Mechanical Injury and Yellow Spot In Bentgrass As Influenced By Fungicides

Peter H. Dernoeden* and Jinmin Fu

Department of Plant Science and Landscape Architecture, University of Maryland, College Park, MD 20742

INTRODUCTION

Summer bentgrass decline generally is caused by a combination of biotic and abiotic stress factors. Some fungicides have been shown to improve summer quality in creeping bentgrass (*Agrostis stolonifera* L.) maintained as putting greens in the absence of disease. For example, previous studies have documented improved summer performance of creeping bentgrass putting green turf treated with fosetyl aluminium (FA), especially when tank-mixed with either chlorothalonil (CHLOR) or pigmented mancozeb (P-MAN) (Dernoeden, 2002). Observations from 2006 showed that selected fungicides played a major role in reducing injury due to scalping and the malady referred to as yellow spot (incitant unknown). Additional information regarding the impact of summer bentgrass decline management, mechanical injury and unusual disorders is warranted.

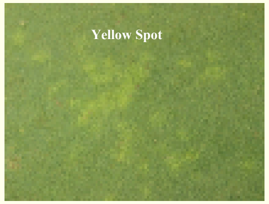
OBJECTIVES

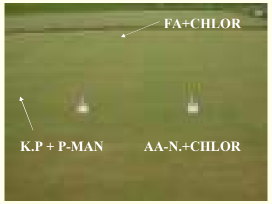
To determine if CHLOR, FA, P-MAN, potassium salts of phosphorous acid (K-P); mancozeb without pigment (MAN); pyraclostrobin (PYRAC); nitrogen from amino acids (AA-N); and other tank-mix combinations would improve the summer quality of creeping bentgrass maintained as a putting green.

MATERIALS AND METHODS

This two year field study was conducted on an 80/20 sand/sphagnum peat moss (v/v) creeping bentgrass putting green constructed to USGA specifications. The area was seeded to "Declaration" creeping bentgrass in September 2005. The bentgrass received between 50 and 75 kg N ha^{-1} from urea in the spring of 2006 and 2007. Except as noted below, the study area received no additional N during the study period in either year. The turf was mowed five times weekly to a height of 3.9 mm and otherwise maintained as a putting green. On 27 July 2007, the site was vertical cut (blade width 1mm; spacing 2 cm) to address puffiness and scalping. An additional 25 kg N ha-1 from 20-20-20 were applied at that time.

Trade names, common chemical names, rates evaluated in English and metric units and manufactures are shown in Table 1. Due to space limitations, all treatment combinations could not be assessed. Treatments were applied with a CO_2 pressurized sprayer (262 kPa) equipped with an 8004E flat fan nozzle and calibrated to deliver 468 L ha^{-1}. Plots were 1.5 m by 3.0 m and arranged as a randomized complete block with four replications. Treatments were applied every two weeks beginning in June and ending late July or early August. From the onset of the study in both years, the bentgrass was subjected to inadvertent scalping, which resulted in a generalized browning of the foliage. Turfgrass quality and color were assessed visually on a 0 to 10 scale where 0 = brown or dead turf; 7.0 = minimum acceptable color or quality for a putting green; 8.0=very good summer color and/or quality; and 10 = optimum greenness, uniformity and density. Injury from vertical cutting was assessed visually on a 0 to 5 scale where 0 = no injury; 2.5 = objectionable browning; and 5.0 = over 50% of the plot area brown or tan. Yellow spot (incitant unknown) became pronounced the week of 24 July 2006 and was evaluated by counting the number of spots in each plot. Data were subjected to analysis of variance and significantly different means were separated by Fisher's least significant difference test (LSD) at $P \leq 0.05$. Some data are not shown.





RESULTS

2006 Results

Color. Turf color differences did not become apparent until a few days following the second application of treatments on 22 June 2006. Between 22 June and 4 August, turf color was improved on all rating dates by FA + CHLOR and K-P + P-MAN (Table 2). Plots treated with either the high rate of PYRAC or AA-N + CHLOR also improved color on most rating dates, when compared to untreated turf. The FA alone improved turf color on 5 out of 11 rating dates, but color ratings were seldom above 7.0 (i.e. minimum acceptable). The low rate of PYRAC and PYRAC + K-P had little or no effect on foliar color. None of the treatments consistently improved color above the 8.0 rating (i.e., very good), but plots treated with FA + CHLOR and K-P + P-MAN generally had higher color ratings than other treatments throughout the study period. Turf color in plots treated with FA + CHLOR and K-P + P-MAN as well as other treatments fell rapidly following the final application on 17 July. This suggested that the pigment in FA and P-MAN was largely responsible for the improved color observed.

Quality. Quality ratings take into consideration color as well as texture, density and the effects of mechanical injury from scalping. FA + CHLOR and K-P + P-MAN had improved quality above the 8.0 level on all dates between 22 June and 21 July (Table 3; some data not shown). Plots treated with the high rate of PYRAC and AA-N + CHLOR also improved bentgrass quality significantly, which generally were quality levels lower than observed in plots treated with FA + CHLOR or K-P + P-MAN. The N component in AA-N likely was responsible for improved quality. The quality of bentgrass treated with FA, PYRAC (low rate) and PYRAC + K-P as well as the untreated control was poor throughout the entire summer. Quality declined rapidly in FA + CHLOR and K-P + P-MAN-treated plots two weeks following the final application of treatments. The improved quality associated with some treatments was due in part to color enhancement, but mostly due to a reduction in injury from scalping.

Yellow spot. Yellow spot appeared in late July 2006, but the cause of yellow spot symptoms observed was not determined. Yellow spot was reduced significantly in plots treated with CHLOR and P-MAN, but not in plots treated with FA or PYRAC on 28 July and 4 August 2006 (Table 4). By 11 August, however, plots treated with K-P + P-MAN experienced an increase in yellow spot to levels equivalent to the untreated control. On 18 August, only plots treated with FA + CHLOR had smaller numbers of yellow spots versus the control. Plots treated with AA-N + CHLOR had yellow spot numbers equivalent to both FA + CHLOR-treated plots and the control at the end of the study. While data support the theory that cyanobacteria were the cause of the yellow spots observed, trichomes of cyanobacteria were not found in turf samples collected from the site.

Table 1. Common chemical name and formulation, trade name, manufacturer and metric-English rates conversions for products evaluated.

Common Name/Code	Trade Name	Manufacturer	Rate kg ai ha^{-1}	Rate oz prod./1000ft²
Chlorothalonil = CHLOR	Daconil Ultrex 82.5 DG	Syngenta Crop Protection, NC	8.0	3.2
Fosetyl Aluminium = FA	Chipco Signature 80 WP	Bayer Environmental Services, NC	9.8	4.0
Mancozeb (Pigmented) = P-MAN	Fore Rainshield 80 WP	Dow AgroSciences, IN	14.6	6.0
Mancozeb = MAN	Protect 75 DF	Cleary Chemical Corp., NJ	18.3	8.0
Mono-and di-potassium salts of phosphorous acid = K-P	Alude 5.2 L	Cleary Chemical Corp., NJ	7.9	4.0
Pyraclostrobin = PYRAC	Insignia 20 WG	BASF Corp., NC	0.30 and 0.55	0.5 and 0.9
Nitrogen from Amino Acids = AA-N	Macrosorb Foliar	Nutrimax Agriculture Inc., MD	7.0 kg N ha^{-1}	2.0

Table 2. Turf color as influenced by fungicides and amino acids targeting summer decline in Declaration creeping bentgrass, College Park, MD, 2006.

Treatment [y]	Rate (kg ai ha^{-1})	Turf color 22 Jun	7 Jul	21 Jul	4 Aug
		0 to 10			
Fostyl-Al	9.8	7.0 bc [z]	6.3 bc	5.9 bcd	5.1 bc
Fostyl-Al + Chlorothalonil	9.8 + 8.0	8.0 a	7.5 a	8.0 a	6.6 a
Pyraclostrobin	0.30	7.0 bc	5.9 bc	5.4 cde	4.9 bcd
Pyraclostrobin	0.55	7.5 ab	6.8 ab	6.4 bc	5.6 b
Pyraclostrobin + K. Phosphite	0.30 + 7.9	6.5 c	5.5 cd	5.3 de	4.6 cd
K. Phosphite + P. Mancozeb	7.9 + 14.6	7.8 ab	7.5 a	7.8 a	6.6 a
Amino Acids + Chlorothalonil	7.0 + 8.0	7.1 bc	6.4 bc	6.5 b	6.6 a
Untreated	--	6.4 c	4.6 d	4.5 e	4.0 d

[y] Treatments were applied on 5 and 19 June; and 3 and 17 July, 2006.
[z] Means followed by the same letters are not significantly different based on a Fisher's least significant difference ($P \leq 0.05$) test.

Table 3. Turf quality as influenced by fungicides and amino acids targeting summer decline in Declaration creeping bentgrass, College Park, MD, 2006.

Treatment [y]	Rate (kg ai ha^{-1})	Turf quality 22 Jun	7 Jul	21 Jul	4 Aug
		0 to 10			
Fostyl-Al	9.8	7.3 ab [z]	6.5 bd	6.1 bc	5.3 c
Fostyl-Al+ Chlorothalonil	9.8 + 8.0	8.0 a	8.3 a	8.3 a	6.9 a
Pyraclostrobin	0.30	7.3 ab	6.3 d	5.5 cd	5.1 c
Pyraclostrobin	0.55	7.8 a	7.3 b	6.5 b	5.8 bc
Pyraclostrobin + K. Phosphite	0.30 + 7.9	6.6 b	6.0 d	5.4 cd	4.9 cd
K. Phosphite + P. Mancozeb	7.9 + 14.6	7.9 a	8.6 a	8.4 a	6.6 ab
Amino Acids + Chlorothalonil	7.0 + 8.0	7.3 ab	7.0 b	6.8 b	6.8 a
Untreated	--	6.6 b	4.6 e	4.6 d	4.1 d

[y] Treatments were applied on 5 and 19 June; and 3 and 17 July, 2006.
[z] Means followed by the same letters are not significantly different based on a Fisher's least significant difference ($P \leq 0.05$) test.

2007 Results

Color. Fungicides initially were applied on 7 June and one week later plots treated with FA + CHLOR and K-P + P-MAN exhibited improved color (data not shown). The aforementioned treatments provided improved color ratings on all dates between 14 June (not shown) and 10 August (Table 5). Plots treated with CHLOR and FA had improved color on 5 or 6 rating dates between 28 June and 10 August. Plots treated with P-MAN and MAN alone did not exhibit improved color until 26 July and 10 August, respectively. K-P and K-P + MAN had no positive effect on turf color. FA + CHLOR and K-P + P-MAN generally provided for improved turf color versus all other treatments. Plots treated with FA alone often had color ratings equivalent to the aforementioned tank-mix treatments. This deviates from 2006 observations, when FA alone had only a small beneficial impact on turf color.

Quality. Fungicide effects on quality were not observed until 7 days (i.e., 28 June) after the second application. Between 28 June and 10 August, quality in plots treated with FA + CHLOR and K-P + P-MAN was superior to untreated turf (Table 6). Plots treated with the aforementioned tank mixes had quality ratings > 8.0 on most rating dates. FA, P-MAN and MAN alone were associated with improved quality on 2 or more rating dates between 12 July and 10 August 2007. Except for FA alone on 12 July, quality ratings associated with the aforementioned treatments were < 8.0, but ratings were not always significantly different from plots treated with tank mixes. CHLOR and K-P alone had no impact on turf quality. As observed in 2006, treatments providing for improved quality had in some way ameliorated the negative effects of scalping.

Vertical Cutting Injury. Declaration creeping bentgrass is known to become "puffy" and as a result it was scalped throughout the summer in 2006 and 2007. On 27 July 2007, the study area was vertical cut in one direction, causing significant mechanical damage. Plots were rated for injury 6 and 14 days following vertical cutting on 2 and 10 August, respectively. Plots treated with MAN and P-MAN alone or tank-mixed with K-P sustained less scalping damage than was observed in all other plots (Table 6). Not only was the injury reduced, but injury ratings were below the objectionable threshold (i.e., < 2.5 rating) as early as 2 August. Plots treated with CHLOR, K-P, FA, and FA + CHLOR had injury ratings equivalent to the control on 2 August. By 10 August, plots treated with FA and FA + CHLOR exhibited less injury than untreated bentgrass. These data suggest that mancozeb in some way improves the ability of bentgrass to resist and/or recover rapidly from mechanical injury.

Table 4. Yellow spot severity as influenced by preventive fungicide applications targeting summer decline in Declaration creeping bentgrass, College Park, MD, 2006.

Treatments [y]	Rate (kg ai/ha)	Yellow spot 4 Aug	11 Aug	18 Aug
		number per plot		
Fosetyl-Al	9.8	16 ab [z]	32 a	26 ab
Fosetyl-Al + Chlorothalonil	9.8 + 8.0	2 b	4 b	3 c
Pyraclostrobin	0.30	24 a	35 a	34 a
Pyraclostrobin	0.55	8 b	16 ab	16 abc
Pyraclostrobin + K. Phosphite	0.30 + 7.9	14 ab	31 a	26 ab
K. Phosphite + P. Mancozeb	7.9 + 14.6	2 b	18 ab	25 ab
Amino Acid N + Chlorothalonil	2.0 + 8.0	2 b	4 b	9 bc
Untreated	--	24 a	31 a	23 abc

[y] Treatments were applied on 5 April, 19 June; and 3 July, and 17 July 2006.
[z] Means in a column followed by the same letter are not significantly different according to Fisher's least significant difference ($P \leq 0.05$) test.

Table 5. Turf color as influenced by fungicides targeting summer bentgrass decline in Declaration CBG, College Park, MD 2007.

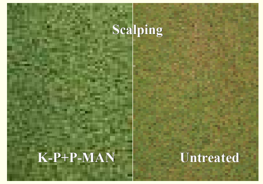
Treatments [y]	Rate (kg ai ha^{-1})	Turf color 28 Jun	12 Jul	26 July	10 Aug
Chlorothalonil	8.0	8.1 bc [z]	8.5 bc	8.0 bcd	7.6 abc
Mancozeb (MAN)	18.3	7.3 cd	7.9 cd	7.8 cd	8.3 ab
Pigmented Mancozeb (P-MAN)	14.6	7.8 bcd	8.4 bc	8.5 abc	8.4 a
Potassium (K.) Phosphite	7.9	6.0 e	7.3 de	7.5 de	7.1 c
Fosetyl Al	9.8	8.0 bc	8.6 ab	8.5 abc	7.6 abc
Fosetyl Al + Chlorothalonil	9.8 + 8.0	9.3 a	9.3 a	9.0 a	7.9 abc
K. Phosphite + MAN	9.8 + 18.3	7.1 cd	7.4 de	7.4 de	8.0 abc
K. Phosphite + P-MAN	9.8 + 14.6	8.5 ab	8.5 bc	8.8 ab	8.5 a
Untreated	--	6.7 de	7.2 e	6.8 e	7.4 bc

[y] Treatments were applied on 7 and 21 June, 5 and 19 July; and 2 August, 2007.
[z] Means in a column followed by the same letter are not significant based on Fisher's least significant difference test ($P \leq 0.05$).

Table 6. Turf quality as influenced by fungicides targeting summer decline in Declaration CBG, College Park, MD 2007.

Treatments [y]	Rate (kg ai/ha)	Turf quality 28 Jun	12 Jul	26 July	10 Aug	Vertical cut injury 2 Aug	10 Aug
		0 to 10				0 to 5	
Chlorothalonil	8.0	6.8 bcd [z]	6.9 cde	6.0 c	6.3 c	3.4 a	2.6 ab
Mancozeb (MAN)	18.3	7.6 abc	7.3 bcd	7.5 ab	7.6 ab	1.4 c	0.8 d
Pigmented Mancozeb (P-MAN)	14.6	7.4 abc	7.8 bc	7.5 ab	7.8 ab	1.4 c	0.8 d
Potassium (K.) Phosphite	7.9	5.6 d	6.4 de	6.5 bc	6.4 c	2.8 ab	2.3 abc
Fosetyl Al	9.8	7.6 abc	8.1 ab	7.8 ab	7.0 bc	2.8 ab	1.5 bcd
Fosetyl Al + Chlorothalonil	9.8 + 8.0	8.0 ab	8.8 a	8.8 a	8.1 ab	2.5 b	1.4 cd
K. Phosphite + MAN	9.8 + 18.3	6.5 cd	6.8 de	6.8 bc	7.1abc	1.4 c	1.1 cd
K. Phosphite + P-MAN	9.8 + 14.6	8.4 a	8.8 a	8.5 a	8.3 a	1.1 c	0.8 d
Untreated	--	6.5 cd	6.3 e	6.0 c	6.0 c	3.3 ab	2.7 a

[y] Treatments were applied on 7 and 21 June; 5 and 19 July; and 2 August, 2007.
[z] Means in a column followed by the same letter are not significant based on Fisher's least significant difference test ($P \leq 0.05$).



DISCUSSION

FA contains a compound called "StressGard®" (a.i. confidential), which is said to have beneficial physiological effects on plants during summer stress periods. FA and P-MAN also contain a pigment that provides a noticeable "paint effect" for about 7 to 10 days. It remains unclear whether or not the pigment in P-MAN or FA is solely responsible for improved color. It was the green pigment in P-MAN that boosted color in plots treated with K-P + P-MAN, since applications of K-P + MAN did not improve color. In the case of MAN and P-MAN, a build-up of Mn in tissue following multiple applications may account for the improved color observed. CHLOR and PYRAC contain neither a pigment nor N and the mechanism for their ability to improve color is unknown. Throughout the study in 2006 and 2007, scalping injury was ameliorated by FA + CHLOR and K-P + P-MAN. Less injury from scalping, and not necessarily color enhancement, was the primary factor responsible for the improved quality. Close visual inspection of plots two weeks following the final application of the aforementioned treatments revealed that the pigment was no longer visually evident and that leaves did not appear to have been damaged by scalping. The ability of selected treatments to improve quality fell rapidly following the final application. Hence, to maintain improved summer quality, the beneficial treatments may need to be applied continuously on a 14-day interval. Furthermore, plots treated with MAN and P-MAN sustained less injury from vertical cutting. The mechanism (s) responsible for improved color, quality and improved tolerance to mechanical damage provided by selected treatments was not determined, but may involve "paint effects", as well as other unknown physiological and possibly pathological factors. The cause of the disease referred to as yellow spot here was not determined. Examination of affected bentgrass samples did not reveal the presence of cyanobacteria as described by Tredway et al. (2006). *Curvularia* spp. were found on senescent and dead tissue in samples, but the yellow spot symptoms observed do not fit the description of Curvularia blight given by Couch (1995). The yellow spot symptoms observed do fit the description given for yellow dwarf, a mollicute disease of bentgrass greens in Japan (Tani and Beard, 1997). Regardless, CHLOR and MAN reduced the severity of the malady observed in this study as well as yellow spot associated with cyanobacteria (Gelenter and Stowell, 2000).

LITERATURE CITED

Dernoeden, P.H. 2002. Creeping Bentgrass Management: Summer Stresses, Weeds and Selected Maladies. John Wiley & Sons, Inc. Hoboken, NJ.

Couch, H.B. 1995. Diseases of Turfgrasses. Third Edition. Krieger Publishing Co. Malabar, FL.

Gelernter, W. and L.J. Stowell. 2000. Cyanobacteria (A.K.A. blue-green algae) WANTED for causing serious damage to turf. PACE INSIGHTS (www.pace-ptri.com) 6 (8):1-4.

Tani, T. and J.B. Beard. 1997. Color Atlas of Turfgrass Diseases. Ann Arbor Press, Chelsea, MI.

Tredway, L.P, L.J. Stowell and W.D. Gelernter. 2006. Yellow spot and the potential role of cyanobacteria as turfgrass pathogens. Golf Course Management 74(11):83-86.

ACKNOWLEDGEMENTS

We thank Dr. Larry Stowell for his examination of bentgrass samples affected with yellow spot symptoms. We are grateful for the financial support provided by BASF Corp., Bayer Environmental Services, and Cleary Chemical Corporation