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Evaluation of fungicide and plant growth regulator tank-mix programmes on dollar spot severity of creeping bentgrass

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Abstract

Dollar spot (*Sclerotinia homoeocarpa* F.T. Bennett) is a common and destructive disease of creeping bentgrass (*Agrostis stolonifera* L.). In 2003 and 2004, field studies were conducted to evaluate 14- and 21-day sequential fungicide tank-mix programmes alone and in combinations with plant growth regulators (PGRs) paclobutrazol, trinexapac-ethyl, or paclobutrazol plus trinexapac-ethyl on dollar spot of fairway-height creeping bentgrass. All fungicide-treated plots, either fungicides plus PGRs or fungicides alone, exhibited greater dollar spot control versus untreated plots. Overall, fungicide efficacy on dollar spot was comparable on plots treated with fungicide tank-mix programmes alone versus fungicides plus PGRs. Creeping bentgrass quality was consistently better in plots treated with fungicides plus PGRs versus fungicides alone. Dollar spot control and creeping bentgrass quality was improved, however, in plots treated with fungicides plus paclobutrazol versus fungicides alone, fungicides plus trinexapac-ethyl, or fungicides plus paclobutrazol plus trinexapac-ethyl.

Keywords: *Sclerotinia homoeocarpa*; Turf; Turfgrass; Turfgrass quality

1. Introduction

Dollar spot (*Sclerotinia homoeocarpa* F.T. Bennett) is a persistent and troublesome foliar disease of turfgrasses worldwide (Couch, 1995). In regions of the USA where the climate is suited to the growth of creeping bentgrass (*Agrostis stolonifera* L.), golf course superintendents frequently apply two or more fungicide products with different modes of action in various tank-mix combinations repeated over a 14- to 28-day interval during the spring, summer, and early autumn to control dollar spot and other diseases that occur during that time (Dernoeden, 2000; Green, 2004; Tredway and Butler, 2004). Within that same time-frame, plant growth regulator (PGR) products are frequently applied to regulate vertical turfgrass growth and canopy height, reduce mowing frequency and clipping yield, improve turfgrass colour and quality, and increase stand density (Beard, 2002; Dernoeden, 1984, 2000; Johnson, 1993; Johnston and Faulkner, 1985; Watschke et al., 1992).

The PGRs registered in commercial turfgrass markets were formerly categorized as either gibberellin biosynthesis inhibitors or mitotic inhibitors (Watschke et al., 1992). A recent revision now places those PGRs into the following five classes: (A) cell elongation inhibitor in late gibberellin biosynthesis pathway (i.e., trinexapac-ethyl); (B) cell elongation inhibitor in early gibberellin biosynthesis pathway (i.e., flurprimidol, paclobutrazol); (C) cell division inhibitor (i.e., mefluidide); (D) herbicides with growth regulating properties (i.e., ethofumesate), and (E) phytohormones (i.e., gibberillic acid) (Turgeon, 2002). PGRs with a triazole-based structure (i.e., paclobutrazol) are chemically similar to some fungicides (i.e., fenarimol, myclobutanil, propiconazole, triadimefon) used to control

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dollar spot in turfgrass (Koller, 1988), and those PGRs have been shown to inhibit growth of *S. homoeocarpa* in vitro (Fletcher et al., 1986). In field studies, Burpee et al. (1996) showed that dollar spot severity was reduced in creeping bentgrass treated with paclobutrazol, but not trinexapac-ethyl. Also, the efficacy of chlorothalonil fungicide on dollar spot was improved on creeping bentgrass pre-treated with paclobutrazol (Burpee et al., 1996).

The effects of combining fungicides and PGRs in sequential tank-mix combinations to golf course turf for dollar spot control are not well documented in the research literature (Burpee et al., 1996; Golembiewski and Danneberger, 1998). Therefore, the objective of this field-based research was to evaluate fungicide plus plant growth regulator tank-mix programmes on dollar spot severity in creeping bentgrass.

2. Materials and methods

2.1. Experiment locations

All test sites were located on golf course fairways in Southeastern Pennsylvania, USA, with a history of dollar spot incidence. In 2003, fungicide and plant growth regulator treatments were applied on a creeping bentgrass fairway on a 14-day interval (experiment one) at Saucon Valley Country Club, Bethlehem, PA, USA, and on a 21-day interval (experiment two) at Wyncote Golf Course, Oxford, PA, USA. In 2004, treatments scheduled on 14- and 21-day intervals (repeat of experiments one and two) were applied at a single location on a creeping bentgrass fairway at St. David's Golf Club, Wayne, PA, USA.

At all three locations, the fairway turf consisted of mostly creeping bentgrass with some annual bluegrass (*Poa annua* L.). All fairway test sites were maintained according to normal or routine mowing, fertilization, irrigation, and other cultural practices normally employed at the golf course (Dernoeden, 2000). The turf population at Bethlehem was visually estimated as 75% creeping bentgrass (cultivar unknown) and 25% annual bluegrass. The fairway was maintained at a 7.6 mm height of cut with a reel mower. Soil pH was 6.2 with 7.7% organic matter on this native soil fairway. The turf at Oxford was mowed at 8.3 mm with a reel mower, and was visually estimated as 80% creeping bentgrass (cv. 'Dominant') and 20% annual bluegrass. Soil pH was 6.5 with 2.3% organic matter on this native soil site. At Wayne, soil pH was 5.7 with 4.5% organic matter. The turf was mowed at 12.7 mm with a reel mower, and visually consisted of 60% creeping bentgrass (cultivar unknown) and 40% annual bluegrass on this native soil site.

2.2. Fungicide and plant growth regulator treatments

The active ingredients of all fungicide and PGR treatments, application rates, and commercial formulations are listed in Table 1. The 14-day interval (experiment one) fungicide tank-mix programme consisted of the following five applications in sequential order: (i) propiconazole + chlorothalonil, (ii) fludioxonil + chlorothalonil, (iii) azoxystrobin + propiconazole, (iv) azoxystrobin + propiconazole, and (v) fludioxonil + chlorothalonil. The 21-day interval (experiment two) fungicide tank-mix programme consisted of the following three applications in sequential order: (i) propiconazole + chlorothalonil, (ii) azoxystrobin + propiconazole, and (iii) azoxystrobin + propiconazole. The sequential fungicide programme was applied alone and in tank-mix combinations with paclobutrazol, trinexapac-ethyl, and paclobutrazol + trinexapac-ethyl. Chlorothalonil is a contact fungicide, whereas the others listed are considered systemic fungicides (Couch, 1995). Paclobutrazol is root absorbed, and trinexapac-ethyl is foliar absorbed in turfgrass (Dernoden, 2000).

Table 1
Fungicide and plant growth regulator (PGR) products applied to creeping bentgrass fairway test sites, 2003 and 2004

Product category	Application rates		
	Active ingredient	kg a.i. ha^{-1}	Commercial formulation[a]
Fungicide	Azoxystrobin	0.30	Heritage 50WG
	Chlorothalonil	4.53	Daconil Ultrex 82.5WDG
	Fludioxonil	0.45	Medallion 50WP
	Propiconazole	0.50	Banner MAXX 1.3MEC
PGR	Paclobutrazol	0.12 or 0.18	Trimmit 2SC
	Trinexapac-ethyl	0.05 or 0.10	Primo MAXX 1MEC

[a]All products manufactured by Syngenta Professional Products, Greensboro, NC, USA.

Therefore, both 14- or 21-day interval experiments consisted of five treatments: (1) fungicides + paclobutrazol, (2) fungicides + trinexapac-ethyl, (3) fungicides + paclobutrazol + trinexapac-ethyl, (4) fungicide programmes applied alone, and (5) an untreated check. These 14- and 21-day fungicide programmes and PGRs were chosen because they are commonly used on creeping bentgrass fairways in the Mid-Atlantic region of the USA (Dernoeden, 2000; Fidanza and Mizikar, 2003; Towers et al., 2003). Specific treatment information, application rates, and application calendar dates for all experiments in both years are listed in Tables 2–5. At all three locations in both years, the experiments began in early June and continued through August which corresponded to dollar spot activity normally observed at that time on those creeping bentgrass fairway sites. All experiments were discontinued by late August.

Table 2
Effect of 14-day interval fungicide and plant growth regulator programmes on dollar spot severity and turfgrass quality of creeping bentgrass at Bethlehem, PA, USA, 2003

Treatments[a]	Dollar spot severity				Creeping bentgrass quality					
	8 July	22 July	5 Aug.	19 Aug.	10 June	25 June	8 July	22 July	5 Aug.	19 Aug.
	No. infection centres[b]				Quality rating[c]					
1. FP + P	2.0	1.3	2.0	9.3	7.7	8.0	8.0	8.7	8.3	8.0
2. FP + T	5.3	1.3	5.7	39.3	8.0	8.0	8.0	7.7	7.8	8.0
3. FP + P + T	1.0	1.0	1.7	8.0	9.0	7.8	8.0	8.8	9.0	8.3
4. FP	2.7	1.7	9.3	37.5	7.8	7.3	7.7	7.0	7.0	6.7
5. Untreated	14.3	35.7	52.0	106.1	7.7	6.8	7.0	7.0	6.7	5.8
Contrasts[d]										
1 versus 4	NS	NS	*	*	NS	NS	NS	*	*	NS
2 versus 4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
3 versus 4	NS	NS	*	*	NS	NS	NS	*	**	NS
1–4 versus 5	***	***	***	***	NS	NS	**	NS	**	*

[a]FP = fungicide programme application calendar dates, treatments, and application rates: 10 June: propiconazole 0.50 kg a.i. ha^{-1} + chlorothalonil 4.53 kg a.i. ha^{-1}. 25 June: fludioxonil 0.45 kg a.i. ha^{-1} + chlorothalonil 4.53 kg a.i. ha^{-1}. 8 July: azoxystrobin 0.30 kg a.i. ha^{-1} + propiconazole 0.50 kg a.i. ha^{-1}. 22 July: azoxystrobin 0.30 kg a.i. ha^{-1} + propiconazole 0.50 kg a.i. ha^{-1}. 5 Aug.: fludioxonil 0.45 kg a.i. ha^{-1} + chlorothalonil 4.53 kg a.i. ha^{-1}. FP + P = fungicide programme plus paclobutrazol 0.18 kg a.i. ha^{-1}. FP + T = fungicide programme plus trinexapac-ethyl 0.10 kg a.i. ha^{-1}. FP + P + T = fungicide programme plus paclobutrazol 0.12 kg a.i. ha^{-1} plus trinexapac-ethyl 0.05 kg a.i. ha^{-1}.
[b]Dollar spot severity was visually assessed by counting the number of active *S. homoeocarpa* infection centres in each plot.
[c]Creeping bentgrass quality on a 1–9 scale, where 9 is the best quality, 6 the minimum acceptable quality, and 1 the worst quality.
[d]NS, *, **, *** equals nonsignificant or significant at $P \leqslant 0.05$, 0.01, or 0.001, respectively.

Table 3
Effect of 21-day interval fungicide and plant growth regulator programmes on dollar spot severity and turfgrass quality of creeping bentgrass at Oxford, PA, USA, 2003

Treatments[a]	Dollar spot severity					Creeping bentgrass quality					
	13 July	21 July	4 Aug.	12 Aug.	20 Aug.	23 June	13 July	21 July	4 Aug.	12 Aug.	20 Aug.
	No. infection centres[b]					Quality rating[c]					
1. FP + P	2.3	4.7	1.3	5.3	8.5	7.3	7.7	7.3	7.7	7.0	8.0
2. FP + T	1.7	2.3	2.7	7.7	14.0	7.3	7.7	7.3	8.0	7.7	7.7
3. FP + P + T	1.3	3.7	2.3	3.0	3.7	7.0	7.3	7.3	7.3	7.8	9.0
4. FP	1.9	4.3	1.7	7.8	11.2	7.0	7.3	7.0	6.5	7.3	6.5
5. Untreated	11.0	52.3	42.7	50.3	54.0	7.0	7.2	6.5	6.0	6.2	6.0
Contrasts[d]											
1 versus 4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
2 versus 4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
3 versus 4	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	**
1–4 versus 5	**	***	***	***	***	NS	NS	NS	**	*	***

[a]FP = fungicide programme application calendar dates, treatments, and application rates: 23 June: propiconazole 0.50 kg a.i. ha^{-1} + chlorothalonil 4.53 kg a.i. ha^{-1}. 13 July: azoxystrobin 0.30 kg a.i. ha^{-1} + propiconazole 0.50 kg a.i. ha^{-1}. 4 Aug.: azoxystrobin 0.30 kg a.i. ha^{-1} + propiconazole 0.50 kg a.i. ha^{-1}. FP + P = fungicide programme plus paclobutrazol 0.18 kg a.i. ha^{-1}. FP + T = fungicide programme plus trinexapac-ethyl 0.10 kg a.i. ha^{-1}. FP + P + T = fungicide programme plus paclobutrazol 0.12 kg a.i. ha^{-1} plus trinexapac-ethyl 0.05 kg a.i. ha^{-1}.
[b]Dollar spot severity was visually assessed by counting the number of active *S. homoeocarpa* infection centres in each plot.
[c]Creeping bentgrass quality on a 1–9 scale, where 9 is the best quality, 6 the minimum acceptable quality, and 1 the worst quality.
[d]NS, *, **, *** equals nonsignificant or significant at $P \leqslant 0.05$, 0.01, or 0.001, respectively.

2.3. Treatment application and experimental design

At all locations in both years, all treatments were applied with a CO_2-powered back-pack sprayer with an operating pressure of 270.0 kPa at the spray boom. The treatments were applied from three 8006E even-flat-fan nozzles at an 80° spray angle and spaced 0.48 m apart at a height of 0.51 m from the turf canopy. All treatments were applied in 407.5 L ha^{-1} water carrier with a pH of 6.9. Spray quality was considered a fine-to-medium water droplet size as

Table 4
Effect of 14-day interval fungicide and plant growth regulator programmes on dollar spot severity and turfgrass quality of creeping bentgrass at Wayne, PA, USA, 2004

Treatments[a]	Dollar spot severity					Creeping bentgrass quality					
	25 June	8 July	21 July	3 Aug.	16 Aug.	10 June	25 June	8 July	21 July	3 Aug.	16 Aug.
	No. infection centres[b]					Quality[c]					
1. FP + P	0.0	1.3	0.0	1.0	5.5	7.0	7.6	8.0	8.3	9.0	8.8
2. FP + T	0.0	0.7	0.0	4.1	11.3	7.3	8.3	8.3	8.3	8.6	7.6
3. FP + P + T	0.0	0.0	0.0	0.0	7.2	7.3	8.3	8.3	8.7	8.5	8.3
4. FP	0.0	0.9	0.0	1.6	14.6	7.3	7.1	7.3	7.0	7.6	7.0
5. Untreated	3.3	5.5	6.2	7.9	18.2	7.3	6.7	6.2	6.0	6.3	6.0
Contrasts[d]											
1 versus 4	NS	NS	NS	NS	*	NS	NS	NS	NS	*	*
2 versus 4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
3 versus 4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1–4 versus 5	**	*	***	*	*	NS	*	***	**	***	**

[a]FP = fungicide programme application calendar dates, treatments, and application rates: 10 June: propiconazole 0.50 kg a.i. ha^{-1} + chlorothalonil 4.53 kg a.i. ha^{-1}. 25 June: fludioxonil 0.45 kg a.i. ha^{-1} + chlorothalonil 4.53 kg a.i. ha^{-1}. 8 July: azoxystrobin 0.30 kg a.i. ha^{-1} + propiconazole 0.50 kg a.i. ha^{-1}. 21 July: azoxystrobin 0.30 kg a.i. ha^{-1} + propiconazole 0.50 kg a.i. ha^{-1}. 3 Aug.: fludioxonil 0.45 kg a.i. ha^{-1} + chlorothalonil 4.53 kg a.i. ha^{-1}. FP + P = fungicide programme plus paclobutrazol 0.18 kg a.i. ha^{-1}. FP + T = fungicide programme plus trinexapac-ethyl 0.10 kg a.i. ha^{-1}. FP + P + T = fungicide programme plus paclobutrazol 0.12 kg a.i. ha^{-1} plus trinexapac-ethyl 0.05 kg a.i. ha^{-1}.
[b]Dollar spot severity was visually assessed by counting the number of active *S. homoeocarpa* infection centres in each plot.
[c]Creeping bentgrass quality on a 1–9 scale, where 9 is the best quality, 6 the minimum acceptable quality, and 1 the worst quality.
[d]NS, *, **, *** equals nonsignificant or significant at $P \leqslant 0.05$, 0.01, or 0.001, respectively.

Table 5
Effect of 21-day interval fungicide and plant growth regulator programmes on dollar spot severity and turfgrass quality of creeping bentgrass at Wayne, PA, USA, 2003

Treatments[a]	Dollar spot severity					Creeping bentgrass quality					
	25 June	8 July	21 July	3 Aug.	16 Aug.	10 June	25 June	8 July	21 July	3 Aug.	16 Aug.
	No. infection centres[b]					Quality[c]					
1. FP + P	0.0	0.0	0.0	5.1	8.6	7.0	8.3	8.5	8.7	8.6	8.1
2. FP + T	0.0	0.0	1.3	8.2	19.3	7.0	8.7	8.7	8.8	8.2	7.7
3. FP + P + T	0.0	0.0	0.0	6.7	16.5	7.3	8.3	8.0	8.0	7.7	7.2
4. FP	0.0	0.0	0.0	7.3	19.8	7.0	8.0	7.7	7.5	7.3	6.5
5. Untreated	4.7	6.1	6.5	16.7	24.9	7.3	6.5	6.3	6.0	5.7	5.9
Contrasts[d]											
1 versus 4	NS	NS	NS	NS	**	NS	NS	NS	*	*	*
2 versus 4	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
3 versus 4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
1–4 versus 5	**	***	**	*	***	NS	***	***	***	***	***

[a]FP = fungicide programme application calendar dates, treatments, and application rates: 10 June: propiconazole 0.50 kg a.i. ha^{-1} + chlorothalonil 4.53 kg a.i. ha^{-1}. 30 June: azoxystrobin 0.30 kg a.i. ha^{-1} + propiconazole 0.50 kg a.i. ha^{-1}. 21 July: azoxystrobin 0.30 kg a.i ha^{-1} + propiconazole 0.50 kg a.i. ha^{-1}. FP + P = fungicide programme plus paclobutrazol 0.18 kg a.i. ha^{-1}. FP + T = fungicide programme plus trinexapac-ethyl 0.10 kg a.i. ha^{-1}. FP + P + T = fungicide programme plus paclobutrazol 0.12 kg a.i. ha^{-1} plus trinexapac-ethyl 0.05 kg a.i. ha^{-1}.
[b]Dollar spot severity was visually assessed by counting the number of active *S. homoeocarpa* infection centres in each plot.
[c]Creeping bentgrass quality on a 1–9 scale, where 9 is the best quality, 6 the minimum acceptable quality, and 1 the worst quality.
[d]NS, *, **, *** equals nonsignificant or significant at $P \leqslant 0.05$, 0.01, or 0.001, respectively.

described in Hewitt et al. (1996) and Matthews (2004). Individual plot size measured 1.5 × 18.3 m for each experiment in 2003, and in 2004 plots were 1.5 × 3.1 m for each experiment. At all locations in both years, all treatments were arranged as a randomized complete block design with three replications.

2.4. Dollar spot severity

Dollar spot was visibly assessed by counting the number of active *S. homoeocarpa* infection centres or foci per plot (Schumann and Wilkinson, 1992). For golf course fairways, ⩽5 infection centres per plot would be classified as

low dollar spot pressure or severity, 6 to 10 foci would be labelled as moderate disease severity, and >10 foci would be considered severe (Couch, 1995). The ranking of dollar spot severity (i.e., low, moderate, or severe) was determined primarily from disease activity in the untreated plots. All plots were evaluated for dollar spot on a range of 7- to 14-day intervals at all locations from June through August in both years. Evaluation calendar dates for all experiments are listed in Tables 2–5.

2.5. Turfgrass quality

Turfgrass quality was determined visually on a 1–9 scale, where 9 is the best quality (i.e., color, density, texture), 6 the minimum acceptable quality for golf course fairway turf, and 1 the worst quality (Skogley and Sawyer, 1992). Only creeping bentgrass quality was determined from healthy, disease-free creeping bentgrass within each test plot. Annual bluegrass quality was not determined since creeping bentgrass was the desired turf species. At all locations from June through August in both years, plots were evaluated on a range of 7- to 14-day intervals. Assessment calendar dates for all experiments are listed in Tables 2–5.

2.6. Data analysis

Data were subjected to analysis of variance using the PROC ANOVA procedure in SAS version 8.0 (SAS Institute, Cary, NC, USA). Treatment means were compared with predetermined, single degree-of-freedom orthogonal contrasts at $P \leqslant 0.05$ (Mead et al., 2003; Steele and Torrie, 1980).

3. Results

3.1. Dollar spot severity: 14-day interval, 2003 (Table 2)

At the Bethlehem site, dollar spot activity was first observed in early July, and disease pressure was considered severe from mid-July through August. In July and August, superior dollar spot control was observed in all fungicide-treated plots versus untreated plots, but no dollar spot severity differences were observed among all fungicide-treated plots. In August, plots treated with fungicides + paclobutrazol or fungicides + paclobutrazol + trinexapac-ethyl enhanced dollar spot control versus fungicides alone.

3.2. Turfgrass quality: 14-day interval, 2003 (Table 2)

Overall creeping bentgrass quality was better in fungicide-treated plots versus untreated plots on one rating date in July and both rating dates in August. In late July and early August, better quality was observed in plots treated with fungicides + paclobutrazol or fungicides + paclobutrazol + trinexapac-ethyl versus fungicides alone.

3.3. Dollar spot severity: 21-day interval, 2003 (Table 3)

At the Oxford site, active dollar spot infection centres were first observed in mid-July, and disease pressure was considered to be severe in early July through August. All fungicide-treated plots provided better dollar spot control versus untreated plots during July and August. No dollar spot severity differences were observed among all fungicide-treated plots except on the last rating date of August. On 20 August, plots treated with fungicides + paclobutrazol + trinexapac-ethyl had better dollar spot control versus fungicides alone.

3.4. Turfgrass quality: 21-day interval, 2003 (Table 3)

Creeping bentgrass quality was better in fungicide-treated plots versus untreated plots during August only. On the last rating date of August, better quality was observed in plots treated with fungicides + paclobutrazol, fungicides + trinexapac-ethyl, or fungicides + paclobutrazol + trinexapac-ethyl versus fungicides alone.

3.5. Dollar spot severity: 14-day interval, 2004 (Table 4)

At the Wayne site, dollar spot was first observed in late June and disease pressure was considered moderate to severe during July and August. Excellent dollar spot control was observed in all fungicide-treated plots versus untreated plots during June–August. All fungicide-treated plots experienced similar levels of dollar spot control except on the last rating date of August. On 16 August, plots treated with fungicides + paclobutrazol exhibited better dollar spot control versus fungicides alone.

3.6. Turfgrass quality: 14-day interval, 2004 (Table 4)

Creeping bentgrass quality was consistently better in fungicide-treated plots versus untreated plots from mid-June through August. In August, plots treated with fungicides + paclobutrazol exhibited better quality versus fungicides alone.

3.7. Dollar spot severity: 21-day interval, 2004 (Table 5)

At this test site in Wayne, moderate to severe dollar spot activity also was observed in late June and persisted through August. All fungicide-treated plots had better dollar spot control versus untreated plots during June–August. Dollar spot control again was similar among all fungicide-treated plots except on the last rating date of August. On 16 August, dollar spot severity was lower in plots treated with fungicides + paclobutrazol versus fungicides alone.

3.8. Turfgrass quality: 21-day interval, 2004 (Table 5)

From mid-June through August, creeping bentgrass quality in fungicide-treated plots was higher compared to untreated plots. In late July only, plots treated with fungicides + trinexapac-ethyl had better quality versus fungicides alone. In late July through August, however, quality was better in plots treated with fungicides + paclobutrazol versus fungicides alone.

4. Discussion

In both experiments during both years, dollar spot control was enhanced or improved in those creeping bentgrass plots treated with fungicides + paclobutrazol versus fungicides alone. This effect was more common throughout the 14-day interval experiments, but was consistent in both 14- and 21-day interval experiments during August of both years. These findings compliment field studies that showed pre-treatment of creeping bentgrass with paclobutrazol enhanced the efficacy of propiconazole fungicide for dollar spot control (Burpee et al., 1996). Other field studies showed that trinexapac-ethyl was effective in reducing dollar spot in fairway-height creeping bentgrass (Golembiewski and Danneberger, 1998), however, trinexapac-ethyl neither reduced nor increased dollar spot incidence in these field studies and the mixture of both PGRs with fungicides negated the benefits of applying paclobutrazol alone with the fungicides. In laboratory studies, paclobutrazol suppressed growth of *S. homoeocarpa*, whereas trinexapac-ethyl had no effect (Burpee et al., 1996). In these field studies, PGR effects (i.e., turfgrass growth regulation) may have contributed to improving the efficacy of the sequential fungicide tank-mix programmes by reducing the amount of turfgrass leaf tissues containing fungicidal active ingredients typically removed by mowing (Burpee et al., 1996). Since paclobutrazol is a triazole-based compound and should contribute to dollar spot control, golf course superintendents should recognize that the use of paclobutrazol could place additional selection pressure on *S. homoeocarpa* populations when using fungicide programmes that include triazole-based fungicides. A consistent observation in both experiments over two consecutive years was fungicide efficacy on dollar spot was not compromised or decreased when applied in sequential tank-mix combinations with paclobutrazol, trinexapac-ethyl, or paclobutrazol + trinexapac-ethyl.

Creeping bentgrass quality was visibly improved or enhanced in plots treated with fungicides + PGRs versus fungicides alone. Also, all fungicide-treated plots exhibited better turfgrass quality versus untreated plots. In both 14- and 21-day interval experiments during both years, this quality effect was more pronounced from mid-July through August, especially in plots treated with fungicides + paclobutrazol. An observed trend was that fungicides + paclobutrazol improved creeping bentgrass quality as well as reduced dollar spot incidence. In these fairway-height creeping bentgrass field trials, plots treated with fungicides + paclobutrazol did not reduce creeping bentgrass quality as has been shown to occur on lower height-of-cut creeping bentgrass putting greens treated with propiconazole fungicide + paclobutrazol (Dernoeden, 2000).

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