Developing Turfgrass Cultivation Programs

Formulating an effective, systematic approach will pay strong dividends over time.

Adverse soil physical conditions are a frequent cause of limited turfgrass growth. Soil compaction, just one cause of poor soil physical properties, is often considered the most important cultural problem on recreational sites.

Alleviation of soil compaction and other physical problems requires several approaches: cultivation, soil modification, drainage, traffic control and careful irrigation. With continual traffic on golf courses, cultivation is the most common means of dealing with adverse soil physical problems.

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Although cultivation *techniques* have been widely used on golf courses, superintendents have found it difficult to develop sound cultivation *programs*. Fertilization programs, for example, are formulated from a wide base of knowledge about turfgrass fertility needs, soil test results, understanding of fertilizer carriers and so forth. From this scientifically based pool of knowledge, a good fertilizer program — setting forth rates, timing of applications and other specific guidelines — is established. In contrast, cultivation programs have been developed more by trial and error.

In this article, the keys to formulating a sound cultivation program will be discussed. Key steps to developing a good program include the following:

- Identifying the problem(s).
- Selecting the best method(s).
- Determining the desired frequency and timing.
- Applying cultivation at correct soil moisture.
- Evaluating your results.

Identification Of The Problem

Unless the specific, primary (basic) soil physical problem or problems on a site can be identified, several things can occur. First, the best cultivation procedure(s) cannot be chosen, and second, the best overall approach to solving it cannot be determined. Perhaps soil modification or drainage would be a better long-term approach. If cultivation is involved, frequency of cultivation is difficult to determine. Included in identifying the problem is its location within the soil profile, such as a surface-compacted layer, a fine-textured soil several feet deep or a clay lens at 12 inches.

Soil physical problems and their location within a soil horizon are not always easy to identify. *Symptoms* that evolve from the presence of a primary problem are what the grower normally observes, such as a waterlogged soil, standing water, poor aeration, black layer, poor rooting, a hard soil, a droughty area, low infiltration/percolation and, in some instances, excessive infiltration/percolation. Unfortunately, various symptoms can be caused by several primary problems.

Some suggestions in identification of soil physical problems are:

- Use a probe or shovel to carefully observe the different layers or horizons in the soil profile to a depth of 1-1/2 to 2 feet. Do not ignore even small layers if they differ distinctly in texture from surrounding layers.
- If you think that a layer interferes with water movement, take a cup-cutter-size core with the layer in the middle portion. Add water to the top

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The amount of traffic and soil type are two of the factors that contribute to the development of soil physical problems.

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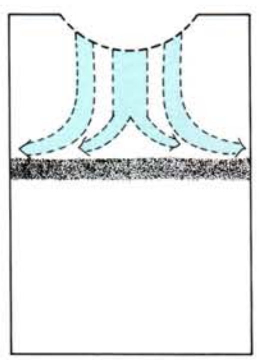
(in a small depression) and see if it will move across the layer.

- When the soil has been thoroughly wetted, such as after a prolonged rain, slowly insert a long, pointed steel probe (pencil-size diameter) in the soil and note whether any areas of high resistance are present. Carefully observe the layers to see whether roots penetrate them or water perches above them.
- Observe the root growth patterns for any indications of limited rooting deeper in the profile. Conditions that hinder rooting throughout the whole profile and not just a zone in the profile are a surface-compacted layer (either thin or several inches in depth) and an excessively fine-textured soil throughout the profile.
- If you suspect a high water table vs. a drainage barrier that perches a water table, core a hole several feet into the soil and follow the depth of the free water table over a three- to four-day period. A high water table normally will remain relatively static, and if it is a perched water table, the deep core should drain it and cause a rapid lowering of the water.
- Use common sense to determine whether poor contouring is simply channeling water into an area in quantities higher than soil infiltration can remove it, thereby causing an excessively wet area.
- If a sodic problem is anticipated, have a soil test conducted.
- Check with individuals with expertise in soil physical problems such as a state extension specialist, USGA agronomist or soil conservation personnel.

Proper identification of the primary soil physical problems is not easy. This is one of the main reasons why good cultivation "programs" have not evolved nearly as rapidly as other routine programs used on golf courses. However, considering the potential for expending much labor and money without results when the wrong approach is chosen, good motivation exists for a more logical approach.



The presence of layers can be determined by applying water to a cup-size core sample and observing downward flow.

Select The Best Method Or Methods

As stated, cultivation is just one choice for alleviating soil physical problems. The pros and cons must be weighed for cultivation, soil modification, drainage and other less important measures such as traffic and irrigation control. Often a combination of approaches is necessary.

Because the focus of this article is cultivation, we will assume that cultivation is the best option in this instance. The next step is to select the best cultivation method or methods to deal with the physical problems on your site. Important questions to answer are:

- How much *surface disruption* will occur? For close-cut turf, this is of particular concern. Also, the degree of disruption is important in determining the time of year an operation can be done, the degree of interference with turf use and how frequently it can be used. Moderate to severe disruption of the sod generally means timing the operation only in a period of rapid regrowth for the species and conducting the procedure as infrequently as possible.
- What is the *longevity* of expected results and what is the *magnitude* of improvement desired? If a procedure results in a reasonably long period of alleviating a problem, then a higher degree of injury may be tolerated. Also, soil physical problems are often corrected by removing excessive water or by altering the pore-size distribution and density of the soil. The later aspects cannot be achieved without soil movement, thus, greater potential for injury in many cases.

If the superintendent desires a major degree of soil cultivation, then closer tine/blade spacings and deeper penetration or both will be necessary.

- *How deep is my problem* located in the soil? Different cultivation procedures may vary from 1/4-inch penetration to 16 inches. Unless cultivation blades or tines penetrate the problem zone, little benefit is expected.
- Is soil *loosening desired* or is penetration without loosening acceptable? Certain cultivation operations have a high degree of loosening while others do not. Loosening alters the pore-size distribution and density of fine-textured soils to produce macropores for root, water and gas movement. These macropores would be in addition to any pore space created directly by the tine or blade and would be between areas of penetration.
- Do you desire to *topdress* with sand after cultivation to modify the soil over time or to keep channels open? Topdressing can be applied after any cultivation procedure that does not bring soil to the surface. However, operations that leave larger or deeper holes require considerable sand to fill the holes, and working the sand into holes is not easy.

Disregarding the difficulties of sand application, sand that fills cultivation cavities (whether small or large) will help prolong the beneficial life of the cultivation operation. It is very desirable to have a cavity open to the soil surface to facilitate maximum water infiltration and gas exchange. A cavity created deeper in the soil that becomes closed to the surface does serve as a root channel but is much less effective for water

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and gas exchange than one open to the surface or filled with sand to the surface.

• Do I want *soil to be brought to the surface?* A grower may wish to bring soil to the surface to remove it from the site as part of a program to partially modify the soil with sand addition. A frequent concern with Verti-drain operations on golf greens is whether to use hollow-tines and bring up a core, remove it and topdress with sand or to use solid tines and topdress.

In this case, the 'ideal" from the soil physics standpoint would be to use hollow tines to reduce side and bottom compaction around the tine. However, the "practical" belief of this author is that the relatively wide tine spacings and loosening tine action minimize these potential problems. This would not be true for hollow vs. solid coring tines where spacings are at 2 inches and tine operation is vertical without appreciable loosening of the soil.

Sometimes growers want soil to be brought to the surface for the additional benefit of a topdressing. This is a factor to consider especially on fairways.

• Will *localized compacted* zones occur somewhere in the soil as a result of using a procedure? The occurrence of a compacted zone immediately beneath 3-inch coring tines — both hollow and solid — have been observed in the field and demonstrated in research situations. Primary factors that influence the development of such layers are: closer tine spacings will result in more rapid formation; soil texture with soils high in clay and silt are more prone to formation of such zones; more frequent cultivation, especially on a moist soil, favor compacted zone development.

Any implement that is pushed into the soil will cause some compaction — the important issue is whether more compaction is alleviated than formed. For example, core aeration at 2-inch spacings with 3-inch tines is useful in correcting a compacted surface zone. At the same time, it may contribute to development of a compacted zone at 3 to 4 inches in the profile over a period of time. Periodic cultivation with a procedure that penetrates deeper will correct the deep zone. Once every two or three years would be sufficient on most sites to destroy any deep zone of compaction created by core aeration.

• *Other practical considerations* in developing a cultivation program include: weight of the equipment on golf greens, cost of purchase of equipment or leasing, availability of equipment for leasing and speed of operation.

Assuming a clear understanding of the problem(s) present on a site, a cultivation program is formulated to correct the situation. This generally means that several different procedures often

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Above: A 1/8-inch coarse sand layer above the clay prevents water from entering. Left: The result of three years of fairway topdressing on an adobe clay fairway. Below: Pattern of dry spots from a hydrophobic sand layer or drainage barrier.

Comparison Of Different Turfgrass Cultivation Methods

Cultivation Procedure	Comments	Depth Of Penetration	Spacing Of Blade/Tine	Degree Of Soil Loosening[z]	Degree Of Soil Brought To The Surface[y]	Soil Moisture For Best Effectiveness[w]
	Tine dia.	**· inch ·**	**· inch ·**	**1-5**	**1-5**	
1. *Coring with hollow tine, spoon, screw devices.*						
a. Tractor-drawn units with spoons or tines that enter the soil at an angle. Some units are motorized.	Several types Interchangeable spoons, hollow tines, slicing blades. 1/2-3/4″	3-6	6	2	2-4	FC
b. Drum-type	Several types Hollow tine	2-3	2-3	1	2-4	FC
c. Verti-Drain	Hollow tine	10-12	1-8	4-5	2-4	FC-DFC
d. Vertically operated tines	Most common form of cultivation Many types 3/8-7/8″ dia.	3-5	2-6	2	3-5	FC
e. Deep-Drill Aerofier	Screw device 1/2-3/4″ dia.	5-10	5	1	2	FC
2. *Coring by solid tine devices.*						
a. Verti-Drain	1/2-1″ dia.	12-16	1-8	4-5	1	DFC
b. Shatter-core vertically operated tines	1/2-3/4″ dia.	3-5	2-6	2-4	1	DFC
c. Units where tines enter the soil with a rotary pattern (Aera-Vator)	1/2″ dia.	3¼	4	2-5 (can be varied)	2	FC-DFC
d. Small diameter solid tine often as a quad tine	1/4″ dia.	2-3	2	1	1	FC
3. *Slicing.* Solid tines or blades, are not power driven. Many types.	Blades pulled through the soil or the weight of the unit pushes tines into the soil.					
a. Straight-line tines	Most common	3-7	6-12	1	1	FC
b. Straight-line blades (verti-slice)	Thin width blades	2-4	4	1	1	FC
c. Offset tines (Aerway)	Larger width blades, 1/3-1/2″	6-8	7	2-4 (can be varied)	1	DFC
4. *Spiking.* Blades are not power driven (i.e. do not cut through the soil but penetrate by machine weight)	Small knife-like blades. Units may be pull type or motorized drive (Spikeaire)	1/4-2	1-2	1	1	FC
5. *Subaerification.* (Yeager-Twose Turf Conditioner)	Vibrator action as blades are pulled through the soil	2-8	9-10	4-5	1	DFC
6. *High Pressure Water Injection* (Toro Hydro-Jet)	Uses high pressure water action	4-20	3-6	2-3	1	FC
7. *Grooving*[x]. Power driven blades that cut through the soil and thatch layer	Used for renovation and not for routine cultivation	1-5	1-4	4-5	4-5	FC-DFC
8. *Forking.*	The "original" spot treatment cultivation method	6	2-4	3-4	1	FC

[z] Degree of soil loosening: 1 = None; 5 = most effective
[y] Degree of soil brought to the surface: 1 = none; 5 = most effective
[x] Grooving causes severe injury to the turf and is not generally used as a true cultivation method but is used to "open up" the turf in renovation.
[w] FC = field capacity; DFC = drier than field capacity

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must be used and that when several methods are used, the timing and frequency of each procedure will differ.

For example, core aerification may be conducted spring and fall on a golf green; pin spiking or small solid tine coring in the summer on a biweekly basis; and Verti-drain or drill aerification once every two or three years. Each procedure is selected to deal with a specific problem, and the superintendent must weigh the pros and cons of different options and select the best methods for his site.

Determine The Desired Frequency And Timing of Cultivation

A proposed program should be developed on paper for each site. Frequency of an operation depends on the severity of a problem and persistence of a problem such as surface soil compaction from normal vehicle and foot traffic. In the case of topsoil that has very high clay content, deep cultivation several times per year would be beneficial for one to two years, followed by a less frequent program of deep cultivation. The same soil, however, would be prone to continual surface compaction and may require core aeration two to three times per year every year.

Timing of cultivation is controlled mainly by the degree of injury that occurs and whether play is disrupted. Operations that cause moderate to severe turf injury should, ideally, be timed when the turf has an opportunity to rapidly heal. For cool-season species, this would be early to late spring and early to mid-autumn. For warm-season grasses, summer is best.

When a cultivation operation is performed that causes initial deterioration in turfgrass quality, golf course superintendents have traditionally applied supplemental nitrogen fertilization before or immediately after the procedure to stimulate recovery. Additional irrigation is also used. Research by B.J. Johnson and R.N. Carrow on Tifway bermudagrass demonstrated a long-term decline in turf quality after core aeration, even under a good lawn-care program, when supplemental nitrogen and irrigation were not used.

Other factors that influence timing are:

- Condition of the turf at the time of cultivation.
- Whether any unusual environmental or pest stresses are present.
- The potential for weed seed exposure, especially *Poa annua*.
- Whether the pre-emergence herbicide barrier to control annual grasses may be disrupted. Researchers at Michigan State and Georgia have demonstrated that this is not a concern in most situations.
- The availability of labor.
- Whether soil moisture is suitable.

Apply Cultivation At Correct Soil Moisture

Different cultivation methods are most effective at a particular soil moisture level at the time of application. If soil moisture is outside this range, effectiveness declines.

If the soil becomes too dry, the implement will not be able to penetrate. . .

Methods that have a loosening action on the soil are more effective if the soil is somewhat drier than field capacity. Field capacity would be the soil moisture at one day after a good irrigation or rainfall event on a fine- textured soil. "Somewhat drier" would be two to four days after irrigation or rainfall.

If the soil becomes too dry, the implement will not be able to penetrate and will lose its effectiveness. In contrast, on excessively moist soils, little loosening action occurs.

For operations that penetrate the soil, but with minimal loosening action, a soil moisture near field capacity would be best. Any cultivation should be avoided at soil moisture above (wetter than) field capacity to avoid destruction of the soil structure.

Evaluate Your Results

The benefits of cultivation are often difficult to evaluate. You should be able to observe improved infiltration/percolation, better rooting, increased shoot growth or loosening of the soil; thus, the grower should see fewer of the symptoms that represent clues to the presence of soil physical problems.

Using the same procedures to identify the primary problems on a site is beneficial in identifying results. Careful observation of the soil profile is particularly beneficial. Sometimes an untreated area can be left for comparison.

While evaluation of cultivation results is difficult, it is well worth the effort to adjust your program over time. Certainly this is one area where the experience of a superintendent and observation over time are essential to evaluate cultivation program effectiveness.

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In conclusion, cultivation programs evolve by long-term experience on a particular site (i.e., trial and error); using what someone else has found effective; using the "latest" device with hopes it will be the right operation; or by a careful analysis of the problems, evaluation of different options and correct use of various procedures.

The main reasons that better cultivation programs have not evolved are:

- Difficulty in determining the primary soil physical problem(s) present on a site.
- A lack of specific, comparative data on how each cultivation method influences soil physical conditions and turfgrass growth.

Historically, growers have had to rely on empirical observation to determine the relative effectiveness of different techniques. In recent years, research projects supported by the USGA Green Section at Michigan State University and the University of Georgia have greatly increased our knowledge about various methods. Much of this information will be published over the next year.

Because soil physical problems exist on almost all golf courses and cultivation is a main tool to alleviate these problems, the development of a sound cultivation program is important. The same logical and scientific approach used in formulating cultivation programs as with other cultural practices will result in improved and more efficient cultivation and better turf. □