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This publication includes lecture notes of papers presented at the 2002 New Jersey Turfgrass Expo. Publication of these lectures provides a readily available source of information covering a wide range of topics and includes technical and popular presentations of importance to the turfgrass industry.

This proceedings also includes research papers that contain original research findings and reviews of selected subjects in turfgrass science. These papers are presented primarily to facilitate the timely dissemination of original turfgrass research for use by the turfgrass industry.

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AERATION PRACTICES FOR GOLF GREENS IN THE UNITED KINGDOM

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Aeration on golf courses is always a delicate balance between long-term needs to ensure healthy grass development, drainage, and thatch control and the short-term problems of disruption to the putting surface as far as the golfers are concerned.

The objective of this paper is to review aeration practices in the United Kingdom and, in particular, to outline a number of possible aeration strategies appropriate for different types of golf green. This must be set against a general background of golf course use in the United Kingdom in which play takes place throughout most of the year. Winters are generally mild enough (or golfers sufficiently hardy!) for disruption through snow and frost to be limited to only 2 or 3 weeks per year, except in the more northern parts of the country.

There are four primary reasons for aeration on turf, namely:

- To relieve compaction caused by machinery and player traffic.
- To encourage essential oxygen and water.
- To develop root growth.
- To control the buildup of organic matter and thatch in the upper profile.

Normally, aeration on greens is undertaken for a combination of needs, and even a well-built green will require aeration to keep the surface free from compaction and to control the accumulation of organic matter.

Compaction occurs when a compressive force is applied to the surface from either machinery or players. This reduces the volume of large macropores while the volume of finer pores remains unchanged or increases. Fewer large pores and limited continuity between macropores means air and water flow into and through the soil is limited and the root growth may be restricted. Through aeration the amount of macroporosity in a compacted soil can be increased, which in turn helps the movement of oxygen, water, and roots.

If managed incorrectly, any green can develop a build up of organic matter over time in the upper profile. This thatch layer is undesirable. Not only does it produce a softer playing surface but it will also hold water, discourage deep root growth, and lead to a higher risk of turfgrass disease. Aeration can modify the profile and by promoting an exchange of material can effectively dilute this accumulation of thatch. Hollow coring is one such process that removes some organic material from the green and in turn allows soil exchange to take place through topdressing. Poor soils are partially replaced by better draining mixes of sand and soil which in the long term improves percolation and surface firmness.

MACHINERY

There is a tremendous variety of machinery to choose from to complete essentially the same task, and it is important to consider specific objectives when selecting different modes of aeration. For example, each season requires work for different reasons; aeration in the fall and winter assists surface drainage, spring work aids recovery, and aeration in summer supports growth and the penetration of irrigation water.

Slit tining is generally undertaken in the fall and winter months when soils are often at their wettest. Any other time of the year and slit marks can open up if the soils become drier. As with all aeration activi-

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ties, care must always be taken to select the correct soil conditions when slitting, as excessive moisture in the soil or frost in the ground will do as much harm as good.

Solid tining provides an alternative to slitting during the spring and summer months. The use of solid tines helps to maintain a permeable turf surface that is receptive to watering. Hollow coring, on the other hand, physically removes cores of soil from the profile and in doing so introduces a large volume of air. This operation is done primarily to remove thatch, poor quality soil, or severe surface compaction.

Both hollow and solid tines can be fitted to many pedestrian and tractor-mounted punch-action aerators. The rapid vertical action of these machines allows a crisp round hole to be punched which reduces disruption. Hollow and solid tines can vary in diameter from 25 mm jumbo tines, through conventional 13 mm times and down to 6 mm micro-tines.

The Verti-Drain adds yet another dimension to soil aeration and is primarily a tool for deep-seated compaction relief. The operating principle is similar to hand forking where deep penetration of the soil profile is combined with a heave action which internally cultivates and fissures the soil. To achieve the best result with the Verti-Drain, the operations must be undertaken on soil which is reasonably dry, although not so dry as to hinder tine penetration. A wet soil will lead to smearing down the side of tine holes and reduced fissuring of the soil, sometimes resulting in a deterioration in drainage.

As well as relieving compaction, the Verti-Drain also provides an opportunity to give distinct, long lasting vertical drainage channels. These channels allow better movement of air, water, and nutrients if filled with a suitable top dressing material. Improved root growth and natural breakdown of thatch through bacterial action follow as a result of this work.

Certain types of machinery operate within certain depths. For example, the Verti-Drain is a tool for deep-seated compaction relief usually operating to a depth of 300 to 400 mm, whereas the majority of vertical punch-action aerators operate to a depth of 75 to 100 mm. It is a common rule that operating depths should be varied so as to prevent the formation of a pan in the profile which can restrict air and water movement.

CASE STUDIES FOR AERATION MANAGEMENT PROGRAMS

Aeration practices will vary considerably depending on the condition of the putting surface. In Table 1, possible annual aeration programs that might be used in the United Kingdom for five widely contrasting types of golf green turf are identified. This includes both the routine aeration program and additional aeration practices that may be carried out to address specific problems. It must, however, be recognized that adjustments to the programs may be needed, depending on weather conditions, and programs may change from year to year as the quality of the turf hopefully improves. The five scenarios presented are for the following situations:

a) Golf greens based on natural soils, usually with a buildup of sandy top dressing, which have been well maintained and are generally in good condition (Table 1).

b) Poor draining greens, e.g. those on heavy clay-rich soils or receiving heavy use (Table 2).

c) Greens where there has been a considerable buildup of thatch (e.g., associated with drainage problems or poor management such as limited organic matter control or over-fertilization) (Table 3).

d) Links courses on fine natural sands (Table 4).

e) Modified rootzones (e.g., with a sand-dominated rootzone over a gravel drainage layer [i.e., a USGA profile]) (Table 5).

For golf greens with significant dry patch problems, additional modifications to the aeration program may be required. This includes the possible use of a sarel roller to increase water entry through hydrophobic layers, the possible use of a HydroJect or tractor mounted water injection to help water penetration to depth, and the use of wetting agents.

CONCLUSION

A long-term program of regular aeration is essential on golf courses. Allowing compaction to build up over time and undertaking occasional heavy treatments will not be sufficient. There is, of course, a political benefit to be had from implementing aeration

techniques which limit disruption during the competition season. A balance can be attained between what is good for the grass and what is acceptable to the golfer. However, golfers must accept that there will be times when disruption to play cannot be avoided and, in the long term, the work is being undertaken for their benefit.

In recent years, aeration has become a far less disruptive operation. Gone are the days where large holes were punched in the green and players suffered from unacceptable surfaces for a month or two. Operations such as micro-tining can now be undertaken in the summer and if followed up by verticutting, the surface will be acceptable within a matter of days. The game of golf is now considered an all-year sport and as a result aeration should be an all-year practice, but the key to success is timing and this will achieve both optimum results and recovery.

Table 1. Possible aeration strategy for good quality soil-based greens

Routine	
Jan to April	8 mm solid tines (3- to 4-week intervals)
April to September	6 mm solid tines (3- to 4-week intervals) or sarel roller (2-week intervals)
October to December	150 to 200 mm slit tines (3- to 4-week intervals)
Additional	
August	6 to 8 mm micro-hollow tines (possibly spring as well)
October	Verti-Drain with 13 mm tines

Table 2. Possible aeration strategy for poor draining soil-based greens

Routine	
January to April	8 mm solid tines (3- to 4-week intervals)
April to September	6 mm solid tines (3- to 4-week intervals)
October to December	150 to 200 mm slit tines (3-week intervals)
Additional	
Hollow coring	13 mm tines (fall and winter), possibly 6 mm tines in summer
Verti-Drain	2 to 3 times (fall and spring) depending on ground conditions

Table 3. Possible aeration strategy for thatchy greens

Routine	
January to April	8 mm solid tines (3- to 4-week intervals)
April to September	6 mm solid tines (3- to 4-week intervals)
October to December	Slit tines or cross tines (3-week intervals)
Additional	
Hollow coring	13 mm or 18 mm tines in fall, 13 mm tines in spring, 6 mm tines in summer
Verti-Drain	Once or twice (fall plus spring or winter) unless thatch is related to poor drainage, in which case frequency may be increased

Table 4. Possible aeration strategy for links greens

Routine	Solid or sometimes chisel tine (4- to 5-week intervals)
	Summer: Sarel roller (3- to 4-week intervals) for water penetration on contoured greens
Additional	
Slit tines	Possibly 1 to 2 times October to December
Hollow tines	Very rarely used, except micro-hollow tines in fall with late oversowing
Verti-Drain	Possibly every second year in fall with 13 mm tine for soil loosening