

# Mastering

By Pam Charbonneau

## the Moss Menace



Mowing heights and fertility rates are decreasing on putting greens, while traffic is increasing and surface organic matter is accumulating. These conditions are ideal for moss encroachment. In fact, moss is becoming one of the biggest problems facing golf course superintendents today.

The dominant invasive species of moss in putting greens is *Bryum argenteum*, commonly known as silvery thread moss. Moss is one of the simplest of the land-dwelling plants and is thought to date back 400 million years.

A survey of U.S. golf superintendents conducted by Cornell University found a high correlation between moss encroachment and close mowing, low potash levels, surface organic accumulation and the loss of heavy metal-based fungicides. The survey was designed to identify the extent of the moss problem and to key in on specific ecological factors that favoured moss invasion.

Researchers at Oregon State University noted moss is most prevalent on sand-based bentgrass putting greens. It has been found on newly constructed sand-based greens within the first year of establishment. In British Columbia, the factors found to encourage moss were low mowing heights, use of walk-behind greens mowers, high populations of bentgrass, periods of low light levels, low nitrogen fertility levels, foliar feeding, undulating greens and localized dry spots.

### Previous studies with copper hydroxide-based products

In January 2002, a four-month research trial funded by the Western Canada Turfgrass Association (WCTA) in co-operation with Evergro Canada Inc., was conducted using a product called Kocide 101 (a copper hydroxide product containing a 50-per cent metallic copper equivalent). The research built on work conducted at Oregon State University using this product.

The newest formulation is Kocide 2000 (a copper hydroxide product containing a 35-per cent metallic copper equivalent), which is a water dispersible granule. Kocide 101 and Kocide 2000 are registered for use in Canada on peppers and tomatoes. The data from British Columbia suggests Kocide 2000 works best applied at a rate of 210 g/100 m<sup>2</sup> from December through April at two-week intervals for a total of five applications. This timing, of course, would not work for putting greens in Ontario because they are covered with snow for most of December through April.

Photos courtesy Pam Charbonneau

**TABLE 1. Moss Control Treatments 2005**

Trt. #	Treatment	Product 100m <sup>2</sup>
1	0.5x rate of Kocide 2000	105 g Kocide 2000 in 8L water
2	1x rate of Kocide 2000	210 g Kocide 2000 in 8L water
3	2x rate of Kocide 2000	420 g Kocide 2000 in 8L water
4	0.5x rate of Kocide 2000 + Greenleaf Rapid Green 5-0-0 with 18% ferrous sulphate and 7% fe	105 g Kocide 2000 in 8L water + 15.3 ml Greenleaf Rapid Green
5	1x rate of Kocide 2000 + Greenleaf Rapid Green 5-0-0 with 18% ferrous sulphate and 7% fe	210 g Kocide 2000 in 8L water + 15.3 ml Greenleaf Rapid Green
6	2x rate of Kocide 2000 + + Greenleaf Rapid Green 5-0-0 with 18% ferrous sulphate and 7% fe	420 g/100 m <sup>2</sup> Kocide 2000 in 8L water + 15.3 ml Greenleaf Rapid Green
7	Greenleaf Rapid Green 5-0-0 with 18% ferrous sulphate and 7% fe	15.3 ml Greenleaf Rapid Green
8	Untreated Control	Water Only

**TABLE 2. Percentage of Moss at GTI, Dec. 29, 2005**

Treatment	Mean % moss
control	5.875a†
.5X Kocide 2000	3.5b
fe only	1.313c
1X Kocide 2000	0.5c
2X Kocide 2000	0.375c
1X Kocide 2000+fe	0.25c
.5X Kocide 2000+fe	0.125c
2X Kocide 2000+fe	0.125c

† Means within columns followed by the same letter are not significantly different (P=0.05)

### Ontario moss control trials

Trials to determine the best timing for moss control using copper hydroxide products began in Ontario in 2003. The moss trial was conducted on a local golf course (Deer Ridge Golf Club, Cambridge, Ont.) and the Guelph Turfgrass Institute (GTI), Guelph, Ont.

Based on data from Cornell, which showed they had the most success when four to six applications of copper hydroxide was applied in the fall, the Ontario moss control trials were conducted in the fall with the two formulations, Kocide 2000 and Kocide 101. Applications began late October 24, 2003. Due to poor weather conditions (an early snowfall), only two applications of Kocide 2000 and Kocide 101 were applied at two-week intervals (Oct. 24 and Nov. 7, 2003). Moss ratings were done in the fall and spring (Oct. 24, 2003, Oct. 31, 2003, Nov. 7, 2003 and April 11, 2004). The data from the GTI was unusable because Canada Geese ate the moss in most of the trial plots. Due to the fact the required number of treatments were not applied because of the early snowfall, the 2003 data will not be presented in this article.

In 2004, a similar trial using only Kocide 2000 was initiated in the fall at the Guelph Turfgrass Institute.

### Materials and methods

#### Location

In 2004, the moss control trial was conducted at the GTI on a mixed stand of creeping bentgrass (*Agrostis stolonifera* L.), annual bluegrass (*Poa annua* L.) and velvet bentgrass (*Agrostis canina* L.), growing on an 80/20-sand/peat rootzone maintained at putting green height.

In 2005, the trials were conducted at GTI as described above and the neighbouring Victoria Park West Golf Course. The golf course trials were established on a mixed stand of creeping bentgrass (*Agrostis stolonifera* L.) and annual bluegrass (*Poa annua* L.), growing on a native soil green maintained at putting green height.

#### Experimental design and applications

The experimental design for 2004 was completely randomized with three treatments and four replications. Plots were 0.25 m<sup>2</sup>. Treatments were applied roughly at two-week intervals using a 1L-pump spray bottle. In 2005, the experimental design was a randomized complete block design with eight treatments and four replications. Treatments were applied roughly at two-week intervals using a CO<sub>2</sub>-powered bicycle sprayer at 20 psi. Plots were 1 m x 1 m.

#### Treatments 2004

- Kocide 2000 applied 4x (210 g/100 m<sup>2</sup> in 8L water)
- Kocide 2000 applied 5x (210 g/100 m<sup>2</sup> in 8L water)
- Control = 8L water only

Application dates were Sept. 23, 2004, Oct. 7, 2004, Oct. 21, 2004, Nov. 10, 2004 and Nov. 29, 2004.

#### Treatments 2005

Treatment details can be found in Table 1. Treatments were applied five times and the treatment dates were Sept. 22, 2005, Oct. 6, 2005, Oct. 20, 2005, Nov. 4, 2005 and Nov. 17, 2005. Greenleaf Rapid Green is a home lawn moss control product that contains 18 per cent ferrous sulphate.

#### Evaluations 2004

Initial moss counts were performed the first day just prior to treatment using a 0.5 x 0.5-m grid divided into 25 (10 x 10-cm) quadrats. It was placed over each plot and moss percentage was estimated in each of the 25 quadrats. Moss was rated every two weeks until Nov. 29, 2004. Plots were rated on Sept. 22, 2004, Oct. 7, 2004, Oct. 21, 2004, Nov. 10, 2004, Nov. 29, 2004 and April 20, 2005.

## Evaluations 2005

Initial moss counts were performed two days before the first treatment and roughly every four weeks after the initial treatment. Moss rating dates were Sept. 20, 2005, Oct. 13, 2005, Nov. 8, 2005 and Dec. 29, 2005. Percentage of moss was estimated visually using a 0.5 x 0.5-m grid, which was divided into four quadrats. Percentage of moss was estimated for each of the quadrats. It was placed over the centre of each plot.

## Results and discussion 2004

The initial moss infestation on the research greens at the Guelph Turfgrass Institute was 10 to 15 per cent (Figure 1). The treatments were four applications of Kocide 2000, five applications of Kocide 2000 and an untreated control. Treatments were applied every two weeks.

The percentage of moss increased slightly from the first observation date to the second. On the third and fourth observation dates, the percentage of moss decreased very slightly. The moss percentage rating after the fourth application of Kocide 2000 showed a dramatic decrease, down to less than two percent of moss (Figure 1). Plots could not be rated after the fifth application due to permanent snow cover.

By the time the plots were rated in the spring, those treated with Kocide 2000 were near zero percent for moss, which was significantly different from the untreated control. There were no significant differences between four and five applications of Kocide 2000 in this study. This data reflects the results from Cornell University that found at least four applications of Kocide 2000 are necessary to achieve good moss control.

## Results and discussion 2005, GTI

### Percent moss control

The 2005 treatments contain a 0.5x rate of Kocide 2000, a 0.5x rate of Kocide 2000 + Greenleaf Rapid Green, a 2x rate of Kocide 2000 and a 2x rate of Kocide 2000 + Greenleaf Rapid Green. These four treatments were requested by the Pest Management Regulatory Agency (PMRA) to determine the lowest effective rate and if there would be any phytotoxicity due to an accidental double application of the product. (This data will not be discussed in this article.)

Initial moss infestation on the selected plot area on the greens at GTI ranged from 10 to 15 per cent. From the time the initial moss ratings were made (Sept. 20, 2005) to the first post-application rating date (Oct. 13, 2005), the percentage of moss increased on all plots (Figure 2). By the last rating (42 days after the last treatment), the control plot had significantly more moss than the 0.5x Kocide 2000 plot (Table 2). All the other treatments were significantly better than the 0.5x Kocide 2000 plot and the untreated control.

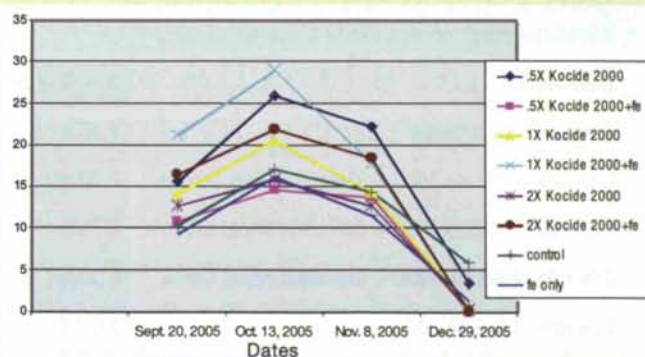
### Quality

Visual quality was rated at the end of the study on a scale of one to nine, with nine being best and six acceptable (Table 3). The highest quality ratings were the plots that received Greenleaf Rapid Green and the 0.5x Kocide 2000 + Greenleaf Rapid Green. These two treatments did not differ significantly from each other. There were significant differences between the 0.5x rate of Kocide 2000 and the 0.5x Kocide 2000 + Greenleaf Rapid Green, with the Kocide 2000 alone having a lower quality rating. The 1x rate of Kocide 2000 and the 1x rate of Kocide 2000 + Greenleaf Rapid Green did not differ significantly.

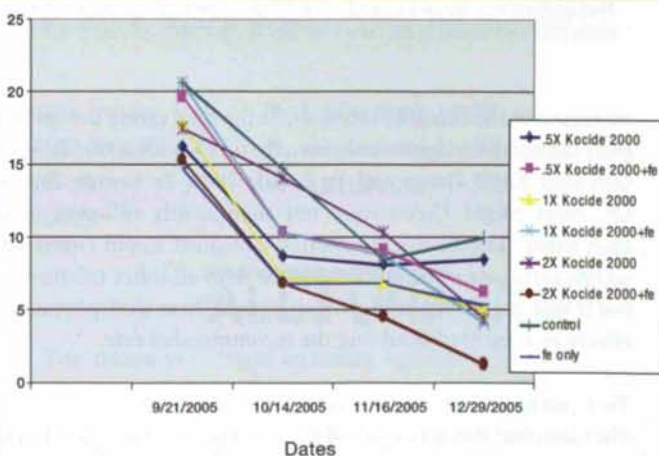
**Figure 1. Effect of Kocide 2000 on Moss at Guelph Turfgrass Institute, 2004**



**Figure 2. Effect of Moss Control Products on Moss at GTI, 2005**



**Figure 3. Effect of Moss Control Treatments on Moss Percentage at Victoria Park Golf Course West, 2005**



## Results and discussion 2005, Victoria Park

### Percentage of moss control

Victoria Park West Golf Course started with moss cover ranging from 15 to 20 per cent (Figure 3). From the beginning to the end of the trial, the percentage of moss decreased at each rating date until Nov. 11, 2005. For the final rating, the percentage of moss

**TABLE 3. Turf Quality Rating at GTI, 2005**

Treatment	Turf Quality
Greenleaf Rapid Green	7.125a†
0.5x rate of Kocide 2000 + Greenleaf Rapid Green	6.625ab
1.0x rate of Kocide 2000 + Greenleaf Rapid Green	6.500bc
1.0x rate of Kocide 2000	6.250bcd
2.0x rate of Kocide 2000 + Greenleaf Rapid Green	6.250bcd
0.5x rate of Kocide 2000	6.000cde
Untreated	5.875de
2.0x rate of Kocide 2000	5.500e

†Turf quality ratings are on a scale of 1-9, with 9 being best and 6 acceptable. Means within columns followed by the same letter are not significantly different (P=0.05)

**TABLE 5. Average Turf Quality Rating at Victoria Park West Golf Course, 2005**

Treatment	Turf Quality
Greenleaf Rapid Green	7.500a†
0.5x rate of Kocide 2000 + Greenleaf Rapid Green	7.000ab
1.0x rate of Kocide 2000 + Greenleaf Rapid Green	6.750b
2.0x rate of Kocide 2000 + Greenleaf Rapid Green	6.500b
1.0x rate of Kocide 2000	5.625c
Untreated	5.625c
0.5x rate of Kocide 2000	5.500c
2.0x rate of Kocide 2000	5.500c

†Turf quality ratings are on a scale of 1-9 with 9 being best and 6 acceptable. Means within columns followed by the same letter are not significantly different (P=0.05)

**TABLE 4. Percentage of Moss at Victoria Park West Golf Course, Dec. 29, 2005**

Treatment	Mean % moss
control	10.00a†
.5x Kocide 2000	8.438ab
.5x Kocide 2000+fe	6.25bc
fe only	5.313c
1x Kocide 2000	5c
2x Kocide 2000	4.375c
1x Kocide 2000+fe	4.063c
2x Kocide 2000+fe	1.25d

† Means within columns followed by the same letter are not significantly different (P=0.05)

### Conclusions

As mentioned, the 2x Kocide 2000 rates were for experimental purposes to determine phytotoxicity to the turf and this data will not be included in the conclusions. Based on the combined moss ratings from the Guelph Turfgrass Institute and the Victoria Park West Golf Course locations, the Greenleaf Rapid Green, 1x Kocide 2000 or the 1x Kocide 2000 + Greenleaf Rapid Green provided significant moss control on mixed stands of turf maintained at putting green height.

When the quality data is also considered, five applications of Greenleaf Rapid Green alone as a fertilizer or the 1x Kocide 2000 + Greenleaf Rapid Green applied at two-week intervals in the fall could be recommended for moss control once Kocide 2000 receives registration from the Pest Management Regulatory Agency.

The 1x Kocide 2000 alone at the Victoria Park West Golf Course resulted in unacceptable turf quality by the end of the study period. Recommendations for the use of five applications of Kocide 2000 applied at two-week intervals in the fall should include regular iron applications to ensure turf quality does not suffer due to copper-induced iron chlorosis from Kocide 2000. Q.

### Literature cited

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increased in the control plots only. At the final rating the control plots did not differ significantly from the 0.5x Kocide 2000 (Table 4). Greenleaf Rapid Green and 1x Kocide 2000, 2x Kocide 2000 + Greenleaf Rapid Green were not significantly different from each other. The 2x Kocide 2000 + Greenleaf Rapid Green was significantly better at controlling moss than all other treatments, but it was only in the trial to determine if there were phytotoxic effects as a result of doubling the recommended rate.

#### *Turf quality at Victoria Park West Golf Course, 2005*

The Greenleaf Rapid Green and the 0.5x Kocide + Greenleaf Rapid Green did not differ significantly in terms of turf quality (Table 5). The Greenleaf Rapid Green had significantly higher overall quality than all the remaining treatments. All rates of Kocide 2000 + Greenleaf Rapid Green did not differ significantly. All rates of Kocide 2000 only and control were significantly lower in quality than the Kocide 2000 rates with the Greenleaf Rapid Green and these were all below the acceptable range (<6).