Aerification Principles for Sports Turf

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Aerification is a mechanical cultivation practice that selectively tills the soil and/or thatch without destroying the turf. Aerification is commonly recognized to: relieve soil compaction; aid in thatch control; improve soil air exchange, enhance water and nutrient penetration into the soil, disrupt undesired soil layers, aid in modifying soil with top-dressing, enhance water and nutrient uptake and pesticide effectiveness, reduce runoff and puddling, reduce effects of localized dry spots, reduce surface hardness, stimulate new growth by cutting stolons and rhizomes, and improve heat and drought tolerance.

The potential negative effects of aerification include: turf injury increasing potential for turf loss during stress; disruption of the turf surface; increased weed and insect problems; increased dessication and/or winter injury; reduced soil strength, and the creation of a localized soil compaction zone.

Soil compaction is the most common reason for aerification and results from the compression of soil particles closer together. Compaction results in reduced soil pore space, increased bulk density, surface runoff, carbon dioxide concentrations, and small pore space.

Possibly the two most important principles of aerification are identifying the problem correctly and then determining the most effective means of alleviating the problem. Common problems relate to the following:

- a compaction layer from player usage which usually occurs in the top three inches of the profile,
- high clay and silt content soils that impede infiltration, percolation, air exchange and rooting, and these problems are increased by traffic,
- presence of layers that impede water and air movement, layers may be a distinct change in soil texture or a buried organic layer,
- compaction deeper in the profile due to repeated cultivation to the same depth,
- compaction deeper in the profile caused by heavy equipment during construction,
- the presence of 'hard' sands generally caused by coarser or angular-shaped sands,
- improper mixing of sand into a soil profile creating a 'mortar' mix layer, and
- salt affected layers where high levels of sodium accumulate and destroy soil structure.

Soil compaction is measured in the lab as bulk density, which is the mass of soil per unit of dry soil volume, including solids and pore space. Sandy soils generally have a higher bulk density than finer textured soils because the sand tends to have few small pore spaces and sandy soils contain particles of different sizes that become tightly packed together. These types of soils generally have bulk densities of 1.3 to 1.8 g/cm3. Finer textured soils have more tiny pore spaces and generally clay and silt loam soils have bulk densities of 1.0 to 1.5 g/cm3. Depending on soil type, the upper ends of these ranges may inhibit root penetration. For example, the USGA recommends a bulk density for putting greens mix of 1.2 to 1.6 g/cm3.

Soil penetrometer resistance is another means of measuring soil compaction. The penetrometer measures the pressure needed to push a rod through the soil. Finally, saturated hydraulic conductivity is another means of assessing soil compaction. This is typically measured with a double-ring infiltrometer which consists of two metal rings one placed inside the other. The rings are driven into the soil and then filled with water. Upon saturation, hydraulic conductivity is measured by the drop in water in the smaller ring over time and measured in inches per hour.

Sports field soil compaction tends to be more of a problem in the upper four inches of the profile. Because rooting depth is limited, water use efficiency is decreased leading to more frequent irrigation, which in turn increases the probability that the surface is wet during field use resulting in increased compaction. Also under such conditions the com-

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pacted soils remain wet and may cause increased hydration of crown tissue leading to winter injury.

During the spring and summer growing season compacted soils lack oxygen, slowing turf growth but not affecting weeds such as goosegrass and knotweed which have a competitive advantage over the turf.

The ultimate effect of soil compaction is decreased root, shoot, rhizome, and stolon growth. Problems that develop from this may include high and low temperature injury, dry or wet wilt, intracellular freezing and winter dessication.

Aerification methods:

Coring: This is the industry standard in which soil cores are removed by hollow tines, screw devices or spoons. The cores may be drag-matted back into the turf as a topdressing or removed. The soil should be moist or at field capacity for coring. Core diameters are generally one-half to one inch in diameter, the depth of coring is 3-10 inches, and core hole spacings are from 2 -10 inches.

With every cultivation program it is important to know what is the impact of the practice. The USGA has recently suggested that perhaps on golf greens 20% of the surface area should be affected annually. To determine impact on the surface area determine the core area surface and hole spacing. For example, one-half inch tines spaced 2x2 inches apart will impact 4.91% of the surface area.

$$\text{Area of a core hole} = \text{pie } (r)^2$$

$$\text{pie } (r)2 = 3.141 \ \ (.25)^2$$

$$= 0.196 \text{ in}^2$$

$$\text{Surface area affected} = 0.196/4 = 0.049 \text{ in}^2 \text{ or } 4.9\%.$$

Another aspect of core aeration is that once the surface seals, air and water exchange essentially stops. Thus, the smaller the diameter tine probably the shorter the impact of the practice. And obviously, topdressing to fill coring holes should extend core hole effectiveness.

All this theory provided, it still boils down to being able to measure the period of impact of any cultural practice.

Solid tine devices: Solid tines are used instead of hollow tines. The objective is to cause soil shattering which is best done when the soil is drier than field capacity. This method minimizes surface disturbance but is more likely to develop a "cultivation pan" just below the depth of penetration. Some units penetrate at such an angle that lifting and shattering occurs.

Deep tine devices: The more common use on sports fields of equipment that penetrates from 8 to 12 inches provides an opportunity to address both surface and subsurface problems. Most of these units operate under the same principles as their shallower penetrating counterpart. However, some units produce a heaving action by forcing tines to move laterally at the deepest point of penetration. If the soil is dry enough, the heaving causes additional cracks for air and water movement into the soil.

Deep drilling: This equipment uses, as is implied, drill bits that may be up to one inch in diameter and penetrate more than 12 inches. The soil removed is granular rather than cores thus easier to drag back into the surface. These units also come with the capacity to "drill and fill" where a soil amendment can be incorporated into the holes as the holes are drilled. This may create an excellent drainage channel through the soil profile. These units tend to be slower than other deep tine units and do bring material to the surface which must be handled.

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Grooving: Grooving is obtained by vertical rotating power driven blades that cut continuous slits through the soil. These units can do considerable dethatching if blade spacing is close and are often used for renovation. Some systems provide opportunity to inject materials into the groove. Generally this practice is most effective with a slightly dry soil.

Slicing: Slicing is conducted by vertical rotating knives or discs that are not power driven and rely on equipment weight for penetration. These units do not dethatch but produce minimal disruption to the playing surface and can generally be used throughout the year. The soil should be moist for slicing and some units provide material injection.

Spiking: Spiking is accomplished by solid tines or flat, pointed blades that are not power driven and penetrate the turf and soil surface. The depth of penetration is generally shallow (fi - 1 inch). This is a mild cultivation practice and the effects may last for a few days and is sometimes used with reseeding. Since this practice produces little disruption it can be done throughout the year and is generally most effective in a moist soil.

Sub-aerification: Sub-aerification refers to subsurface cultivation by means of vibrating blades. The unit generally cuts slices into the turf on six to eight inch spacing. The blades vibrate to shatter compacted layers and thus perform best in moderately drier soil. This equipment generally produces minimal surface disruption and some units have injection capabilities. If surface compaction is the problem, these units are not as effective as many other options.

High pressure water or air injection: These units use high pressure to force water or air into the soil displacing soil particles randomly. Like other systems that use vibration as a means of cultivation, these units perform best in a moderately dry soil. Both types of systems offer the potential to inject other materials into the soil, both are relatively slow, and both create a relatively small surface opening.

Aerification timing: Very little research has been done regarding cultivation and sports fields. Ideally timing should be based on the level of plant growth limitation, the effect on the playing surface, and scheduling. Timing generally coincides with the beginning of the more active growth periods. For cool season grasses, most cultivation is generally done early to mid spring and late summer to late fall. Warm season grasses are generally cultivated from early spring to mid summer. On severely compacted areas, more frequent cultivation may be needed. The larger the

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space created by cultivation, obviously the longer the growing period needed for recovery.

Another factor on sandy soil profiles is player stability. On sandy soils it should be recognized that most cultivation procedures will reduce field stability for a period of time. For example, any practice that cuts rhizomes and stolons late in a growing season may not allow for adequate recovery, resulting in an unstable surface.

Research by Murphy et al. (1993) on bentgrass putting greens compared hollow and solid tines and measured saturated hydraulic conductivity, and penetration resistance. They reported that hollow tines were more effective than solid in improving drainage in compacted soils. In non-compacted soils, there was no effect from aerification. Reductions in soil penetrometer resistance were obvious within one week of aerification and the effects lasted nearly three weeks. They concluded that regular aerification was needed to avoid soil compaction and that care is needed to avoid development of a compacted layer at the end of the penetration depth, specially for solid tine aerification. They further suggested that varying aerification depth should reduce the development of a compacted layer.

Research by Guertal and Han (2002) compared results on compacted and non-compacted bermudagrass sports fields during one year. They used a 3/4" diameter hollow tine that penetrated eight inches once, twice or four times from July through April (once - July; twice - July and October; and four times - July, October, January and April). Using a penetrometer, they observed reduced compaction six inches deep for about three weeks after aerification on the compacted site. On the non-compacted site, one aerification was enough to relieve soil compaction.

Considerable research has shown that a "cultivation pan" will develop from consistent coring to the same depth and this appears to be more of a problem on finer textured soils.

All aerification practices have limitations. It is up to the manager to properly identify the most limiting factor and select the best procedure to reduce the limitation.

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