(USGA cont'd.)

Enough talk about the weather. The lightweight, floating head mowers are getting the best of **Poa annua** in fairways. The bent has really moved out this year, especially where superintendents have been able to adequately control the irrigation. Where the bent is well scattered through an area it can do its own thing without chemical help — but with patience.

Plant growth regulators have taken up the anti-Poa fight with a vengence and are performing very well in bent, blue and ryegrass fairways. The only ill effects noted so far occurred when a crosswind blew one material around quite a bit and when a heavy rain washed another application into surface drainage areas. Good results were obtained on spring applications to fall seeded bent following turf eradication. There are still lessons to be learned, but the outlook is good. And there are other materials yet to be fully tested in this area.

None of these things are free and now that budgeting time is nearly upon us, let's look at some numbers. I note from the new Pannell-Kerr-Forster report that the maintenance cost per hole on Midwest courses in 1986 was $19,610. That's about $353,000 for 18 holes, a 9% rise over 1985. The national average was $21,101 per holes, up 7.8% from the previous year. Other areas — East, $17,607 per hole — up 11.8%; South, $20,568 per hole — up 7.8%; the Far West, $28,177 per hole — up 3.5%. The numbers are interesting, but their meaning depends on what one is trying to prove.

An entomological note: The mild winter certainly helped increase the golf course bug problem this year. Just note the number of strange yellowed blotches on greens — with a perfect green outline of a foot right in the middle. It's been a great year for cutworms and ants, too.

The Good Turn of the Year: Superintendent Vern Burks in Great Falls hired 30 Boy Scouts to transplant aerator plugs from the surviving parts of greens to the aeration holes on high mounds where the turf was lost to desiccation. His green cover, by the way, was a hydromulch fiber that had been successful for the previous nine years. This time it blew off.

The observation of the season: The development of grain on fairways, from tee toward the green, which can be worrisome at the start of a backswing. Golf cars. So get out the vertical mowers to go with the aerators.

And the worry of the year: Spots on some greens that look very much like the C-15 disease ... except the grass isn't C-15. At this writing, tests are being rechecked at U/W and MSU.

Remember When? USGA Championships were played on greens mowed at 3/16 inch — only 10 years ago at the Womens Open at Hazeltine. Maintenance programs have, since then, given the players the best conditioned golf courses they have ever seen. There are two operations responsible for most of this — light and frequent topdressing with properly sized sandy material (straight or mixed) and lightweight mowing of fairways. Both have their drawbacks but none are insurmountable. Both require additional operations but higher quality usually demands a higher price. Both demand enlightened operational management and that's why continuing education is so important to all of us today. Remember —

The Wisconsin Golf Turf Symposium	October 28-29
The North Central Turf Expo	December 8-10

Black Layer — Anaerobiosis is the Condition but Sulfur is not the Cause

by Houston B. Couch
Professor of Plant Pathology
Virginia Polytechnic Inst. & State University

If the black layer problem of bentgrass greens that is being reported from various areas of the country is going to be effectively dealt with, research must be addressed to correcting the condition that is causing the decline and death of the plants, rather than being preoccupied with trying to reproduce the "black layer" pattern that sometimes accompanies it. The condition that is causing plant death is anaerobiosis, the black layer is the "by-product" of this activity.

Anaerobiosis is a dynamic series of events taking place in an oxygen depleted environment. When the soil becomes anaerobic, there are significant changes in both the form and solubility of certain nutrient elements. In their reduced state, these elements may be taken up by the plant more rapidly than they can be metabolized, thereby becoming toxic. In addition, the root systems of plants do not function properly in anaerobic soils. Their ability to absorb water and nutrients may be reduced signifcantly. Also, anaerobic microorganisms growing in the soil can produce toxic metabolities that cause either an outright death of the roots or an unthrifty growth of the overall plant.

While this problem is receiving more attention that it did in times past, anaerobiosis of bentgrass greens to the point of

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decline and dying-out is not new. For some 30 years, I have observed this condition in various stages of severity on bentgrass putting greens in a wide range of locations in United States. During the past two years, I have diagnosed cases of acute anaerobiosis in plugs from greens with both predominantly sand and predominantly soil construction.

In considering the dynamics of anaerobiosis and how to control it, one must understand that sometimes a black layer accompanies the condition, sometimes it doesn't. Sometimes, there is a strong odor of hydrogen sulfide, sometimes there isn't. Sometimes there is a high population of algae on the surface of the green, sometimes there isn't. The one thing all of these situations have in common is an anaerobic condition caused by the filling of the soil's pore spaces with water.

This water accumulation can be the result of prolonged periods of rainfall, or impaired infiltration brought on by (i) problems with the initial construction or (ii) an aerification program that included improper selection of sand type for the topdressing.

Anaerobiosis can be rapidly accelerated by an accumulation of algae on the surface of the green. Algae proliferate very rapidly on high sand content greens. This is probably due to (i) the fact that they grow better on wet, light, sandy soils, (ii) the microbial competition is not as great as that found in predominantly soil mixes, (iii) irrigation practices on high sand content greens are oftentimes excessive, and (iv) there is a wide amplitude in the "swing" of availability of various nutrient elements.

Algae produce complex polysaccharides that have the consistency of gelatin. This material can move downward in the profile, plug the pores in the soil, and thus impede the infiltration of water. Not only do these polysaccharides contribute to the development of the anaerobic condition in the soil, but they can also serve as a growth medium for anaerobic microorganisms. Algae, then, can be an important factor in the development of anaerobically-induced decline of turfgrass.

An article entitled "Black Layer Formation in Highly Maintained Turfgrass Soils" appearing in the June 1987 issue of Golf Course Management theorizes that sulfur is the cause of anaerobiosis. It is the opinion of the authors that sulfur, not excess water, initiates the anaerobic state in the soil, and that sulfur (in the form of hydrogen sulfide) is the cause of the death of the plants. Their premise centers primarily around the fact that sulfur does have the potential for developing a blackened condition in the soil, and that in their field trials, they were able to produce black layers with sulfur treatments.

Their hypothesis assumes that (i) sulfur at presently used rates will induce an anaerobic condition in the soil, (ii) sulfur at presently used rates will produce black layers in the soil, and (iii) all conditions of anaerobiosis in soils lead to the formation of black layers. None of these assumptions is correct. In fact, the results of their tests showed that sulfur applications within the normal use range does not produce black layers.

Their experimental design consisted of applying sulfur at two separate rates, 1 pound and 5 pounds per 1,000 square feet. Seventy five percent of the experimental units that had been treated with 5 pounds of sulfur per 1,000 square feet developed the black layer. None of the experimental units treated with 1 pound of sulfur per 1,000 square feet developed black layers.

Where sulfur and products containing sulfur are concerned, there is no published scientific evidence that elemental sulfur used at the rates currently recommended, or that the levels of sulfur in fertilizers currently in use in turfgrass management, either cause or contribute to the development of anaerobiosis. Sulfur is not a factor in the development of anaerobiosis. This means, then, that sulfur at the rates currently recommended will not **induce** anaerobiosis, and refraining from using sulfur will not **reduce** anaerobiosis.

The impact of anaerobiosis on plant growth can be either chronic or acute. It can exist in soil long before there is strong evidence of affected plant growth. It can exist without producing black layers. Prevention of the problem is accomplished by close monitoring of the infiltration rates of the greens. When the rate begins to drop, even though it may not appear to be significant, direct measures should be taken to correct the matter.

When it has been determined that anaerobiosis has developed, steps should be taken to increase the oxygen levels in the root zone. This means following a watering program that allows the soil moisture to be extracted well below field capacity between irrigations. It means aerification — including deep aerification if drainage barriers exist. It may also mean installing supplementary drainage for the greens.

Another important aspect of preventing anaerobiosis from developing to the acute stage is the control of surface algae. At the present time, the only pesticide that can be used on putting greens for algae control is mancozeb (Manzate, Fore, Tersan LSR). This material is effective in the control of Helminthosporium-incited diseases, and is also effective in reducing the impact of Pythium blight. Its inclusion in the spray schedule, then, can serve more than one purpose.