organisms that are responsible for the breakdown of plant residues.

All turf management practices affect thatch accumulation and decomposition. Starting with a good root-zone medium to prevent thatch is more economical than to mitigate the problem afterward. Many materials have been tested to improve the physical properties of golf green root zones. By the early 1990s, peat has become an irreplaceable component in sand-based root zones and a benchmark for the evaluation of new organic and inorganic soil amendments.

Topdressing should be considered as a continuation of root-zone construction. It is not rare for golf greens and sport fields to rise a few inches over the original root zone as a result of years of topdressing. Since any two layers of material together will have less water conductivity than that of either of the material alone, layering must be avoided by the use of a material that is stable and consistent in property for many years to come.

Sources and characteristics

Peat is abundant and renewable. People extract nearly 100 million cubic meters of peat per year while the earth generates a similar volume naturally. Peat in Canada is growing more than 70 times as fast as it is being harvested. Canada is harvesting less than 1 percent of the peat bogs (Moore, 2001).

Peats are generally not rich in nutrients other than nitrogen. Generally speaking, high organic content, low ash content, uniform fiber sizes, and low-to-medium pHs are the best quality to mix with sand for root-zone construction and topdressing.

Compost is defined as organic residues, or a mixture of organic residues and soil, that have been mixed, piled and moistened, with or without addition of fertilizer and lime, and generally allowed to undergo thermophilic decomposition until the original organic materials have been substantially altered or decomposed. Compost is sometimes called "artificial manure" or "synthetic manure."

Today's compost from municipal waste has a bad reputation because of contamination by heavy metals, plastic film and glass. Some compost may have other chemical residues such as defoliant in cotton burrs and herbicides in other plant materials. Implementing new standards is promising, but the quality of compost still faces serious contamination and hygienic problems because of the difficulties in source separation.

Manure and compost have recently been reported showing disease suppression effects. Most of the tests used immature composts and compared with unfertilized control, which makes comparison of soil fertility level unavailable. However, the information or soil nitrogen levels is needed because disease severity is affected by the N-level in the soil.

Stockwell, et al. (1994) tested 104 strains of actinomycetes isolated from different composts and found that no strains give significant control of pythium root rot or brown patch, and only five strains showed control of dollar spot. Highly saline composts enhance pythium and phytophthora diseases. Composts prepared from municipal sewage have a low carbon-to-nitrogen ratio and release large amount of N which may enhance fusarium wilt.

Quality compost should be high in organic matter content, free from heavy metal and chemical contamination, free of disease agents and low in silt and clay fraction. Since most of the composts are used as alternatives for fertilizers, the nutrient release of the compost should be evaluated before its use. Fast release of surplus N can cause turfgrass burn.

Prices of the organic materials are not the topic of this discussion. However, golf course and sports turf facilities are often targeted as big dollar markets by many companies. Some basic characteristics of organic materials are listed in Table 1 to help turf managers choose a suitable product.

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Curing Soil Compaction Means Knowing the Causes

By Phil Brown and Bert McCarty

Soil compaction is a potentially serious problem for turfgrass managers. The altered soil physical properties caused by compaction can adversely influence plant growth and irrigation management (O'Neil and Carrow, 1983).

Particularly troublesome areas of soil compaction have been sports fields, putting greens, areas adjacent to cart paths and other intensely trafficked areas (Swartz and Kardos, 1963).

Soil compaction is the pressing together of soil particles, resulting in a more dense soil mass with less pore space (Carrow and Petrovic, 1982). A number of physical changes to the soil may occur as a result of compaction including reduced aeration porosity, increased bulk density, increased soil strength and altered pore size distribution (O'Neil and Carrow, 1983). These physical changes can have detrimental effects on turfgrass growth such as decreased root growth, decreased shoot growth, reduced carbohydrate reserves and decline in overall quality (O'Neil and Carrow, 1983). Destruction of the soil structure also may occur (Murphy, Reike, and Erickson, 1993).

Areas such as putting greens and athletic fields are particularly susceptible to compaction because of near constant traffic. However foot traffic is not the only cause of compaction. Vehicular traffic can also contribute to this. Sports fields maintained by heavy machinery can be particularly susceptible to compaction.

Soil is particularly susceptible to compaction when it is wet, especially when heavily trafficked. Water acts as a lubricant in the soil, allowing the soil particles to move easier while they are pressing together (McCarty, 2001). As water surrounds the soil particles, they are able to press together due to the reduced friction created by the lubricating effect of the water. If heavy machinery is then allowed on the soil, the particles will move closer together and compaction will increase.

Measuring soil compaction

Bulk Density: Several methods of measuring soil compaction exist. The most common is bulk-density sampling. Bulk-density sampling involves taking core samples of a known volume of soil, drying it and using the bulk-density equation of:

$$BD^* = \frac{\text{Dry Weight of Soil Sample (grams)}}{\text{Volume of Soil Sample (cm}^3\text{)}}$$

***Bulk density is expressed as grams per cm^3 (g/cm^3).**

It is important to know what type of soil being sampled. Sandy soils may have a higher bulk density than clay soils, but may not necessarily be more compact. This is because of the relative weight of the soil fractions. Sand particles are heavier than clay particles so a sand-dominated soil will be heavier than a clay-dominated one (Table 1). Common bulk densities range from 1.2 to 1.6 g/cm^3.

Surface hardness: Surface hardness can also be used as a measure of compaction. Surface hardness in turf is most often determined using an instrument such as a Clegg Impact Soil Tester (CIST). The CIST is a weight dropped through a cylinder and upon impact with the ground, the peak deceleration of the weight is measured and displayed. The reading is expressed as a gmax. Typical gmax values for sports fields fall between 70 and 120.

Water infiltration: Water infiltration is another method of assessing compaction. Water infiltration measures the rate at which water can enter the soil. It is commonly determined using a double-ring infiltometer. Double-ring infiltrometers are two rings: a smaller diameter ring set inside a larger diameter ring.

The infiltrometer is forced into the ground, and both rings are filled with water. The time required for water to drop in the rings is measured and the infiltration rate determined. This is commonly expressed in centimeters or inches per hour.

Soil oil strength: Soil strength may also be used as a measure of compaction. Soil strength is measured using a penetrometer, which is a prong forced into the ground, providing readings of soil strength at certain depths. The more compact a soil the higher the soil strength, hence the higher the reading from the penetrometer.

Reducing soil compaction

There are several methods to reduce soil compactions, including soil profile modification, soil cultivation and control of traffic. Of these three methods, soil cultivation is the most common method used on existing turf installations.

Soil cultivation usually involves machinery, which alters the structure of the soil, especially the soil surface, without destroying the turf (Landry, 2003).

Soil cultivation can be split into several method including coring (hollow and solid tine, and drill), high-pressure water injection (or hydrojet), slicing, spiking, grooving, forking and subaerification (Carrow and Petrovic, 1992).

On putting greens, core cultivation is typically performed with Vertically Operating Hollow Tine (VOHT) units, which selectively remove soil cores from the turf (Murphy, Reike and Erickson, 1993). The primary objective of core cultivation is the alleviation of soil compaction (Murphy, Reike and Erickson, 1993), which is often concentrated in the upper 3 inches of soil (Carrow and Petrovic, 1992).

Cultivation with solid tines has gained popularity in recent years as it causes less turf surface disruption and has lower equipment and labor costs associated with soil core cleanup following cultivation (Murphy, Reike and Erickson, 1993).

Since soil is not removed, little soil compaction relief accompanies solid tine cultivation. Furthermore, this method is popular for short-term compaction relief with minimal disruption of the playing surface. To reduce soil compaction, bulk density must be reduced. This is performed in turf by removing cores following aerification. Since soil is not removed, a major criticism of solid-tine aerification is additional compaction at the bottom and sides of the cultivation zone (Murphy, Reike and Erickson, 1993).

Murphy, et al, (1993) compared hollow-tine and solid-tine cultivation on a Penneagle bentgrass putting green. Under wet soil conditions, hollow-tine cultivation yielded best turf quality. Cultivation, however, did not lower soil density compared to the control from 0 to 3 inches in depth. In addition, the effect of cultivation was dependent on the tine type.

TABLE 1

Soil textural class and their relative bulk densities (McCarty, 2001).

SOIL TEXTURAL CLASS	BULK DENSITY (G/CM3)	
Sands or Compacted Clay	1.4 - 1.8	more compacted
Loam	1.2 - 1.6	↓
Loose silt loams or clay	1.0 - 1.4	
Organic soils	0.2 - 1.0	less compacted

Hollow-tine cultivation produced 20 percent higher air porosity values compared to solid tine cultivation. In compacted soils, hollow-tine cultivation also increased porosity 30 percent more than solid tine cultivation over two years, and both cultivation techniques increased overall porosity compared to the control.

Solid-tine cultivation also provides only short-term benefits and requires repeated application (at least three times yearly) to be an effective tool in the management of soil compaction (Murphy et al, 1993). Furthermore, with repeat use, solid tines exhibit a great potential for the development of a cultivation (or hard) pan.

Weicko, et al (1993) compared hollow and solid tine cultivation techniques along with a number of other treatments. Both solid and hollow tine aerification cultivation decreased soil bulk density from 1.69 g/cm^3 in the top two inches of the untreated, compared to 1.58 and 1.59 g/cm^3 for the hollow and solid tines, respectively. They also noticed a pan layer began to form between 4 to 6 inches below the surfaces for both the hollow and solid-tine cultivations.

Deep-tine aerification operates in a similar way to both the hollow- and solid-tine devices. The difference is that the deep-tine aerifier penetrates to depths of 8 inches to 12 inches. Some deep-tine aerifiers will also heave the soil when they reach the lowest point, further breaking up the soil structure (Landry, 2003).

Of the other methods of alleviating soil

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compaction, soil slicing is popular. Slicing can be performed in several ways. Originally, blades with triangular teeth were used to create a non-continuous strip of sliced soil. More recently, a continuous type of slicing equipment, known as "verti-slicing," has been used where the blades are more rounded resulting in continuous furrows (Carrow and Petrovic, 1992). Both slicing techniques operate in a similar way to solid tine aerification, designed to break up the soil structure in the upper levels of the soil.

Hollow-tine cultivation produced 20 percent higher air porosity versus solid-tine cultivation.

For greens, this can be done by simply moving the pin regularly so play is not continuously focused on one area. Turf managers can do this by putting up rope fences or signs restricting the traffic use on the grass, especially when wet.

Another option is to alter or modify the soil (Carrow and Petrovic, 1992). Modifications can be performed using amendments such as sand, peat or chemical products that alter the soil. It is important to be careful when altering the soil as just one-eighth of an inch layer of an alternate texture soil on top of the existing soil can cause drainage problems and lead to further compaction problems. Although effective, soil modification is usually expensive and time consuming.

Research

Three studies were established at Clemson University in 2002 to investigate the most efficient and effective means of relieving soil compaction in a heavy soil. Studies were conducted on a heavily trafficked band practice field with a Cecil sandy clay loam soil. Treatments are being assessed by bulk-density analysis, infiltration, surface hardness (using a Clegg impact soil tester) and visual turfgrass quality.

The first study is designed to compare the effectiveness of deep- and shallow-tine aerification and incorporating or removing the plugs extracted by the aerifier. Two tine lengths are being used: 3-inch or shallow tines, and 7-inch or deep tines. Cores extracted from the aerification are either removed or incorporated back into the plot using a brush.

Study two compares the effectiveness of hollow-tine and solid-tine aerification with the addition of topdressing. Both the hollow tine and solid tine used are 3 inches in length. The effectiveness of two different topdressing materials are being compared: sand and a peanut-based biosolid provided by Naturize.

Study three is comparing effectiveness of solid and hollow tine aerification. Both the hollow tine and solid tine used are 3 inches in length.

All studies were being conducted through the end of last year, and results are being compiled. The goal of the studies is to determine the most effective means of relieving soil compaction with minimal disruption to the playing surface and minimum labor costs.

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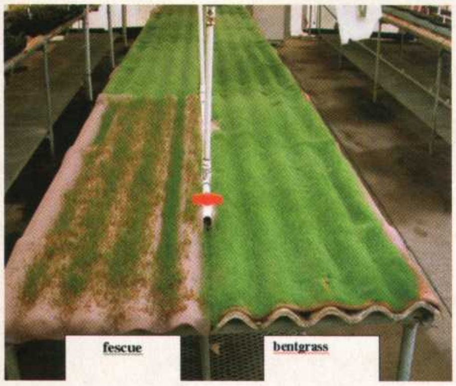
Thin Foam Sheets Can Speed Turf Germination

By Gregory E. Welbaum and Erik Ervin

In recent years, several products have been developed to establish turf in soil-less media such as straw mats or polymers. Seed mats also help reduce weed problems and provide faster, more uniform establishment.

Our research program is investigating the use of thin sheets of low-density polyurethane foam for turfgrass establishment. This material is inexpensive, well aerated and can be easily cut or rolled to rapidly establish turf on bare spots or disturbed areas. The foam also degrades and does not persist in the environment.

Companies such as PDC Marketing, CP Medius, International Horticultural Technologies and Grow-Tech sell foam-based media products commercially. However, most of the existing foam-based products are block shaped for plug trays and intended for bedding plant production and not turf. CP Medius has supplied us with polyurethane sheets in different sizes and thicknesses to develop the turf foam sheet concept.



These are the greenhouse mistbeds used to grow turf foam sheets.

Attempts to incorporate grass seed near the surface of the foam sheets during the manufacturing process have not met expectations. Seeds are exposed to temperatures as high as 300 degrees Fahrenheit when the foam is poured, which negatively affects seed quality. It is likely that modifications to the manufacturing process can overcome this problem so that seeds will eventually be incorporated into the foam.

However, while this problem is being solved, we established the turf by hand-sowing seed on top of the foam sheets on a mistbed to obtain rapid and uniform germination in a greenhouse. The mistbed was raised and the foam sheets rested on fiberglass panels. The roots could not penetrate the fiberglass and formed a mat underneath the foam in just a few days. The curves in the fiberglass panels provided drainage.

In these greenhouse experiments, seeds of Viper creeping bentgrass, Tiger colonial bentgrass, Bingo tall fescue and Longfellow Chewings fescue from Cebeco International Seeds, were uniformly seeded on top of either one or two 68-inch by 23-inch foam sheets that were .25 inch thick.

The mistbed was programmed to deliver 10 seconds of mist every 8 minutes. With this system, the seeds were left uncovered and not mulched because the mist kept the seeds sufficiently hydrated to ensure rapid germination. The test was designed to determine whether rapid early-season establishment could be obtained with bentgrass foam sheets on a putting green collar, and fescue foam sheets on a bare-soil bank with an 8 percent slope. The seeds were planted in mid-March for early-season establishment. Greenhouse temperatures ranged from 17 degrees Celsius to 27 degrees Celsius.

The test was designed to determine whether rapid early-season establishment could be obtained with bentgrass foam sheets on a putting green collar and fescue foam sheets on a bare-soil bank with an 8 percent slope.

The bentgrass seeds germinated first producing green sheets after just seven days. The rapid establishment of bentgrass may have been the result of the small seed size of the seeds, which made intimate contact with the pores in the foam. The fescue seeds germinated more slowly, and initial root growth into the foam was delayed slightly because of the larger seed size. However, 12 days after germination, fescue roots had grown through both the single and double thicknesses of foam. Bentgrass roots were slower to perforate the foam sheets and even after one month had less root development beneath the foam compared to fescue.

The polyurethane foam sheets are inert and have no cation exchange capacity. We anticipated nutrient deficiency symptoms because of this, but none were obvious during the first 12 days of growth. To help maintain rapid growth and to aid establishment after transplanting, turf sheets were fertilized with water-soluble 24-12-24 to deliver .25 pounds of nitrogen per 1,000 square feet at 12 days after planting.

Here is the bentgrass growing on polyurethane sheets seven days after seeding in a greenhouse.

Bentgrass was susceptible to dollar spot, which first appeared 12 days after seeding. Fescue did not show any disease symptoms in the greenhouse. After 14 days, constant sprinkler irrigation was discontinued to harden plants with irrigation consisting of only one light hand-watering per day.

Sixteen days after planting, the sheets were rolled, transported and placed on bare soil at the Virginia Tech Turfgrass Research Center in Blacksburg, Va. The wet turf sheets were fairly heavy and would tear apart if pulled or lifted at the corners. The fescue sheets were planted on bare soil on a sloping bank and secured with stakes at the corners. The bentgrass sheets were spread across the collar of a newly seeded bentgrass research green.

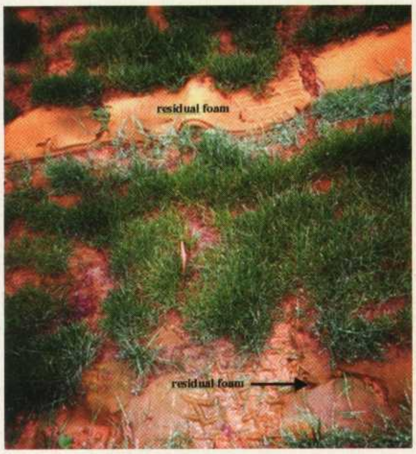
The foam was better suited for fescue root growth than for bentgrass.

After placement in the field, the sheets were sprinkler irrigated for five minutes every hour during daylight hours. Wet foam sheets were very stable and did not move in the wind, but as the sheets dried, the corners in particular were susceptible to blowing in the wind.

There were no obvious wilting or visual symptoms of stress the first two days after field planting under cloudy conditions when the daytime high temperatures were below 68 degrees Fahrenheit. However, full sun, air temperatures of 80 degrees Fahrenheit and windy conditions on April 6 resulted in some desiccation to the fescue and severe desiccation to the bentgrass. Despite multiple short sprinkler irrigation cycles, inadequate moisture retention by the foam media under high evapotranspiration conditions killed some plants.

Analysis of plot photographs taken 2 months after field planting revealed that approximately 75 percent of the fescue turf had survived compared to less than 20 percent for bentgrass. Apparently, greater root proliferation by the fescue through the foam sheets allowed soil water uptake that sustained plants as the foam media dried.

There were no differences in the survival percentages of turf grown on double vs. single foam sheets. These results showed that water retention of the foam sheets was a limiting factor in successful establishment. More frequent irrigation could have been employed since the foam is porous and extremely well drained. However, frequent irrigation uses more water, electricity and may lead to disease problems such as pythium, dollar spot and brown patch.



The fescue sheet looked like this a month after field planting. The top plot was grown on two thicknesses of foam while the bottom was on a single sheet. The foam became brittle and cracked easily several weeks after field planting.

Apparently, the foam was better suited for fescue root growth than for bentgrass. Pore size can be modified during manufacturing to alter foam characteristics, but larger pores mean even less water retention. When designing foam media, the challenge appears to be selecting the optimum pore size to favor both root growth and moisture retention.

The foam sheets photodegraded within two months after field planting and crumbled when stepped on or handled, so the turf could be mowed later in the season without interference.

Foam sheets that were .5-inch thick (twice the thickness of the original sheets) were planted with Bingo fescue in mid-October for a fall trial started on a greenhouse mistbed as described above. However, in this trial half the foam sheets were laid on Sunshine mix potting soil rather than fiberglass benches.

After two weeks, the fescue roots had grown

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through the foam and into the potting soil below. Sheets were transferred to the field on Nov. 11, with potting mix adhering to roots or coiled beneath the sheets that were grown on fiberglass panels. Two days after field planting, the turf was exposed to high winds and subfreezing temperatures.

After two weeks, only the sheets grown on potting mix remained green and healthy. Using potting soil to sustain root growth below the turf sheets resulted in healthier root development and decreased transplant shock in the field because of uneven soil-root contact.

When planted on a slope, the fescue sheets were holding up well one month after planting.

Turf foam sheets are currently not available commercially. However, it appears that with additional research this technology could have commercial application because turf foam sheets could be rapidly established in a greenhouse and used to repair disturbed areas if properly irrigated. Such a greenhouse production system would be rather expensive but may be used for high-end applications like rapid establishment and slope stabilization on bunker faces or repair of athletic fields.

However, a much broader application would be to integrate seeds directly into the foam with sufficient moisture-holding capacity so the sheets could be established outdoors with minimal irrigation. This would allow a foam-based product to be used for erosion control and rapid covering of disturbed sites in areas where irrigation is not available.

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Dealing With Dreaded Dollar Spot

Where is the industry going in fighting this ever-present fungal disease?

BY PAUL VINCELLI

If you were to ask superintendents to list the problems they would most like to see go away, you can bet that dollar spot would be near the top. Although a number of diseases plague turf across the country, dollar spot remains the most troublesome and persistent nationwide.

As long as there has been turfgrass management, dollar spot has been a problem. Yet even today, more fungicides are used each year to prevent or treat dollar spot problems than for any other turf disease. Unfortunately, when you look at what promotes dollar spot, the answers usually involve the cultural, biological and chemical trends that make up current turfgrass management practices.

Cultural influences

As the popularity of golf has grown, mowing heights have gone down to accommodate players' demands. The closer you mow, the more manicured the appearance of the turf and the faster the putting surface. The tighter the fairway, the easier it is to play. But there are downsides to this practice.

Lower mowing heights increase the stress on any turfgrass and the susceptibility to numerous diseases. So while changing standards improve course conditions, they also increase the potential for disease — especially dollar spot.

The same is true for other trends for putting-green management, such as maintaining low soil moistures and minimal nitrogen content during the summer. Lower nitrogen content slows turf growth rates, which helps keep the playing conditions more consistent throughout the day. Importantly, it also helps reduce the potential for diseases like pythium cottony blight and brown patch. But lower nitrogen fertility also makes the turf more susceptible to dollar spot.

Reduced irrigation frequency and lower soil moisture have the same effect. These factors manage *Poa annua* infestation, but turf growing in soil with low moisture is more prone to dollar spot. In many ways, it's a trade off each superintendent needs to consider.

Dollar spot remains one of the most troublesome and persistent disease problems nationwide, despite new chemistries developed to fight it.