Computer Models Examine Core and Topdressing Programs

By Deying Li, Dave Minner and Nick Christians

Superintendents are quite familiar with the use of core aerification and/or topdressing to manage thatch and to alleviate soil compaction. Core aerification and topdressing have considerable advantages, including improvement of air and water infiltration through the soil; encouraging root and shoot growth; thatch-control; modification of soil structure; smoothing and leveling of the playing surface; protection of turfgrass from winter kill; and renovation of problematic turf.

Later in this article, we will introduce a computer model that can be used to simulate core aerification and/or topdressing and to demonstrate how to use the model to facilitate making a turf cultivation plan under various conditions. A turf manager can have a better idea of the effects of the coring/topdressing program by simply changing the tines and depth of topdressing. The model is not intended to replace

Computer modeling allows managers to predict the results of various topdressing and aerification programs.

the best judgment based on common sense by turf managers. On the contrary, it's our hope that this model can stimulate judicious decision making from superintendents.

Not so long ago, short hollow tines and vertical spikes were the only tools turf managers could use for aeration. Today, however, there is an arsenal of technologies that are faster and more effective. High pressure water/air injection, for example, can reach as deep as 12 inches without noticeable disturbance on the surface of the turf. Collectively, coring, spiking, slicing, forking, vertical mowing and topdressing are called supplemental cultural practices, or cultivation. Cultivation is the process of mechanically and selectively tilling of the sod with minimum damage to the turf.

It's core cultivation that truly releases the soil compaction if used correctly while the other cultivation practices are generally for thatch control and turfgrass reestablishment. The term aeration/aerification is widely used as a euphemism for coring although neither aeration nor aerification carries the true connotation, the full purpose or the consequences of core cultivation. The way superintendents choose from those techniques reflects not only the understanding of turf management, but also the philosophical view of different cultures.

Given the potential benefits of core cultivation and the relative ease of operating such equipment, it's no surprise turf managers are so tempted to use them routinely despite the earlier warnings by experts that cultivation should not be used as a routine cultural practice other than as necessary. It's not that turf managers are indifferent about the collateral damage to the grass by the cultivating operation. Instead, it's the lack of information on soil physical properties necessary for decision-making and the inconvenience in scheduling the operation that limits the options of the managers.

Often, turf managers need to decide whether core aerification should be used as often as possible or how much is too much. To answer these questions, they must first learn to effectively assess the results of core cultivation practice while it's still possible to prevent them from being overused.

A turf manager may not only be interested in the total impacted areas, but also sand percentage at certain depths of soil profiles and the soil's physical properties. When thatch control is the main purpose of aeration and topdressing, the two practices should be used in combi-

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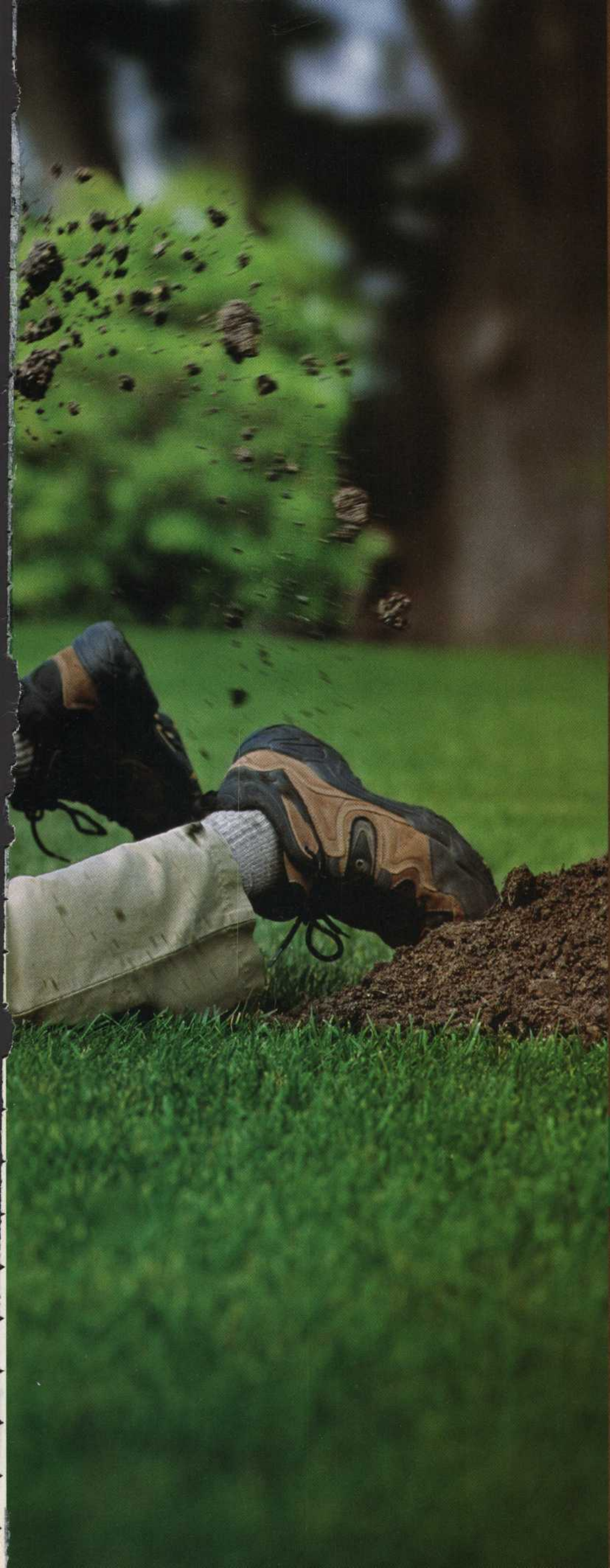

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nation to achieve the best results. This by no means suggests that one can't maintain a healthy turf by using them separately. The question is how to make sure that coring and topdressing complement one another rather than obstruct. Whether core aerification is used alone or is accompanied by topdressing, it's always a good practice to keep the operations well-planned and well-documented. Ideally, the soil's physical conditions should be monitored regularly. Such conditions include the amount of soil organic matter, bulk density, water conductivity and air permeability.

Many turf managers send their soil samples for testing on fertility regularly but seldom request tests on the soil's physical properties. There are technologies that can be used to measure those parameters on-site or in a lab quickly and inexpensively. Keeping a good record of core aerification/topdressing practices and soil test results allows the managers to make decisions based up-to-date and reliable information. A simple comparison between the cost of fertilization and aerification/topdressing will show that soil's physical properties is as valuable as soil fertility tests.

The results of core aerification and topdressing are affected by many factors such as the tine diameter, tine length, tine spacing, sand content in the original soil, targeted depth of the root zone, and the efficiency of operations. One can choose from the diameters of three-sixteenths of an inch to 1 inch, and tine length of 3.5 inches to 15 inches, as well as different tine spacing on either hollow or solid tines. Turf managers need to know how often those practices should be executed to meet a targeted sand percentage, a total impacted area or both. Most importantly, they need to know how to reach this goal with lowest input.

Many studies evaluated the effectiveness of topdressing and aerification and compared different coring equipment. However, since there are so many types of equipment available in the turf industry, a thorough comparison of different equipment with different tine sizes and coring depths will be very time consuming and cost prohibitive. Presently, there are some Web-based calculators that superintendents can use to calculate the impacted areas for certain tine diameter and spacing (assuming the same setting of equipment is used all the time) or to calculate the amount of sand needed for topdressing at a given depth. Some of those calculators

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TABLE 1

Coring and Topdressing Scenarios in Turf Management.

Case #	Coring	Moving Cores	Topdressing with Sand	Effects on Sand Percentage
1	+	+	+	After coring, remove the cores and follow up with topdressing that fills the holes and leave a sand layer on the top.
2	+	-	+	After coring, topdress with sand and break down the cores; holes are filled with a mixture of sand and soil.
3	+	+	-	Cored and the cores are moved. No topdressing. Holes are left unfilled. May affect sand percentage.
4	-	-	+	Topdressing only. Case 3 plus case 4 is equivalent to case 1. Sand increases.
5	+	-	-	After coring we break the cores. Holes will be filled eventually with same core materials. No sand increase.
6	-	-	-	None.
7	-	+	+	Not relevant.
8	-	+	-	Not relevant.

Strategies for fall fertilization

A strong turf fertilization program is designed to ensure maximum performance of turfgrass stands by providing necessary nutrients at the proper time. Golf courses are generally evaluated by the playability of the greens, tees, fairways and roughs, although standards vary considerably. An important aspect of a good turf management program is the proper selection and timing of fall fertilizers for both cool- and warm-season grasses.

For cool-season grasses, research indicates that fall applications of fertilizer improve turf density, color and the ability of turf to withstand winter stress, as well as providing early spring green-up. As top growth slows or stops in the fall, more nutrients are stored in the forms of carbohydrates and proteins in the crown and root system. The first step of an effective fall fertilization program is to improve turf density and recovery from summer stress by making a late-summer/early-fall application, which will help to prepare the turf for another application in late fall.

The late-fall application should be made to coincide with the last regular mowing, or when the rate of growth has significantly slowed in warmer areas. Slow-release nitrogen sources at rates of .75 to 1 pound of nitrogen per 1,000 square feet can be applied at this time. Equivalent rates of potassium are also beneficial. This timetable will vary, however, with the source of nitrogen applied. As soil temperatures drop in the fall, fertilizers that are highly influenced by soil temperature should be applied three to four weeks earlier than more soluble sources to provide an effective late-season response without reducing spring green-up. Applications must be made before the ground is frozen or close to freezing so that the nutrients will be available to the plant.

In the South, fall fertilization creates several benefits to bermudagrass prior to and through the dormancy period. The objective is to provide adequate nitrogen, phosphorus and potassium through the fall to have controlled growth and color throughout the remainder of the season. This results in storage of carbohydrates to aid cold tolerance and spring green-up without excessive spring growth. It's important to remember that bermudagrass roots continue feeding long after the top growth has ceased, which is the perfect time to store food. Application timing will vary upon climatic conditions running from September through December. Nitrogen and potassium rates will vary from a 1:1 to 1:4 ratio depending on the needs for fall growth and color.

Warm-season grasses slated for overseeding require a little different program. Nitrogen amounts should be minimal leading into seeding to reduce competition with the ryegrasses. At overseeding time, a quality starter fertilizer that serves a dual purpose of feeding the bermudagrass and providing stimulus to the ryegrass seedlings is desirable. Ratios can vary from a 1:2:2 to 1:2:1. If phosphorus is already ample, a formula such as 10-15-30 or 15-0-29 will complete the task.

The Andersons produce a variety of coated- and methylene-urea based slow-release fertilizers designed to meet the diverse agronomic and climatic conditions throughout the country.

The Andersons Poly-S and Poly NS-52 are polymer-sulfur coated urea fertilizers, whose release is primarily dependent on coating thickness and moisture and less on temperature. In Western states, 17-3-17 w/63 percent Poly NS-52 plus 3 percent Iron & 2 percent Manganese provides an excellent initial green-up from ammonium sulfate and sustained feeding from the NS-52. In the North, 30-3-9 w/50 percent Poly-S and 28-3-10 w/50 percent Poly NS-52 are popular choices for fairways in the fall. In Southern climates where a 1:2, nitrogen-to-potassium ratio is desired, 15-0-29 w/ 100 percent Poly-S is a good choice. If a 1:1, nitrogen-to-potassium product is desired, 20-3-20 w/ 40 percent Poly-S and 2 percent Iron is popular.

The Andersons produce many methylene-urea formulations that rely on water-soluble and slowly available water-soluble nitrogen features to insure an effective response even under cool fall soil conditions. Several of the Andersons methylene-urea based Contec® greens formulations fall into this category. They are 17-3-17, 18-9-18 and 9-18-18.

Nutralene®-based products are also available. Golf courses in the North and West have found the Andersons 31-3-10 homogenous methylene urea with minors to be an outstanding fall fertilizer for low-cut fairways requiring small particle sizes. In the North, 25-5-15 w/50 percent Nutralene/Iron and Micros is ideal for bentgrass fairways cut below one-half inch. In Southern turf, 20-5-20 w/50 percent Nutralene/2 percent Iron and Micros or 10-5-25 w/50 percent Nutralene are popular choices on low-cut bermudagrass fairways.

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oversimplify real situations, and the information from those calculations is not sufficient in real-life practices where coring and topdressing parameters vary from time to time and often are used in combination.

In addition to methods being used for core aerification and topdressing, the time of the year when it is conducted, turfgrass growing status, soil moisture, soil tilth, soil organic matter, and soil texture are all important factors in this practice of punching holes and spreading sand. The best time for aerification is when the grass is still actively growing to recover quickly from the mechanical injury. There are times, however, when aerification can be conducted late in the growing season in the cool region to take the advantage of the freeze/thaw effect for releasing the soil compaction. A general guideline is to pick a time when the soil moisture is not too high and not too low to facilitate core penetration and avoid soil compaction caused by equipment during the operation.

Soil organic matter

Understanding the advantages and disadvantages of soil organic matter in the root zones and knowing how they build up in the soil is helpful for superintendents to make sound core/topdressing programs. An adequate amount of soil organic matter provides food to beneficial soil microbes and earthworms and improves soil structure and surface playing quality. Too much soil organic matter, on the other hand, will promote disease and insect pests, decrease root depth, block water and air infiltration, and reduce the surface stability.

Soil organic matter in the range of 3 percent to 5 percent is considered optimum. There seems to be a controversy regarding whether or not to include organic matter in the topdressing materials because of concerns that extra organic matter may add to the thatch problems and make the situation worse. Apparently there is not a clear definition and/or understanding between the helpful general soil organic matter and the organic material that is thatch.

Furthermore, it's not well-understood how the decomposed organic material applied as topdressing, among other factors, affects the status of thatch. Any factors that affect turfgrass growth and activities of microbes in the soil will influence the build-up speed of organic matter. The keys to keep the thatch in balance are maintaining soil pH in the neutral range, balancing soil nitrogen fertilizers, using herbicides and fungicides carefully, and keeping a sound cultivation program.

Simulated scenarios

There are eight different scenarios from various combinations of topdressing and aerification with or without core removing. Of the eight combinations, five are realistic (Table 1).

Java language is used in writing the program to handle the calculations under the first four scenarios as identified above. The program also allows users to change tine dimension and spacing, and to include soil conditions such as sand content and bulk density in each coring/topdressing practice.

A sand-based media with soil sod installed on the top is treated as a separate scenario to simulate some sport field constructions. Users can also use "case variables" under each medium type to simulate coring and/or topdressing operations with four cases intermittent.

Figure 1 shows one of the interfaces where users can input equipment parameters, soil conditions, and coring/topdressing combinations to calculate total coring and topdressing times, amount of sand needed and areas impacted to reach a goal. The program is available at *www.ag.ndsu.nodak.edu/plantsci/turf/main.htm.*

Tine diameters used in the simulation range from three-sixteenths of an inch to 1.25 inches, tine length from 2.5 inches to 12 inches, and tine space from 1 inch to 6 inches.

How to use the software

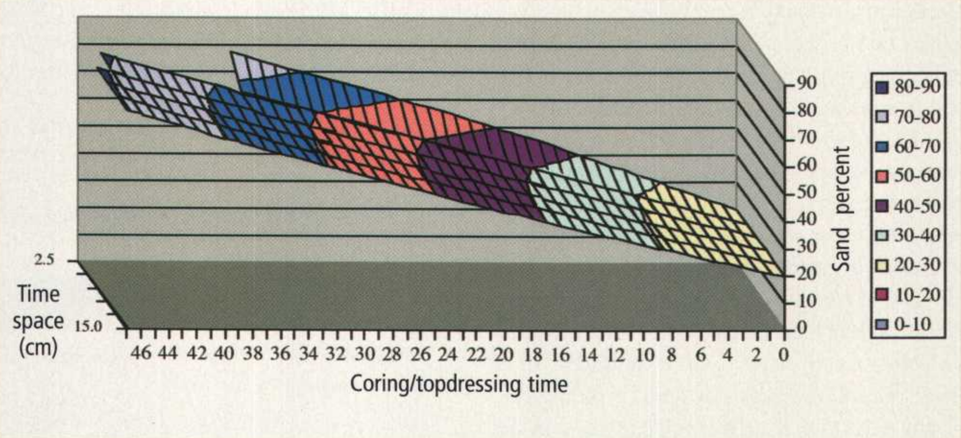
Soil-based medium: For example, a soil-based field with 20 percent (by weight) sand content is topdressed .1 inch each time with the targeted sand percentage in the top 6 inches being 80 percent (by weight), assuming that there is no overlap in coring areas before the whole field is impacted. It takes 36 operations to reach 77 percent sand for tines of three-sixteenths of an inch in diameter., 2.5 inches long and at 1-inch center.

In order to reach 80 percent sand or above, coring areas have to be overlapped. For the same tine dimension, it takes 46 operations to reach the 80 percent sand goal if the tines are at 2-inch center, and it takes 47 operations to reach the goal if the tines are at 3-inch, 4-inch, 5-inch, or 6-inch center, respectively.

Increasing the tine length to 4-inch, it takes

FIGURE 1

a. 4.76 mm tine dia., 63.5 mm tine length



Increasing the tine length to 4-inch, it takes 28 operations to reach the 80 percent sand goal if tines are at 1-inch center, and it takes 44, 46, 47, 47, 47 operations if the tines are at 2-inch, 3-inch, 4-inch, 5-inch and 6-inch centers, respectively.

Increasing the tine length further to 5.5-inch, it takes 24, 42, 45, 46, 47, 47 operations to reach 80 percent sand if the tines are at 1-inch, 2-inch, 3-inch, 4-inch, 5-inch, and 6-inch centers, respectively. The results do not change when the tine length increases from 5.5-inch to 7-inch.

When tine diameter is increased to eleven-sixteenths of an inch, it takes two operations to reach 43.7 percent sand (by weight) at 2.5-inch length and 1-inch center. Coring areas have to be overlapped to further increase the sand percentage in the top 6-inch of soil profile. Sand percentage reaches to 55 percent and 66.2 percent for 2.5-inch long tines at 2-inch and 3-inch centers, respectively, before coring areas overlap.

It takes 40, 43 and 45 operations to reach the goal of 80 percent sand for tine spaces of 4-inch, 5-inch and 6-inch, respectively. The effects of tine length are similar to the case of 3/16-inch diameter.

The impacted area increases as the tine diameter gets larger and the tine space get smaller. Thus, the total impacted area at the time when sand percentage reaches the goal or before the coring overlaps changes with the changing of tine dimension and spacing at a power of two.

Sand-based medium with sod/soil layer: Assume the original sand content is 95 percent, and a 1-inch layer of sod containing 20 percent sand is laid on the top. Suppose the goal is to restore 95 percent sand in the top 6 inches by coring and topdressing one-tenth of an inch of sand each time. For tines of three-sixteenths of an inch diameter, it takes 36 operations to bring sand percentage to 91.8 percent and coring areas have to be overlapped to reach the goal if the tine is 2.5 inches long and at 1-inch center.

However, after 24 operations, the sand percentage increases slowly because the sod layer has been buried by the topdressing sand and beyond the reach of tines. Sand percentage in the top 6 inches increases quickly again after 50 times of operation when further coring and topdressing will push the sod layer out of the considered zone of 6 inches.

Increasing the tine space will further slow down the process, while increasing the tine length will increase the coring efficiency in terms of reaching the targeted sand percentage without overlapping the coring areas. The best way to reach 95 percent sand in top 6 inches is to increase tine diameter to certain acceptable dimension and increase the tine length up to 5.5 inches.

The amount of impacted areas when sand percentage reaches the goal or before coring areas overlap is affected exponentially with the increase in tine diameter and decrease in tine space.

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Lessons from the simulation

Although increasing the core diameter or decreasing the tine space both affect the impacted area, the ultimate result is dictated by the topdressing thickness and the targeted sand percentage in certain depth of the field. Research has to be conducted to investigate the effect of tine diameter on turf recovery. Changing the tine length according to the progress in reaching the goal can increase the efficacy of coring and topdressing.

In case of a sand-based medium, the modeling allows managers to predict the results and take necessary measures before the sod layer is buried beyond the reach of tines, avoiding the layering effects. A long-term program can be made based on the resources and goals before actual operations by using the model to simulate different scenarios before putting them into practice. The program also can be used as an education model in classroom. Further field or laboratory research is needed to fine-tune the model and better simulate the actual situations.

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