Dr Stephen Baker, Head of Soils and Sports Surface Science at the STRI, looks at the current and future research on golf course agronomy with particular emphasis on the problem of winter wear

Into the 3rd Millennium

The parties are over, the hangovers have receded and, yes, we are into the year 2000. In the December 1999 issue of Greenkeeper International, I considered aspects of research on golf course agronomy through the last century. As we move into the new millennium it is appropriate to review the implications of current research projects and to identify some of the many areas where future work is needed.

On the evidence of the last century, the needs for research with respect to golf course agronomy progressively change. This results from both factors within the game (e.g. increased play, more winter use, expectations of the golfer) and external factors, for example changes in pesticide legislation, increased demands on water resources throughout society and in the longer term climatic change, with its potential impact on turf irrigation, grass selection and the incidence of disease.

The R&A's Golf Course Advisory Panel has identified key strategic issues likely to affect golf in the future. These include:

(i) Climatic change
(ii) Water use and conservation
(iii) Environmental issues
(iv) Demographic/planning issues
(v) Chemical inputs and outputs
(vi) Implications of increasing usage

Greenkeeping staff also have strong views on the practical problems they encounter. As part of an R&A strategy to identify research priorities, greenkeepers were asked, through a questionnaire in Greenkeeper International (June 1998), to indicate priorities for research particularly with respect to conditions on their course. The five main problem areas were identified as: i) the control and management of annual meadow-grass, ii) traffic management/winter wear, iii) the control of earthworm casting, iv) rabbit control, and v) wear by golf trolleys.

In an article of this length, it would be unrealistic to address all the issues where research needs have been identified. Instead, I wish to focus on the topical issue of winter wear on golf courses, in particular on two areas where we are currently carrying out research work and two areas where we consider that future research would be profitable.

Green construction

One of the main factors affecting the quality of greens in winter (or necessitating the frequent use of temporary puffing surfaces) is the poor soil physical characteristics of many greens. In the R&A sponsored survey of 74 golf courses between 1993 and 1994, we found that 43% of greens had water infiltration rates below 10 mm/hr and 41% of greens had less than 5% air-filled pore space. Such values mean the greens are slow draining, prone to water logging and may suffer from restricted root development. In most cases, this resulted from the use of existing soils with relatively high silt and clay contents.

To achieve more free-draining and firmer putting surfaces through the winter, sand-dominated rootzones are now widely used in green construction. However, in the past comparatively little research work has been undertaken to examine the performance of different rootzones supporting fescue/bent turf. In June 1995, thanks to R&A funding, we established a trial at Bingley examining the performance of 18 different rootzone materials formed from combinations of two sands (medium and medium-coarse), three amendment materials (sandy loam topsoil, organic fensoil and sphagnum peat) and three mixing ratios of sand amendment. Each of the rootzones was installed as a 300 mm deep layer overlying a 50 mm blinding layer of 1-4 mm grit and a 5-10 mm diameter drainage layer.

The trial has received simulated wear since July 1996 and this has allowed us to examine changes that occur over time. Soil physical properties have been strongly influenced by rootzone composition and recent results are shown in Table 1. Infiltration rates were inevitably highest on mixes incorporating coarse sand with low quantities of amendment. Infiltration rates were higher for the mixes containing peat than those with topsoil or fensoil. After deliberately flooding the surface, water drained quickly from the pore space of all mixtures meaning that air-filled porosity was satisfactory for all rootzone materials. However, moisture contents were highest on the medium sand and for the 70:30 mixes. They were also higher on the fensoil and peat mixes than on mixes incorporating sandy loam soil. The firmness of the putting surface was also influenced by rootzone composition. In particular the rootzones containing peat gave the softest surface and firmness decreased as the amount of amendment material was increased from 10% to 30% by volume.

The plots were originally sown with a mix of 40% Chewing's fescue, 40% slender creeping red fescue and

20% browntop bent but our most recent botanical analysis (September 1999) indicates average values of 53% bent, 33% fescue and 12% annual meadow-grass (plus 2% dead or bare). Annual meadow-grass is higher on the more moisture-retentive medium sands and higher when topsoil was used as the amendment material, particularly for the coarser sands.

As part of the same project, we have also examined the effects of a range of alternative organic amendment materials on the soil physical properties of rootzone mixes. Materials have included green waste, coir (derived from coconut shells), sewage and straw, rape residue and wood fibres. When mixed with a suitable sand, it was possible to formulate mixtures that met with USGA criteria for hydraulic conductivity, total porosity, air-filled porosity and capillary porosity for all the amendment materials.

The work on rootzone mixtures is still continuing but in the relatively near future we should be in a position to publish guidelines, supported by scientific data, on the optimum rootzone materials for UK conditions.

Earthworms and casting

The problems of earthworm control and winter wear are often closely linked, as smeared casts are one of the main factors contributing to muddy fairways and tees. We have just had another mild, wet autumn and many courses have either suffered from heavy casting or spent often thousands of pounds on pesticides that give only short-lived control. Last year, we published two articles in Greenkeeper International outlining the work that has been carried out on earthworm control and steps that can be taken to reduce casting. It has to be stressed that, in the absence of pesticides such as chlordane (the use of which has been illegal since 1992), there are no single solutions to the problems of earthworm casting, indeed total control is unlikely. However, casting can be reduced by sound greenkeeping practices such as the use of acidifying fertilisers, avoidance of lime-rich top dressing and, where appropriate, the removal of grass clippings.

Our current research on casting control has four main themes:

a) Further examination of the use of sulphur for soil acidification. In particular this is being directed at predicting the most suitable application rates for a range of soils, whereby casting is reduced as much as possible without detrimental effects on the sward.

b) Mowing practices and fertiliser application based on ammonium sulphate to reduce casting on fairway-type turf.

c) Use of horizontal barriers in the soil to restrict burrowing activity. We recently carried out a detailed survey of 32 golf courses to examine population distribution of earthworms in the UK. We identified 13 different species altogether, but three species (Aporrectodea longa, A. caliginosa and Lumbricus terrestris) made up 87% of the 8,000 earthworms that we sampled. A. longa and L. terrestris in particular have deep burrow systems that can reach one metre or more into the soil. Clearly any barrier would stop earthworms coming to the surface to eject soil taken from the deeper soil horizons. However, of greater long-term importance is the fact that these species use the burrows to escape the effects of drought or heavy frost. If earthworms cannot migrate downwards at times of unfavourable weather conditions, their chances of survival and subsequent reproduction are small. There is a precedent for this approach in the literature of the pre-war years with references to layers of coarse sand, iron filings or broken glass to discourage earthworms, but we are instead examining different grades of plastic mesh material at depths of 100 mm and 200 mm and also the effects of a coarse, angular grit layer.

It would, of course, be disruptive and impractical to use this approach on existing areas but where there is any re-construction it may be an option to be considered, although the implications on water movement and deep aeration work must also be considered.

d) Our other current avenue of research has been to examine the effect of the injection of compressed air into the soil. Equipment such as the Robin Dagger or Air-Jet 2000 have been used for relieving compaction in the soil by releasing a pulse(s) of air at pressures of around 150 psi. Under the right conditions, this causes considerable heaving of the ground and this may have implications for soft-bodied creatures such as earthworms. This autumn we have been looking at effects on the survival of earthworms and casting rates, and results should be available next spring. (Incidentally, if any readers have observations on casting activity following air injection work, we would be interested in details.)

Wear by golf trolleys and buggies

The issue of trolleys and buggies on golf courses is a sensitive one and has always raised debate within golf clubs. Such equipment has clearly allowed many older or less mobile golfers to continue enjoying the game of golf for much longer periods. However, in the winter months in particular, trolleys and buggies can contribute to wear on the golf course. Thankfully, the use of narrow-wheeled trolleys has now ended and most trolleys have a wheel width of at least 70 mm. This means the ground pressure of a trolley with a full bag is reduced to about 13 kPa, which is only half that of a player standing with both feet in contact with the ground and considerably less than the force exerted during walking. This is typically in the order of 70 kPa with even higher values as

Soil physical properties four years after construction

	Infiltration rate (mm/hr)	*Moisture content 1 hour after flooding 0-100mm (%)*	*Hardness (gravities)*
Assessment date (1999)	**March 15**	**March 22**	**March 22**
Effect of sand type			
Medium sand	86	26.2	74
Medium-coarse sand	110	21.8	71
Effect of amendment			
Sandy loam soil	88	21.0	75
Fensoil	91	25.6	73
Peat	114	25.2	69
Effect of mixing ration			
90:10 (sand:amendment)	116	20.4	75
80:20	97	24.2	72
70:30	80	27.1	69

the heel makes contact with the ground. However, trolleys and buggies have the disadvantage that their use tends to cause golfers to be channelled along specific routes on the golf course and it is here that the effects of wear become more apparent. Furthermore, the very fact that golfers do not have to carry their own bags over their shoulder does increase the temptation to fill the bag with extra items, thus contributing to soil compaction. For powered equipment, the possibility of wheels spinning on slopes in wet conditions must also be considered, as this is potentially a significant source of damage, particularly at times of the year when the turf will be slow to recover.

There is very little independent scientific information on the effects of trolleys (unpowered and powered) or buggies on turfgrass wear, and this is an area where we believe work would be of considerable benefit. In particular, there should be detailed assessments to develop criteria defining conditions when trolleys or buggies are likely to cause significant turf damage and conversely when their use is perfectly acceptable.

Alternative spikes

There is increasing evidence from the United States that the wide range of plastic spikes and studs causes less wear on putting greens (and indeed other areas of the golf course such as teeing mats, wooden steps and bridges) than conventional metal spikes. However, there are also concerns that traction or grip may be affected by changes of spike type. This may be particularly relevant in Britain where golf continues throughout the winter and grip on steeper slopes and banks may be affected by wet conditions or, for example, mud arising from earthworm casts. Similarly, wet grass clippings may also affect traction properties, therefore the interaction between spike design, weather and management practices needs to be examined.

Most of the American work that has been carried out has been on creeping bent greens on which the grass, because of its lateral growth habit, is particularly prone to "plucking" type damage. This may be less relevant on British greens where the predominant grass types are browntop and Highland bent, fescue and annual meadow-grass. However, until research is carried out, there will be many unanswered questions and, as the use of alternative spikes has safety as well as wear implications, work is needed to assess whether their use should be encouraged on British golf courses.

I have focused on just four topics connected with winter wear. Future development work on for example mechanical treatments, black layer control and turfgrass breeding is also relevant to the problems experienced through the colder, wetter months. The last century brought about vast improvements in our knowledge of golf course management and the range of equipment available to exploit that knowledge. There is no reason that these improvements should not continue through the 21st century.