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Controlling moss in putting greens

Extensive testing shows that some products control moss infestation to some degree, but a dense stand of turf is still the best defense.

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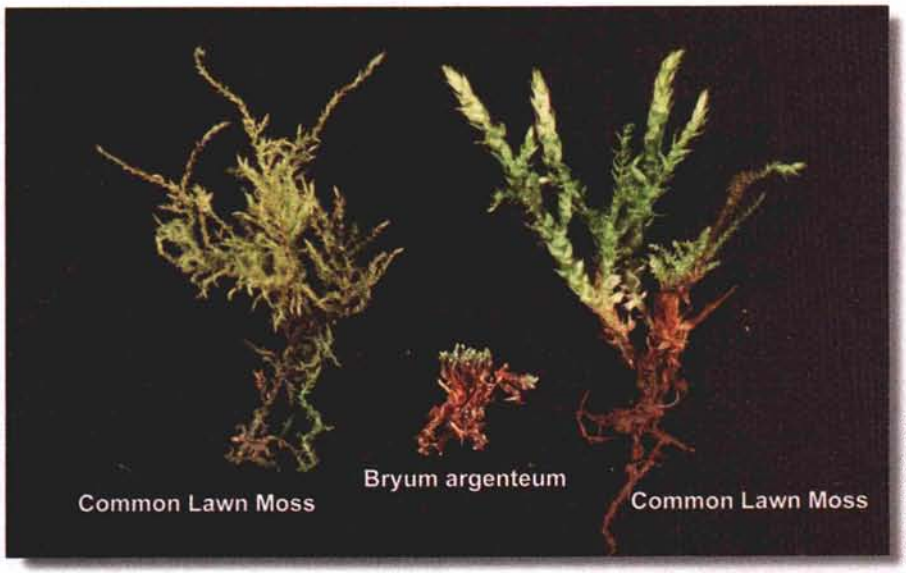
The virtual epidemic of moss on putting greens has prompted four years of research on a wide range of chemical control strategies. Although this research remains a work in progress, it has revealed a great deal about what works and what doesn't and about moss growth in putting greens. Here we outline current control strategies and point out areas of future research.

Biology and ecology of putting green moss

Of approximately 20 species of moss found in association with turf in temperate climates, *Bryum argenteum*, or silvery thread moss, is the species most commonly associated with putting greens. In nature, *B. argenteum* is found from sea level to timberline and from the Arctic to Antarctica. It is common in cold and temperate climates but rare in tropical ones. Cosmopolitan and ubiquitous, it colonizes disturbed, often dry sites and generally is considered a pioneering species. It is often part of the early succession on sand dunes, bare rock and gravelly soil. Along with a small number of other mosses, it is well adapted to human-altered environments, including sand-based putting greens and push-up greens that have been top-dressed regularly with sand. Unlike many mosses, it grows well in both wet, shady environments and hot, dry sites in full sun.

Like most bryophytes, *B. argenteum* is not a vascular plant and has no roots. It is anchored by rhizoids, which resemble roots but do not appear to function in uptake of water or nutrients. Without xylem and phloem, it has no means to translocate foliar-absorbed nutrients. Like other mosses associated with turf, *B. argenteum* reproduces via spores produced in distinctive capsules and by plant fragments likely spread during mowing and other cultural practices such as coring. To date, we have not observed spore capsules on moss growing in putting turf.

The current prevalence of moss in putting greens probably reflects recent trends in putting green culture, including extremely low mowing, minimal nitrogen fertilizer, increased use of sand growing



Photos courtesy of Tom Cook

Bryum argenteum, the moss most commonly associated with putting greens, differs in appearance from common lawn mosses.

KEY points

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- ***Bryum argenteum,*** or silvery thread moss, has become a common pest on putting greens.
- **Products containing** copper hydroxide, iron and fatty acids have all shown some ability to control moss in putting greens.
- **A drastic change** in cultural practices may be the best defense against moss infestations.

mediums, intense sand topdressing and loss of mercury fungicides, which were highly toxic to moss. It occurs on both bentgrass and *Poa annua* greens but is by far a bigger problem on sand-based bentgrass greens. We have found significant populations on first-year greens on new golf courses. It often shows up first in weak areas such as ridges and mounds where grass is thin because of scalping or drought stress. It aggressively colonizes low, wet areas and thrives on soil-based greens with shallow layers of sand built up by topdressing.

Research strategies

Our research, conducted at Oregon State University, primarily concerns moss growing in creeping bentgrass greens, and the following results are from work done entirely on Providence creeping bentgrass in sand-based growing mediums and SR 7200 velvet bentgrass growing on soil and topdressed with sand. To date we have concentrated on large-scale broadcast treatments rather than spot treatments directed at localized infestations. Most of the chemical treatments have been applied during fall and winter when temperatures range from 40 to 65 F and moisture from precipitation is common. Soil pH in the area is typically 5.5 to 6.5, and salt levels are very low.

Early screening trials

After unsuccessful attempts by superintendents to try iron products at normal putting green rates, we screened a wide range of products by applying each at a variety of rates from low to very high. Products included in our experiments were selected because reports in the literature indicated that they controlled moss or that they were being applied on putting greens in an attempt to control moss. We eliminated products that caused turf damage and others that had no effect on the moss. The following products were tested and eliminated from consideration.

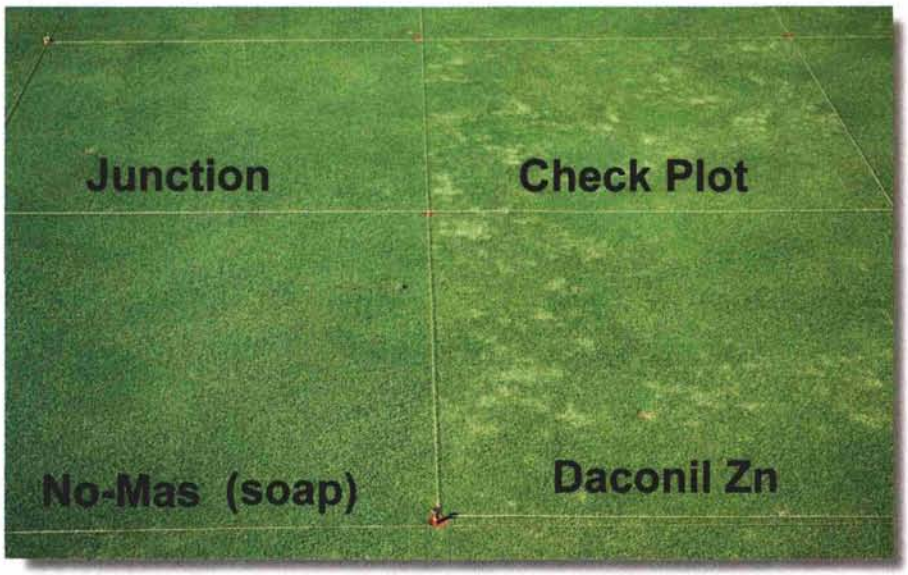
Copper sulfate. Copper sulfate is not labeled for moss control. In our tests, it caused severe turf injury at rates necessary for moss kill. Caused root stunting in turf.

Copper soaps. Copper soaps are not labeled for moss control. We found them to be highly effective moss killers but toxic to turf, even at moderate rates.

Zinc sulfate. These products are not labeled for moss control in putting greens, although some retail products are labeled for moss control in lawns. Acceptable moss control but caused significant turf injury at marginally high rates.

Daconil Zn and Daconil Ultrex. Both products are labeled as fungicides and not for moss control. They were ineffective in controlling moss under low-temperature conditions. Some reports indicate control at higher summer temperatures. No undesirable side effects on turf even after 15 repeat treatments.

Dawn Ultra. Dawn Ultra was ineffective on moss at rates ranging from 2 to 8 ounces of product/1,000 square feet when applied during cool, wet conditions. Dawn Ultra is marketed as a dishwashing liquid, and certified commercial pesticide applicators cannot legally apply Dawn Ultra for moss control. Doing so would be the same as applying an unregistered pesticide.



Drought-preconditioning helps maintain a higher turf quality under heat stress. Kentucky bluegrass at 15 days of heat stress following exposure to well-watered conditions without preconditioning (left) and two cycles of drying and re-watering (drought preconditioning) (right).

Advanced screening

The next phase involved further testing of products that showed promise for moss control and caused little or no turf injury. Products included ferrous and ferric sulfate, fatty acid soaps and copper hydroxide products. All of these have been tested repeatedly at several rates and with varying numbers of repeat applications. Research results for these products are summarized below.

Iron products

Normal rates of iron for turf color enhancement are about 0.03 pound iron/1,000 square feet. Under cool, wet conditions, rates of 0.15 to 0.20 pound iron/1,000 square feet controlled moss marginally without injury or blackening of Providence creeping bentgrass turf. Ferric sulfate is more effective at killing moss than ferrous sulfate, but both require a series of five to seven treatments applied at two-week intervals. Turf is exceptionally dark green during treatment. We achieved up to 90 percent moss control with both ferrous and ferric sulfate, which is encouraging but not as effective as we would like. Annual applications may be necessary, and control is not always consistent. Field test results have been mixed, with most tests using ferrous sulfate and reporting fair to good control.

Copper hydroxide products

Most of our research has used Kocide 2000, which is straight copper hydroxide, and Junction, which contains both copper hydroxide and mancozeb fungicide. Both products show similar activity and are registered for moss control.

In western Oregon, we achieved effective moss control with five to seven treatments applied at two-week intervals at rates of 0.1 to 0.15 pound copper/1,000 square feet during

cool wet weather between October and March. Moss injury occurs gradually and is progressively greater with each application. A minimum of five treatments is needed to prevent the moss from growing back. We normally plan on six to seven treatments. During treatment turf darkens slightly but not as dramatically as with iron products. Darkening continues into the spring even after treatments have been completed. A single treatment series of seven applications has provided one to two years of acceptable moss control in our local area.

Potential problems

Using copper hydroxide for moss control raises several concerns. One is the potential buildup of copper in the root zone, which may stunt root growth. In early screening trials, applying the equivalent of 6 pounds of copper/1,000 square feet over a one-year period stunted root growth. Although this is four to seven times the amount that would be applied in a normal treatment sequence, it is still cause for concern. We now advise applying copper treatments no more than two years in a row at a total rate of 1.0 pound copper/1,000 square feet/year. However, surface soil levels of copper as high as 42 ppm have been noted without any apparent root stunting under our climate conditions.

Copper-induced iron chlorosis is another concern with copper hydroxide products. The problem was first observed where copper treatments had been applied on golf courses for two consecutive years. No problems occurred the first year, but severe chlorosis developed the second year. Symptoms were worse on weak or shaded greens. Greens in full sun were not affected. We concluded that the symptoms were not phytotoxicity but iron chlorosis. Further experiments in which we alternated copper treatments with 0.05 pound iron/1,000 square feet during a sequence eliminated signs of chlorosis.

Current recommendations

Current recommendations are to apply copper hydroxide products during cool weather at 0.10-0.15 pound copper/1,000 square feet at two-week intervals for a total of five to seven applications. If signs of iron chlorosis occur during or after treatment with copper hydroxide, apply iron at 0.05 pound iron/1,000 square feet as needed to eliminate chlorosis. Iron can be tank-mixed with copper hydroxide if constant agitation is maintained in the spray solution. A minimum spray volume of 2 gallons/1,000 square feet is suggested.

Please note: In areas with hot, stressful summers where summer root loss is common, conduct thorough on-site testing on nursery turf to make sure copper treatments do not cause root stunting and thus increase the chance of turf loss during the summer.

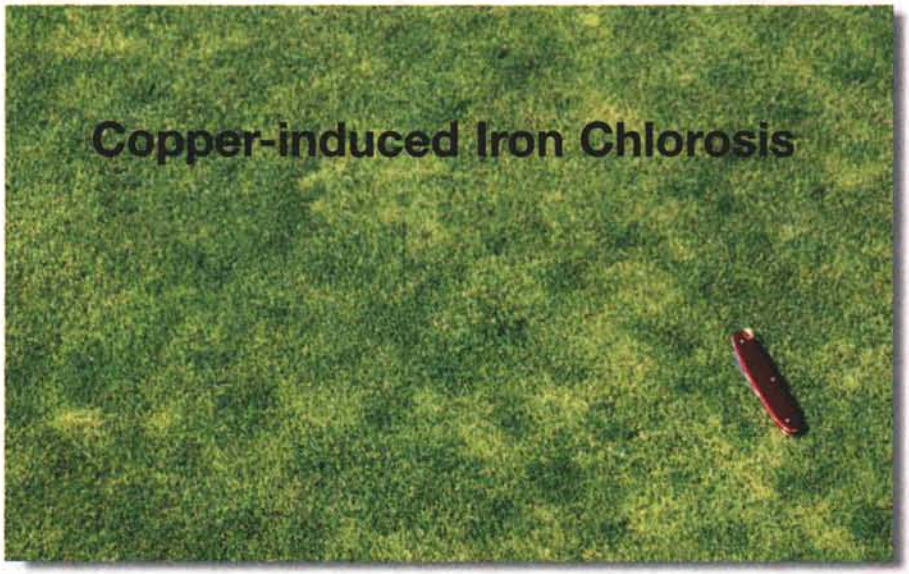
Superintendents who have used copper hydroxide products have reported mixed field results. In western Oregon and Washington and parts of California, superintendents have reported excellent and fairly long-lasting control without deleterious effects to turf. Other superintendents have reported short-term or partial control, and in parts of California, some have reported no control at all. Factors that may affect control are lack of extended periods of cool temperatures, low-humidity environments, high soil and water pH, and elevated salt levels in irrigation and/or spray solutions. Copper may not be effective in these situations, but further research is clearly needed.

Fatty-acid soaps

Soap products have been used for many years for lawn moss control, and anecdotal reports of control with products such as Dawn Ultra detergent, which is not labeled as a pesticide, prompted evaluation of soap products for use on putting greens. We screened several products based on fatty acids, all of which were effective in killing moss. Since initial screening, we have concentrated on one product recently registered as No-Mas, which is a 22 percent active formulation of a fatty-acid salt.

Testing soap products differs from testing common pesticides because the amount of water applied as a carrier profoundly affects the optimal rate of active ingredient. At a given rate of active ingredient, phytotoxicity increases as the total volume of spray solution decreases. After much testing, we established a rate of 0.63 gallon of product/1,000 square feet applied in a minimum of 6 gallons of spray solution/1,000 square feet. The same rate applied in 12 gallons of spray solution/1,000 square feet is probably optimal for maximum moss control without turf injury, but it is virtually impossible to achieve with most spray systems.

Note: There are many soap products on the market registered for general moss control.



Copper-induced iron chlorosis on putting green turf can be prevented by tank-mixing copper with iron or following copper treatments with iron applications.

They vary greatly in concentration and recommended dilution rates. Be sure to study specific product labels carefully to avoid inadvertent turf injury.

Our research indicates that two applications applied two weeks apart generally achieve a high level of control. Moss kill is rapid and appears as a pronounced bleaching of moss accompanied by a slight lightening of turf. Turf lightening increases with each subsequent application. Alternating soap applications with iron applications at 0.05 pound iron/1,000 square feet maintains turf color and darkens the dead moss, improving the overall appearance of the turf. Iron applications can be made to soap-treated plots the day following soap application. Iron will precipitate out and clog spray nozzles if it is mixed with the soap solution.

Soap treatments have been generally effective in western Oregon and Washington. Reports from research in California indicate poor control with winter applications in an arid environment with high pH water and high pH soils. In the Pacific Northwest, we generally expect residual control during the growing season after treatment. Long-term control is not as good as for copper-treated plots, and it appears annual treatments will be required.

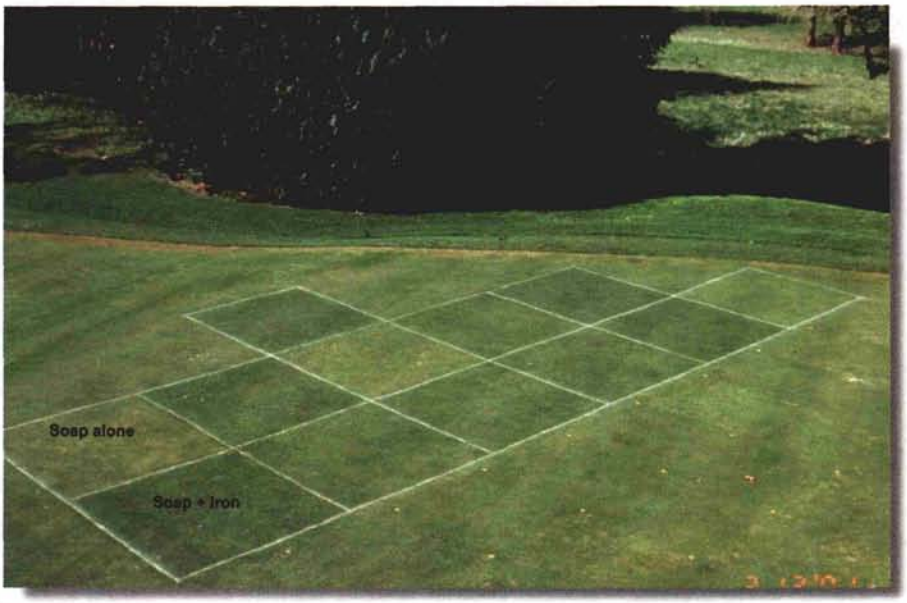
Potential problems

Problems we have encountered include excessive phytotoxicity when soap applications are followed by frost. *Poa annua* appears to be more sensitive than Providence creeping bentgrass under these conditions. Occasionally turf scorching has occurred even when treatments have been applied under optimal conditions of mild rainy weather. Rinsing treated plots within an hour of soap application will generally minimize turf scorching. Turf scorch from soap applications is similar to a light tip burn from soluble fertilizer applications. Turf recovery is generally very rapid. Thoroughly test soap products on site before using in wide-scale spray programs.

Summary

At some point assessing the impact of cultural practices on moss encroachment becomes important. The starvation theory of putting green maintenance has been followed to the point where in some cases the turf is gone and only the moss remains. Growing a dense healthy stand of turf is still the best way to prevent moss from dominating turf. Superintendents should experiment with ways to generate green speed other than starving turf to the point of thinning and mowing so low that adequate density cannot be maintained. As long as current trends in turf management continue, moss problems will persist.

Once moss invades putting greens, foolproof control is impossible. The treatment approaches described in this paper have provided acceptable moss control in the environmental conditions of the Pacific Northwest. According to our results, the most effective products include copper hydroxide products applied during cool weather in sequential applications. Iron products applied during cool weather in sequential applications have been almost as effective, and fatty-acid soap products show great promise. All treatments have side effects that must be considered. Treatments discussed in this paper are not effective in some areas of the country, and regional research is needed to fine-tune treatment programs.



Follow-up applications of iron can mask the lightening effect of soaps on turf.

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