Aeration and soil compaction in turf

The effects of traffic and compaction in turf are usually easy to see—thin turf, worn paths, areas of bare ground that do not respond to applications of fertilizer or water. Turfgrass growing in compacted areas has shallow rooting, causing greater susceptibility to drought and other stress. The soils in compacted areas have low air porosity and reduced infiltration. Such compaction is most likely to occur in fine-textured soils (those with a higher clay content), but over time all soils are susceptible to compaction.

Turf managers know that one key to correcting soil compaction in turf is aeration, also known as aerification. Aerification is performed using a wide range of equipment which drills, slices, spikes, punches or water-injects the turf and its underlying soil to various depths. Sometimes the equipment removes a plug of turf, and sometimes it only cuts a slit or punches a hole. With some equipment there is the additional benefit of a small amount of thatch control, as the slicing or core removal also removes some thatch. Regardless of the exact piece of equipment used, almost every turf manager has a piece of aerification equipment in their shed.

Factors affecting the effectiveness of aerification include soil wetness, tine size, depth of aerification, soil texture, aerification frequency, and equipment type. Turf aerification research is somewhat difficult to do. Studying soil compaction requires large plots, uniform areas of compacted (and noncompacted) turf, and possibly many different pieces of equipment. Additionally, collecting the data required to show treatment differences requires intensive sampling and a lot of labor. Typical data collected from compaction studies may include soil bulk density, soil penetrometer resistance, surface hardness, water infiltration, shoot density, and root length or weight. The objectives of this article is to provide explanations of the type of data collected in turf compaction experiments, and to discuss some past and current turfgrass compaction research.

RESEARCH

Our previous work at Auburn University found that aerification was less likely to have an effect in noncompacted soils as compared compacted. We looked at the effects of using a deep, hollow tine aerifier (8 inch deep, 3/4 inch diameter) at two locations: a heavily trafficked and compacted marching band practice field, and a lightly trafficked field at the Auburn University Turfgrass Research Unit.

At the heavily trafficked site, every additional core aerification in a given year decreased soil resistance. This was not the case at the lightly compacted site. Only one aerification was needed in a given year to produce a significant reduction in soil resistance. At the heavily trafficked site, the effects of deep-tine aerification usually lasted about 3 weeks. This supports the conclusions of previous workers that frequent aerification might be needed on compacted sites.

However we did not evaluate the effects of different equipment (e.g., tine depth, solid vs. hollow tine) on compaction in trafficked turf. We also wondered if continuous aerification would allow a compacted layer of soil to form at the bottom of the tine working depth. These "aerification pans" can form over time from the effect of tines pressing down on the soil below the level where they actually penetrate and remove soil.

This research looked used three different pieces of equipment (a pull-behind aerifier, a GA-60 standard tine aerifier and a Soil Reliever deep tine aerifier) using both solid and hollow tines. Plots were aerified four times per year and traffic was artificially applied with a heavy roller to induce compaction. Compaction was evaluated by measuring soil resistance to a soil penetrometer at depths down to 12 inches.

The equipment used has a large effect on the amount of compaction relief and where it occurs. The deep tine aerifier (8 inches deep) reduced soil resistance when either solid or hollow tines (5/8-inch diameter) were used. The standard tine aerifier (4 inches deep) often produced a significant reduction in resistance when hollow tines (5/8-inch diameter) were used.

The effect of the different sizes of aerification equipment on the relief of compaction as measured by soil resistance was studied. The deep tine aerifier reduced soil resistance from 3.5 inches down to 7.6 inches, but did not reduce compaction in the top 3 ½ inches. The standard tine unit did reduce resistance significantly in the top 3 inches, but had no effect deeper in the soil.

The long-term effects of continued aerification with a standard tine unit fitted with solid tines (5/8-inch diameter) for 3 years in a row, at a depth of 2.3-5 inches, showed that there was significantly more resistance than in unaerified plots. This indicates that a layer of compacter soil (known as a "pan" or "aerification pan") had developed near the bottom of the tine stroke. This illustrates the need for periodic deep tine aerification to avoid this problem. The pan of compacted soil was less severe when hollow tines were used, but still could build up over time.

When the surface hardness of the turf was measured using a Clegg hammer, all forms of aerification produced a softer surface at least for one week after treatment. The standard tine aerifier with hollow tines tended to produce the softest surface.

CONCLUSIONS

- Compaction of turfgrass soils lowers the percent macropores in the soil; a decrease in macropores limits soil aeration, which hurts root growth.
- Core aerification, especially solid tine, may not help eliminate thatch.
- Effects of aerification in heavily trafficked soils may be short-lived (about 1 month).
- Diagnostic techniques for detecting compacted soils, such as infiltration measurements or soil penetrometer readings, are widely variable, even across supposedly uniform surfaces such as a putting green.
- Compacted "pans" develop over time at the bottom of the tine's penetration into the soil, especially when using solid tine equipment.
- Deep tine equipment is more effective at reducing soil compaction at depths below 2.5 inches. ■

Beth Guertal is a professor of agronomy & soils at Auburn University; Dave Han is an associate professor of agronomy & soils at Auburn University.

Things we measure in turfgrass compaction experiments

SOIL BULK DENSITY

Bulk density is defined as the mass of a unit volume of dry soil. To collect a bulk density reading a sample of known depth and diameter (typically 6 inches deep and 3 inches in diameter) is removed from the soil. The soil sample is dried and weighed and the bulk density is expressed as the mass per volume (grams per cubic centimeter). As the soil is compacted the bulk density increases, because more soil particles are forced into a smaller volume and soil pore space is reduced. Sandy soils typically have a higher bulk density than soils high in clay or loam, because sandy soils have few of the very small pores associated with fine-textured soils that have clay and organic matter. Additionally, sandy soils that contain sand in a range of sizes (as is a typically sand-based putting green) are already tightly packed, as smaller sand grains fit in between larger.

Typical bulk densities for clay and silt loam soils may range from 1.0 to 1.5 g/cm3, while the bulk density of sand-based soils may range from 1.3 to 1.8 g/cm3. At the upper end of these ranges the bulk density is great enough that root penetration may be inhibited. As comparison, the USGA recommendation for bulk density of putting green rootzone mix is 1.2 to 1.6 g/cm2. It's important to note that bulk density is highly variable from location to location. One sample will usually not be an indicator of the bulk density of an entire field or turf area.

SOIL PENETROMETER READINGS

A soil penetrometer is a device used to measure the compaction of the soil. What is actually measured is the resistance, or amount of pressure needed to push a tipped rod through the soil. The rod tip is equipped with a load-sensing cell, and the soil strength is recorded as the tip is pushed down through the soil. Soil penetrometers used for research are very sensitive, and require some practice to use correctly to obtain accurate measurements. They are also very expensive, about $6,000.

HYDRAULIC CONDUCTIVITY

Hydraulic conductivity is the ease with which soil transmits water. In turfgrass what we often measure is the saturated hydraulic conductivity, which occurs when all soil pores are filled with water.

Saturated hydraulic conductivity is typically measured using a double ring infiltrometer, which consists of two metal rings (one around 12 inches in diameter and the other around 18 inches), with the smaller placed inside the larger. Water is added to both rings until a height of water is maintained for a period of time, which indicates that the underlying soil has become saturated. The drop in the height of water inside the smaller ring during a given period of time is used to calculate the saturated hydraulic conductivity, which is reported in units such as inches per hour.

Small-diameter (6 inches) infiltrometers can be purchased from many turf supply catalogs. The intended use of these units is to provide turf managers the ability to measure infiltration rates of their turf soils quickly and directly in the field. Because research has shown that double-ring infiltrometers with an inside ring diameter of at least 12 inches produce the most accurate measurements of water infiltration, the accuracy of 6 inch diameter rings is a concern. A 1991 research study by D.H. Taylor compared single and double-ring infiltrometers with inner-ring diameters of 6, 8 and 12 inches on a variety of turf areas, from golf greens to football fields. They found that infiltration rates varied widely within each sampled turf area, even when the largest diameter rings were used. The conclusion from their work was that infiltration rates measured with ponded water should be used only as a rough estimate, and results should be used with caution.

CLEGG IMPACT READINGS

Typically used to measure the hardness of a turf surface, the Clegg hammer calculates the hardness of a surface based on its reaction to a weight dropped on the surface from a consistent height.

A diagnostic tool for discovering differences in surface hardness due to aerification treatments, work has also started on calibrating Clegg hammer readings to field hardness or softness. For example, a survey of 24 high school athletic fields had Clegg values that ranged from 33 to 167 Gmax. For comparison, a tiled concrete basement floor had a Gmax reading of 1280, which was reduced to 260 when the floor was covered with a carpet pad. In another study, compacted Kentucky bluegrass plots had a value of 206 Gmax, while plots that were not compacted had a value of 93. A survey of college and professional soccer players compared their perceptions of soccer fields that had been used to collect Clegg data. Typically, fields with a hardness reading between 90 and 120 Gmax could not be differentiated by players.

New fertilizer laws call for enhanced efficiency

Editor's note: *This article was submitted by Agrium Advanced Technologies; it discusses how a complex web of legislation is affecting residential and commercial fertilizer applications across the US.*

ONE OF THE MOST SENSITIVE ISSUES facing the turfgrass industry today is the movement to limit the use of fertilizers—or in extreme cases, to ban them altogether.

Led by environmental activists at a number of levels, there is growing concern about environmental contamination from fertilizers in both residential and commercial settings. As a result, many states are moving to enact legislation which would restrict or prohibit fertilizer applications.

In April 2011, the state of Maryland passed new laws that affect numerous aspects of turf and ornamental fertilization, including product usage, ingredients, labeling and more.

This year, the New Jersey legislature ratified a bill which is being called the toughest fertilizer law ever. This law is being hailed by some proponents as a landmark, and is being closely observed by activists in nearby states who want to push for similar legislation.

In Florida, there is intense disagreement about who has the legal authority to impose fertilizer bans or restrictions. Dozens of individual counties and municipalities across the state have already crafted their own laws to determine how, when and where fertilizers may be used.

"LOGISTICAL NIGHTMARE"

"The debate is generating a lot of emotion on both sides of the argument," said Sarah Fox, Sustainability Initiatives specialist, Agrium Advanced Technologies (AAT). "Aside from personal feelings, having different laws from county to county in any state would be a financial and logistical nightmare."

On the other hand, many people around Florida believe that broad-based statewide laws cannot properly address their unique local concerns and specific regional challenges. In fact, some counties are pushing to get "emergency" anti-fertilizer laws onto their books before the state rules take effect.

"It's all very complicated, and I don't see it getting any less complicated in the near future," said Alan Blaylock, agronomy manager, AAT. "Policy makers are reacting to the fears of their constituents and interest groups with what seems like a logical solution. But part of the problem is these responses are often made without an understanding of the science of nutrient management and its consequences."

WHAT'S BEHIND THE LEGISLATION?

Why are so many lawmakers suddenly jumping on the anti-fertilizer bandwagon? The crux of the issue is fertilizer runoff, which can often be traced to improper application, especially of traditional, quick-release products.

Unused plant nutrients may migrate through the soil for several reasons. Once that happens, they are considered pollutants. Water and gravity naturally deposit those escaped fertilizer elements in nearby ponds, lakes and streams, contributing to a problem known as eutrophication. Eutrophication occurs when excess nitrogen and phosphorus get into the water. They nourish the aquatic plants and other organisms there, especially algae.

"When people see algal blooms in their neighborhood pond or local body of water, they call their homeowners' association and want something done to clean it up," said

Blaylock. "That gets various agencies and interest groups involved, and it can become a political battleground. Of course, everyone wants clean water, but these problems can be prevented with proper fertilizer use."

IDENTIFYING THE CAUSES

Many people feel that a rise in eutrophication and algal blooms can be attributed to a cumulative effect of both "point" and "non-point" polluting sources. A point source refers to a single polluter, such as a factory or a mine. Non-point sources are widespread and individually unidentifiable.

In the case of fertilizer misuse and runoff, there may literally be millions of non-point contributors. Fingers are specifically being pointed at the improper use of fertilizers by homeowners and other non-professional applicators.

State and local laws regulating fertilizer usage are evidence of concern about the potential for fertilizer misuse among non-professionals, and many of the new restrictions are based on common-sense considerations. For example, some laws prohibit fertilizers from being applied on frozen ground or near pavement, or right before heavy rain. Other laws require a fertilizer-free buffer zone between landscapes and water sources, such as streams or canals. Some states have "black out" periods when fertilizers cannot be applied at all.

"The legislative efforts are usually focused on homeowners and lawn care operators," said Fox. "Some homeowners don't realize the impact their fertilizer application could have on surrounding water bodies. They apply a bag of fertilizer without really thinking about it, and many believe that if some fertilizer is good, then more is even better."

Many industry professionals are exempt from certain fertilizer laws in their respective states. Legislation often makes exceptions for golf courses, sports/municipal facilities, agricultural uses and qualified landscape situations, frequently with a stipulation that the users have been trained and certified in proper fertilizer handling and application.

"They (the activists and legislators) understand that golf course superintendents, sports turf managers and lawn care professionals have a science-based knowledge of fertilizer," added Fox. "They know that skilled experts in turfgrass and commercial landscape maintenance are conscientious stewards of the environment."

ENHANCED-EFFICIENCY FERTILIZERS

The dangers and repercussions of fertilizer misuse exist on different levels, some of which cannot be fixed with rules. For one thing, many of the laws are essentially unenforceable. If a homeowner is going to over-apply fertilizer, either intentionally or accidentally, what can be done to prevent it?

"That's definitely part of the problem," said Fox. "Local municipalities don't necessarily have the resources to actively police the laws. That's why manufacturers, blenders, retailers and university Extension services realize it's up to the industry to get people to comply."

One tremendous step forward is the increased recognition of enhanced-efficiency fertilizers (EEFs) as useful tools, particularly slow-release or controlled-release products. The Association of American Plant Food Control Officials (AAPFCO) defines EEFs as fertilizers that increase nutrient availability/uptake and decrease losses to the environment, when compared to appropriate traditional fertilizers.

EEFs encapsulate granular nitrogen and other nutrients within special polymer coatings. When applied to turfgrass, the coated granules release nutrients gradually and evenly over an extended period.

Meanwhile, traditional soluble fertilizers dissolve into the soil quickly. When plants can't readily absorb those nutrients, the potential increases for them to be lost from the soil (and sometimes into surface and groundwater).

"Nitrogen in the soil is very mobile, which is important for plants to be able to rapidly take up what they need," explained Blaylock. "Healthy roots are aggressive feeders. Actively growing turfgrass consumes nutrients quickly, so the trick is to synch the nutrient supply to the plant demand.

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That's what slow- and controlled-release fertilizers do. When you feed grass steadily and constantly—as the roots need it—the fertilizer doesn't have a chance to get lost."

By gradually delivering nitrogen and other nutrients to correspond to plants' uptake, slow- and controlled-release fertilizers can virtually eliminate nutrient loss. Steady feeding minimizes surge growth and reduces the number of fertilizer applications needed during a season.

The advantages and benefits of EEFs are becoming an important part of the new legislative trends. As industry experts, scientists, stakeholders and policy makers look for ways to alleviate nitrogen runoff, EEFs are tested alternatives that can be a significant part of the solution.

BEST MANAGEMENT PRACTICES

Fertilizer advocates and industry leaders have adopted the "4R Nutrient Stewardship," a science-based approach to best management practices. The 4R system calls for the Right Product to be applied at the Right Rate, Right Time and Right Place. When those criteria are met, plants should thrive and fertilizer should stay where it's intended to be.

"Proper use of plant nutrients can actually improve water quality, while banning them could have the opposite effect," said Blaylock. "Properly fertilized plants are healthier, so they're better able to utilize the nutrients in the soil and protect the soil from degradation. Unhealthy plants have poor root systems and stimulate less biological activity in the soil. They don't use nutrients efficiently, which leads to greater probability of nutrient and soil loss."

"People are accepting the idea of EEFs, and we continue to learn how to better use these tools," Blaylock said. "The advances in technology are amazing in terms of what we can do to control fertilizer release and minimize pollution," added Fox. "It's exciting to realize we have the knowledge and abilities to do this right." ■

Rob Stevenson is a writer for Canyon Communications, Mesa, AZ. Reprinted with permission from the Turfgrass Producers International's Turf News.