TURFGRASS TRENDS

MANAGING BLUE-GREEN ALGAE

Cultural Practices as Important as Chemicals for Blue-Green Algae Control

By Steven M. Borst, J. Scott McElroy and Greg K. Breeden

With the ever-increasing demand for faster, more-competitive putting surfaces, superintendents are finding blue-green algae encroachment on bentgrass putting greens all too often. Excessive organic matter and moisture in the upper layers of the root zone accompanied with cultural and environmental stresses make golf greens an excellent growing medium for blue-green algae, various fungi and microflora.

Blue-green algae are prokaryotic organisms often referred to as cyanobacteria; but they differ from bacteria because they contain chlorophyll-a and release oxygen during photosynthesis (Bold and Wynne, 1985). Blue-green algae associated with turf decline have been identified as *Phormidium* and *Oscillatoria* species (Tredway et al., 2006). However, because of the diversity of soil bacteria, other species can be involved and can potentially be apart of the blue-green algae problem. Research is being conducted to identify all the agents that comprise the blue-green algae complex and determine exactly which organisms are the true pathogen/weed problems on bentgrass putting greens.

Blue-green algae cause two distinct problems on putting greens: surface slime

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PHOTO 1

Blue-green algae encroachment on bentgrass putting greens can manifest as a slime surface mat or a subsurface black layer.

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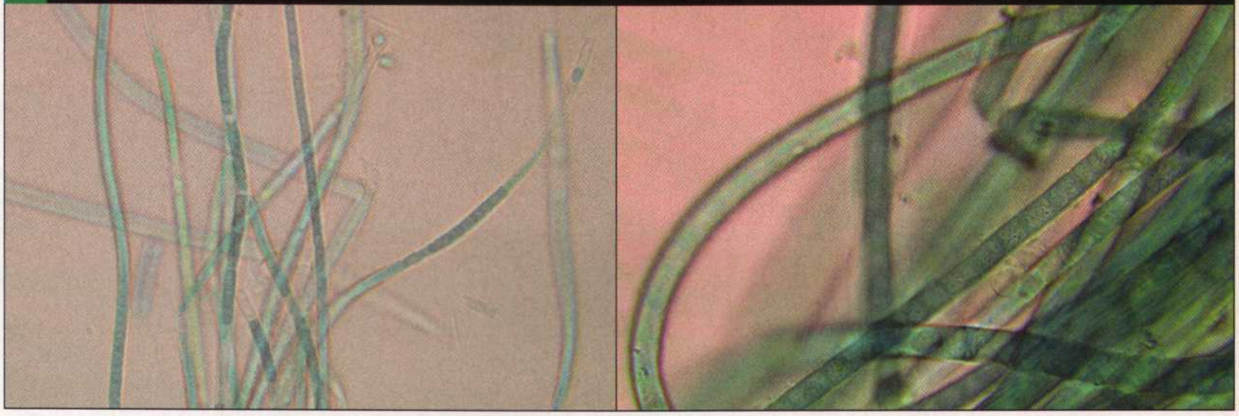
PHOTO 2



Blue-green algae isolates taken in Knoxville, Tenn. Crust layers can range in color from green to brown or black.

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mats and subsurface black layer. The slime mats are described generally as scum or crust layers and range in color from green to brown or black (Baldwin and Whitton, 1992). Surface slime mats are the most common problem occurring on bentgrass putting greens. These mats disrupt the playing surface and create a soil medium unsuitable for bentgrass growth. They are a result of a mucilage substance that the blue-green algae secrete, which the organism uses for protection and conservation of water. When this slime dries, it creates a crust that is impermeable to water, limiting bentgrass growth (Turgeon and Vargas, 2006).

Blue-green algae, through these mats and fibrous growth, can clog soil pores and cause anaerobic conditions making the sand medium susceptible to subsurface black layer. When a soil becomes anaerobic, it allows sulfur-reducing bacteria to thrive and cause turf decline (Tredway et al., 2006).

Recent research identifies a new possible blue-green algae associated problem found on golf course greens: yellow spot disease. Identified on golf greens as yellowing small blotches, yellow spot disease is becoming a problem in the southeastern and western United States (Tredway et al., 2006). Though the disease does not pose a serious killing threat to turf stands, it does pose a problem with aesthetics.

Blue-green algae complex

A major factor for blue-green algae encroachment is water status. (Baldwin and Whitton, 1992). Persistent wet conditions favor blue-green algae development on putting greens (Turgeon and Vargas 2006).

A poorly drained root zone can increase blue-green algae encroachment, as well as pose a problem for bentgrass establishment and growth. Blue-green algae problems tend to occur in these poorly drained areas along with areas that are bare in the turf or where the turf stand is weak (Baldwin and Whitton, 1992). These bare areas can be a result of mechanical stress, such as areas where mower overlap and mower turn stress occur, poor seedling establishment, or perhaps areas distressed by disease.

Without competition from the bentgrass stand, blue-green algae growth can expand over the entire golf green.

Without competition from the bentgrass stand, blue-green algae growth can increase and expand over the entire golf green. Along with water issues, poor air circulation, which delays proper drying of the turf canopy, can increase the chance of blue-green algae encroachment as well.

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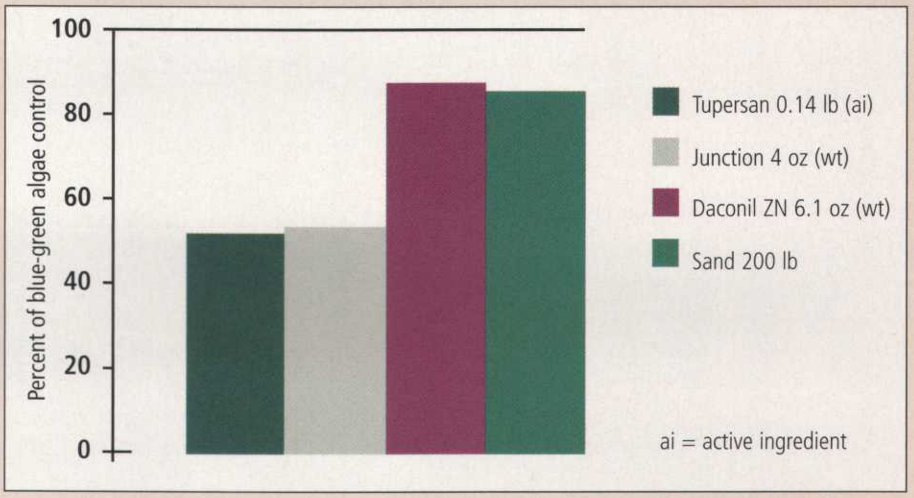
TABLE 1

Comparison of chemical and cultural methods of blue-green algae control. All rates are given per 1,000 square feet.



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In the turf market, there are numerous fungicide/algaecide control options that have been studied for control of blue-green algae on bentgrass putting greens. However, these control methods should be second to alleviating the conditions that are favoring blue-green algae growth.

Water management should be one of the first cultural practices considered when trying to remedy algae encroachment. Drainage and excessive subsurface water retention should be improved in order to decrease anaerobic conditions and improve turfgrass vigor. Air circulation should be enhanced around the surrounding area to increase water evaporation and maintain adequate subsurface water levels.

Cultivation methods such as aerification or spiking should be used to break up the blue-green algae crust and allow water and air circulation into the root zone (Turgeon & Vargas 2006). Topdressing also can be used to coat the algal mat to help break up the crust layer. Blue-green algae are photosynthesizing organisms, so a layer of sand above the photosynthetic tissue can create a stress on the organism allowing bentgrass to compete. Once conditions that favor blue-green algae growth have been corrected, overseeding and chemical control can be considered.

Current research

Research at the University of Tennessee has identified the same species of blue-green algae that have been identified by Tredway et al. In addition, other microflora have been isolated, further adding to the complexity of the blue-green algae complex.

The diversity and makeup of the blue-green algae complex could potentially be

> The diversity and composition of blue-green algae complex might explain efficacy variation that can be seen with control products.

the reason for control variation that can be seen with control products. Each chemical could be toxic to one species of cyanobacteria but have no effect on another. Hypothetically this could be why timing of application and combinations of chemicals yield different control results.

In Table 1, Daconil ZN, applied at 6.1 ounces/1,000 square feet controlled the algae population 87 percent when applied every two weeks. Sand topdressing controlled algae at 85 percent, which is comparable to the Daconil treatments and proves that cultural practices are just as important in control of algae as chemicals. Junction applied at 4 ounces/1,000 square feet controlled algae at 53 percent. Similar control with Tupersan (siduron), which is not labeled for algae control, was also observed. In our research it is becoming apparent that Junction is a potentially better algae preventive than it is an afterbloom control agent.

Further understanding the biology of blue-green algae can fuel efforts to achieve consistent cultural and chemical control.

Various fungicide/algaecides are available for blue-green algae control. Mancozeb (Junction, Fore), chlorothalonil (Daconil Ultrex, Daconil Zn), sodium carbonate peroxyhydrate (TerraCyte), hydrogen dioxide (ZeroTol) and copper hydroxide (Kocide 3000) are some examples of materials labeled for the control of blue-green algae in turf. According to Dernoeden and Shmitt, (1992), chlorothalonil is effective for blue-green algae control, and different formulations did not change effectiveness.

Elliot (1998) also noted this same result in a study with different formulations of chlorothalonil on bermudagrass putting greens. Mancozeb and chlorothalonil will effectively suppress development of blue-green algae on putting greens (Elliot, 1998). When these chemicals were tested as preventive instead of curative applications, better results were observed, and both chlorothalonil and mancozeb were able to restrain the encroachment of blue-green algae on bermudagrass putting greens (Elliot, 1998).

According to Elliot, mancozeb and chlorothalonil can be used as an effective preventive of blue-green algae encroachment. Chemical control always should be secondary to alleviating environmental and cultural factors contributing to blue-green algae encroachment. Monitoring weather patterns and applying these chemicals as labeled can help to prevent blue-green algae from encroaching onto golf course greens.

Both chemical and cultural-control options are available for control of blue-green algae control on bentgrass putting greens. But while some success has be achieved in the area of blue-green algae control, minimal information is available regarding the biology of the organism. Further understanding the biology of these organisms could aid in our continuous efforts to achieve consistent cultural and chemical control.

Steven M. Borst is a graduate student, J. Scott McElroy an assistant professor of turfgrass science and Greg K. Breeden a research associate in turfgrass science. All are at the University of Tennessee.

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Glyphosate Resistance Prompts Integrated Management

By *Stevan Knezevic*

Repeated use of the same herbicide is the main reason for weed resistance to herbicides worldwide. The widespread use of glyphosate-tolerant crops and repeated use of glyphosate herbicide is slowly resulting in glyphosate resistance and shifts in weed species.

Weed resistance to herbicides is not a new thing. It began to occur as man started using chemicals for weed control. There is well-documented literature about weed resistance suggesting that at least 44 weed species have been reported to have biotypes resistant to one or more of 15 herbicides or herbicide families. Repeated use of the same herbicide is the main reason for weed resistance to herbicides worldwide.

The widespread use of glyphosate-tolerant crops and repeated use of glyphosate herbicide resulted in many practical concerns due to single-selection pressure on weed populations, which is already resulting in glyphosate resistance and shifts in weed species. In addition, widespread use of glyphosate-tolerant crops results in uncontrolled movement of pollen containing a herbicide-resistant gene, also known as a gene escape.

Glyphosate resistance

Prior to introduction of glyphosate-tolerant crops, there were only a few weed species known to develop resistance to glyphosate worldwide, including rigid ryegrass (*Lolium rigidum*) in Australia (Powels, 1998) and California and goosegrass (*Eleusine indica*) in Malaysia. However, the number of glyphosate resistant weeds tripled in about eight years of repeated glyphosate use over a much larger land area (more than 100 million acres).

Current examples of glyphosate-resistant weeds in the United States include: waterhemp (*Amaranthus rubis*, Sauer), lambsquarters (*Chenopodium album*), marestail (horseweed) (*Conyza canadensis*)(Davis et al. 2006), giant ragweed (*Ambrosia trifida*), common ragweed (*Ambrosia artemisiifolia*) (Smeda R. 2006), and palmer amaranth (*Amaranthus palmeri*). These weeds are found in various parts of Midwestern and Southern states.

There are marestail populations with various levels of resistance to glyphosate in at least eight states. The objective of this study is to develop dose response curves for glyphosate on five marestail populations and compare their resistance levels.

Seeds of five marestail populations were collected last fall in Nebraska and Indiana, greenhouse bioassays conducted last summer, and dose response curves for glyphosate defined for each marestail population. Curve comparisons clearly showed a glyphosate resistance level ranging from three times to six times depending on the population. For example, 90 percent control of a susceptible population was achieved with 32 ounces of glyphosate (3 pounds per gallon acid equivalent, at one-times rate), while the resistant populations needed about 100 ounces/acre (three-times rate) and 200 ounces (6-times rate) in order to achieve the same level of control.

Weed shifts

Weedy and invasive species can adapt easily to changes in the crop or turf system management in order to take advantage of the available niche (Mooney and Cleland, 2001).

Species that do not adapt to management changes become "less frequent" compared to those that do adapt. Therefore, despite the fact that glyphosate controls many weed species, it does not control all plant species (Franz et al., 1997). Certain weed species can survive in crop or turfgrass systems based on glyphosate-tolerant crops because of their natural tolerance to glyphosate, and/or because of growth types or life cycles that help them avoid being treated (Madsen and Streibig, 2000).

As a result of repeated use of glyphosate in Nebraska, there is a slow shift in weed species occurring from three stand points: 1) from glyphosate-susceptible to glyphosate-resistant populations, 2) from weeds easily controlled by glyphosate to those with natural tolerance to the current label rate of this herbicide, and 3) to those weed species that have growth types, or life cycles, that helped them avoid being treated by glyphosate, such as an increase in winter annual weed species (Knezevic S, 2006).

Knezevic and Klein (2005, 2006) compiled a list of problematic weed species in field crops, which included: wild buckwheat (*Polygonum convolvulus*), Pennsylvania smartweed (*P. pensilvanicum*), lady's thumb (*P. lapathifolium*), ivyleaf morning glory (*Ipomea hederacea*), venice mallow (*Hibiscus trionum*), horseweed (*Conyza canadensis*), yellow sweet clover (*Melilotus officinalis*), and field bindweed (*Convolvulus arvensis*).

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If the trends in weed shifts continue to occur, glyphosate used alone will no longer be a viable tool for weed control in the systems based on glyphosate-tolerant crops.

Mixing glyphosate with other post-emergence broadleaf herbicides or using soil-applied herbicides after crop planting will be needed to control these species effectively. But it will increase the overall cost of weed control because the producers have to pay for both the technology fee and additional herbicides (Knezevic and Klein, 2006).

An increase in occurrence of winter annual weeds was also reported for cropping systems based on glyphosate-tolerant crops in Nebraska (Knezevic S. 2006). It is believed that the overall increase in winter annual species is likely the result of reduced use of pre-emergent herbicides, and/or those post-herbicides that have residual activity in glyphosate-tolerant crops (Knezevic S, 2006). The list of commonly found winter annuals includes: field pennycress (*Thlaspi arvense L.*), shepherds purse (*Capsella bursa-pastoris*), henbit (*Lamium amplexicaule*), and tansy mustard (*Descurainia pinnata* Walt. Britt).

These species are becoming a common scene during late fall (October, November) and early spring (March-April) throughout eastern Nebraska and western Iowa. Designing management strategies for winter annuals is needed, but it will increase the overall cost of weed control.

Gene escape

The potential for "gene escape" conferring herbicide resistance via pollen from glyphosate-resistant crops to other plant species is another major concern, especially from crops closely related to wild relatives (Zemetra et al. 1998). A herbicide-resistance gene was naturally transferred via pollen from herbicide-tolerant IMI-wheat to jointed goatgrass (*Aegilops cylindrica*) in the northwestern United States (Seefeldt et al., 1998). Others also have reported that pollen flow was the main reason for naturally occurring multiple resistance of canola (*Brassica napus*) to three commonly used herbicides (glyphosate, glufosinate and imazethapyr) in Alberta, Canada (Hall et al., 2000).

The probability of gene escape increases if the plant species are closely related (e.g. same genus) because of the possibility of cross pollination (Harlan, 1982). The list of so called "high risk crops" and their weedy relatives includes: sorghum and its weedy relatives shattercane and johnsongrass; canola and mustards; wheat with jointed goat-grass and quackgrass; rice and red rice; sunflower and wild sunflower; and various grassy species (turfgrasses).

Proper use of herbicide-tolerant technology, as a component of an integrated weed-management program, is the key for getting the most benefits out of this technology while avoiding many of the concerns about their use or misuse.

Dr. Stevan Knezevic is an integrated weed-management specialist and associate professor with research and extension appointments at the University of Nebraska Haskell Agricultural Laboratory.

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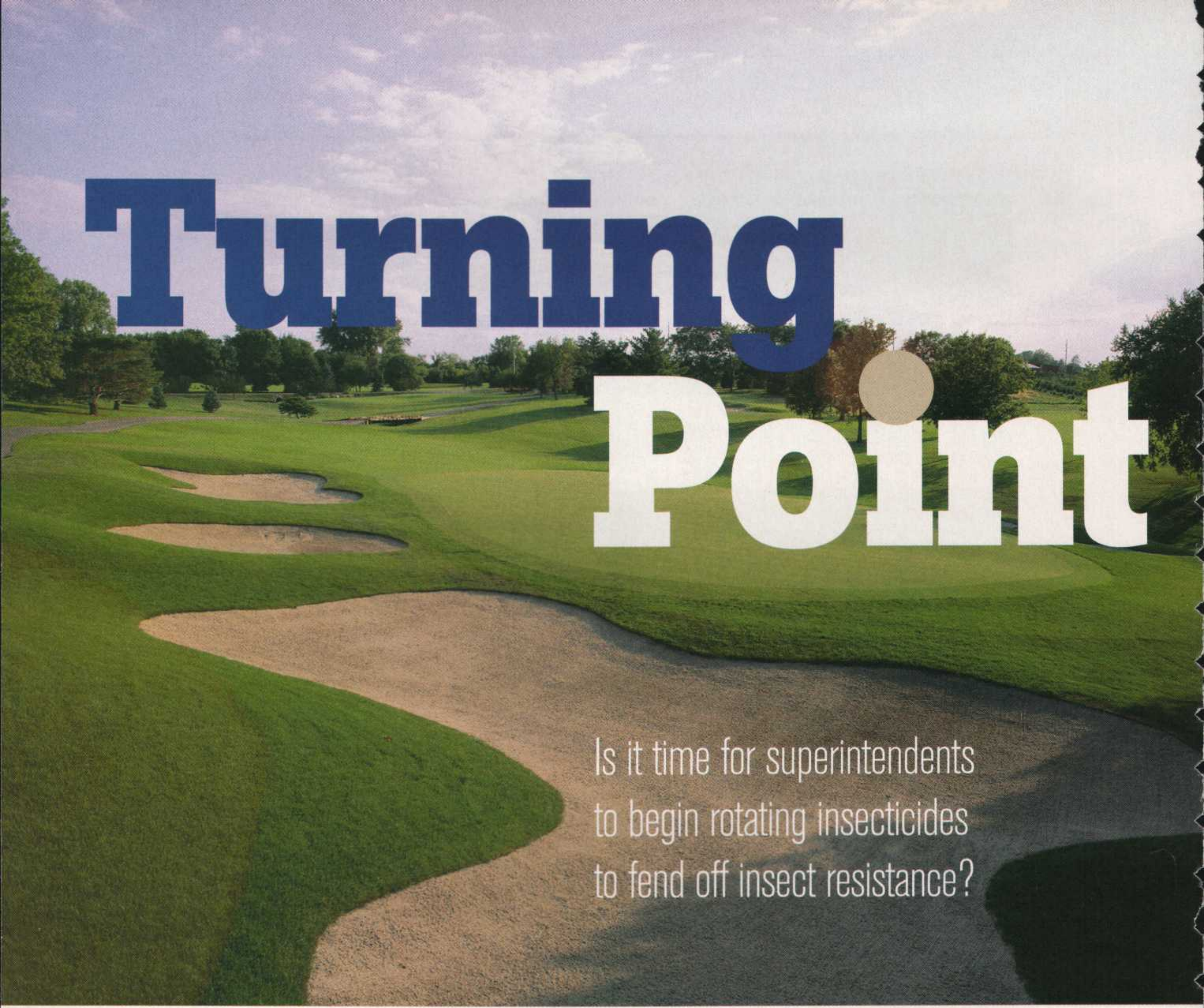

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BY ANTHONY PIOPPI
CONTRIBUTING EDITOR

A basic tenet of golf course maintenance calls for the rotation of fungicides during the course of year to stave off turf disease resistance. Rarely, if ever, is the same rule applied to insecticide applications, and the word "resistance" is almost never mentioned. That is until now. Researchers in the Northeast have documented the resistance of pyrethroids by annual bluegrass weevils.

"Evolution happens, and resistance happens," said Rich Cowles, a scientist at The Connecticut Agricultural Experiment Station in New Haven, Conn.

Because bluegrass weevils are one of the very few pests on golf courses that receive multiple applications of insecticides, Cowles said it was just a matter of time before they developed resistance to insecticides. Back in 1980, when he saw insect resistance to pyrethroids in tree fruit systems, Cowles said he realized the same outcome was inevitable on golf turf.

"I would say that in the next two to three years, this is going to blow up in the faces of superintendents all over the Northeast," he said of bluegrass weevil resistance. "The time bomb counts off not in minutes, but in the number of applications of pyrethroids. Every turf pathologist in the Northeast is working at this problem."

Cowles said superintendents are on a "pesticide treadmill." He explained that most superintendents use one highly effective pesticide exclusively until it loses its usefulness. Then when the next great product comes along,

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