

Research You Can Use

Of Moss and Men

Research trials from across the U.S. have identified control options for this invasive weed of putting green turf. Field observations indicate management is an important component of successful eradication.

BY MATT NELSON

Moss invasion of putting green turf has become an increasing problem at golf courses across the United States over the past ten years. Moss encroachment into putting greens has progressed from a regional concern a few decades ago to a more widespread problem on creeping bentgrass greens with sand rootzones during the late 1990s, to an even wider problem today on greens with mixed stands of creeping bentgrass and annual bluegrass growing in a variety of rootzone compositions. As a result, research conducted at various sites across the country has identified control methods and probable causes of moss invasion.

WHERE DID IT COME FROM?

Silvery thread moss (*Bryum argenteum*), the moss species that invades putting green turf, is a primitive plant adapted to a variety of climates around the world.^{1,3,6,11} Moss is a non-vascular plant that must be in contact with free water to establish. Moss also can tolerate nearly 80% dehydration, however, which makes it extremely well adapted to and competitive in putting greens. It reproduces sexually via spores that can be disseminated over great distances by wind. Moss also can reproduce asexually from displaced fragments, which is a likely means of spreading across golf course putting greens. Water, wind, maintenance equipment, or foot traffic can effectively spread moss.

Research agronomists speculate that increased moss encroachment problems can be correlated to discontinued use of mercury fungicides and perhaps a change in pesticide formulations.^{3,9,11,12,13} A more likely explanation is continued reductions in mowing height and insufficient nitrogen fertilization of putting green turf with the intent of promoting faster green speed.^{3,6,7,8,9,12,13} Lower mowing heights and reduced fertility compromise the competitive ability of turf and increase opportunity for weed invasion. This claim is supported by the progression of moss invasion from select regions of the country to more widespread observation on creeping bentgrass turf growing in sand rootzones, to greens of all mixes of annual bluegrass and creeping bentgrass in a wide variety of soil media. Sand retains less nutrients and water than soil, and bentgrass typically has less density (shoots per unit area) than perennial biotypes of *Poa annua* at mowing heights below 1/8 inch. Moss invasion problems in collars, tees, and fairways are undocumented.

As a result of more widespread moss problems, golf course superintendents and researchers have experimented with a plethora of potential control agents, including liquid soaps, fatty acids, baking soda, mouthwash, fabric softener, various metals, fungicides, herbicides, peroxides, various combinations of these materials, and who knows what else. Fortunately, con-

trolled research efforts have yielded some positive results.

CALL IT . . . HEAVY METAL!

In the past, heavy metal fungicides were a one-way ticket to moss-free greens. For good reasons, these products are no longer available for use in the turf industry. Weber and McAvoy demonstrated effective moss control with silver nitrate by electromotive destruction of chlorophyll, whereby the magnesium ion at the core of the chlorophyll molecule is oxidized by the metal ion.¹¹ A silver nitrate pesticide has not been registered for use on golf turf.

Iron sulfate has long been recognized as a viable control tool, although repeated application at high rates is necessary to provide good control.^{3,7,12} High rates of iron sulfate applied repeatedly with very high water volume have demonstrated effective eradication of moss at several golf courses in the western U.S., although some researchers have questioned the long-term consequences of such a program.²

Copper hydroxide fungicides have been shown to provide effective moss suppression through research conducted at Oregon State University, Cornell University, and Penn State University.^{3,7,9} Four to six applications of copper hydroxide fungicides at weekly intervals in the fall have provided the best results. Water pH is critical to control and additives are

necessary to be sure that water in the spray tank is adjusted to a pH of 5-6.5 prior to adding the copper hydroxide product. Repeated copper applications can inhibit iron metabolism in the plant and result in toxicity problems in the soil. Observation in the Rocky Mountain region of the U.S. indicates copper hydroxide can effectively control moss, but this approach has not been widely practiced.

ANOTHER "CIDE" OF CONTROL

Researchers have discovered that another fungicide (chlorothalonil) and one herbicide (carfentrazone) can provide selective control of moss in putting green turf.^{10,12,13} Results indicate that sequential applications of chlorothalonil can provide good control of moss without turfgrass phytotoxicity when daytime temperatures are above 80 degrees F.¹² Use of this product when temperatures are cool exhibits limited efficacy on moss, so using this product in a disease management program will provide moss suppression. Label limitations on annual chlorothalonil use on greens must be considered when using this product for moss control.

Carfentrazone (Quicksilver, FMC Corp., Philadelphia, Pa.) has recently gained registration for silvery thread moss control on putting greens, and research trials have shown good to excellent control.^{10,13} Carfentrazone appears to provide good control of moss over a broad temperature range. Field observation in the western U.S. has shown excellent moss control results when applications are made between daytime temperatures of 55 and 85 degrees F. Two or three applications 7 to 14 days apart at the label rate in 100 gallons of water per acre with a non-ionic surfactant at a rate of 0.25% volume/volume have demonstrated the best results. Since moss lacks roots and vascular tissue and has an extremely high biomass surface relative to volume, spray volume and surfactant



Moss invasion has been linked to low mowing, and invasion is often first noticed on ridges or crowns in putting greens where scalping is more likely.

use are important for maximum coverage, absorption of product, and control. To date, carfentrazone has provided the best selective control of moss in putting greens across the western U.S.

OTHER OPTIONS

As mentioned previously, many different materials have been evaluated for moss control in the field. Researchers in Illinois have shown that baking soda, when spot applied in a solution of 6 oz. baking soda/gallon of water, is capable of providing season-long control, although significant turf injury is probable with baking soda use.¹⁰ Also, broad application of this product may be difficult, and spot treatment with any product rarely provides acceptable moss control. Visible moss colonies often indicate a more widespread moss invasion when close analysis of the turfgrass canopy is conducted. Baking soda is not registered as a pesticide.

Dawn Ultra dishwashing liquid has provided variable moss suppression in the field, although researchers at Penn State University were unable to



Iron tends to blacken moss when used as a selective control. In this case spot applications fail to control smaller moss plants evident in the turf canopy, and they seldom provide acceptable control.

demonstrate effective control.⁷ Spot applications of Dawn Ultra at a 4 oz./gal. of water dilution rate seem to provide better moss desiccation than broadcast applications in field observations. Again, this product is not a registered pesticide.

Sodium carbonate peroxyhydrate (Terracyte, Biosafe Systems, Glastonbury, Conn.) is currently marketed for selective control of silvery thread moss on golf courses, and field observations have demonstrated poor to excellent moss control. This product uses ground dolomitic limestone as a carrier and can be difficult to apply accurately. Terracyte may cause some turf injury to annual bluegrass and creeping bentgrass during high temperatures and/or humidity, especially if consecutive day treatments are used.⁷ At PSU, 4 to 5 applications of Terracyte at 8 lb. per 1,000 sq. ft. every two weeks provided good control, although it did not eradicate moss. As with copper products, Cornell University researchers have found better control with this product in fall vs. spring.⁹ They speculate that moss is either more susceptible to control or has less recuperative potential in the fall. Best results with this product in field observations from the western U.S. occur when turf is lightly irrigated immediately before and after application at an 8 lb. per 1,000 sq. ft. rate with a drop spreader. Spot applications do not typically provide acceptable moss control.



Copper products, desiccation control agents, and carfentrazone typically cause moss to turn a bronze or brownish color, indicating efficacy. Repeated applications are usually required with any product to provide acceptable moss eradication.

THE CULTURE OF MOSS CONTROL

While research continues to identify selective controls of silvery thread moss in putting green turf, adjustments in cultural management programs are the real key to achieving long-term moss suppression. Without question, low mowing and insufficient fertilization are the primary causes of moss infestation. Ridges, crowns, and other areas prone to scalping injury are typically those that moss first invades. Increasing the height of cut and fertility when applying products to selectively control moss will improve success. Utilize rolling or double mowing to achieve the desired green speed in lieu of mowing too low.⁵ Field observation indicates moss infestation problems are absent or much less severe when nitrogen fertilizer is applied at 0.4–0.5 lbs. N per 1,000 sq. ft. per month of active growth.

Since moss must be in contact with free water to establish, even microscopic layers in the upper soil profile may be sufficient to effectively perch water and favor moss. Controlling organic matter in the upper soil profile with aeration and topdressing is integral to good moss control. Other factors that affect turfgrass vigor, including the growing environment, irrigation practices, traffic management, and drainage, should be evaluated if moss infestation is noticed or has become a serious problem. Minor amounts of moss can quickly become a major problem if left unchecked, so review the research and implement a complete control strategy early. Ultimately, the best advice when battling moss is to evaluate all factors and grow grass, not moss.

LITERATURE CITED

1. Burnell, K. D., F. H. Yelverton, J. C. Neal, T. W. Gannon, and J. S. McElroy. 2004. Control of silvery-thread moss (*Byrum argenteum* Hedw.) in creeping bentgrass (*Agrostis palustris* Huds.) putting greens. *Weed Technology*. July-Sept. 18(3):560-565.

2. Cook, T. 2005. Ironing out your fertilizer program. *USGA Green Section Record*. March/April. 43(2):19-21.
3. Cook, T., B. McDonald, and K. Merrifield. 2002. Controlling moss in putting greens. *Golf Course Management*. Sept. 70(9):103-106.
4. Dudones, D., and F. Rossi. 2001. Silvery thread moss research at Cornell University. *Cornell University Turfgrass Times*. Summer. 12(2):6-9.
5. Gilhuly, L. 2006. Green speed: Trick or treat? *USGA Green Section Record*. July/August. 44(4):17-19.
6. Happ, K. A. 1998. Moss eradication in putting green turf. *USGA Green Section Record*. Sept./Oct. 36(5):1-5.
7. Landschoot, P., J. Cook, and B. Park. 2004. Moss control — new products and strategies. *USGA Green Section Record*. July/August. 42(4):7-9.
8. Nelson, M., and L. Gilhuly. 2005. Where is green speed taking the game? *USGA Green Section Record*. May/June. 43(3):8-10.
9. Rossi, F. 2002. Cornell researchers tackle moss control. *Cornell University Turfgrass Times*. Spring. 13(1):10-11.

10. Settle, D. M., R. T. Kane, and G. L. Miller. 2006. Evaluation of newer products for selective control of moss on creeping bentgrass greens. *USGA Turfgrass and Environmental Research Summary*. p. 64.
 11. Weber, A. P., and T. O. McAvoy. 2003. Moss infestations in putting greens. *USGA Green Section Record*. July/August. 41(4):32-36.
 12. Yelverton, F. H. 2005. Managing silvery thread moss in creeping bentgrass greens. *Golf Course Management*. March. 73(3):103-107.
 13. Yelverton, F. H. 2005. Moss on bentgrass greens — why do we have it and how do you get rid of it? Presented at *USGA regional conference*. Pinehurst, N.C.
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Thatch and/or layering in the upper soil profile can predispose turf to moss invasion. Notice the lack of moss in the perimeter of this green where mowing imparts more wear injury and limits productivity and thatch production.