Thoughts on the Black Layer

By Lee Berndt and Joe Vargas

A s with other poorly understood phe-
omena, a great deal of controversy ex-
ists regarding the black layer. Hypotheses have arisen suggesting that the occurrence of black layer and its turfgrass decline may be directly related to root-
fecting fungi, algae, excess water, improper construction, poor management, and sometimes poor management come into 
play by effecting conditions of soil anaerobi-
osis), a black layer was formed.

When these same soils did not receive sulfur applications, but were subjected to identical inoculations and water conditions, the black layer did not develop. Also, when a creeping bentgrass golf green composed of similar sand soils was subjected to ex-
tensive waterlogging, a black layer was formed.

Both layers were shown by inorganic spot analysis to be composed of reduced iron and sulfur compounds. Thus, it appears that the presence of sulfur (from whatever source), metals, anaerobiosis and soil bac-
teria are necessary for black layer formation.

As far as sulfur is concerned, there is usually a considerable input to most highly maintained turfgrass soils, even though most soil sulfur is considered to be tied up in organic matter. Sulfur may accumulate in soils through the application of elemental sulfur, fertilizers, iron sulfate, irrigation water, acid rain, thiol-based fungicides and pes-
ticides, micronutrient solutions, organic mat-
ter containing sulfur amino acids, and direct adsorption of gaseous sulfur dioxide.

In fact, it is estimated that in cities such as Gary, IN it is not unusual to have greater than 50# sulfur per 1,000 square feet per year deposited from rainfall alone. Thus we believe that the anaerobic chemistry of such sulfur compounds (originating from whatever source) is related to black layer development.

The appearance of the black layer itself may not initially be detrimental to turfgrass growth, but is an indication of "reducing" soil conditions, which may eventually lead to turf thinning and loss. The decline of turf-
grass is probably due to the lack of available oxygen, and the accumulation of toxic anaerobic metabolites such as hydrogen sulfide, methyl mercaptans, volatile fatty acids, alcohols and ethylene which natural-
ly occur with anaerobiosis.

However, if lengthy anaerobic conditions remain, as when spring and fall rains occur, metallic sulfides may accumulate in pore spaces and eventually produce a layer or profile with a gluelike consistency. The metallic sulfide particles in the gluelike layer may then actually help maintain the anaero-
bic conditions by chemically attracting and binding diffusing oxygen.

When diffusing oxygen is scavenged in this way, it becomes unavailable for respi-ation, and the detrimental effects produced by lack of oxygen and accumulation of toxic soil compounds can be extended. Sulfur will not initially induce anaerobic conditions in soil. However, if sulfur is present in suffi-
cient quantities and is allowed to reduce, the resulting compound(s) will make diffusing oxygen less available. In fact, reduced sulfur compounds are routinely used as "reduc-
ting agents" to chemically scavenge oxygen in anaerobic microbiological media, as microbiologists know.

In summary, dissipative sulfate reduc-
tion plays a key role in anaerobic black layer formation and the associated turfgrass decline, regardless of whether the sulfur originated in organic matter, acid rain, irri-
gation water, or from supplemental input. Reduced sulfur compounds such as ferrous sulfide (FeS) impart the characteristic black color commonly associated with many black layers. This has been experimentally shown in our laboratory.

These reduced sulfur compounds also bind diffusing oxygen, making it less avail-
able to the turf plant. Thus, if you have experienced problems with black layer in your soil, additional sulfur will only aggra-
vate the situation if conditions for black layer again become favorable.

The key ingredients for black layer development include anaerobic conditions, the presence of sulfur compounds and soil metals (from whatever source), organic mat-
er and sulfate-reducing bacteria. Reduced sulfur compounds, such as hydrogen sul-
fide and methyl mercaptans, in association with naturally occurring anaerobic metabo-
lites such as ethylene, fatty acids and car-
bon dioxide, impart the characteristic foul odor associated with the layer and are thought to be responsible for the observed turfgrass decline.

Thus it is clear that the anaerobic bio-
chemistry of black layer (and its related anaerobic metabolites) should receive the brunt of research attention, since giving the golfer or sports turf user a playable surface with acceptable aesthetics is the name of the turf-management game.

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