PACE INSIGHTS April 1998 Volume 4 Number 4

Mosses on Golf Course Greens: An Emerging Problem?

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It's growing nicely and gradually spreading across your new putting green -- and it's a beautiful dark green, velvety and dense in appearance. There's no problem if the irrigation system fails every once in a while, because it survives desiccation very well. And best of all, it doesn't require mowing, since it's maximum height is well under 1/8 inch. So what's not to love?

The description above of course refers to mosses, an increasingly troublesome pest on putting greens, and not to a new, genetically engineered miracle variety of bentgrass. But it is ironic that this pest of putting greens, which we are seeing with increasing frequency in California (and in the rest of the country, as the matter of fact), has some of the attributes of the ideal putting green surface. These attributes are unfortunately more than offset by the many problems that mosses cause on golf courses, and particularly on putting greens, including:

- an unacceptably bumpy putting surface
- does not remain green during cooler weather
- production of unsightly brown sporophyte plant
- implicated in sealing of soil, black layer
- out-competes turfgrass

In this issue of *PACE Insights*, we will review the biology of mosses in attempt to understand why they occur on putting greens, and what we can do to manage them.

What are mosses?

Mosses are primitive, chlorophyll-producing, perennial plants that are most familiar to us as the velvety green carpets, composed of hundreds of individual moss plants, seen in forests and other moist and shady environments. Another commonly known moss is the most commercially valuable of all the mosses -- peat mosses (in the genus *Sphagnum*), which due to their drying and water holding properties can be used as fuel for burning, insulation and packing material, as a component of horticultural soil mixes and root zone soil mixtures. However, of the 15,000 species of mosses known, there are tremendous variations in appearance and growth habitats. For example, one of the largest known mosses occurs in Australiasia and can reach over 2 feet in height, while the smallest known moss occurs in the Arctic and never grows higher than 1/10 inch.

The conventional view of mosses -- that they grow only in cool, shady and moist environments, is truly erroneous. Some mosses grow near hot springs, while others thrive on islands of ice that float in the Arctic Sea. Some grow in arid and sunny environments, such as sand dunes, while othesr live in submerged water. Mosses are frequently one of the first plants to grow in inhospitable environments such as rocks, tree trunks, and sand dunes -- locations that are free from competition from higher plants. This last feature is of particular importance in moss management, as will be discussed later in this volume.

Although they are members of the plant kingdom, mosses differ from flowering plants in many ways. First, the vascular system of xylem and phloem which higher plants use to conduct water and nutrients is non-existent in mosses. Instead, water and minerals are most frequently absorbed in soluble form, directly through the plant stem and leaves. There are no flowers and no pollen produced by mosses; rather, sexual reproduction takes place when mobile sperm swim through a film of water to reach the female egg. And the life cycle of mosses is quite unique and complex, with at least three different stages including

the **gametophore** (the moss plant that most of us are familiar with), a **protonema** (a green slime that gives rise to the moss plant), and a brownish-reddish **sporophyte** plant, which arises from the fertilized egg and which produces spores that are air-borne and give rise to new moss plants in new locations. In addition, pieces of moss known as **gemmae** can break off from the moss plant, and once deposited on a new substrate, can give rise to a new colony of mosses in another location. Thus, mosses can spread by spores (sexual reproduction) which are normally air-borne, as well as by gemmae (asexual reproduction) which are frequently moved around the golf course on equipment.

Mosses on putting greens: why are they there?

Mosses have been an increasing problem on putting greens for the past 10-15 years. One oft-cited reason for this change are the increasing demands for fast, low-mowed greens. Due to the stress placed on the turf plant by frequent mowing, low nitrogen, rolling, compaction, etc., the turf thins, and mosses can do what they do best -- move in and colonize areas where no other plants are present. In contrast, when the turf cutting height is raised to 3/16 inch and the turf is dense and healthy, mosses are not able to invade putting greens (Snow, 1984). But once mosses are established, it's almost impossible to get rid of them.

Another contributing factor to the rise in moss occurrences on golf courses may ironically be due to a progressive trend in our industry -- the commercialization of safer, more specific pesticides. In the past, broad spectrum products that contained ingredients such as copper and mercury were used on golf courses for disease control, and may have inadvertently controlled mosses as well. With the cancellation of these products and the development of environmentally "softer" products, mosses may be just one of several new pests that we now have to learn to contend with.

Blue-green algae (such as *Oscillatoria)* are another of the new, unexpected pests we have just begun to deal with on putting greens (Stowell and Gelernter, 1997), and they often occur in the same areas as mosses. Is there a connection between the two? While it is still too early to tell, several pieces of evidence point in this direction. First, we have observed blue-green algae on the leaves of mosses that were growing on putting greens. And researchers such as Giddens (1982) and Reddy and Giddens (1981) have documented a relationship between blue-green algae and a moss that is common on putting greens known as *Bryum* (see below). These researchers believe that the association between moss and blue-green algae may be symbiotic -- that is, the algae fix nitrogen that can be used by the moss, and the moss secretes nutrients that the algae needs. If this is the case, then management of blue-green algae may be important in controlling moss populations on putting greens as well. We hope to learn more about the association between algae and mosses during PACE's 1998 field research season, and will be reporting back to you on results as they become available.

***Bryum argenteum*, the king of putting green mosses**

During the 1980's, a moss known as *Bryum argenteum* (sometimes known as silvery thread moss), was identified on putting greens in the northeast (Hummel, 1988). Since that time, *B. argenteum* has been identified from putting greens in the southeast as well (Dr. Fred Yelverton, North Carolina State University; personal communication). We recently were able to obtain an identification of moss samples from Southern California putting greens, and lo and behold! The moss was positively identified as *B. argenteum* also. This moss produces the velvety carpet that is characteristic of many mosses in the Family Bryaceae, and is composed of small green plants (about 2/10" in height), tightly packed together to form a dense mat. The spore-producing sporophyte plant is reddish-brown in color, and consists of a narrow, thread-like stalk (1/3 - 1/2 inch in height) that grows up vertically from the moss plant, and is capped at the top with a bell shaped capsule that contains moss spores.

Some of the features of *B. argenteum* that make it so successful on putting greens include its ability to withstand desiccation (the moss survived for two years without water, and then began to grow again once it was re-hydrated) and it's ability to colonize sandy habitats including sand dunes (Richardson, 1981). The fact that this particular moss is so ubiquitous on golf courses indicates that it is well adapted to conditions on putting greens -- it's here to stay.

Management practices

Cultural methods: It has been known since the 1920s that overgrazed grass pastures and frequently mown lawns are subject to invasion by moss (Schofield, 1985). Similarly, moss infestations are not known to occur on higher mown collars, even when adjacent greens are badly infested. Therefore, it stands to reason that higher mown turf and/or healthy and dense turf will be able to resist moss invasion. Based on this information, the following steps will help slow down, or hopefully stop a moss infestation in its early stages:

- raise mowing heights to 3/16 inches
- increase nitrogen fertilization
- institute a program of regular verticutting and brushing to restore turf vigor and competitiveness
- core cultivate and fill holes with sand to improve drainage and relieve compaction
- physically remove new patches of moss, via plugging, while they are still small
- remove trees and shrubs that shade putting greens

Chemical methods: While the recommendations above may actually control a moss infestation if it is caught in its early stages, increased mowing heights and slower green speeds may not be acceptable at some courses. In addition, full-fledged moss infestations are stubborn and may be impossible to reverse using cultural methods alone. This is where chemical control comes in. Unfortunately, mosses present the same problem as many weeds -- there are many products available which will kill the moss, but most of them will kill the turfgrass as well. We are therefore looking for an effective moss killing agent that will not damage turf, and that will prevent the moss from returning once chemical applications are stopped.

Many of the techniques in current use are only partially effective. For example, iron sulfate and/or hydrated lime are used by many superintendents, but only as spot treatments, since both can damage turfgrass. In addition, the moss appears to come back after applications have stopped. Some hopeful news from university research trials from North Carolina State University (Yelverton and Hinton, 1997) indicates that a 4-0-0 fertilizer that contains 18% iron (IMC Products) did an excellent job controlling moss, without damage to turfgrass. Several innovative ideas have been proposed by superintendents over the Internet, including the use of Ultra Dawn dishwashing liquid or a three-way mixture of Subdue 2E plus Lesco Spreader Sticker plus Lesco Wet. However, these products are not currently labeled for use as moss control agents and have not been tested in replicated trials.

During the 1998 field season, PACE will be testing the above treatments in a field research program at Friendly Hills Country Club, in collaboration with superintendent David Michael, CGCS. In addition, we will test several products targeted against algae (including Daconil 2787, Fore Flo and a quaternary ammonia product known as RD-20 [Monterey Chemical]), on the theory that blue-green algae infestations may pre-dispose an area to invasion by mosses. We will report to you as results become available.

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