division and an ecology department comprising Bob Taylor and Lee Penrose.

"The increasing importance placed on golf course ecology has been one of the most significant changes in recent years. Bob and Lee judge the BIGGA Golf Environment Competition sponsored by Scotts, Symbio and now WRAP," said Gordon.

The STRI enjoys a close relationship with the USGA Green Section and their other sister organisation, the New Zealand Sports Turf Institute, and there is a regular exchange of staff and knowledge with each.

"On the advisory side we have an annual exchange with the USGA and Steve Baker has sat on a number of the USGA committees including the one looking at the USGA specification. We also have a research and a construction departmental exchange every other year.

"With the NZSTRI we regularly send speakers to their biannual conference. There is a whole raft of benefits to be had from such arrangements including seeing how different people and organisations tackle problems in different climatic conditions to how different organisations manage and run themselves and how they interact with their governing bodies," explained Gordon.

For instance the USGA Green Section is purely golf and is funded for by the USGA and it means agronomists can visit golf clubs throughout the county and offer heavily subsidised advice. In New Zealand, the New Zealand Golf Association or the Cricket of Bowls Association give the Institute a sum of money to visit all the golf, cricket or bowls clubs.

"Neither, as we do, relies on individual subscriptions. It's swings and roundabout really. It would be nice to have that sort of income but having to depend on ourselves keeps us on our toes," smiled Gordon.

Among the research work which is being carried out at Bingley at the moment is glass sand testing for WRAP; composting trials on behalf of the R&A and Stephen Baker's work on the European green specification.

One area which has had a significant impact on the Institute is in the area of professional indemnity insurance which has become increasing hard to get and, particularly after 9/11, become much more expensive.

"When I started we were paying £15,000 a year for it but it has escalated to the stage where we now pay £65,000," said Gordon, who added that living in such an increasingly litigious society was one of the reasons behind the STRI splitting into two with STRI and STRI Ltd.

"That way we can protect the assets of the main organisation by grouping everything we do which isn't liable to come under the professional indemnity into STRI Ltd. Unfortunately we have to pass on the added cost of insurances to our customers but some companies must have gone out of business because they couldn't get insurance or it was too expensive," explained Gordon.

Both Anne and Gordon are relieved, not to say adamant, that it will be someone else who is involved in organising the Institute's Centenary as the 75th celebrations have taken up considerable time and effort.

You can be sure that their work will be rewarded on the day and that staff and invited guests will be toasting 1929 and wishing the STRI every success for the next 75 years and beyond.

Ecological Management on a "Shoestring"

The issue of Ecology has become a major factor in golfing circles, so Conservation Manager Will Bowden has taken a look at how this can be managed at little cost.

The objective of this article is to highlight the common misconception that any worthwhile ecological management programme requires large expenditure and an unrealistic strain on human resources and materials. In truth environmental enhancements rely on four basic principles:

- Understanding the nature of your golf course.
- Imagination/visualising the potential to improve an area of natural value.
- Organising and planning.
- Commitment and seeing the work through to its completion.

As with any form of project management the primary concerns are of limiting factors such as staff shortages, time and money constraints therefore you must ensure your objectives are realistic, '**SMART**' - **S**pecific, **M**easurable, **A**chievable, **R**ealistic and **T**imed. We can soon lose control of the situation if targets are not sustainable.

The best advice is to prioritise areas on your site that would most benefit from improvements. List these areas and research how best they can be enhanced with regard to their ecological value. It is imperative to involve the whole team, as these are the people who will be at the sharp end of what you are trying to achieve and in order to make it a success you must enlist their support and all agree upon what is both realistic and worthwhile.

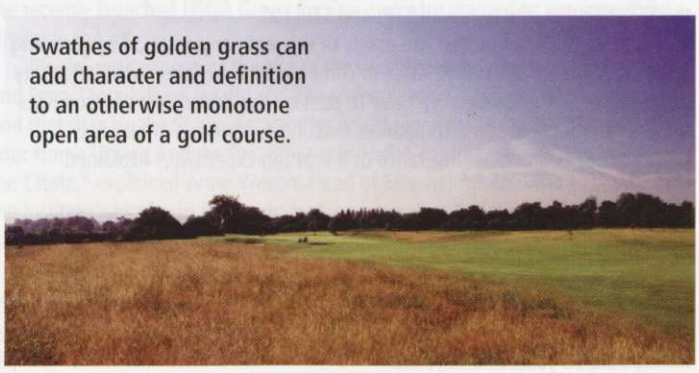
In this article I shall refer to examples from previous experience to illustrate how, with a clear goal and relatively small investments in time and money, significant improvements to your golf course can be made.

Planning and Communication

As golf course managers we are accustomed to planning. We plan at the start of every year. These plans involve revising fertilizer regimes, pesticide treatments, cultural operations through to in-house construction projects. If you are serious about embarking upon a long-term commitment of ecological management, then planning for such work must also become an integral part of this annual thought process.

Communication on all levels is critical, especially when dealing with the potentially emotive subject of the environment. As well as the involvement of the greenkeeping team, make every effort to inform members and clubhouse staff. This can often be a thankless and unappreciated task, however it will help to reduce the likely hood of future conflict if all parties are kept informed.

As well as relatively cheap ways of improving the appeal of your golf course, environmental work can be used as a method of breaching the widespread void of communication that exists within many golf clubs between the clubhouse and the maintenance staff. If adopted as a more 'global' theme throughout the club such work can be the focus of raising our professional profiles and increasing the respect and appreciation we are afforded. This is where planning and communication play a pivotal role in establishing a viable and legitimate environmental work programme.



Swathes of golden grass can add character and definition to an otherwise monotone open area of a golf course.

Before clearance work.

Focus on habitat restoration

You must adopt a long-term perspective when considering any ecological work. The key to a successful and worthwhile environmental management plan (EMP) is habitat restoration as opposed to quick fix gimmicks or PR exercises. Your time is far better invested in fieldwork, be it; scrub clearance, tree transplanting, grassland management etc. Rather than constructing bird and bat boxes, or putting up feeders!

Although these measures may benefit from short term success and spark initial enthusiasm and appreciation from the membership, it is the time you invest in broader scale, long-term improvements that will have a further reaching impact on both the enhancement of the course and its appeal to wildlife. The key to this is understanding your 'target species'.

What are the specific species of flora or fauna that you are aiming to encourage? How can this best be achieved? This initial work may involve studying historical records to form an understanding of how the site has been managed historically and perhaps reestablishment of some of these methods.

One such project I've been involved in was the restoration of bluebell woodlands. It was established that the original nature of the site was coppiced/managed woodland allowing light and air to reach the under storey and encouraging the spring bloom of bluebells once commonplace. What had happened through decades of neglect was the development of a degenerate woodland scrub.

Invasive bramble and bracken had over run the previously open woodland floor, effectively suffocating local flora and in so doing reducing both the areas aesthetical appeal and ecological value.

The initial step was to divide the general area in to manageable sections (i.e. zone A, B, C etc.) and deal with each zone over the next five years. This division was based upon a list of priorities and we decided to tackle the worst effected areas first.

Step 1. Assessment

The woodland had become infested with thick under storey, bramble, bracken and ivy, all effectively starved the environment of light and air. Many young trees had been inhibited and numerous saplings died.

During clearance.

An orchid in the rough – its establishment was encouraged by the development of natural roughs.

A cleared woodland floor in spring – the bluebell 'carpet' is reinstated.

Step 2. Clearance

This is where dividing an area up in to a manageable zone is essential. The work involved, brush cutting, burning and root digging, in order to open up the woodland floor. It was also necessary to remove many young dead trees - these would later be replaced with appropriate local transplants.

Step 3. Regular management

On going - the area must be observed and appraised each year. In this instance the onus was on constant bracken and bramble removal for years one - two and the gradual replanting of indigenous deciduous and evergreen tree and shrub species. The end result - 18 months on - pays tribute to the work carried out and the time invested in to such a project. In all, approximately 32 man-hours were spent on this area, with no external costs incurred.

Another low cost management project I've been involved with is the reestablishment of grassland areas in the meadowland habitats of a golf course. As with many modern pay and play establishments the commercial objectives centre around volume of play and specifically throughput of golf. The general impression within the club hierarchy was that this could only be achieved through the wall-to-wall mowing of the course with the rough never exceeding four inchs in height.

The expansive nature of the site meant that certain areas of the course were being unnecessarily maintained at a high frequency of mowing and as a net result elements of character and definition were suffering. The objective was therefore to establish swathes of native grassland habitat in between appropriate holes, these had to be carefully considered so as not to intrude along the lines of play or create an unfair challenge.

As the photo illustrates (see opposite, bottom left) these areas of native grass added definition and colour to these previously open parts of the site. That year I undertook a small-scale butterfly survey of these enhanced areas.

The results indicated an increase of over 55% in species diversity from the previous year, an impressive "bio indicator" as to the success of this project.

This was coupled with a significant increase in species variety with regard to local flora, species as diverse as ragged robin, wild pansy and orchid (pictured above, right) were flourishing within the sanctuary of these grassland habitats.

All this had been achieved with no extra costs and in fact a reduction in man-hours required to mow the roughs! Throughput of golf had not suffered and we constantly reviewed specific areas to ensure these were not causing a slowing up of play.

Proving the fact that through a clear vision, open communication and understanding of what needs to be achieved, significant ecological improvements can be made to your course on a shoestring budget.

We spend a considerable amount of our time planning improvements to the golf course. Understandably the majority of these plans are focussed on playing areas, however if you can discipline yourself and your team to consider the wider picture and incorporate these natural areas in to an overall management objective for the course then great achievements can be made. Not to mention other issues such as staff morale and job satisfaction.

Our profession should be so much more than just grass maintenance, our feeling of self worth and the respect of others can be fulfilled if we look beyond the cutting of grass.

I hope this article has shown how, with a little imagination and enthusiasm, we can all improve our golf courses, both for the good of the golfer and above all the environment and all of this at little financial cost!

Exploring the hidden mysteries beneath our feet –

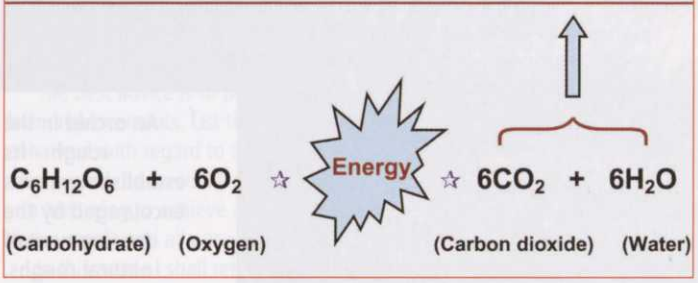
Soil Aeration and the Rooting Environment

Adequate soil aeration is an essential component of any healthy turfgrass stand and is influenced by the physical and biological characteristics of the soil. 'Aeration' as a maintenance practice receives a lot of media attention, while 'aeration' as a soil condition and the phenomena involved are rarely discussed.

Continue to learn

Turfgrass roots and the vast majority of heterotrophic soil microbes, that is micro-organisms that need preformed carbon compounds such as carbohydrates for energy, require oxygen for respiration. In a process similar to our own respiration needs, carbohydrates ($C_6H_{12}O_6$) and oxygen (O_2) are utilised to provide energy for growth and development, giving off carbon dioxide (CO_2) and water (H_2O) as by-products of the chemical reaction.

Figure 1. The Chemical Reactions in Aerobic Respiration



Respiration will accelerate with rising temperatures, provided that there is no restriction in the input of carbohydrates or oxygen. For efficient respiration by roots and microbes, oxygen must be supplied into the soil atmosphere in adequate amounts, while excess carbon dioxide and other potentially harmful gases must be removed.

The Phenomenon of Diffusion

An exchange of these gases between the soil atmosphere and the outside atmosphere occurs by the phenomenon of diffusion and the aeration status of a soil can be measured by the **Oxygen Diffusion Rate** (ODR). The ODR indicates the rate at which oxygen can be replenished when it is used by respiring roots or micro-organisms. Fortunately, the diffusion rate will also increase as the temperature rises, thereby compensating to some extent for the increased demands by roots and microbes during warmer weather.

Diffusion occurs primarily through soil 'macropores', defined as soil pores that are greater than 75 micrometres (expressed as **'μm'**, and 1000 μm = 1mm) in diameter. As can be seen in Figure 2 below, water will drain from macropores to allow entry of air. Smaller pores will remain full of water because the water is held at tensions greater than gravitational pull. The smaller the diameter of the pore, the greater is the tension at which the water is held.

Figure 2. Size Classification of Soil Pores and Some Functions of Each Size Class (from Brewer, 1964)

Simplified class	Class	Diameter range (μm)	Characterisitcs and Functions
Macropores	Macropores	> 75	Water drains by gravity, accommodates roots, habitat for certain soil animals.
Micropores	Mesopores	30 - 75	Retain water after drainage, transmit water by capillarity, accommodate fungi and root hairs.
	Micropores	5 - 30	Retain available water, accommodate most bacteria.
	Ultramicropores	0.1 - 5	Retain unavailable water, exclude most micro-organisms
	Cryptopores	< 0.1	Exclude all micro-organisms, too small for large molecules.

The efficiency of diffusion is largely reliant on an extensive and continuous network of macropores from the surface and down through the soil. It is essential that the macropore system extends well beyond the rooting depth of the grasses.

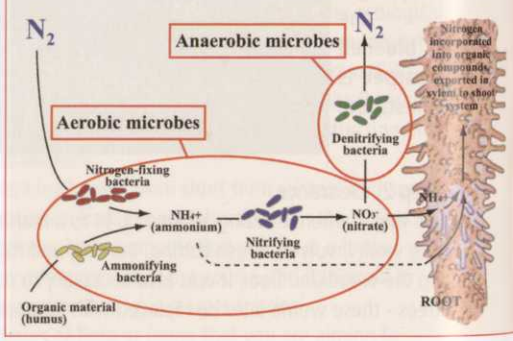
The outside atmosphere contains about 79 per cent Nitrogen (N_2), 21 per cent Oxygen (O_2), and 0.035 per cent Carbon dioxide (CO_2). Concentrations of CO_2 can commonly be 10- to 100-times greater in soil air as a result of respiration of roots and organisms. While the N_2 concentrations in soil air remains much as it is in the outside atmosphere, the O_2 content can vary considerably. It may be only slightly below 20 per cent in the upper layers of a well structured soil but can drop to less than five per cent or even to near-zero in the lower horizons of a poorly drained soil with few macropores.

In well-drained, well-aerated soils in a cool, temperate climate such as Britain, the exchange of gases is normally rapid enough to maintain adequate oxygen levels for plant growth.

Sufficient oxygen can diffuse into the soil, provided the air-filled porosity of the soil exceeds about 10 per cent of the soil volume, for most plants to survive. Generally, turfgrass species are more tolerant of lower oxygen concentrations than the majority of arable crops and decorative plants.

If a soil becomes saturated, diffusion of oxygen virtually ceases and the concentrations can decline to levels that cannot support aerobic metabolism. The soil can become anaerobic (without oxygen) within around 24 hours of saturation. When anaerobic conditions prevail, organisms that can use alternatives to oxygen become highly activated. The first groups of bacteria to have a major influence are those capable of using nitrate (NO_3^-) and denitrification commences (Figure 3 below).

Figure 3. The Role of Soil Bacteria in the Nitrogen Nutrition of Plants



The organisms that carry out this process are commonly present in large numbers and are mostly facultative anaerobic bacteria in genera such as Pseudomonas, Bacillus, Micrococcus and Achromobacter. These organisms are all heterotrophs but some autotrophs (organisms that obtain their energy from sources other than the oxidation of organic compounds) such as Thiobacillus denitrificans, can be involved.

In a series of steps, Nitrates (NO_3^-) that would have been available for plant uptake in an aerobic soil become reduced to Nitrites (NO_2^-), and then to nitrogen gases that include Nitric oxide (NO), Nitrous oxide (N_2O) and Dinitrogen gas (N_2). This is why grasses turn to a pale, sickly green in waterlogged conditions. Contrary to popular belief, nitrites can be taken up by the plants, but cannot be utilised as a source of nitrogen for growth. In fact, the nitrite ion is toxic to plants.

In the presence of organic matter as a food source, other oxidised constituents of a soil will be used and the soil environment will become chemically reduced, as well as anaerobic. As anaerobic conditions continue, oxidised reserves of manganese and iron will be reduced and levels of soluble manganese and iron will increase. Manganese may even reach levels that become toxic. With continuing anaerobiosis, sulphur-reducing bacteria will produce hydrogen sulphide (which is toxic to turfgrass roots) and this will react with the reduced forms of iron to form black ferrous sulphide, the familiar black layer phenomenon of poorly drained golf greens and other sports areas.

Anaerobic conditions will also cause anatomical and morphological adaptations in turfgrasses. Ethylene production in anaerobic soils initiates shallow, adventitious rooting to the detriment of deep, explorative rooting. However, some species display an anatomical response to oxygen deprivation by which the ethylene causes some of the cells in the root cortex to age and die. Enzymatic destruction of the cell walls

Martyn T. Jones, National Turfgrass Foundation, delves into the complexities of soil aeration, its importance, how it occurs and how to preserve it.

▲ **The Toro HydroJet water-injection aerator is ideal for summer aeration with minimal surface disruption.**

creates air tubes (aerenchyma), thereby increasing root porosity and providing oxygen to the roots. Signs of oxidation in the rhizosphere around some roots can provide visual confirmation of this phenomenon in poorly drained soils.

In well-aerated soils, roots will produce cytokinins and gibberellins but low O_2 levels will inhibit their production and movement through the plant. In contrast, abscisic acid production will increase. The net result is that shoot initiation and growth is suppressed, leaf senescence is accelerated and shallow rooting is encouraged.

What are the causes of poor soil aeration?

Inadequate soil aeration can occur in a number of circumstances. Some, such as severely-compacted, fine-textured soils or flooded environments, are obvious problems. But other occurrences of low aeration status can be less obvious.

There are numerous occasions, even when sufficient total air space is available in the soil, when the exchange of gases between the soil and the outside atmosphere is so slow that an adequate concentration of soil oxygen cannot be maintained.

When things heat up

During hot weather, the demand for soil oxygen by roots and microbes may be greater than the rate at which it can diffuse into the soil. While this most commonly occurs in fine-textured soils or compacted soils, it can occur in non-compacted, coarse-textured soils during periods of very high temperatures.

Traffic, be it pedestrians or vehicles, will compact the surface, reducing the majority of macropores to micropores and, consequently, diminishing oxygen diffusion rates. And the compaction does not need to be to a great depth. Even a relatively thin surface layer of compacted soil can significantly reduce oxygen diffusion rates to the detriment of turfgrass root survival. Indeed, it is frequently a restricted soil aeration condition stemming from a compacted surface, and not a soil drought, which results in turfgrass wilting during periods of high temperatures in the summer months.

The accumulation of organic residues within the soil pores further creates a rootzone dominated by water-filled micropores. Oxygen diffusion through water is ten thousand times slower than it is through air and, therefore, it is little wonder that restricted soil aeration is a common problem of sports soils in the rather wet climate of the UK.

Additionally, under conditions of restricted aeration the organic residues will provide an ideal environment for anaerobic micro-organism activity. Hence the occurrence of black-layer formation within the organic zone or at the interface between the organic zone and the mineral zone beneath.

The surface organic-rich layer, ranging in depth from 80mm to 150mm, depending on the turfgrass species, rootzone material used in the green's construction and maintenance regime is the zone in which there is the greatest demand for oxygen. The highest population of soil organisms occupies this zone and it is the main rooting layer for closely mown turfgrasses.

As a consequence, it is the area in which most respiration occurs and the need for gaseous exchange is greatest. As temperatures rise, and as long as drought does not become a limiting factor, the demand for oxygen by turfgrass roots and soil microbes increases. Therefore it is important that this zone is maintained in an open state throughout the growing season when the demand for oxygen is at its highest. It is far less important during the dormant season when respiration rates are minimal.

The moral to this story is that we must undertake summertime aeration operations when the demand for soil oxygen is at its greatest. It is at this time that the grass roots and the soil microbes are respiring most rapidly and when a good supply of soil oxygen will be most beneficial.

Piercing the organic-rich layer and increasing ODRs will accelerate water infiltration and minimise run-off. It will encourage microbe activity and organic matter decomposition, slowly releasing nutrients (Figure 3 above), improving soil structure and reducing potential disease problems. Keeping the surface open during warm weather is vital in preserving diffusion rates between soil- and outside-atmospheres.

Mechanical aeration versus soil aeration

To ensure adequate soil aeration, it is essential that the number and distribution of macropores are preserved or increased and that there is an uninterrupted network from the surface, down to the full rooting depth. It is the macropore system that provides the means for gaseous exchange between the soil and the outside atmosphere. As an extensive and continuous matrix of macropores is fundamental to efficient soil aeration, any mechanical aeration technique should be directed at preserving the existing macropores and, preferably, creating additional ones.

Selection of the most appropriate and effective mechanical aeration technique must be determined by the soil type, the moisture content of the soil, the extent of the problem, and the mode of action of the equipment. Each piece of equipment has some potential benefits but, equally, each can have detrimental effects if incorrectly applied.

Maintaining an open surface with high water infiltration and oxygen diffusion rates is a prerequisite to good soil aeration but, all too often, the influence of this zone is overlooked. The organic-rich zone in the upper horizons of a soil is where the greatest demand for oxygen occurs. And it is this zone that requires the greatest attention.

As already stated, the main seasons of the year in which there is a demand for oxygen are late spring, early summer and autumn when roots and microbes are most active. Also, there must be adequate aeration during the hot months of summer, provided that drought is not adversely affecting root and microbe metabolism. There is little to no demand for soil aeration during winter when soil temperatures are near freezing and/or when the soil is continuously saturated by daily rainfall. The vast majority of mechanical cultivation techniques will not assist soil drainage at such times.

Regular, light applications of a suitable sandy topdressing material will help preserve the macropore system at the surface and dilute the organic matter content. Timing and quantity is dependent on growth rate of the turfgrasses and extent of organic matter present.

Avoid frequent, heavy irrigation at any time of the year. A saturated soil will have greatly diminished oxygen diffusion rates and will be prone to further compaction.

Achieving effective soil aeration by mechanical means is one of the greatest challenges facing our industry and while we may not witness any major revolution in techniques, evolution in design will bring many improvements.

Saltex 2004

The Sunshine Show

Saltex 2004 enjoyed the sort of weather many UK-based holiday makers would have given their right eye for in July and August. Temperatures soared and the sun beat down on exhibitors and visitors alike and the ice cream stalls were doing a roaring trade.

Among the new features of the 2004 Windsor Show was the Instant Stadium, which showcased what is required for a modern day sports facility. It also hosted a number of events during the course of the three days.

Another noticeable feature of the 2004 show was the significant increase in machinery demonstrations with a large portion of land in the middle of the racecourse given over to companies to display their wares in action.

Among those to attract the galleries was the new remote controlled Spider mower from Ransomes Jacobsen which collected one of the major awards given over the week.

BIGGA had its usual strong representation at the Show and were on hand to meet with many existing and new members to update them on BIGGA events and services.

Woburn Golf & Country Club won the annual Blazon 'SprayWatch' promotion.

This year's promotion featured Blazon LoDrift-Xtra, a three-in-one combination spraying aid from GreenLink International.

From a high number of entries across mainland UK, Woburn's name was the first to be drawn and the club will receive a free state-of-the-art tractor mounted Gambetti Barre amenity sprayer.

Course Manager Chris Hunt was unable to attend the presentation ceremony so Barry McCloskey, of Avoncrop Amenity Products, the company from whom Woburn purchased the Blazon received the sprayer on Woburns behalf.

The prize was presented by the current Chairman of BIGGA, Andy Campbell, together with John Pemberton, BIGGA's Chief Executive. In attendance also was Avoncrop Amenity's sales manager Chris Briggs and Richard from GreenLink International Ltd.

Blazon LoDrift-Xtra contains the industry's only washable spray pattern indicator plus anti drift and spray fast agents.

This unique combination ensure that the operator can target with great accuracy the placement of the spray, reduce the risk of drift and gain improved chemical efficacy. And, with Blazon's non-staining formulation, any skin or clothing contamination is easily washed off with just soap and water.

▲ **On behalf of the winners of annual Blazon 'SprayWatch' promotion, Woburn Golf & Country Club, Barry McCloskey (third from right), of Avoncrop Amenity Products, is presented with a Gambetti Barre amenity sprayer by BIGGA Chairman Andy Campbell.**

Philip Helmn, Course Manager of Overstone Park Golf Club, Northampton, was one of three Vitax competition winners, taking home a magnum of champagne from Saltex.

P.G. Butler a bowling green contractor from Fornham, Cambridgeshire and John Kenton, of Knaphill Bowls Club, from Kenton in Surrey, also each won a bottle of bubbly for guessing the size of the area that could be treated with the entire contents of a large container filled with packs of Vitax's new fungicide Insignia.

The competition, which was held each day of Saltex prompted over 700 entries from all areas of the industry, and has been judged a great success by the company.

"As conditions for fusarium are usually right at this time of year, we wanted to promote the cost effectiveness of Insignia, as well as giving our customers a bit of fun," said Clive Williams, Vitax's Commercial Manager.

▲ **Vitax Competition winner Philip Helmn, Course Manger of Overstone Park Golf Club, shows off his magnum of champagne.**