The electric-powered mower has yet to grab the imagination of the UK and European greenkeeping fraternity. Chris Squires, Head Greenkeeper at Rutland County Golf Club, shares his experiences as he enters the third season using this alternative technology.

A positive charge

Above: The bearings of the powered roller brushes are packed with a special lubricant to reduce friction

Rutland County Golf Club is set in 169 acres of gently undulating countryside, just north of Stamford, adjacent to the main A1 trunk road. It is owned by a group of private investors and construction began in spring 1991 on the site of a former mixed arable and sheep farm. Not long after that I joined the team to oversee the final construction phase and the subsequent growing-in period.

Cameron Sinclair was retained as the course architect and specified that the greens and the tees should be constructed to USGA standards using a 70/30 sand and soil mix. The 18-hole course is a par 71 and we also have a 9-hole pitch and putt course and a 20 bay driving range. The main soil type is a heavy loam sitting on limestone, which is very free draining, although there is a small acreage of heavy clay that can cause minor water-logging problems.

We operate a mixed fleet of turf maintenance equipment with no particular allegiance to any one manufacturer, but select specialist machinery that best suits our needs and, importantly, our budget.

Therefore my greenkeeping facility houses a range of equipment from John Deere, Massey Ferguson, Deutz, Saxon, Kawasaki, Amazone and Textron. We also run a small fleet of E-Z-GO golf buggies, available for hire from the Pro Shop.

For turf maintenance around the complex we use two Ransomes Super

A positive charge

Certes 61 pedestrian mowers and a GT Classic for the greens, a nine-year old Fairway 350D that's still performing faultlessly, a Ransomes 180 for the tees, and a set of Ransomes trailed gangs with Magna reels for the semi-rough and Sportcutter reels for the driving range and pitch and putt course.

Our final piece of turf maintenance kit, used exclusively for mowing the greens, is the Ransomes E-Plex II purchased in March 1999. It cost around £17,500 then, although I'm reliably informed that it now costs just over £1,000 less. I'm a great believer in keeping equipment simple whenever possible so we opted for the version without power steering, but we included as an optional extra a set of powered roller brushes. 11-knife cutting units completed the specification.

Many greenkeeping professionals reading this piece will be highly sceptical when it comes to using electric greens mowers, but from my experience over the past two years I can honestly say, from the outset, that I'd certainly buy another one.

Legislation, pressure groups and technology, not to mention the recent fuel crisis in the UK, are just some of the factors that will result in our profession looking a lot more closely at the use of alternative fuels – and in the not too distant future.

America is already leading the way with stricter laws on noise pollution and California in particular, one of the most environmentally-aware states in America, is introducing legislation restricting the use of petrol/diesel-powered equipment within 250 feet of residential property between 9am and 5pm, Monday to Saturday and banning all use on Sundays and holidays.

Here, in the UK, with increased pressure on our green spaces for housing development, more and more golf courses will have residential properties adjacent to their borders.

So, even ignoring prospective legislation, what has convinced me that the electric greens mower is here to stay? Well, the key reasons are its utmost simplicity and operator comfort. Maintenance is absolutely minimal. There's no engine oil, so there's no need to check the oil filter, oil levels or carry out oil changes; there's no hydraulic oil, so there's no threat of leaks and ruined greens; there's no fuel, so there's no need for in-line filters or the possibility of fuel contamination; there's no radiator so there's no water level checks to worry about.

All we have to do when we've run out of charge is park up in the bay, loosen the cell caps on top of the batteries, check the electrolyte level and plug in. Next morning we unplug, tighten the battery caps and off we go. No routine checks or maintenance procedures; just drive out onto the course and begin work. Installation of the recharging unit presented no problems, all we had to do was select the position in the shed for the machine, install a standard 3-pin plug socket and plug in the charger unit. Recharging takes approximately 7 hours and there's an automatic cutout when recharging is complete.

Best of all, there's the absence of noise. In transport mode the machine is virtually silent and in mowing mode the only noise is from the cylinders, so operator fatigue is almost non-existent. The roar of a high revving diesel or petrol engine is a thing of the past and you can actually hear the cylinders rotating and can be aware of any potential problems simply by listening to the reels. Mind you, this does have its drawbacks as you can also hear what the golfers are saying about the condition of the course!

If proof is needed to support the argument about operator comfort this can be seen on any morning when all my team try to get in early so that they can have first option to use the machine.

I also believe that you get a better cut with the E-Plex. The reel speed is faster and constant because there are no losses due to any inefficiencies in the hydraulic system or reduction in engine output. Therefore, you get more cuts per metre and a consistent number of cuts per metre.

So, what's the downside?

Well, you can't verticut or scarify

Above right: The battery pack provides enough power to cut 22-23 greens per charge. Initial conditioning is crucial for optimum performance

Below: "The machine is almost silent", says Chris Squires. "Mind you, this does mean that you can hear what the golfers are saying about the condition of the course!"

with this machine. That's because you can't put too much load on the cylinders. The resistance generated by soil penetration will cause added drain on the power output. That's why it's vital that the machine is set to its optimum operating level at all times. We use a special lubricant; a very liquid grease for the bearings in the powered rear roller and brushes to lessen friction and the bottom blade to cylinder clearance is crucial, again to prevent too much load. However, this is best practice and helps prolong the life of the cutting units, whether you're running electric or diesel-powered equipment, so it's not really any different.

You'll find that you also have to plan more. You need to introduce a regime that ensures you run the batteries down to a minimum, every time. Here at Rutland, we cut all 18 greens and then use the remaining battery life to cut the pitch and putt greens.

Another aspect that requires thought, and indeed guidance from your dealer, is the initial conditioning of the batteries, and this should never be underestimated. It took us a month to condition ours from new, where we were able to cut just nine greens per charge before reaching our average of 22-23 per charge.

The machine now has over 590 hours on the clock and in the main has performed very well. There's been the odd problem with a burnt out cylinder drive motor and a lift arm motor, but Textron's local dealer, Lawn Mower Services, has replaced these speedily and efficiently, under warranty.

After sales support was an important ingredient when we negotiated the purchase. We were entering into an area of new technology and it was vital that we had confidence in both the manufacturer and their dealer. Dave Hampshire fronts the sales operation for Lawn Mower Services and fully appreciated our wariness. He has provided advice and on-site support of the highest order supported by his team back at Wellingore, near Lincoln. My advice to any greenkeeper contemplating the purchase of an electric mower is be confident that your dealer can provide the service, back-up and moral support for your investment.

I'll conclude by restating what I said earlier and that is that I would definitely buy another E-Plex, especially with the advances in battery technology that will come on stream in the next five years. The benefits of effortless operation and operator comfort far outweigh any negatives and I'm sure that many more course owners and greenkeepers will be embracing this technology during the next decade, be it by choice or because of new legislation.

Dr Stephen Baker looks at the work that is being carried out to ensure you choose the most suitable sand for your bunkers

True

A frequent source of debate within golf clubs concerns the performance of bunker sands. Regular complaints about bunker sands include excessive crusting, soft and fluffy lies, excessive plugging of the ball on impact and unstable footing. Undoubtedly, some of these comments are influenced by the way in which the sand was installed and its subsequent maintenance. However, the physical composition of the sand also has major effects on the performance of golf bunkers. The objective of this article is to review research studies that have looked in detail on the effects of sand type within bunkers, particularly on playing performance.

Apart from playing characteristics, many issues need to be taken into account when choosing sands for bunkers. The sand should be free draining and in particular contamination with silt and clay may reduce drainage rates. High silt and clay contents may also contribute to the development of a surface crust following rainfall and subsequent drying. As a guideline, sands with more than 2% silt and clay should be avoided.

Windblow

Windblow is an important consideration. On links courses, most of the local sands used within bunkers fall in the size range of 0.1-0.35 mm diameter. This may be appropriate for the generally deeper and narrow bunkers typical of a links course but this would be a potential disaster on

grit

many inland courses. The fine sands on links courses are usually a product of transportation by wind before stabilisation by vegetation. Therefore, their use on more open bunkers, particularly on exposed inland courses, would be a recipe for disaster.

In selecting a bunker sand, it must always be remembered that golfers are liable to blast sand out of bunkers while playing from the hazard. If the sand contains a lot of coarse material, greater than about 1.5 mm, this is liable to remain on the surface where it can interfere with putting and may also damage mowers. The localised accumulation of considerable quantities of excessively coarse sand splashed from a bunker may also make the turf more drought susceptible. Similarly, on inland courses, the lime content of the sand is important. If the sand contains appreciable amounts of lime (eg. as shell fragments), this may accelerate the invasion of annual meadow-grass and broad-leafed weeds, encourage earthworm activity and on newer, sand-dominated greens make the turf more susceptible to take-all patch disease.

Sands can stack at different angles. When moisture is present, a sand can easily be raked up and remain against a very steep bunker face. Fine sands retain moisture more readily and they can maintain a steeper angle for longer periods than coarse grained sands, which can quickly dry out. Dry sands have a maximum slope, known as the angle of repose, above which they will not be stable. If the sand has a higher angle of repose, it remains against bunker faces more easily and thus less maintenance is needed.

Colour

The colour of bunker sands can have a major visual impact on a golf course. In general, light coloured sands are preferred (tan, white or occasionally light grey). Light reflection and glare can sometimes be a problem with white sands, although perhaps less so with the British climate than in other parts of the world!

There have been three main studies in which the playing performance of bunker sands has been examined. The first was carried out by Brown and Thomas of the Texas Agricultural Experiment Station and the Texas A&M University and was reported in 1986. The second was a study at the Sports Turf Research Institute reported in 1994. While the most recent was from the now defunct Australian Turfgrass Research Institute that was initially reported in 1994 but which lead to a Bunker Sand Specification for Australian Golf Courses, which was published in conjunction with the Australian Golf Union in 1995.

The Texas study, carried out with the assistance of USGA agronomists, examined 42 sands from all over the United States including materials that were reported to perform well and others that performed very poorly. The size and the shape of the grains were assessed and related to a number of physical properties.

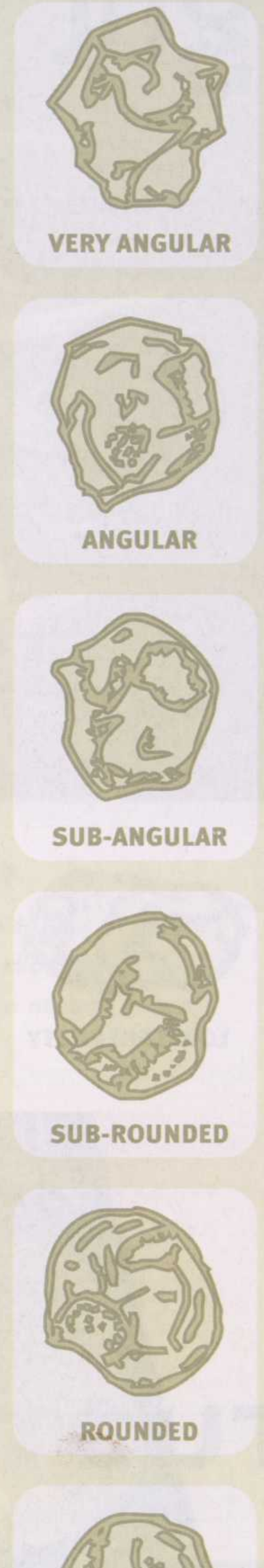
The development of a crust on the sand surface detracts from its quality and this was examined by saturating samples of the sand by sprinkling with tap water, then drying for 24-48 hours until the sand was dry. Crust development was evaluated by sliding a spatula under the sand and lifting it up. Problems of crust development were greatest on sands containing more than 3% silt plus clay.

Penetration

Ball penetration was evaluated by placing a golf ball on the surface of the sand and pressing it into the surface to half the depth of the ball. The force required was recorded using a penetrometer. Angular sands generally required greater pressure to force the ball into the sand and were most resistant to the so-called "fried egg lies", whereby the ball becomes deeply embedded with the sand after impact. Sands with ball penetration values less than 0.18 MPa were particularly susceptible to excessive ball penetration, while sands with values exceeding 0.24 MPa were preferred.

Our study at the STRI extended these principles to assess golf ball impact, surface stability for footing and the angle of repose of bunker sands. For each of the 23 sands studied, we assessed the average grain size, the uniformity of the particle size distribution, the angularity and sphericity of the grains, initial mois-

CLASSIFICATION OF SAND GRAIN SHAPE



True. grit

VARIATIONS IN GRAIN SPHERICITY

ture content and the packing density of the sands after compaction.

We measured golf ball impact by firing balls using a modified bowling machine into sand prepared under a variety of conditions. The machine had two independently rotating wheels that allowed us to simulate various conditions of ball velocity, backspin and approach angle. For the eventual tests we used an angle of 710, a velocity of 19 in/sec and a backspin of 597 radians/sec. This is equivalent roughly to the impact of an eight iron shot landing on a horizontal surface, although with slightly less backspin than would be achieved by the best players.

Plugging depth (ie the distance between the bottom of the ball and the original sand surface) averaged 31 mm on dry sand, 20 mm on wet unraked sand and 30 mm on wet raked sand. There was a tremendous variation between sands and, for example, on the dry sand, plugging depth varied from 21 mm (approximately half the diameter of a golf ball) to 44 mm, in which case the entire ball was below the surface. For the wet, raked sands the difference was even greater (9-37 mm) because on a number of sands the ball bounced out of the initial impact mark and simply rested elsewhere on the surface.

We examined relationships between plugging depth and sand characteristics and found that plugging depth increased with coarser sands and those with a more uniform spread of particles. Stability of footing was measured as penetration resistance, i.e. the force required to push a 28.7 mm diameter probe into the surface. For dry conditions, results between sands varied by a factor of two and, for wet conditions, there was a fourfold difference in readings. The more unstable sands were those with a very uniform size distribution that lead to a low packing density. Sands with more spherical grains were also more unstable.

We also measured the maximum angle of dry sand. This ranged from 29.50 to 35.60. Rounded sands typically had values around 310 and sub angular sands had values averaging about 340.

This work enabled us to publish guidelines on the selection of bunker sands in my book "Sands for Sports Turf Construction and Maintenance."

The preferred particle size distribution for inland golf courses is given in Table 1. Because of possible stability problems, it was also recommended that there should be no more than 60% of particles in the rounded and well-rounded shape categories. Similarly, sands with a very uniform grain size distribution are probably best avoided, especially if there is a high proportion of material above 0.5 mm diameter or the content of rounded grains is high. In case of problems with sand splash, it was also recommended that lime content for bunker sands on inland courses should not exceed 0.5%.

The Australian studies confirmed many of our findings; in particular that the depth of plugging was dependent on the uniformity of sand grains and that the angle of repose was dependent on grain shape. They also found that the angle of repose was higher in bunker sands with increased clay content and the development of a surface crust was influenced by packing density and the presence of more angular grains. On the basis of their results and those of the previous studies, they were able to publish a specification for bunker sands and this is reproduced in Table 2.

The three studies have shown that it is possible to characterise the performance of sands for bunkers to give practical guidelines on how well different sands might perform. However, there have been reported cases of sands being accepted as excellent by members at one golf club while the same sand is considered poor on other courses. This may simply be a result of the fickleness of the golfer, but clearly further work is needed to improve our understanding of the effects of installation methods, sand depth and maintenance.

Dr Stephen Baker is Head of Soils and Sports Surface Science at the STRI

Table 1

Recommended particle size distribution for bunker sands on inland golf courses

Sieve size (mm)	*% passed*
8.0	100
4.0	100
2.0	100
1.0	90-100
0.50	35-90
0.25	0-40
0.125	0-2
0.063	0-1

Table 2

Bunker sand specification for Australian Golf Courses

Criteria under test	*Recommended value*
Particle size distribution	Inland courses 0.2mm to 1.0mm Coastal courses 0.1mm to 1.0mm
Particle shape	Angular
Surface crusting	Less than 1.0kg/cm2
Angle of Repose	Greater than 300
Material composition	Silica
Ball Plugging	Greater than 2.5kg/cm2
Hydraulic conductivity	Greater than 25cm/hr
Colour	Light without glare

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BOSS

A revolution is taking place in turfgrass genetics. Exciting new molecular techniques are being developed that will accelerate conventional plant breeding. Scott MacCallum finds out more ...

Gene genie

Mapping out the future

Golf courses have taken a battering over the winter and many may have to come to terms with more frequent winter flooding and summer drought conditions if the global warming prophets are proved correct. But help is at hand, scientists are already able to develop grass varieties more tolerant to climatic and environmental stresses and the pace of innovation is accelerating.

A revolution is taking place in turfgrass genetics. Exciting new molecular techniques are being developed that will accelerate conventional plant breeding. And most of the progress is being made in this country at the Institute of Grassland & Environmental Research (IGER) – the site of the only UK-based turfgrass breeding programme.

Funded by British Seed Houses since 1988, the IGER turfgrass breeding programme – recognised for the development of AberElf and AberImp – is now benefiting from the latest advances in molecular biology, as well as an internationally-recognised grass genetic database and seed bank – all on site just outside Aberystwyth.

According to IGER senior research scientist and cell biologist, Dr Mike Humphreys, it is now possible to track precisely the transfer of genes for stress resistance from fescue grasses into ryegrass in conventional breeding programmes. A number of novel techniques are being developed which will allow the geneticist to test whether the fescue genes have been transferred successfully and are functioning normally in the genome of the ryegrass.

"Our objective is to identify molecular gene markers closely linked to particular desirable turfgrass traits such as drought and/or wear tolerance and fineness of leaf. These markers – or 'genetic fingerprints' – can then be used to identify potential grasses that possess the trait without expensive, laborious, and time-based testing over successive plant generations," he explained.

What's more, as they try to develop better cultivars, IGER turfgrass breeders have no shortage of natural grass plant material to choose from. IGER scientists have been collecting grass plants since 1974 and now have priority access to a genetic database representing over 10,000 individual plant populations from all over the world.

"Each population has been catalogued together with details on its habitat, abundance, soil situation and growing environment. Habitats as diverse as quarries, monastery courtyards, football pitches, scrublands and mountain-tops have all been sampled so that we can identify novel, natural genetic material which turfgrass breeders can utilise," said Mike.

Once material has been catalogued, there is now no barrier to better genetic understanding even though most of the traits that interest turfgrass breeders are complex and governed by a combination of genes of varying importance. Grass chromosomes can be viewed under the microscope and IGER has developed a technique that allows the observer to locate different suites of genes – relevant to a range of important traits – to specific regions of the chromosome. Once their presence has been confirmed, their effect may be determined.

Genomic In Situ Hybridisation

Gene genie

Mapping out the future

Above and previous page: A party of greenkeepers listen intently to IGER staff

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IGER senior research scientist/cell biologist, Dr Mike Humphreys

(GISH) may be a mouthful, but this exciting new 'gene painting' technique is currently being used to distinguish between chromosomes from ryegrass and those from fescues in a hybrid plant. In effect, DNA from the two species is labelled in different colours.

"Access to this technology means that by using a combination of genetic markers and GISH, we can develop models which will allow our turfgrass breeders to more quickly assess the feasibility of transferring desirable genes to and from ryegrass and fescue in the future," explained Dr Humphreys.

IGER – in collaboration with partners in France, Poland and Norway – is currently working on an EU funded project (SAGES)† looking at how grasses withstand environmental stresses. A major effort is being made to identify the genes involved in traits such as cold and drought resistance in the fescues with a view to their transfer into ryegrass. IGER scientists are also aware of potential 'flood tolerant' genes in rice that may, theoretically, eventually offer benefits for amenity grass areas prone to flooding.

According to IGER turfgrass breeder Danny Thorogood, working in partnership with his Institute colleagues working in molecular biology means greenkeepers can expect to see an increase in the number of new, adaptable turfgrass varieties coming to the market.

"Over the last 20 years, traditional plant breeding has made an enormous difference to the quality of turfgrass cultivars available to greenkeepers and groundsmen. But just as the advances in molecular genetics have helped map human genes to help accelerate the development of new healthcare treatments, the new technology will do the same for turfgrass breeding over the next decade.

"For example, thanks to this progress, traditional breeding objectives on the IGER ryegrass, fescue and bent grass development programmes are now being more easily combined with aesthetic and sustainability issues such as disease resistance, colour retention, and metal, salt and herbicide tolerance (eg. chemical control of Poa annua on golf greens).

"Until recently, the use of molecular tools in plant breeding was at the experimental stage, but now by utilising the gene identification capabilities of modern molecular genetics much of the 'trial and error' of conventional plant breeding is being removed. The future is bright," he predicts.

† Further SAGES project information can be found on the following website; http://www.iger.bbsrc.ac.uk/igerweb/SAGES/welcome.html

Further information on the IGER turfgrass breeding programme is available in a technical publication. Free copies of 'The IGER Advantage' are available from British Seed Houses on 01522 868714