CUTT

Silvery Thread Moss Research at Cornell University

Program Spotlight

Seven hundred golf course superintendents were surveyed, with a 17% response rate. Low mowing, nutrient deficiency, lack of metal-based fungicides, and excessive surface moisture were consistently associated with high moss populations.

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Increased demand for golf in the United States has lead to more heavily trafficked putting surfaces. Poor design, excessive maintenance and high performance expectations result in weak turf. Weak turf is characterized by low surface density likely to be infested by weeds. Recently, an "epidemic" invasion of the moss species *Bryum argenteum*, has been identified that reduces functional and aesthetic quality below an acceptable level. The TriState Turfgrass Research Foundation and the Metropolitan Golf Course Superintendent Association provided the major funding for a project to develop a more thorough understanding of the moss problem on putting greens. Specifically, our objectives were to identify ecological factors associated with moss invasion and persistence, develop postemergence control, and establish a sustainable moss exclusion program.

David Dudones was accepted for graduate study at Cornell University in January 1999 and worked with Dr. Frank Rossi on the moss project. An eight page survey was developed to identify the extent of the moss problem and specific ecological factors associated with moss distribution. Seven hundred golf course superintendents were surveyed, with a 17% response rate. Fifty percent of the respondents had objectionable moss populations. We were unable to identify a clear ecological niche based on the low survey response rate. However, low mowing, nutrient deficiency, lack of metal-based fungicides, and excessive surface moisture were consistently associated with high moss populations.

A field study was initiated in 1999 to ascertain the influence of environmental conditions, topdressing, spray volume, and formulation of copper hydroxide with and without mancozeb (a zinc manganese based fungicide) on moss efficacy. The study was conducted on golf courses in NY, NJ, and CT. Copper hydroxide, an organic fungicide and source of Cu nutrition, decreased moss populations by as much as 40% depending on environmental conditions and spray volume. Fall applications provided the best control. An additional field study was conducted in 2000 to evaluate the use of desiccants such as peroxide and fatty acid based products. A potassium based fatty acid reduced moss populations over 65%. Growth chamber studies were conducted in 2000-01 to evaluate potential moss exclusion programs. Biweekly low rate applications of copper hydroxide or fatty acid materials were applied to juvenile moss plants. Results indicated that 1000 ppm Cu applied as copper hydroxide and a potassium based fatty acid provided 85 to 95% moss control. Further research is needed to evaluate soil and tissue copper accumulation, as well as phytotoxicity of fatty acid based compounds.

2000-2001 Progress Report

One of the critical aspects of this project was to develop a more thorough understanding of the biological and ecological aspects of moss invasion. A considerable effort was made to review previous studies and confer with experts in the field of bryology, notably Professor Jon Shaw of Duke University. The information gathering phase of the project identified several key points that lead us to conclude:

1. The ability to maintain a dry putting green surface would reduce the invasion of moss, but not likely control existing populations. In fact, microscopic perched water tables that result from soil layers or organic matter accumulation would be sufficient for moss to invade.
2. Increased mowing heights will reduce the invasion of moss primarily by maintaining high turf density and minimizing voids. However, increased mowing heights will only mask existing populations.
3. Increased nitrogen fertility will reduce moss invasion by maintaining high surface density. Research from Ohio State University demonstrated how 10 lbs. of nitrogen per 1000 sq. ft. controlled existing moss populations. We believe this may be related to a nutrient complex that involves a significant pH reduction at the surface and the uptake of metal ions.
4. Moss distribution, specifically *Bryum argenteum*, is significantly limited in the pres-

ence of metal ions (see Figure 1). In fact, a small study at Oregon State University demonstrated the potential for Cu and Zn to be effective in reducing moss populations

5. Moss growth is less active under environmental conditions similar to the fall season in northern climates.
6. *Bryum argenteum* reproduces almost exclusively from the vegetative phase under managed putting green conditions. Spores do not represent a major source of distribution on greens as a result of the close mowing.

2000-01 Studies

Abbreviated Methods

Field studies that attempted to exploit the susceptibility of moss to low levels of metal ions were initiated in 1999-2000 at three locations (Westchester CC, Galloway National, and Fairview CC). Initial soil tests were taken to establish baseline soil nutrient levels and initial moss population counts to evaluate control methods.

CuOH with and without mancozeb (Zn and Mn base) was applied in a CO_2 backpack sprayer calibrated to deliver 2 or 4 gallons of water per 1000 sq. ft. The pH of the spray solution water was 6.5. Half of the applications were made after an abrasive topdressing procedure. Application regimes occurred in fall only (4 apps), fall and spring (8 apps), or spring only (4 apps).

Controlled environment studies were initiated in the winter of 2000 and repeated in the spring of 2001 to investigate potential exclusion programs. Applications of a K-based soap or 250 ppm, 500 ppm, or 1000 ppm Cu supplied as CuOH were applied every three weeks to substrate that harbors moss. Applications were made with a CO_2 backpack sprayer calibrated to deliver 2 gallons of water per 1000 sq. ft. Population counts were made following three applications.

Abbreviated Results

1. No statistical differences were detected between chemical treatments suggesting that Cu levels were the limiting factor.
2. Overview of all treatments suggested main effects of timing and spray volume to be significant (see Figure 2).
3. Fall applications were more effective than Spring (see Figure 3).

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Figure 1

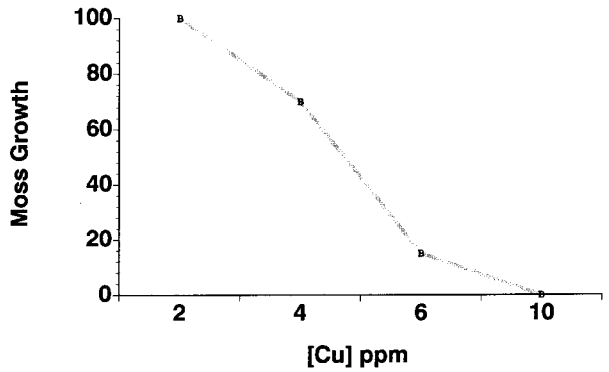


Figure 2

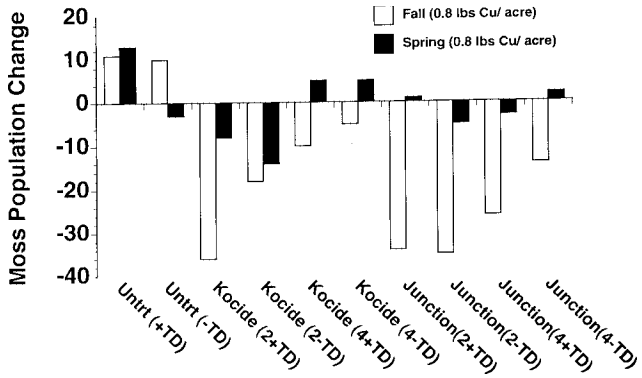
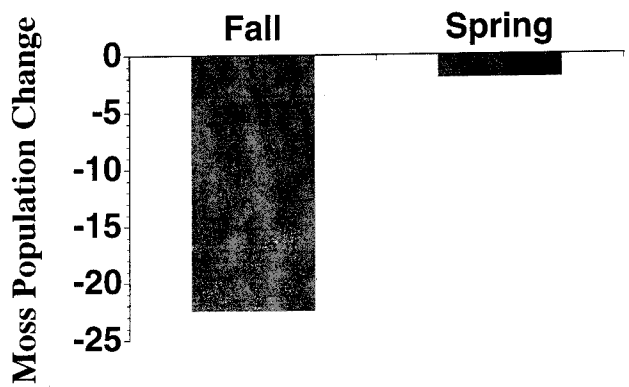


Figure 3



Silvery Moss

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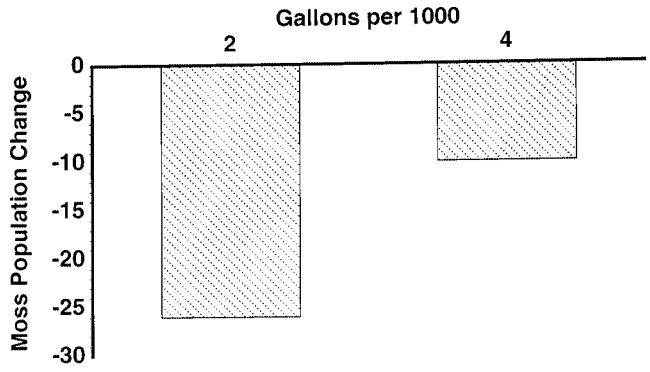
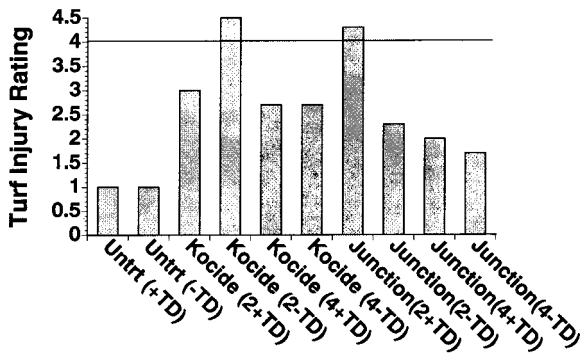
4. The 2-gallon per 1000 sq. ft. spray volume was more effective than 4-gallon (see Figure 4).

Figure 4



5. Significant injury to annual bluegrass was noted on Westchester CC plots after two applications (see Figure 5). However, this injury was short lived and was not detected on bentgrass.

Figure 5



6. Follow-up leaf and root tissues samples indicated significant increase in Cu levels (see Figure 6). Nutritional research suggests that Cu levels in the plant can vary from 25 ppm to as high 600 ppm, depending on species.
7. Soil Cu levels were highly variable and revealed weaknesses in soil testing procedures (see Figure 7). Still, on soils with pH in the 5.5 to 6.0 range, very little soil accumulation was noted. Higher pH soils might accumulate more; however, the Cu will not be available.
8. Follow-up evaluation of K- and Cu-based soap applied in Fall 2000 demonstrated substantial moss population reductions (see Figure 8).
9. Controlled environment studies begin to suggest potential for multiple low rate applications of CuOH at 1000 ppm or K-based soap product (see Figure 9).

Major Accomplishments to Date

1. Improved understanding of moss biology and ecology and the role of cultural practices in both establishment and mature phase.
2. Development of NOFA approved organic moss control.
3. Identification of optimum timing and spray volume for moss control programs.
4. Identification of potential desiccant product for moss control.
5. Potential for low rate exclusion programs to reduce moss invasion.
6. Dave Dudones' MS degree in July 2001.

Additional Studies

1. Improved understanding of the role of soil and tank water pH on control, persistence, uptake, and injury.
2. Develop "safener" technology to reduce injury that results from nutrient deficiencies.
3. Field test exclusion program.
4. Further research with K-soap to secure label in US.
5. Improve understanding of genetic diversity of putting green populations.
6. Develop cultural program to support improved chemical control and exclusion.

David Dudones and Frank S. Rossi

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Figure 6

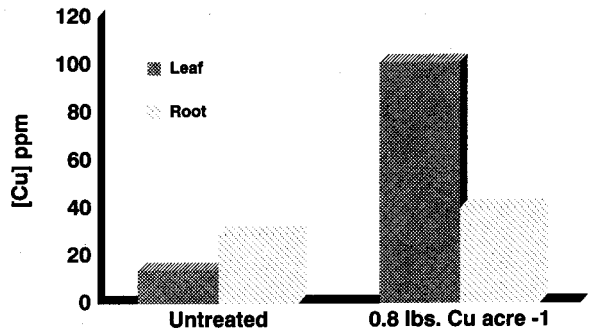

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Figure 7

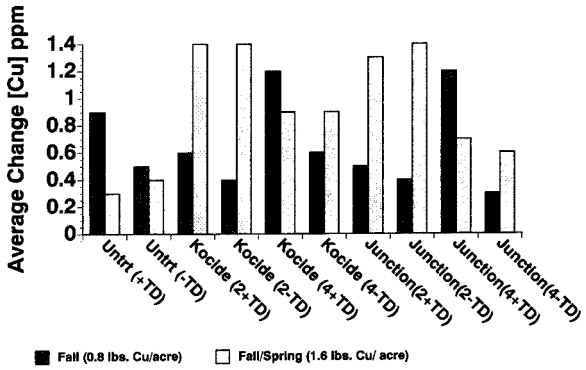

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Figure 8

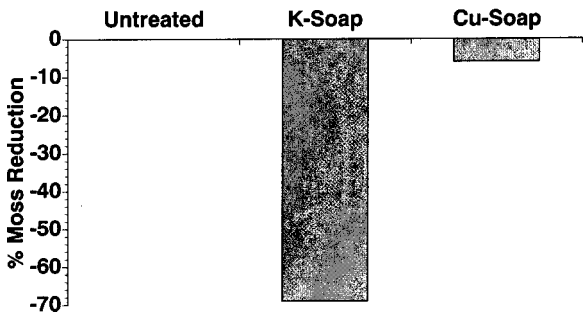

Figure 9