Surface organic matter in bermudagrass greens: A primary stress?

Excessive organic matter can deprive bermudagrass greens of oxygen and nutrients.

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In the preceding article, "Surface organic matter in creeping bentgrass greens," I discuss primary and secondary problems associated with organic matter dynamics in the surface soil zone (0-2 inches [5.1 centimeters]) of creeping bentgrass putting greens and research on managing these stresses (1). Many of the creeping bentgrass and bermudagrass cultivars used on putting greens have a strong tendency to accumulate organic matter within the surface zone (1,3,6). The preceding article also presents an overview of past and current research related to the influence of organic matter content on soil physical properties of putting greens constructed with a high-sand-content root zone (hereafter referred to as "high-sand greens").

Hypothesis

The hypothesis I present here is that adverse soil physical conditions triggered by excessive organic matter accumulation in ultradwarf bermudagrass greens are usually the primary stresses that lead to many of the problems observed on these greens. Examples of these problems are root-rot organisms (for example, *Gaeumannomyces* species, which cause bermudagrass decline) (Figure 1); *Curvularia* species; root rot; limited rooting depth and associated irrigation and fertilization challenges, etc.

The distinction between *primary stresses* and *secondary stresses* or symptoms is very important for the development of successful management protocols. A primary stress is a condition that causes direct physiological or pest stress on a plant, but it also creates conditions favorable for the occurrence of other secondary stresses. Symptoms or secondary stresses are often the problems that are seen by superintendents and golfers. In turfgrass management, secondary stresses must be dealt with when they occur, but to prevent frequent reoccurrence, the long-term maintenance goal should be elimination of the primary stresses or underlying causes.

Other scientists or superintendents may not agree about which stresses are primary and which are secondary for bermudagrass greens, but I hope to stimulate dialogue and research directed to these issues. The most constructive dialogue takes place when an alternative hypothesis is presented that explains the observed responses.

Organic matter dynamics

The first problem

In the preceding article, I noted two types of organic matter problems on creeping bentgrass greens (1,5). One problem occurred when direct high-temperature stress caused rapid deterioration of creeping bentgrass surface roots and changed the nature of the organic matter from live roots with a structure to gelatinous dead tissue. When live roots are present, higher organic matter content may be present without causing adverse soil physical responses, such as low aeration or low water infiltration. After the roots have died over a period of a few days, the gelatinous dead tissues can rapidly seal the surface.

Because bermudagrasses have superior high-temperature tolerance, high temperatures would not be expected to kill bermudagrass roots. However, the cool-season grass used in overseeding bermudagrass greens could suffer this injury in late spring. In that situation, the bermudagrass green would exhibit low infiltration and a soggy surface for a period of time until the microorganisms break down the fresh organic matter. During this period of low oxygen, some bermudagrass root damage could occur. Salt or other stresses could also cause rapid death of overseeded grasses on occasion and induce temporary low-oxygen levels.

The second problem

The second organic matter problem, excessive accumulation of organic matter, is more likely to be serious on bermudagrass greens and sometimes fairways and tees. For all grass species, organic matter levels greater than 4-5% (by weight) favor adverse soil physical responses. At these levels, the number of larger macropores (aeration porosity, drainage porosity) rapidly starts to decline, and moisture retention increases at the expense of aeration within the 0-2-inch surface zone (1,5). With fewer macropores, water infiltration and oxygen diffusion decline across the zone. Thus, common themes are associated with excessive organic matter in the surface zone of both creeping bentgrass and bermudagrass greens with high sand content(1,5):

- excess moisture retention
- low aeration (oxygen) within the zone
- reduced water infiltration
- decreased gas exchange across the zone unless cultivation creates temporary macropore channels for water/air flow

KEY points

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Excessive organic matter accumulation is a primary stress on bermudagrass greens that can lead to secondary stresses.

Secondary stresses include: excessive moisture retention, low oxygen levels, reduced water infiltration and decreased gas exchange.

Aggressive topdressing along with hollow-tine aeration helps prevent organic matter buildup.

Managing the primary stress can reduce secondary stresses.

Primary stresses

I propose that organic matter accumulation and associated adverse soil physical responses are the primary stresses on ultradwarf bermudagrasses, because in most instances they occur before other commonly reported stresses are observed. As with creeping bentgrass, subsurface layers of fines, surface compaction or a push-up green with too many fines can create the same high-moisture and low-oxygen conditions caused by excessive organic matter. However, on high-sand green mixes, these conditions are most often caused by too much organic matter. Push-up bermudagrass greens frequently contain more clay and silt than high-sand greens, but vigorous topdressing often creates a sand cap, which can exhibit surface organic matter accumulation just as a high-sand green does.

Figure 1. Thinning associated with bermudagrass decline of *Cynodon* species turf (Reprinted from *Compendium of Turfgrass Diseases,* 2nd ed., APS Press, 1992).

Conditions favoring organic matter

On bermudagrass greens, organic matter accumulation seems to be associated with one or more of the conditions discussed below.

Grass type

Ultradwarf bermudagrass cultivars have a tendency to accumulate organic matter within the surface zone (Figure 2). The dense surface and very close mowing heights used on these grasses also make incorporation of topdressing difficult. Seashore paspalum on greens is less prone to developing excessive surface organic matter than the ultradwarf bermudagrasses if it is maintained according to paspalum requirements and not as a bermudagrass (2). For seashore paspalum, reducing nitrogen rates and irrigating on a deeper and less frequent basis are effective in preventing excessive organic matter.

Anaerobic conditions

Whenever oxygen within the 0-2-inch (0-5.1-centimeter) zone is limited enough to create anaerobic conditions, decomposition of organic matter greatly declines because microbial activity slows. Thus, when organic matter accumulation is sufficient to limit aeration within this zone, reduced microbial activity will probably cause even more accumulation. Prolonged wet weather or daily irrigation is especially conducive to enhancing organic matter buildup because the moist conditions maintain a consistently anaerobic status.

On a high-sand green, soil oxygen may be adequate for deeper roots below the zone if cultivation operations have created sufficient macropores to allow oxygen diffusion across the surface zone. However, within the surface zone, conditions are more anaerobic. Anaerobic conditions at the surface often stimulate grasses to produce adventitious or surface roots, which add to the surface organic matter biomass. Poor internal drainage deeper within the soil profile would cause a waterlogged condition at the surface and foster organic matter accumulation during wet weather.

Acidic conditions

An acidic condition in the first inch (2.5 centimeters) of the soil surface can occur on acid sands in humid regions, when acidic nitrogen fertilizers are used or when routine water acidification is practiced. When soil is sampled at 3 to 4 inches (7.6-10.2 centimeters), low pH at the surface may not be apparent. Soil pH below 5.5 greatly restricts the growth of bacterial populations that are important in decomposing more-resistant organic matter.

Poor air drainage or humid weather

When the surface zone does not rapidly dry after irrigation or rain, longer periods of anaerobic conditions are favored (Figure 3).

Secondary problems or symptoms

Diverse secondary problems or symptoms arise in response to the adverse soil physical conditions created by excessive organic matter, and several can occur at one time. Often a green fails because of multiple primary and secondary problems rather than a single cause. Common secondary problems include the following (3,6).

Limited rooting depth

A tendency for reduced rooting depth within one to two years after establishment has been commonly observed on bermudagrass greens with high sand content, even though bermudagrasses have the genetic capability to be deep rooted. Limited root depth may be a result of one or more factors.

Organic matter can limit oxygen diffusion across the surface zone into the deeper root media, especially in wet weather. Roots require oxygen 24 hours a day, and oxygen demand by the plant and microorganisms can be high in summer. Without adequate oxygen, root growth rate declines, and under severe oxygen stress, roots may die back. Creating temporary macropores by cultivation operations across this zone can help maintain better oxygen diffusion. Integrating sufficient topdressing sand into the zone can enhance water and air flow.

Limited oxygen within the zone stresses roots and may cause root pruning. This obviously influences deeper roots.

Figure 2. Ultradwarf bermudagrass greens show evidence of excessive organic matter in the top 2 inches of soil two years after establishment.

Prolonged cloudy weather and close mowing may contribute to root decline by providing less favorable conditions for producing the plant carbohydrates (food) necessary to maintain current roots or generate new ones (3).

Root and crown tissue injury

All living tissues within the surface 2 inches (5.1 centimeters) must have adequate oxygen to maintain viability. Prolonged exposure to low oxygen can cause root and lower crown injury, making these tissues less viable and more susceptible to root pathogens and drought stress if they occur. Thus, lack of oxygen and not just root-rot organisms may cause root rot or lower crown rot.

Inhibition of nutrient and water uptake

The combination of restricted rooting depth and injury to root or crown tissue inhibits nutrient and water uptake. When exposed to low-oxygen conditions, even relatively healthy roots are less efficient at nutrient and water uptake. When roots become so limited that frequent irrigation becomes necessary, the surface zone then remains moist most of the time, which promotes low oxygen and limited rooting conditions. Although cation exchange capacity (CEC) tends to be adequate for nutrient retention within 2-4 centimoles/kilogram, most of the CEC resides within the surface 0-2 inches (0-5.1 centimeters) in the organic matter. When roots are shallow, fertilization is a challenge. During drier periods, frequent irrigation is required to avoid drought stress. With a limited root system and roots that may not be very healthy, spoon-feeding all nutrients is necessary.

Bermudagrass decline and root rot

Root rot associated with *Gaeumannomyces* species is probably the most recognized root-rot injury, but other causes may be anthracnose basal rot, *Helminthosporium* species and *Pythium* species. Prolonged periods of rainy weather will trigger root-rot activity. The combination of prolonged cloudy and wet weather is especially conducive to root rot development: Cloudy weather can place carbohydrate stress on roots while fostering a moist surface, which favors the disease organism and low-oxygen stress on the root and lower crown tissues (3). A high-sand surface condition would allow excess water to drain, the surface to dry, and oxygen within the surface to be adequate.

Photos courtesy of P. O'Brien and C. Hartwiger

The important issue is whether the superintendent approaches the problem believing the primary problem is a root pathogen or excessive organic matter that creates conditions conducive to root rot. When root-rot organisms are active, it is important to focus on treating the disease, but, in the longer term, controlling the organic matter may be the way to reduce the frequency of the problem and fungicide treatments.

In my experience, the organic matter zone is very effective in screening the fungicide from the organisms below the surface zone or in the lower region of the zone. Thus, superintendents may wish to consider a solid tine operation (¼ inch [6.4 millimeters] in diameter) or a HydroJect operation just before fungicide application to allow the fungicide to penetrate though the zone.

Other secondary problems

Other secondary problems include the following.

- Algae.
- Soft, soggy surfaces. If water infiltration declines too much, the surface may remain too soggy or waterlogged and prone to tracking from vehicles.
- Greater potential for intracellular freezing damage during wet periods of late winter and early spring may occur in the more northern areas of bermudagrass adaptation.
- Excessive drying, desiccation and extra-cellular freezing of tissues in the upper surface of the high-organic-matter zone may increase in regions with cold winters without snow cover.
- Light frequent irrigation with saline water can lead to salt accumulation in the organic matter zone and root stress.

Management

The primary reason for this article was to explain the adverse effects of excessive organic matter in the surface zone in the context of problems observed on bermudagrass greens. It is important for superintendents to determine whether a problem is a secondary problem or symptom, or whether it is the result of excessive organic matter in the surface.

Proper identification of the primary or underlying problems allows superintendents to focus on preventing future problems with less emphasis on crisis management. It is important to note, however, that environmental conditions alone may cause a disease that is usually associated with excessive organic matter, even though excessive organic matter is not present. In such a case, the disease would be considered a primary problem.

Should all organic matter be removed?

As previously noted, organic matter content of more than 4-5% (by weight) favors low aeration and low water infiltration. Does this mean that all organic matter should be removed from putting greens? No!

Along the Gulf coast from Florida to Louisiana, golf courses that exhibited very little organic matter accumulation still had 1.5% organic matter content in the 0-2 inch (0-5.1 centimeter) surface zone, and this organic matter was live turf. Living and dead organic matter are very difficult to separate, but a background level of 1.5% is reasonable. These courses also had very low (<1.0 centimoles/kilogram) CEC because little dead organic matter was present at CEC sites and essentially no clay was found. Thus, some organic matter enhances CEC status.

Thatch or mat?

Is the surface zone of high organic matter thatch or mat? *Thatch* is a zone of dead and living organic matter without appreciable sand integrated into it. Sometimes a thatch zone created during grow-in becomes buried and remains as a thatch layer problem. *Mat* is an organic zone that has considerable sand integrated within it, with sand as the dominant matrix.

From field observations, it appears that the quantity of sand topdressing sufficient to maintain a uniform, stable surface with good putting speed is often less than the quantity of topdressing required to create a true mat. The surface zone of many greens appears to be a "near mat," but with insufficient sand to negate the organic matter. When sand is not maintained as the primary matrix, the result is considerable sand floating in the organic matter. In that case, the organic matter, not the sand, controls the aeration and moisture status.

Management practices

Surface organic matter accumulation is managed by a combination of the following practices.

Dilution. Dilution of the surface organic matter through aggressive topdressing, especially in combination with hollow-tine aeration and venting operations, is the backbone of any successful program. A recent article (5) provides excellent options and guidelines that are appropriate for bermudagrass and creeping bentgrass greens. The suggested target range for annual topdressing on many sites, 40-50 cubic feet/1,000 square feet (121.9-152.4 cubic meters/hectare), is based on historical rates that were used until a few years ago when ultralight but more frequent applications became the norm and resulted in less total sand applied.

Using adequate hollow-tine core aeration operations and venting operations to maintain macropores across the surface organic matter zone at all times is important for ensuring oxygen diffusion across the zone to reach underlying roots. Developing and maintaining deeper roots allows less-frequent irrigation so that the surface zone has the opportunity to dry somewhat, which greatly improves oxygen status within the zone. If topdressing and cultivation operations are insufficient to control the surface organic matter zone quickly, the result will be shallow roots, which require light, frequent irrigation and frequent spoonfeeding. This situation fosters even more organic matter accumulation.

Photo courtesy of R.N. Carrow

Figure 3. Greens with poor air circulation and drainage often exhibit excessive organic matter in the surface layer. Excessive organic matter induces high moisture and lower oxygen content in the root zone, inhibiting microbial decomposition of the organic matter.

Surface pH levels. The surface pH should be higher than 5.5 to allow adequate bacterial populations for organic matter decomposition. One practice that has been recommended for bermudagrass decline has been the use of acidifying fertilizers. One response that occurs on soils with at least some clay is that at pH below 5.5, more soluble manganese is often observed. However, on sands with CEC from primarily organic matter, this is not the case. Adequate manganese is important for suppressing take-all patch (3,4). If the surface pH is below 5.5, the reason for a low pH should be determined. Water acidification can cause a low pH at the surface while also adding appreciable soluble sulfur. If anaerobic conditions start within or below the surface organic matter zone, the presence of soluble sulfur will greatly increase the chance for black layer (6).

Take-all. On sites with an existing organic matter problem and a history of take-all, it may be worthwhile to test not only foliar applications of manganese, but also some granular applications to achieve higher manganese levels within both the plant and organic zone.

Secondary stresses. If excessive organic matter stimulates a particular secondary stress, then practices to control the secondary stress will be of immediate concern.

Summary

In summary, the new ultradwarf bermudagrasses used on putting greens have a strong tendency to accumulate organic matter within the surface zone, and certain stresses are frequently observed on these grasses (decreased rooting over time, root-rot pathogens, others). The challenge for the superintendent is to identify the primary or underlying stresses and manage them aggressively.

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