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Article abstract

The control of dollar spot by paclobutrazol applied as a growth regulator on a creeping bentgrass (*Agrostis palustris*) and annual bluegrass (*Poa annua*) fairway turf was compared with two standard fungicide treatments in Minnesota during two growing seasons. Paclobutrazol was applied every 3 weeks, staggered by about 10 days with fungicide treatments (chlorothalonil or propiconazole), also applied every 3 weeks. Paclobutrazol alone significantly reduced the number of dollar spot infection centers during both summers, often by as much as 80%. Chlorothalonil or propiconazole were usually more effective in controlling dollar spot than paclobutrazol. Paclobutrazol improved disease control by fungicides when tested in combination with various rates of chlorothalonil or propiconazole. Paclobutrazol applied as a growth regulator could thus be used to reduce the base line severity of dollar spot of turf.

Use of the growth regulator paclobutrazol in the management of dollar spot of creeping bentgrass in Minnesota

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[Utilisation de la substance de croissance paclobutrazol pour la lutte à la brûlure en plaques de l'agrostide au Minnesota]

La lutte à la brûlure en plaques par le paclobutrazol, utilisé comme substance de croissance sur le gazon composé d'agrostide (*Agrostis palustris*) et de pâturin annuel (*Poa annua*), a été comparée à deux fongicides couramment utilisés au Minnesota durant deux saisons de croissance. Le paclobutrazol fut appliqué à des intervalles de 3 semaines, décalé par environ 10 jours avec les traitements de fongicides (chlorothalonil ou propiconazole), aussi appliqués toutes les 3 semaines. Le paclobutrazol appliqué seul a réduit significativement le nombre de foyers d'infection de brûlure en plaques durant les deux années, souvent par 80 % ou plus. Toutefois, le chlorothalonil et le propiconazole ont été généralement plus efficaces que le paclobutrazol pour la suppression de la brûlure en plaques. Le paclobutrazol a aussi aidé à réduire la gravité de la maladie dans les traitements fongicides, lorsqu'il fut combiné avec différentes doses de chlorothalonil ou de propiconazole. Le paclobutrazol, lorsque utilisé comme régulateur de croissance, peut donc servir à réduire la gravité de la brûlure en plaques.

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INTRODUCTION

Dollar spot, caused by *Sclerotinia homoeocarpa* F.T. Bennett, is a foliar disease affecting creeping bentgrass (*Agrostis palustris Hudson*) and other turf species throughout the growing season (Walsh *et al.* 1999). On golf courses, the management of dollar spot usually requires regular fungicide applications while proper nitrogen fertilization and reducing the period of leaf wetness can help reduce disease severity (Vargas 1994; Walsh *et al.* 1999; Williams *et al.* 1996). Recently, Burpee *et al.* (1996) reported that two gibberellin biosynthesis inhibitors (GBI), flurprimidol and paclobutrazol, were fungistatic and significantly reduced the severity of dollar spot in creeping bentgrass for up to 37 d. Furthermore, these GBI also improved control conferred by fungicides (Burpee *et al.* 1996). Gibberellin biosynthesis inhibitors are used on turf as growth regulators in the United States to reduce the height of the turf canopy and the frequency of mowing (Watschke *et al.* 1992). The purpose of this research was to determine whether the use of paclobutrazol as a growth regulator can be useful for the management of dollar spot of creeping bentgrass throughout the growing season under Minnesota conditions. The effect of paclobutrazol was compared with two standard fungicides applied at recommended rates. Paclobutrazol was also tested in combination with various rates of fungicides to determine whether it could improve disease management by fungicides.

MATERIALS AND METHODS

The experiments were carried out in 1997 and 1998 on creeping bentgrass cv. Penncross mixed with annual bluegrass (*Poa annua* L.) maintained as a fairway turf at the University of Minnesota. The grass was maintained at a height of 1.5 cm by mowing three times a wk. A different area of turf was used each yr. The chemical treatments were the growth regulator paclobutrazol (Turf Enhancer 2SC, O.M. Scott and Sons Company, Marysville, OH), the fungicides chlorothalonil (tetrachloroisophthalonitrile, Daconil Weather Stik, ISK Biosciense Corporation, Mentor, OH) and propiconazole (1-(2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-ylmethyl)-1H-1,2,4-triazole, Banner, Novartis, Greensboro, NC). Chemicals were applied at the recommended label rates of 0.26, 10.3 and 0.91 kg a.i. ha^{-1} for paclobutrazol, chlorothalonil and propiconazole, respectively. Dates of chemical treatments and fertilization for both yr are shown on Table 1. In 1997, both fungicides were also tested at reduced rates, 60 and 80% of the recommended rate for chlorothalonil and 50 and 75% for propiconazole. In 1998, only chlorothalonil was tested at reduced rates (60 and 80% of the recommended rate). Treatments were combinations of paclobutrazol and the various rates of fungicides, including untreated controls (no paclobutrazol or no fungicide). Paclobutrazol and fungicides were applied approximately every 21 d, with fungicide applications staggered with paclobutrazol applications by about 8-10 d. Individual plots had an area of 1.5 m^2 and were arranged in a randomized complete block design with four replicates. Chemical treatments were applied in a volume of 815 L ha^{-1} with a compressed CO_2 sprayer adjusted at 207 kPa with two nozzles delivering a total of 3 L of liquid per min. Disease was evaluated weekly as the number of dollar spot infection centers per square meter. Results on graphs are reported for Julian days (JD). Data were analyzed statistically with the general linear model procedure (GLM) from SAS (SAS Institute Inc. 1988) and differences etween individual treatments were determined by the least square means at the 0.05 level.

S. homoeocarpa inoculum was prepared by growing the fungus on autoclaved wheat grain for approximately 2 wk. After air-drying, the colonized grain was ground and sieved through a no. 10 sieve. Forty mL of ground inoculum preparation was applied by hand in each plot on 11 August 1997. The plots were not inoculated in 1998.

Table 1. Schedule of treatments and fertilization for the 1997 and 1998 experiments

Date	Julian day	Treatment
1997		
9 June	160	Paclobutrazol
18 June	169	Fertilization (Anderson 20-4-12)
30 June	181	Paclobutrazol
10 July	191	Fertilization (Milorganite 6-2-0)
11 July	192	Fungicides
23 July	204	Paclobutrazol
25 July	206	Fertilization (Milorganite 6-2-0)
6 August	218	Fungicides
7 August	219	Fertilization (Milorganite 6-2-0)
11 August	223	Inoculation with *S. homoeocarpa*
15 August	227	Paclobutrazol
26 August	238	Fungicides
1998		
22 May	142	Fertilization (Milorganite 6-2-0)
17 June	168	Fertilization (Milorganite 6-2-0)
22 June	173	Paclobutrazol
1 July	182	Fertilization (Milorganite 6-2-0)
1 July	182	Fungicides
14 July	195	Paclobutrazol
20 July	201	Fungicides
24 July	205	Fertilization (Milorganite 6-2-0)
6 August	218	Paclobutrazol
11 August	223	Fungicides
20 August	232	Fertilization (Milorganite 6-2-0)
25 August	237	Paclobutrazol

RESULTS AND DISCUSSION

In 1997, there was little occurrence of dollar spot in the first part of the summer (Fig. 1), which eventually made the inoculation of the plots necessary. This resulted in a severe dollar spot epidemic during the second half of August and the month of September. In the early part of the epidemic, disease suppression by paclobutrazol alone ranged from 76 to 97% (JD 232 and 238). As the disease became more severe, disease reduction by paclobutrazol was 40% of the control (JD 260). At that time, the fungicide treatments provided the best disease control (Fig. 1). Beside causing a significant reduction in the severity of dollar spot ($P < 0.001$), paclobutrazol also had a significant interaction with fungicides ($P < 0.001$). In the period of high disease severity, paclobutrazol improved control obtained by various rates of chlorothalonil and propiconazole (Table 2).

In 1998, there was a regular occurrence of dollar spot throughout the season and the plots were not inoculated (Fig. 2). On most days paclobutrazol reduced significantly the severity of dollar spot, by as much as 80% (Fig. 2). Chlorothalonil and propiconazole were usually more effective than the growth regulator in suppressing the disease, although no significant differences were observed between paclobutrazol and the fungicides on JD 190, 202 and 210 (Fig. 2). For 1998, the overall effect of paclobutrazol on the reduction of dollar spot was significant ($P < 0.001$), as well as its interaction with fungicides ($P < 0.001$). Because of very low severity of dollar spot in the fungicide treatments, it was not always possible to measure whether paclobutrazol improved control of the

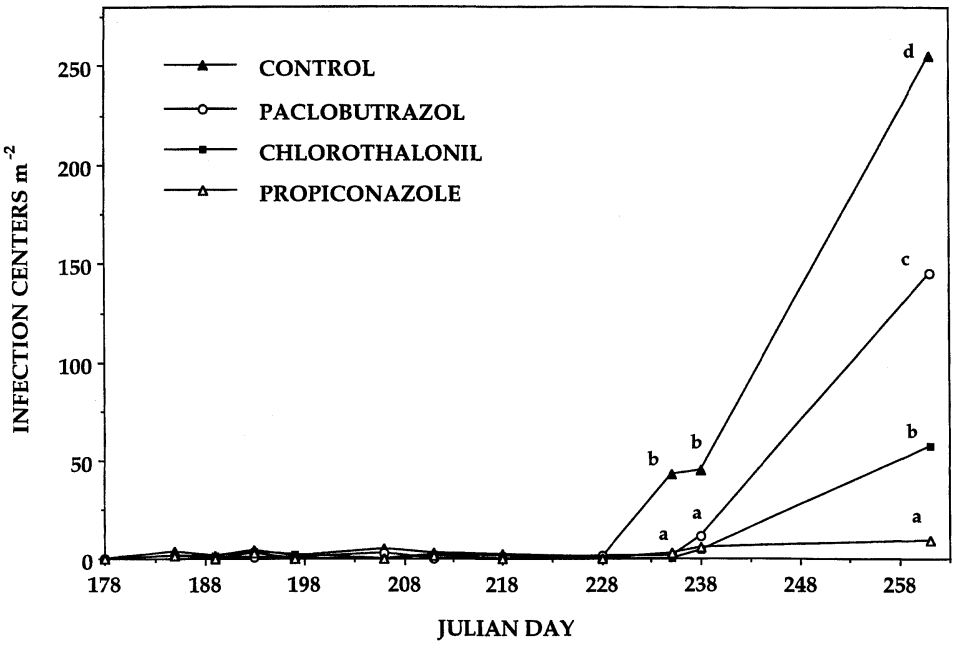

Figure 1. Number of dollar spot infection centers per square meter in plots treated with paclobutrazol or fungicides at recommended rates in 1997. Time is expressed as Julian days. Letters for a given day indicate significant differences according to the least square means at the 0.05 level.

Table 2. Number of dollar spots per square meter for fungicide treatments with and without applications of paclobutrazol in 1997

Fungicide treatment	Date of disease rating			
	25 Aug.		17 Sept.	
	Paclobutrazol	No growth regulator	Paclobutrazol	No growth regulator
Chlorothalonil				
60% rate	4	5 ns	61	108 *
80% rate	1	11 *	36	60 *
100% rate	3	4 ns	22	57 ns
Propiconazole				
50% rate	1	10 *	15	59 *
75% rate	2	8 ns	3	42 *
100% rate	0	6 *	1	9 *

*: statistically significant at the 0.05 level; ns: non significant.

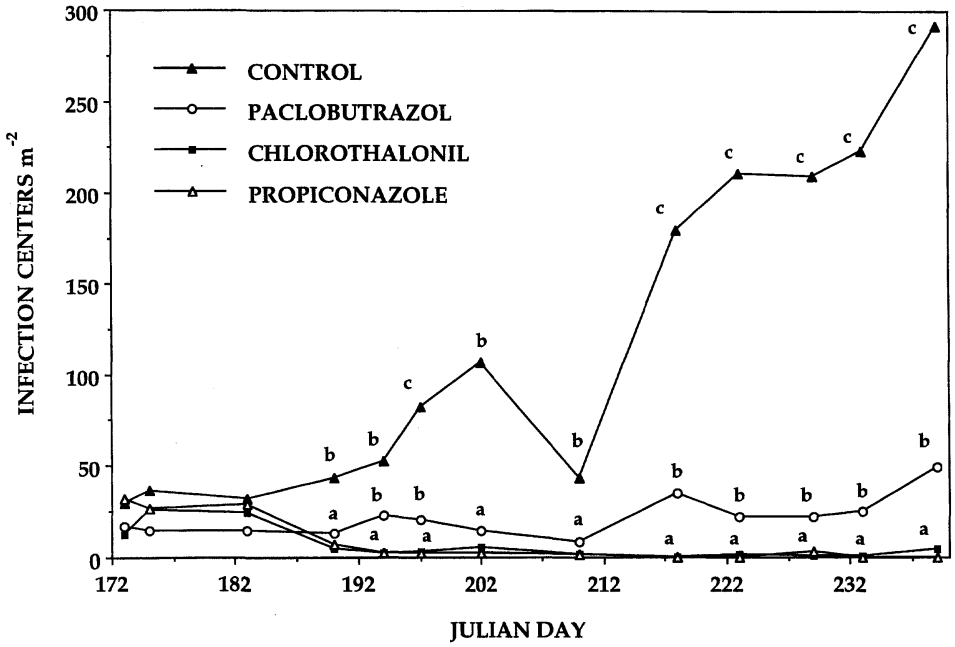

Figure 2. Number of dollar spot infection centers per square meter in plots treated with paclobutrazol or fungicides at recommended rates in 1998. Time is expressed as Julian days. Letters for a given day indicate significant differences according to the least square means at the 0.05 level.

disease by fungicides. Dates where such differences could be detected are shown on Table 3. On these dates, paclobutrazol sometimes improved disease control when chlorothalonil was applied at 60 or 80% or the recommended rate. On both years, the grass treated with paclobutrazol had a darker appearance and a more prostrate growth habit.

Overall, these results show that the use of paclobutrazol at the recommended rate as a growth regulator (every 21 d) is advantageous as it reduces the severity of dollar spot throughout the growing season (Fig. 1 and Fig. 2). While control of dollar spot by paclobutrazol was reported by Burpee *et al.* (1996), its effect over a whole growing season had not been studied previously. Another growth regulator, flurprimidol, although more effective than paclobutrazol in suppressing dollar spot (Burpee *et al.* 1996) is not used in Minnesota because of possible phytotoxic effects. Because paclobutrazol was not as effective as fungicides, this growth regulator could probably not provide complete dollar spot management. However, depending on the level of disease control required, it is likely that the number of fungicide applications could be reduced when paclobutrazol is used. In this research, paclobutrazol and fungicide applications were purposely staggered by about 10 d (Table 1). This was done because of the possibility that fungicides alone could easily mask the mild antifungal activity of paclobutrazol if both treatments were applied at the same time. Staggered applications would likely provide more protection as the antifungal activity of one compound fading with time would be replaced by the newly applied chemical, thus keeping the turf protected.

Paclobutrazol was tested in combination with various fungicide rates to better evaluate the possible improvement of disease management by chlorothalonil and propiconazole. As reported previously by Burpee *et al.* (1996),

Table 3. Number of dollar spots per square meter for fungicide treatments with and without applications of paclobutrazol in 1998

Fungicide treatment	Date of disease rating								
	21 July			11 Aug.			27 Aug.		
	Paclo-butrazol	No growth regulator		Paclo-butrazol	No growth regulator		Paclo-butrazol	No growth regulator	
Chlorothalonil									
60% rate	5	30	*	3	17	*	0	9	*
80% rate	3	7	ns	0	15	*	3	1	ns
100% rate	0	5	ns	0	1	ns	0	5	ns
Propiconazole									
100% rate	0	2	ns	0	0	ns	0	0	ns

*: statistically significant at the 0.05 level; ns : non significant.

the use of paclobutrazol improved disease control by these fungicides. On several dates, because of acceptable disease control conferred by paclobutrazol in combination with reduced fungicide rates (Table 2, 3), reducing fungicide rates could also be an option for lowering fungicide use on turf. Such an approach could be especially advantageous with systemic fungicides such as propiconazole, as the use of reduced rate can help delay the development of resistant population of *S. homoeocarpa* (Sanders *et al.* 1985). Paclobutrazol could also be combined with alternative disease control strategies. Approaches such as the application of antagonistic microorganisms or organic amendments were shown in several cases to control dollar spots, although rarely as effectively as fungicides (Walsh *et al.* 1999). Paclobutrazol could provide the base line reduction in dollar spot severity making possible the implementation of such biocontrol strategies.

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