



*To ensure best results from aerification and topdressing operations, the topdressing must be thoroughly brushed into the aerification holes.*

# AERATION: Needed More Today Than Ever Before

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**T**RADITIONAL hollow-tine aeration is probably the most unpopular maintenance practice performed on the golf course. From the crew's point of view this operation ranks near repairing an irrigation leak on a bone-chilling morning or redistributing wet sand to the slopes of washed-out bunker faces. From the golfer's point of view, well . . . "expletives deleted."

However, as the amount of play increases at most golf courses, so does the need to address the detrimental effects of wear and compaction caused

by concentrated foot traffic, motorized golf cart use, and maintenance equipment. The combination of these factors and the often unreasonable expectations for flawless day-to-day playing conditions exact a toll on the turf and the superintendent. Golfers view superb playing conditions on television each weekend but fail to realize that it has taken months and sometimes years to prepare a course for these events. The number of rounds played at most courses is unlikely to decrease, so the best chance for maintaining a high-quality stand of turf is to provide

optimal growing conditions — which is why a sound aeration program is so important.

The ideal growing medium for turf is considered to be 50% mineral matter, 25% air, and 25% water by volume. The amount of large pores should roughly equal the amount of small pores. Large pores, called macropores, drain quickly and ensure the movement of air and water through the soil profile. Small pores, called micropores, hold water against gravity, through capillary action. Most of the water in micropores is available to plant roots.

Traffic compresses the soil and reduces the percentage of macropores, while the percentage of micropores remains unchanged or is slightly increased. The shift in the distribution of pore space limits the infiltration of water into the playing surface and slows the movement of water through the soil. Since air is "pulled" into macropores as water drains through the soil profile, the loss of large pores indirectly affects root growth by limiting the amount of oxygen available for root respiration.

The physical resistance of tight soils to root penetration alters rooting patterns to a point where most root growth occurs close to the surface and is exposed to environmental extremes. Compacted, poorly drained soils warm more slowly than dry soils during spring, another factor that further limits root growth. When the turfgrass root system is compromised, sooner or later the effects are seen on the surface as reduced quality or a limited ability to recover from stress.

Once a significant amount of soil compaction has occurred, the only practical way to reestablish more favorable growing conditions on an established stand of turf is to aerate. For the record, though, there is little scientific evidence that aeration increases the amount of oxygen in the soil between the holes. Therefore, the only portions of the soil that are actually "aerated" are the sidewalls and bottom of the empty holes. A more appropriate term for "aeration" would be hollow-tine, solid-tine, water, drill, etc., cultivation.

There are, however, many well-documented benefits of aeration. The holes and channels accelerate the movement of rain or irrigation water into the soil. The timely removal of excess moisture from the surface equates to fewer delays of play and more consistent playing conditions. The physical removal of cores lowers the bulk density — a measurement directly related to the degree of soil compaction.

The prolific amount of rooting that occurs in aeration holes is apparent when the cups are changed. A dense mass of white, healthy roots often can be seen in aeration holes even during the peak stress periods of midsummer.

The benefits of aeration are not limited to improving the soil's physical properties. Hollow-tine aeration is the most effective way to minimize the undesirable effects of excess thatch accumulation — short of stripping the sod. One pass with a "punch-type" aerifier equipped with  $\frac{1}{2}$ " diameter



*The key to "good greens" is matching the rate and frequency of topdressing application to the growth of the turf. Less-intensive aeration operations are necessary on greens built to USGA recommended specifications when the inputs of fertilizer, topdressing, irrigation, etc. are carefully managed.*

hollow tines on a 2" × 2" spacing removes about 5% of the surface area when the cores are broken up and the soil worked back into the playing surface with a brush or dragmat. As done on most tees and fairways, most of the organic material remains on the surface and is easily blown away or collected with the clippings.

The incorporation of broken cores into a thatchy playing surface modifies the physical properties of this layer and introduces soil microorganisms responsible for organic matter decay. We are in the era of biostimulants, composted microbes, natural extracts, etc., and some manufacturers have claimed or suggested thatch control. Until research proves otherwise, though, the best chance of enhancing the degradation of organic matter is to improve the conditions for the native microbes already present in or under the thatch as described above — and it doesn't cost a cent.

Not too long ago the choices were simple: a pull-behind drum aerifier for the fairways/tees and a punch-type machine for the putting surface. Today there are many choices, and some units have more specific applications than others.

### Splicer/Spiker

A slicer utilizes triangular or rectangular knives mounted on a drum or axle. These units are simple to use and cause very little disruption to the playing surface. This operation is useful for breaking up a surface crust and promoting more rapid infiltration of water into the soil. The severing of stolons or rhizomes can improve turf density as well. Slicers, though, do not bring soil to the surface and have a limited depth of penetration on compacted sites.

### Hollow Tines

Hollow-tine aeration is the standard against which all other forms of aeration are compared. There are two types of hollow-tine aerifiers: those with tines mounted on a drum, and the "punch-type" units that utilize vertically operated tines.

Drum aerifiers are simple to use, have few moving parts to wear out or break down, and can cover considerable acreage in a relatively short time. Unfortunately, the depth of penetration is highly dependent on the degree of soil compaction and the moisture content of the



*On the other hand, aeration is needed when greens become severely layered due to an excessive accumulation of organic matter that can occur during the "grow in" period or when the greens are topdressed infrequently. Note the "black layer" and the deep penetration of roots through the aeration hole.*

soil, and close spacing is sacrificed for speed. If soil conditions are not ideal, these units tend to ride over compacted sites, producing the least effect where penetration is needed the most. The holes can be quite ragged, which limits the use of most drum units on greens. This type of equipment will continue to perform an important task on many low- to moderate-budget courses.

The vertically operated hollow-tine units are the most versatile aerators on the market. They cause much less surface disruption than the drum or open-spoon type designs, making them well suited for use on greens. There is no better way to overcome the effects of compaction, increase the infiltration rate of water into the soil, encourage deep root growth, and minimize excessive thatch accumulation in one operation.

The price of versatility is a considerable amount of surface disruption — much less than the old designs, but still enough to aggravate golfers, especially on greens. Core removal or breakup has traditionally been a time-consuming, labor-intensive task, but with specialized equipment such as core harvesters, core pulverizers, and highly efficient sweepers, this operation has been

greatly simplified. The slow ground speed of punch-type aerators once limited their use on the golf course, but now fairway units have been developed that can remove deep, closely spaced cores at a rate of up to an acre per hour.

The optimal time to aerify is a subject for debate. After hearing all the arguments from superintendents and golfers, it seems that there is no "best" time. They say not to aerify in early spring because soil temperatures are low, turf is not actively growing, and the holes will take a long time to heal. Some don't aerify in late spring because *Poa annua* is germinating and they believe the open holes invite encroachment of this weed. Others can't aerify during summer because the open holes will cause severe wilting. Early fall is out, because of tournaments, and late fall to winter is impossible because of a limited labor force and little chance to dry the cores before breakup or collection.

All might be valid arguments, but the overall benefits of aeration, especially on heavily compacted areas, far outweigh the disadvantages. For example, some *Poa annua* may germinate in the holes during spring, but by relieving compaction and improving drainage the more desirable species have a better

chance of competing with and crowding out the *Poa annua*. The potential loss of turf from severe wilt following aeration during midsummer is a concern, especially on a hot, windy day with low relative humidity. Timely irrigation or syringing, though, can prevent serious drought stress.

A variation of hollow-tine aeration not utilized to its full potential on golf courses is "quadra-tine" aeration. Quadra-tines are  $\frac{1}{4}$ " diameter tines that penetrate up to  $1\frac{1}{2}$ " deep on a  $1" \times 1"$  spacing. Due to the close spacing, the amount of surface area removed after one pass is only slightly less than the amount removed following  $\frac{1}{2}$ " diameter aeration on a  $2" \times 2"$  spacing. A primary advantage is little surface disruption and fewer golfer complaints.

The close spacing of holes greatly increases the amount of exposed surface area, which accelerates the evaporation of excess moisture from poorly drained, shaded sites. This operation also can relieve surface compaction during periods of heavy play and be a beneficial pre-treatment to the application of wetting agents to relieve localized dry spots.

Several superintendents have had good success overseeding into quadra-tine aeration holes. This is a practical way to introduce new, improved bentgrass cultivars into a green. The depth of penetration can be adjusted to about  $\frac{1}{2}$ ", and a mixture of seed, topdressing, and a little fertilizer can be worked into the holes with a brush or upside-down piece of carpet. The numerous, shallow holes are an ideal place for germination and development of seedlings.

### Solid Tine

There are no cores to collect following solid-tine aeration, and this is perhaps the only advantage to this operation. The use of solid tines is sometimes called "shatter-core" aeration because the jarring effect of inserting blunt tines into the soil, in theory, loosens the soil and relieves compaction. The benefits tend to be short-lived, though, and the operation has little beneficial effect on compaction when the soil is moist. In fact, there is a greater potential to develop a compaction pan when solid tines are used because soil is not removed from the hole. The pros and cons of hollow-versus solid-tine aeration are further discussed in the September/October 1990 issue of the GREEN SECTION RECORD.



*The ever-increasing amount of play at most golf courses necessitates the use of aeration on a wider scale.*

### **Verti-Drain**

Routine use of hollow-tine aeration can create a layer of compaction called a cultivation pan located just beyond the depth of tine penetration. Evidence of a cultivation pan is a soil core that breaks apart about 4" deep when cups are changed. A cultivation pan slows the movement of water through the green and restricts root penetration. An effective way to minimize the effects of this kind of compaction is by deep-tine aeration.

A Verti-Drain deep-tine aerator utilizes ½" to 1" diameter solid or hollow tines that penetrate up to 12" deep. When fully inserted, a "kicking action"

is imparted on the tines which fractures the surrounding soil profile. The depth of penetration and amount of kick are adjustable to minimize surface disruption. The kick has more effect when the soil is a little on the dry side because dry soil fractures more readily than wet soil — not too dry, though, because the tines then lift and tear the sod.

Many superintendents hire contractors to perform deep-tine aeration because the contractors have experienced operators and because a Verti-Drain is expensive and requires the use of a high-powered tractor. Usually, only greens and perhaps tees are aerated to keep rental costs to a minimum. Those fortunate enough to own the equipment

have found that this operation is effective on fairway soils and cart-trafficked rough areas as well.

Never assume that the least amount of disruption will occur when the smallest diameter tines are used. Arrange a demonstration using several tine sizes on the practice green before making a decision. You may be surprised to find that the use of ¾" diameter solid tines may be less disruptive than ½" tines because there is less chance of bending or bowing the heavier tines in rocky or heavily compacted soil. Furthermore, the large holes are more easily filled with topdressing than small holes. Taking the time to fill holes with sand or a suitable mix prolongs the beneficial

effects of this operation by preserving the integrity of the holes. A similar argument can be made for removing the cores and filling the holes with topdressing after hollow-tine aeration on greens and tees. More material is required, but the long-term benefits are usually worth the added cost.

### Floyd-McKay Deep Drill

The deep drill also is capable of reaching beyond the depth of standard aeration tines. It is a self-propelled unit that utilizes two sets of carbide-tipped drills to bore holes up to 10 inches deep. The operation deposits a small amount of soil on the playing surface, and cleanup is usually required on greens. There is no kicking action, so the beneficial effect on subsurface compaction is probably less than that achieved with deep-tine aeration. Similar to deep tine, deep-drill aeration provides the most benefit where permeable soil exists below the layer of compaction.

Relatively few problems have been observed in the field with either operation. As mentioned above, a notable exception is a lifting or tearing of shallow-rooted turf when these operations are performed under dry soil conditions. This effect also is observed when standard aeration is performed under similar conditions.

### Water Injection

Water injection is an innovative method of aerating, and is in its first season of use on most golf courses. High-pressure jets of water are utilized to produce deep, irregular channels into the soil. The primary benefits are the variable depth of penetration and the absence of surface disruption under most conditions.

Initial research was performed at Michigan State University on a sandy loam soil where water injection was compared to hollow-tine aeration. Various soil physical properties, such as bulk density, porosity, and saturated hydraulic conductivity (percolation rate) were measured, as were rooting, clipping yield, and turf quality. Water injection generally performed as well or better than standard aeration, and the results were similar on either bentgrass or Kentucky bluegrass turf. Only hollow-tine aeration, though, limited thatch accumulation, because water injection neither removes thatch nor is it supposed to bring soil to the playing surface.

This study is a promising indication that water injection is an operation well suited to relieve compaction on fairways and tees. It provides the unique opportunity to relieve compaction and improve drainage during midsummer without disrupting play. Current research is investigating the potential benefits of mixing additives such as phosphorus or wetting agents with the injection water.

Its effect on high-sand-content greens built to USGA recommended specifications is not well understood. Neither is the effect on old native-soil greens which have been topdressed with sand for a number of years.

Many greens have received water injection treatments this season with positive results — deeper root penetration, improved drainage, etc. A few problems have occurred on greens having a substantial accumulation of sandy topdressing above the original construction mix of coarse sand, peat, and soil. Contamination of the topdressing with back-washed silt and clay and the deposition of fine gravel on the putting surface have been observed on a few greens.

Whether or not these isolated cases are cause for concern has yet to be determined. As superintendents become more familiar with water injection, the appropriate uses will become evident. The prudent course of action is to

proceed slowly with any new equipment until the more common problems are discovered and addressed.

### Summary

The key to success with aeration is to determine the problem and then choose the most appropriate equipment and method of aeration. There is no need to purchase a \$100,000 subhydro-vertimole deep-drill shatterslicer to break up a surface crust of algae on the greens. Combinations of techniques are more likely to produce better results than a single unit. For example, an early spring deep-tine aeration, supplemented by quadra-tine or Hydroject aeration during the summer, topped off with a standard hollow-tine aeration during the fall could produce great results with limited disruption to the playing surface.

There is no shortage of reasons to postpone aeration, and before you know it, it has not been performed at all. The potential benefits of aeration are usually well worth the trouble.

Finally, keep the golfers well informed about when and, more important, why aeration is being performed. Make the extra effort to communicate with golfers and you might be surprised how much support there is for your programs.

*Quadra-tine aeration is an excellent way to improve drainage and "dry out" the turf in a moist, shaded site.*

