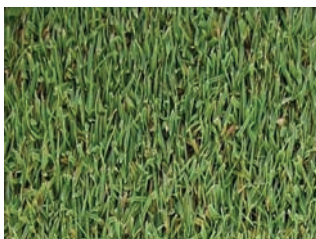




Fungicides can mitigate injury and improve creeping bentgrass quality

Tank-mixing can improve summer turf quality of creeping bentgrass greens.



Summer decline of putting green turf is generally caused by a combination of biotic and abiotic stress factors. In the absence of disease, some fungicides improve summer quality in creeping bentgrass (*Agrostis stolonifera*) maintained as greens. Previous studies have documented improved summer performance of creeping bentgrass greens treated with Chipco Signature (fosetyl aluminum; Bayer Environmental Science), especially when tank-mixed with either Daconil Ultrex (chlorothalonil; Syngenta Crop Protection) or Fore Rainshield (pigmented mancozeb; Dow AgroSciences) (2). A 2006 study showed that selected fungicides played a major role in reducing yellow spot (causal agent not determined) and injury from scalping. A 2007 follow-up study pursued additional information regarding the impact of fungicides on summer bentgrass decline management, mechanical injury and unusual disorders. The objectives of this study were to determine whether Chipco Signature, Alude (potassium salts of phosphorous acid), Fore Rainshield, Insignia (pyraclostrobin), Macrosorb Foliar (amino acids), Protect (mancozeb without pigment), Trinity (triticonazole) and other tank-mix combinations would improve the summer quality of creeping bentgrass maintained as a green.

Scalping

Scalping and yellow spot provided the most important treatment effects in this two-year field study. Scalping is the removal of excessive shoot tissue, which leaves turf appearing tan or

brown. Scalping may occur when the mower is out of adjustment, if mowing height is drastically reduced or if the bedknife is worn too thin (7). Scalping also is promoted by excessive shoot growth and by the presence of thick thatch layers. Excessive shoot growth can result from applications of large amounts of nitrogen or weather conditions that force long periods without mowing. During periods of heat stress and high humidity when turf is too wet from excessive rain or irrigation, the thatch and plant stems swell, causing the stems to lift. When this occurs, the grass is said to be “puffy.” Mowers sink into swollen thatch and remove an excessive amount of plant tissue, scalping the turf.

Yellow spot

Yellow spot is an undescribed malady of closely mowed turf on golf courses. In the mid-Atlantic region of the U.S., it is seen mainly in creeping bentgrass on sand-based root zones of greens and tees. Symptoms appear in summer as yellow spots or patches ranging from 1 to 6 inches (2.5 to 15 centimeters) in diameter, and spots are typically about 2 to 3 inches (5.0 to 7.5 centimeters) across. Turf within the spots usually does not thin out, making yellow spot largely a visual problem. Yellow spot often appears almost overnight in large numbers in the summer during periods of high humidity and nighttime temperatures (>70 F [>21 C]). The spots may rapidly disappear with the advent of cooler night temperatures (<65 F [<18 C]) in late August, but some can remain

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In the mid-Atlantic region of the U.S., yellow spot is seen mainly in creeping bentgrass on sand-based root zones of greens and tees. Photos by P. Dernoeden

until October, when night temperatures normally are below 60 F (≤ 15.6 C).

The proposed causal agents of yellow spot are cyanobacteria in the genera *Oscillatoria* and *Phormidium* (6). Cyanobacteria previously were classified as blue-green algae. Among true algae, only a few species of green algae are found in turf, and their possible role in turf maladies is unknown (4). Cyanobacteria are common in turf, and high populations can accumulate to form scum, which can seal the surface. Their slimy filaments also can bind sand particles and impede water infiltration and percolation.

Although the mechanism of inducing chlorosis is not known, high levels of cyanobacteria may cause chlorosis through the production of a toxin or of iron-chelating compounds called siderophores (6).

Materials and methods

In 2006 and 2007, the study was conducted on an 80/20 sand/sphagnum peat moss (volume/volume) creeping bentgrass green constructed to

USGA recommendations. The area was stripped of existing sod and seeded to Declaration creeping bentgrass in September 2005. Declaration creeping bentgrass became puffy in June and was inadvertently scalped in July and August in both study years.

Fertility

The study area was fertilized with 4.5 pounds nitrogen/1,000 square feet (21.9 grams/square meter) mostly from 20-20-20 (N-P-K) between Sept. 20 and Nov. 11, 2005. Between Sept. 20 and Nov. 17, 2006, the site received 0.25 pound nitrogen/1,000 square feet (1.2 grams/square meter) at two-week intervals to provide 1.5 pounds nitrogen/1,000 square feet (7.3 grams/square meter) from 20-20-20 (N-P-K). The turf received 1.0 to 1.75 pounds nitrogen/1,000 square feet (4.9-8.5 grams/square meter) in April and May 2006 and 2007. Except as noted below, no additional nitrogen was applied during the study period in 2006 or 2007.

Mowing

Turf was mowed five times weekly at 0.156 inch (4.0 millimeters) and otherwise maintained as a green. On July 27, 2007, the site was verticut (blade width = 1 millimeter; spacing = 2 centimeters) to address puffiness and scalping, and an additional 0.5 pound nitrogen/1,000 square feet (2.4 grams/square meter) from 20-20-20 (N-P-K) was applied.

Applications

Treatments were applied every two weeks beginning in June and ending in late July or early August of both years. The products tested and their application rates are listed in Table 1.

Evaluated products

Trade name and formulation	Common name	Manufacturer	Rate	
			Kilograms a.i./hectare	Ounces product/1,000 square feet
Daconil Ultrex 2.5 DG	chlorothalonil	Syngenta Crop Protection	8.0	3.2
Chipco Signature 80 WP	fosetyl aluminum	Bayer Environmental Science	9.8	4.0
Fore Rainshield 80 WP	mancozeb (pigmented)	Dow AgroSciences	14.6	6.0
Protect 75 DF	mancozeb	Cleary Chemical	18.3	8.0
Alude 5.2 L	mono- and di-potassium salts of phosphorous acid	Cleary Chemical	7.9/10.9	4.0/5.5
Insignia 20 WG	pyraclostrobin	BASF	0.30/0.55	0.5/0.9
Trinity 1.69 SC	triticonazole	BASF	0.6	1.0
Macrosorb Foliar	nitrogen from amino acids	Nutrimax Agriculture	7.0 kg N/ha	2.0

Table 1. Trade name, common chemical name, manufacturer and metric-English rate conversions for products evaluated.



Turf quality and yellow spot, 2006

Treatment*	Rate (ounces/1,000 square feet)	Turf quality (0-10)						Yellow spot (no./plot)		
		Jun 15	Jul 5	Jul 14	Jul 28	Aug 4	Aug 18	Aug 4	Aug 11	Aug 18
Chipco Signature	4.0	7.8 abc [†]	6.4 cd	6.3 de	5.6 cd	5.3 c	5.6 abc	16 ab	32 a	26 ab
Chipco Signature + Daconil Ultrex	4.0 + 3.2	8.3 ab	8.1 ab	8.1 ab	8.1 a	6.9 a	6.6 a	2 b	4 b	3 c
Insignia	0.5	7.5 c	6.3 cd	6.5 cd	5.4 de	5.1 c	5.1 bc	24 a	35 a	34 a
Insignia	0.9	8.3 ab	7.3 bc	7.4 bc	6.6 bc	5.8 bc	5.9 abc	8 b	16 ab	16 abc
Insignia + Alude	0.5 + 4.0	7.5 c	5.8 de	6.1 de	5.3 de	4.9 cd	5.0 c	14 ab	31 a	26 ab
Alude + Fore Rainshield	4.0 + 6.0	8.4 a	8.5 a	8.6 a	8.0 a	6.6 ab	6.3 ab	2 b	18 ab	25 ab
Macrosorb Foliar + Daconil Ultrex	2.0 + 3.2	8.3 ab	6.5 cd	7.9 ab	7.4 ab	6.8 a	6.4 a	2 b	4 b	9 bc
Untreated	—	7.3 c	5.0 e	5.4 e	4.6 e	4.1 d	4.8 c	24 a	31 a	23 ab

*Applied on June 5, June 19, July 3 and July 17, 2006.

[†]Means in a column followed by the same letters are not significantly different.

Table 2. Turf quality and yellow spot severity in Declaration creeping bentgrass, as influenced by fungicides and Macrosorb Foliar targeting summer bentgrass decline in College Park, Md., in 2006.



Left: Treated with Alude + Fore Rainshield. **Right:** Untreated. On all rating dates, Chipco Signature + Daconil Ultrex and Alude + Fore Rainshield ameliorated scalping injury.

Ratings

Turfgrass quality was rated visually on a 0-10 scale, where 0 is brown or dead turf, 7 is minimal acceptable quality for a creeping bentgrass putting green, 8 is very good summer quality, and 10 is optimal uniformity and density. Injury from vertical cutting was assessed visually on a 0-5 scale, where 0 is no injury; 2.5 is objectionable browning and 5.0 is more than 50% of the plot area brown or tan. Yellow spot became pronounced the week of July 24, 2006, and Aug. 6, 2007, and was evaluated by counting the number of spots in each plot.

Dollar spot, brown patch and other diseases

did not develop beyond trace levels in the study site during the experiments. Not all treatments were assessed in both years, and not all data are shown because of space limitations.

2006 results

Quality

From the onset of the study, the creeping bentgrass was subjected to inadvertent scalping, which resulted in a generalized browning of the foliage. Scalping caused by “puffy” turf was the principal reason for the poor quality observed in untreated plots and many treated plots. On all rating dates, the scalping injury was ameliorated by Chipco Signature + Daconil Ultrex and Alude + Fore Rainshield (Table 2). Both treatments had improved quality to a rating of 8.0 (that is, very good quality) or above between June 15 and July 28, but not thereafter.

Plots treated with the high rate of Insignia and Macrosorb Foliar + Daconil Ultrex also improved bentgrass quality significantly (Table 2), but quality was generally lower than that observed in plots treated with Chipco Signature + Daconil Ultrex and Alude + Fore Rainshield. The nitrogen component in Macrosorb Foliar likely was responsible for improved color and quality. Indeed, plots treated with Macrosorb Foliar + Daconil Ultrex exhibited improved quality on all rating dates, when compared to untreated plots. The high rate of Insignia improved turf quality from June 15 to Aug. 4, but not thereafter. The quality of creeping bentgrass treated with Insignia (low rate) and Insignia + Alude was poor throughout the summer. Chipco Signature applied alone only slightly improved quality on some dates (Table 2).

Yellow spot

Yellow spot unexpectedly developed uniformly across the study area in late July 2006. The number of yellow spots was reduced significantly in plots treated with Daconil Ultrex and Fore Rainshield, but not in plots treated with Chipco Signature or Insignia on July 28 and Aug. 4 (Table 2). By Aug. 11, however, yellow spot in plots treated with Alude + Fore Rainshield was equivalent to yellow spot in the control. On Aug. 18, only plots treated with Signature + Daconil Ultrex had smaller numbers of yellow spots than the control. Plots treated with Macrosorb Foliar + Daconil Ultrex had yellow spot numbers equivalent to both Signature + Daconil-treated plots and the control at the end of the study.

Daconil and Fore Rainshield are known to control cyanobacteria (that is, blue-green algae) on greens, but Daconil generally is superior for

this purpose (2). Cyanobacteria were not seen in turf samples, but an unidentified species of *Curvularia* was isolated from yellow leaf tissue, which had no lesions.

2007 results

Quality

The effects of fungicides on creeping bentgrass quality were first observed 14 days (June 28) after the initial application (Table 3). Between June 28 and Aug. 25 (some data not shown), plots treated with Chipco Signature + Daconil Ultrex or Alude + Fore Rainshield had quality superior to that of untreated turf and had quality ratings greater than 8.0 (that is, very good summer quality) on nearly all rating dates. Signature, Fore and Protect alone were associated with improved quality on three of four rating dates between July 12 and Aug. 1. After Aug. 1, the quality of plots treated with Signature alone was similar to that of untreated turf, but plots treated with Fore and Protect showed improved quality until Aug. 25. Except for July 12, quality ratings associated with Signature alone were less than 8.0 on all rating dates between June 14 and July 26. After July 26, Signature-treated turf had generally poor quality, and plots often had ratings at or below 7.0 (minimally acceptable). As observed in 2006, Daconil Ultrex and Alude alone did not affect turf quality. Trinity had no effect on quality until after applications ceased on Aug. 2. Trinity-treated plots exhibited enhanced turf quality from Aug. 10 to Aug. 31 (some data not shown).

Vertical cutting injury

On July 27, the study area was vertical cut in one direction to reduce puffiness. This operation caused significant mechanical damage. Plots were rated for injury six, 14 and 21 days following vertical cutting (Table 3).

Some fungicide treatments had striking effects. Plots treated with Protect, Fore Rainshield, Alude + Protect and Alude + Fore sustained less damage than was observed in all other plots. These fungicides reduced injury ratings below the objectionable threshold (2.5), but plots treated with Daconil Ultrex, Trinity, Alude, Signature and Signature + Daconil Ultrex had injury ratings equivalent to the control for the first 14 days after vertical cutting. By Aug. 17, only trace levels (≤ 1.0) of injury were observed in plots treated with Alude + Fore and Trinity.

These data suggest that Protect and Fore in some way protect, strengthen or modify plants and thus improve their ability to resist and/or recover more rapidly from mechanical injury.

Yellow spot

Yellow spot levels in 2007 were too low to draw any conclusions.

Discussion

Scalping

Throughout the summer in 2006 and 2007, plots treated with Chipco Signature + Daconil Ultrex and Alude + Fore Rainshield suffered less injury from scalping, which resulted in improved quality ratings. Chipco Signature contains a proprietary compound called StressGard, which is said to have beneficial physiological effects on plants during periods of summer stress. Chipco Signature and Fore Rainshield also contain a pigment that provides a noticeable "paint effect" for about seven to 10 days, but it probably was not responsible for masking all of the scalping injury.

Chipco Signature + Daconil Ultrex and Alude + Fore Rainshield showed improved quality (that is, less scalping injury) within 14 days after their final application in 2006 and within 23 days afterward in 2007. Therefore, to maintain improved summer quality, the treatments may need to be applied continuously on a 14- to 21-day interval.

This may be the first study that has demonstrated that, in addition to Chipco Signature, a potassium phosphite product, Alude, tank-mixed with Fore Rainshield, also dramatically improves summer bentgrass quality. Furthermore, this

Turf quality and vertical cutting injury, 2007

Treatments*	Rate (ounces/ 1,000 square feet)	Turf quality (0-10)						Vertical cutting injury (0-5)		
		Jun 14	Jun 28	Jul 12	Jul 26	Aug 1	Aug 25	Aug 2	Aug 10	Aug 17
Daconil Ultrex	3.2	6.8 bc ¹	6.8 cde	6.9 def	6.0 d	6.1 de	6.8 cd	3.4 a	2.6 a	2.4 ab
Protect	8.0	6.9 bc	7.6 abcd	7.3 cde	7.5 bc	7.1 cd	8.0 ab	1.4 c	0.8 cd	1.1 c
Fore Rainshield	6.0	7.0 abc	7.4 bcd	7.8 cd	7.5 bc	7.3 bcd	7.6 bc	1.4 c	0.8 cd	1.1 c
Trinity	1.0	6.9 bc	6.4 de	6.0 f	5.5 d	5.6 e	8.8 ab	2.9 a	1.8 abc	0.9 cd
Alude	5.5	6.4 c	5.6 e	6.4 ef	6.5 cd	6.1 de	6.6 cd	2.8 ab	2.3 ab	2.3 ab
Chipco Signature	4.0	7.0 abc	7.6 abcd	8.1 bc	7.8 bc	6.5 de	6.6 cd	2.8 ab	1.5 bcd	1.8 bc
Chipco Signature + Daconil	4.0 + 3.2	7.3 abc	8.0 abc	8.8 ab	8.8 ab	8.1 abc	8.1 ab	2.5 b	1.4 bcd	1.3 bc
Chipco Signature + experimental	4.0 + 1.5	7.6 ab	8.8 a	9.5 a	9.6 a	9.0 a	9.0 a	0.8 c	0.5 d	0.1 d
Alude + Protect	5.5 + 8.0	6.9 bc	6.5 de	6.8 ef	6.8 cd	6.8 de	6.6 cd	1.4 c	1.1 cd	1.5 bc
Alude + Fore Rainshield	5.5 + 6.0	7.9 a	8.4 ab	8.8 ab	8.5 ab	8.4 ab	7.8 bc	1.1 c	0.8 cd	0.9 cd
Untreated	-	7.1 abc	6.5 de	6.3 ef	6.0 d	5.6 e	6.2 d	3.3 ab	2.7 a	2.8 a

*Applied on June 7, June 21, July 5, July 19 and Aug. 2, 2007.

¹Means in a column followed by the same letter are not significantly different.

Table 3. Quality and vertical cutting injury in Declaration creeping bentgrass as influenced by fungicides targeting summer bentgrass decline, College Park, Md., in 2007.



Left: Treated with Alude + Fore Rainshield. **Right:** Untreated. Plots treated with Protect, Fore Rainshield, Alude + Protect and Alude + Fore sustained less damage from verticutting than all other treatments.



The research says

→ Chipco Signature + Daconil Ultrex and Alude + Fore Rainshield improved summer creeping bentgrass quality and reduced scalping injury.

→ Protect and Fore, individually and in combination with Alude, reduced injury from vertical cutting.

→ The mechanisms by which fungicides mitigate scalping and vertical cutting injury were not determined, but several theories are proposed.

→ We did not determine the cause of yellow spot, but Daconil Ultrex and Fore Rainshield reduced its severity.

likely is the first report of mancozeb (Protect and Fore) reducing injury from vertical cutting.

Cursory Maryland field studies have shown that creeping bentgrass plants treated with Chipco Signature do not have elevated chlorophyll or nutrient levels, they do not exhibit improved photosynthesis or more efficient respiration, and their canopy temperature is unaffected (Dernoeden, unpublished). Research at Virginia Tech, however, has shown that treating turf with Chipco Signature results in longer maintenance of antioxidant activity during heat stress (E. Ervin, personal communication). Antioxidants improve heat-stress tolerance in plants and delay tissue senescence.

The mechanism enabling Chipco Signature + Daconil Ultrex and Alude + Fore Rainshield to mitigate scalping injury is unknown. Close visual inspection of plots two weeks following the final application of these treatments revealed that the pigment was no longer visible and that leaves did not appear to have been damaged by scalping. Therefore, the beneficial effects associated with these treatments are not simply a “paint effect.” Perhaps these fungicide combinations modify plant morphology, structure, growth habit or growth rate. For example, creeping bentgrass leaves treated with these fungicides may develop thicker cuticles and/or cell walls or possibly slow growth or in some way reduce puffiness.

Yellow spot

We did not determine the cause of the disease we call yellow spot. In 2006 and 2007, affected creeping bentgrass samples did not contain cyanobacteria as described by other researchers (6). *Curvularia* species were found on senescent and dead tissue in samples, but the yellow spot symptoms observed did not fit a description of *Curvularia* blight (1). The yellow spot symptoms observed did mimic the description of yellow dwarf, a dis-

ease of creeping bentgrass greens in Japan (5). Regardless, Daconil Ultrex and Fore Rainshield reduced the severity of the malady observed in this study and yellow spot associated with cyanobacteria in California (3).

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