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Effect of watered-in demethylation-inhibitor fungicide and paclobutrazol applications on foliar disease severity and turfgrass quality of creeping bentgrass putting greens

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ABSTRACT

Preventive, watered-in applications of DMI fungicides provide control of several soilborne turfgrass diseases on golf putting greens. The objectives of this two-year field study were to determine the impact of these applications on foliar diseases, and evaluate the impact of application timing of paclobutrazol, a plant growth regulator, on disease severity and turfgrass quality. Triadimefon (1.58 kg a.i. ha^{-1}), tebuconazole (0.82 kg a.i. ha^{-1}), metconazole (0.43 kg a.i. ha^{-1}), and triticonazole (0.64 kg a.i. ha^{-1}), were applied twice in late April and May and immediately watered in to the soil profile with 5 mm of post application irrigation. Paclobutrazol (0.28 kg a.i. ha^{-1}) was applied alone, in a tank-mix with the fungicide application, 7 days or 14 days after the fungicide application. Overall dollar spot severity, assessed as area under the disease progress curve (AUDPC), was significantly lower in fungicide treated plots than non-treated plots in both trial years. The date of threshold symptom observation ($\geq$5 infection centers per plot), however, was not different between fungicide treated and non-treated plots in 2011. Triadimefon treated plots had lower AUDPC values than other fungicide treatments. Brown patch severity was not significantly different among treatments. Paclobutrazol applied alone did not reduce dollar spot or brown patch severity, however, paclobutrazol + fungicide treatments resulted in lower dollar spot severity than plots treated with fungicide alone. Short-lived phytotoxicity (bronze discoloration) was observed in plots treated with triadimefon or paclobutrazol + fungicide. Spring preventive fungicide applications targeted at soilborne disease control also provided residual control of dollar spot in this study.

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1. Introduction

Creeping bentgrass (*Agrostis stolonifera* L.) is a fine-textured turfgrass that produces a dense canopy under low mowing heights, making it suitable for use on golf course putting greens (Turgeon, 2004). Creeping bentgrass is a susceptible host to a variety of foliar and soilborne turfgrass pathogens that limit aesthetics and utility. In addition, disease thresholds are particularly low on putting greens and cultural practices alone are not sufficient for acceptable control. Periodic fungicide applications, often on a 10–14 d schedule, are relied upon during conditions for favorable disease development. Dollar spot, caused by *Sclerotinia homoeocarpa* F.T. Bennett, is the most common turfgrass disease on creeping bentgrass in North America, necessitating more fungicide applications targeted for control than any other disease (Couch, 1995; Vargas, 1994). Dollar spot occurrence in mid to late spring often precedes brown patch caused by *Rhizoctonia solani* Kühn, which will blight and thin creeping bentgrass throughout the summer months.

Recent research demonstrated two, low label rate preventive applications of certain demethylation inhibitor (DMI) fungicides reduced fairy ring incidence and severity on creeping bentgrass putting greens (Miller et al., 2012). To be effective, these applications must be watered-in to deliver the fungicide to the soilborne pathogen within the target rootzone. Although several studies have examined the impact of irrigation frequency or amount on the severity of foliar turfgrass diseases, (Fidanza and Dernoeden, 1996; Jiang et al., 1998; McDonald et al., 2006; Settle et al., 2001), relatively few have examined the effect of post-application irrigation (PAI) on fungicide performance. Previous research investigating PAI on fungicide performance for foliar turfgrass disease control

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involved curative applications (Couch, 1985), or heavy (25–32 mm) simulated rainfall events (Pigati et al., 2010). In a single year study, Soika et al. (2011) showed dollar spot suppression with two spring applications of pyraclostrobin + boscalid, triticonazole, and an alternation of triticonazole and triadimefon watered-in 10 h post-application with 2.5–5 mm of irrigation.

Many golf superintendents also apply the plant growth regulator (PGR) paclobutrazol in the spring to inhibit the growth of *Poa annua* L., a troublesome and competitive weed on golf putting greens. Paclobutrazol is a root absorbed class B gibberellin biosynthesis inhibitor, a group that also includes flurprimidol and the class A PGR trinexapac-ethyl, which are commonly used in turfgrass systems (Davis et al., 1991). Gibberellin biosynthesis PGRs are either pyrimidines or, like paclobutrazol, a triazole, and chemically related to the DMI class of fungicides (Köller, 1988). Paclobutrazol suppresses *S. homoeocarpa* growth *in vitro* and suppresses dollar spot development in the field (Burpee et al., 1996; Fidanza et al., 2006; Fletcher et al., 1986; Putman and Kaminski, 2011). Both the DMI fungicides and paclobutrazol also block sterol biosynthesis in plants by inhibiting obtusifoliol 14α-methyl demethylase (Taton et al., 1998). During heat stress periods, phytotoxicity may result, and there is some concern in scheduling application of both paclobutrazol and the DMI fungicides within a short timeframe (Reicher and Throssell, 1997).

The potential to control foliar turfgrass diseases on bentgrass golf greens from preventive fungicide applications targeting soilborne diseases requires investigation. The first objective of this field research was to determine the residual disease control and resultant turfgrass quality from a fungicide program utilizing two low-rate watered-in preventive DMI fungicide applications. To provide insight on integration of a spring PGR program with preventive DMI applications, a second research objective was to assess the influence on disease control and turfgrass quality of paclobutrazol applications tank-mixed with fungicides or applied at different intervals after fungicide application.

2. Materials and methods

2.1. Site description

The two-year field experiment was conducted in 2011 and 2012 at the University of Missouri Turfgrass Research Farm in Columbia, MO on a 'Penn A-4' creeping bentgrass research green. The research green was built in 1992 and constructed according to USGA specifications (Beard, 1992) with a 30-cm deep layer consisting of 90% sand and 10% sphagnum peat moss over a 10-cm layer of pea gravel and drainage. The research plot had a soil pH of 6.4, 1.1% organic matter, and an infiltration rate of 69.2 cm h^{-1}. Plots were mowed 4 times a week at 3.4 mm. The experimental area was aerified in early October of both years with 1.3 cm diameter hollow tines set at 2.5 cm spacing. From April–August, the research area was fertilized with nitrogen at a rate of 73.2 kg ha^{-1} in 2011 and 74 kg ha^{-1} in 2012. For insect control, chloroantraniliprole was applied at 0.12 kg ha^{-1} in both years. Bensulide was applied for pre-emergent weed control at 7.33 kg ha^{-1} and 9.77 kg ha^{-1} in 2011 and 2012, respectively. No soil surfactant or fungicide other than the treatments was applied to the research area over the course of the study. During the assessment period, the study was irrigated to prevent drought stress.

2.2. Experimental design & treatment

Plots were 1.5 × 1.5 m with treatments arranged in a randomized complete block design with four blocks and four replications. Treatments included fungicide and paclobutrazol application timing. Treatments were initiated in the spring when 5-day average soil temperatures reached 13–16 °C, which was determined in previous studies to target soilborne turfgrass diseases (Latin, 2005, 2011; Miller et al., 2012). Precipitation, air, and soil temperatures were recorded daily with an on-site weather station (Model CR10, Campbell Scientific, Logan, UT). Soil temperatures were measured with an external soil probe located 5 cm below the soil surface. Fungicides included metconazole (Tourney 50WG, Valent Corporation), tebuconazole (Torque 3.6SC, Cleary Chemicals), triadimefon (Bayleton FLO 4.15SC, Bayer CropScience), and triticonazole (Trinity 1.69SC, BASF Corporation) applied at low label rates (Table 1) twice on 22 Apr and 20 May in 2011, and on 24 Apr and 22 May in 2012. PGR treatments included no application, or paclobutrazol (Trimmit 2SC, Syngenta Crop Protection, LLC) applied twice at 0.28 kg ha^{-1} as a tank-mix, 7 d after, or 14 d after the DMI fungicide application. The DMI and tank-mix applications were watered-in immediately with 5 mm of irrigation by hand with a hose, with time and spray pattern previously calibrated with rain gauges. Subsequent 7 d and 14 d paclobutrazol treatments were not watered-in. All treatments were applied with a CO_2-powered boom sprayer at 193 kPa using three flat fan nozzles (TeeJet 8008; TeeJet Technologies, Wheaton, IL) calibrated to deliver H_2O at 815 L ha^{-1}. For 24 h post treatment, irrigation was withheld and no precipitation occurred.

2.3. Disease assessment

Disease severity was evaluated every 3–10 days from May through early August. Artificial inoculation was not conducted, and diseases occurred naturally in the plot area. Dollar spot severity was assessed as the number of infection centers per plot. Brown patch severity was assessed as a visual estimation of the percent symptomatic area per plot. Area under the disease progress curve (AUDPC) was calculated for both diseases with the formula $\sum[(y_i + y_i+1)/2][t_{i+1} - t_i]$, where $i = 1,2,3, \ldots, n-1$, y_i is the amount of disease (count or percent area) and t_i is the time at *i*th rating (Shaner and Finney, 1977). T_i is the ordinal date when ≥5 infection centers occurred or when any brown patch was observed in a plot.

2.4. Turfgrass quality assessment

Turfgrass quality was estimated visually on a 1–9 scale (1 = completely dead turf, 5 = acceptable, 9 = excellent). Phytotoxicity was visually assessed on a 0–10 scale (0 = none, 2 = brown discoloration, 10 = total turf loss). Area under the turfgrass quality curve (AUTQC) and area under the phytotoxicity curve (AUPPC) were calculated as described above.

2.5. Data analysis

Statistical analyses were conducted using SAS (version 9.3; SAS Institute, Cary, NC). Least square means (LSMeans) for disease severity, T_i, AUDPC, AUTQC, and AUPPC were subjected to analysis of variance (ANOVA) using the PROC GLIMMIX procedure. Year was added as a treatment variable to determine if differences among the two years existed, and if these data could be combined for analysis. Count data for dollar spot severity assessment was analyzed with a negative binomial distribution model (O'Hara and Kotze, 2010). Percent symptomatic area used for assessing brown patch severity was square root transformed prior to analysis to correct for non-normality. Treatment means were compared with predetermined, single degree-of-freedom orthogonal contrasts at $P \leq 0.05$ (Mead et al., 2003).

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