Interaction of Nitrogen Source, Application Timing, and Fungicide on Rhizoctonia Blight in Ryegrass

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Abstract. Rhizoctonia blight (RB), incited by *Rhizoctonia solani* Kühn, is a common disease of cool-season turfgrasses. This 2-year field study was conducted to determine the influence of N source, N application timing, and fungicide treatment on RB severity in 'Caravelle' perennial ryegrass (*Lolium perenne* L.). Ringer Lawn Restore (Ringer), a slow-release N source, was compared to water-soluble urea. Nitrogen was applied according to either a spring (March, May, June, and September) or fall (September, October, November, and May) schedule. Plots received either N only or N plus the fungicide iprodione (3.1 kg a.i./ha applied at 21-day intervals). RB was reduced with fall-applied Ringer compared to spring-applied urea in both years in fungicide-free plots. Nitrogen generally enhanced foliar mycelium growth and RB during the initial infection periods (i.e., late June to late July). By mid- to late August there were extremely high levels of blighting among all fungicide-free treatments. Nitrogen source and N application time had no effect on the level of blighting in iprodione-treated plots. During early disease outbreaks, iprodione did not always prevent foliar mycelium from appearing, but it did protect turf from severe RB. Iprodione reduced blighting, but the level of disease suppression and resulting turfgrass quality provided on the extended spray interval was not acceptable for high-quality golf course fairways. Chemical name used: 3-(3,5-dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidine carboxamide (iprodione).

Rhizoctonia blight (RB), also known as brown patch, is among the most economically important diseases of turfgrasses worldwide, is caused by *Rhizoctonia solani* (Smiley et al., 1992; Smith et al., 1989), and typically is associated with high N levels (Bloom and Couch, 1960; Burpee, 1995; Vargas, 1994). There is, however, little information on the influence of N source on RB, and to our knowledge, no published reports describe the impact of N application timing on this disease. From the earliest observations of RB, Oakley (1924, 1925) suggested that a well-screened, loamy compost topdressing plus an organic or ammonium-based N source would reduce RB severity on *Agrostis* sp. putting greens. Decomposing organic soil amendments reduced *R. solani* survival in field soil (Davey and Papavizas, 1960; Papavizas et al., 1962). The level of RB suppression with natural, organic N sources, however, has not been consistent. Nelson and Craft (1990) and Soika and Sanders (1991) reported a reduction in RB with natural, organic N sources, when compared to nonfertilized turf in one season. Peacock and Daniel (1992), however, observed no effect of

natural, organic N on RB in a greenhouse study. For zoysiagrass (*Zoysia japonica* Steud.), Green et al. (1994) reported that no N source (i.e., urea, ureaformaldehyde, poultry litter, sewage sludge, or bovine waste material) influenced large patch (caused by *R. solani*) severity. Nitrogen application timing influenced the severity of anthracnose [*Colletotrichum graminicola* (Ces.) Wils.] (Danneberger et al., 1983) and dollar spot (*Sclerotinia homoeocarpa* F.T. Bennett) (Turgeon and Meyer, 1974).

Integrated pest management (IPM) is considered a broad, multidisciplinary approach to managing turfgrass pests (Shurtleff et al., 1987). The integration of fungicide use with cultural practices may enhance the level of turf protection and recovery from diseases along with a reduction in fungicide usage (Bruneau et al., 1992; Smiley et al., 1992). Realistic RB management programs that stress reduced fungicide inputs without a significant loss of turfgrass function and quality are greatly needed in professional turfgrass management. Therefore, our primary objective was not only to evaluate the effect of N application timing (spring vs. fall schedule) on RB, but also to evaluate the effect of a fungicide used in concert with two N sources. The fungicide iprodione was applied at the recommended rate, but on a 21-day interval rather than the recommended 10- to 14-day spray interval for RB control in high-humidity transition zone regions (Watschke et al., 1994). The ultimate goal was to identify an N source or an N

application time that would reduce RB while providing acceptable turf quality, where fungicide application frequency was reduced relative to that recommended. Other objectives were to determine these treatment effects on foliar *R. solani* mycelium cover, overall turfgrass quality, crown tissue carbohydrate content, and soil pH.

Materials and Methods

This field study was initiated at the Univ. of Maryland Turfgrass Research and Education Facility, Silver Spring, in Sept. 1991. Soil was a Chillum silt loam (fine-silty, mixed mesic Typic Hapludult) with an initial pH of 5.8 and 24 mg organic matter/g soil. Initial P and K levels were high, 115 and 195 kg-ha⁻¹, respectively.

Turf was a stand of 'Caravelle' perennial ryegrass seeded in 1990. Treatments were arranged as a randomized complete-block design with four replications. Individual plots measured 1.5 × 1.5 m. From May through Sept. 1992 and 1993, plots were mowed three times weekly to a height of 1.7 cm with a reel mower and twice weekly at other times; clippings always were removed.

The two N sources, Ringer Lawn Restore (10N–0.9P–5K) (Ringer Corp., Minneapolis) and urea (46N–0P–0K), were applied according to either a spring or fall fertilization schedule. There were fungicide-treated and fungicide-free plots for each N source. Nitrogen was applied once in March, May, June, and September for the spring schedule and once in May, September, October, and November for the fall schedule. On each application date, N was applied at 49 kg-ha⁻¹, for a total of 196 kg-ha⁻¹ each year for each schedule. Nitrogen first was applied in Sept. 1991, and the fungicide iprodione first was applied in June 1992. After plots were mowed, the N sources were applied with a shaker jar, and plots were irrigated with ≈20 mm water.

In 1992 and 1993, iprodione was applied at a standard rate of 3.1 kg a.i./ha on 21-day intervals beginning the second week of June through August, for a total of five applications per year. The fungicide was applied with a CO₂-pressurized (262 kPa) sprayer equipped with an 8010 flat-fan nozzle and calibrated to deliver water at 1018 liters-ha⁻¹. On dates when iprodione was applied, plots were visually evaluated for disease severity and turf quality before the fungicide was reapplied.

Disease developed from natural inoculum, and blighted tissues were examined microscopically each week to ensure *R. solani* was the primary pathogen. The plots were assessed visually for RB on a percentage basis using the Horsfall–Barratt scale (Horsfall and Cowling, 1978; Schumann and Wilkinson, 1992). Since percent plot area diseased was the desired variable, each class value was converted to a percentage, according to the midpoint rule, before statistical analysis (Campbell and Madden, 1991). During periods conducive to disease development, plots were rated weekly for area blighted, and at times, they were rated for active *R. solani* foliar mycelium cover. Re-

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sidual RB ratings were obtained at the end of the season after the disease subsided and turf had begun to recover. Subjectively, RB intensity >2% and >5% would be unacceptable commercially or in an IPM program, respectively.

Visual quality ratings were recorded twice weekly during active RB periods and monthly thereafter. A 0 to 10 scale was used to rate overall turf quality, where 0 = entire plot area brown or dead and 10 = optimum color and density. Quality ratings >9.5, >8.5, >7.5, and <6.9 were considered excellent, good, fair, or unacceptable, respectively, for a perennial ryegrass fairway or professionally managed lawn maintained in an IPM program. For each season of the year, overall quality data were combined for statistical analysis, but only summer and fall quality data are presented. Turf quality ratings between 21 June and 20 Sept. were combined for summer, and ratings between 21 Sept. and 20 Dec. were combined for fall. Carbohydrate content, specifically glucose, fructose, and sucrose, was determined by taking a random sample of 10 plants per plot at the conclusion of the study on 9 Sept. 1993. The plant crowns were removed, cleaned of soil and debris, and immediately placed in ice. In the laboratory, the crowns were removed from ice storage and freeze-dried. Each sample of 10 freeze-dried plant crowns was ground in a Wiley mill to pass through a 425- μ m mesh screen. Carbohydrate extraction and analysis were performed from procedures detailed by Slaughter and Livingston (1994).

Soil pH was determined by randomly removing 10 soil plugs (2 cm in diameter $\times$ 6 cm deep) from each plot on 16 Sept. 1993. Soil plugs were partitioned into 0- to 3-cm and 3- to 6-cm zones. Soil from each plot was mixed, air-dried, then pulverized with a soil grinder. Soil pH was determined according to the procedure described by Smiley (1972).

The turf was irrigated as needed to prevent drought stress throughout the duration of the study. In Apr. 1992 and 1993, 3,5-pyridine-dicarbothioic acid, 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-5,5-dimethyl ester (dithiopyr) was applied at 0.55 kg a.i./ha for preemergence smooth crabgrass [*Digitaria ischaemum* (Schreb. ex Schweig) Schreb. ex Muhl.] control. On 6, 8, 22, and 28 July and 13 May 1992 and 3, 16, and 20 June and 3 July 1993, 2-(2-chlorophenyl)-2-(4-chlorophenyl)-5-pyrimidine-methanol (fenarimol) was applied at 0.2 kg a.i./ha to control dollar spot. Fenarimol was used because it has little or no effect on RB, particularly at 0.2 kg a.i./ha (Dernoeden et al., 1994). Plots received *N*-(2,6-dimethylphenyl)-*N*-(methoxyacetyl) alanine methylester (metalaxyl) at 1.6 kg a.i./ha on 14 July 1993 to prevent pythium blight (*Pythium* spp.).

All disease severity and turfgrass quality data were subjected to analysis of variance performed on Statistical Analysis Software (SAS Inst., 1985). Significantly different means were separated using Fisher's protected least significant difference test at $P \leq 0.05$ (Chew, 1976; Steel and Torrie, 1980). Brown patch severity data were used to calculate the area

under the disease progress curve (AUDPC) and the area under the crop recovery curve (AUCRC) as described by Lawton and Burpee (1990). The AUDPC and AUCRC, expressed as percent disease $\times$ day, were calculated by the following formula: $\Sigma[(y_i + y_{i+1}) \div 2] [t_{i+1} - t_i]$, where $i = 1, 2, 3 \dots n-1$; y_i = percent of plot area diseased; and t_i = the time of the i th rating (Berger, 1988; Shaner and Finney, 1977). Mean values of AUDPC and AUCRC were analyzed as previously described. The AUDPC and AUCRC values for 1992 and 1993 represent data collected on the evaluation dates footnoted in Tables 1 and 3. Disease progress and crop recovery data also were analyzed as a randomized complete-block design combined over 2 years (McIntosh, 1983). Soil pH data were analyzed as a split-plot design with four replications, where the whole plot was the N source and the subplot was the soil sampling depth. Where appropriate, plant carbohydrate, soil pH, and disease severity data were subjected to correlation analysis according to procedures described by Freund and Littell (1991).

Results

Combined analyses of AUDPC and AUCRC data for 1992 and 1993 revealed a significant treatment $\times$ year interaction, and data were analyzed separately for each year.

Foliar mycelium, blight, and turfgrass quality, 1992

Plots without fungicide. By 10 and 22 July, the area with *R. solani* mycelium was largest where Ringer was spring-applied (Table 1). In plots that received no N, mycelium cover averaged $\leq 6\%$ on all dates, except 22 July. Spring-applied urea was associated with large amounts of foliar mycelium (22% to 45%) on 22 and 24 July (data not shown for 24 July); these levels on 22 July, however, were $\approx 60\%$ of those with spring-applied Ringer. Through-

out July, mycelium cover was mostly lower in turf treated with N in fall than in spring. Overall N, in particular spring-applied N, enhanced the development of foliar mycelium.

Despite copious amounts of mycelium in some plots on 1 July, the level of RB recorded by 8 July ranged from only 6% to 16% (RB data not shown). Between 8 July and 6 Aug., blighting was generally highest in plots where N was applied in spring. Despite severe damage in all plots by 31 Aug. (33% to 63%), the residual injury observed following fall turf recovery was remarkably low (2% to 8% blight) on 12 Oct.

The AUDPC data revealed that higher RB levels occurred with spring-applied N and fall-applied urea compared to nonfertilized plots (Table 1). The AUDPC value was lowest with the nonfertilized control, which was similar to the value for fall-applied Ringer. The AUDPC value was higher with spring-applied urea vs. fall-applied Ringer. Hence, no N source reduced blighting significantly when compared to nonfertilized turf. There were few AUCRC differences among plots, but recovery values were lower in turf treated with fall-applied Ringer than with fall-applied urea.

Summer quality was poor in all fungicide-free plots (Table 2). Fall quality was fair (i.e., >7.5) in fall-applied N plots and in turf receiving Ringer in spring. The fall quality of nonfertilized plots was inferior to that of plots receiving N.

Fungicide-treated plots. Mycelium cover differences existed only on 1 July and 22 July (Table 1). Nonfertilized plots averaged $\geq 4\%$ mycelium cover. By these dates, iprodione had failed to prevent the development of foliar mycelium, especially in turf treated with spring-applied Ringer. Remarkably, however, RB was absent in these plots when rated 8 July (i.e., 7 days after iprodione was last applied) (RB data not shown). Iprodione was effective in reducing foliar *R. solani* growth (averaging $\leq 2\%$ mycelium cover) when rated on 2 (data not shown) and 10 July. By 22 July, all

Table 1. Influence of N source, N application timing, and iprodione on *R. solani* foliar mycelium and rhizoctonia blight development in perennial ryegrass as expressed by the area under disease progress and crop recovery curves (AUDPC and AUCRC, respectively) in 1992.

N source	T ^y	Plot area covered with mycelium (%) ^z			AUDPC ^x	AUCRC ^x
		1 July	10 July	22 July		
No fungicide						
Urea	F	17 bc ^w	5 b	6 d	2152 bc	1910 a
	S	26 b	7 b	45 bc	2666 ab	1697 a–c
Ringer	F	12 bc	12 b	11 d	1600 cd	1108 b–e
	S	18 bc	36 a	76 a	2864 a	1291 a–d
No fertilizer		1 c	0 b	22 cd	1495 d	1794 ab
Plus fungicide ^v						
Urea	F	12 bc	0 b	22 cd	200 e	475 ef
	S	23 b	0 b	16 cd	240 e	707 d–f
Ringer	F	17 bc	0 b	24 cd	606 e	1007 c–f
	S	61 a	0 b	65 ab	90 e	264 f
No fertilizer		1 c	0 b	4 d	342 e	959 c–f

^zPercentage of plot area covered with mycelium was visually estimated on a 0% to 100% scale, where 0% = no visible mycelium and 100% = entire plot area covered with mycelium.

^yTiming (T) = N applied at 49 kg $\cdot$ ha⁻¹ per application in fall (F) or spring (S), where F = September, October, November, and May, and S = March, May, June, and September.

^xThe 1992 AUDPC data were collected between 8 July and 24 Aug., and AUCRC data were collected between 25 Aug. and 12 Oct.

^wMean separation within columns by Fisher's protected least significant difference test at $P \leq 0.05$.

^vThe fungicide iprodione was applied at 3.1 kg a.i./ha on 10 June, 1 and 22 July, and 11 and 31 Aug. 1992.

iprodione-treated plots (last treated 1 July) had active foliar mycelium, with highest levels in Ringer (spring) and lowest levels in nonfertilized plots. Again, little injury (0% to 3% blight) was observed in these plots on 27 July. Therefore, iprodione effectively protected turf from blighting, but did not always prevent the appearance of foliar mycelium. Large amounts of foliar mycelium only appeared after ≥14 days had elapsed since iprodione was last applied. By 14 Aug. (3 days after iprodione was applied) and thereafter, blighting was generally unacceptable (i.e., ≥5% plot area blighted; data not shown), demonstrating the inability of iprodione to effectively control RB throughout the summer when applied on a 21-day interval. Residual RB ratings, however, ranged from only 1% to 2% in fungicide-treated plots on 12 Oct. (data not shown). There were no AUDPC or AUCRC differences among fungicide-treated plots (Table

1). All fungicide-treated plots, however, had much lower AUDPC and AUCRC values than the respective fungicide-free plots.

Fungicide-treated N plots (Table 2B) generally had higher summer quality than fungicide-free turf (Table 2A). Highest summer quality was in plots fertilized in spring with Ringer, but these values were similar to plots receiving urea in spring. Plots treated in spring with urea exhibited reduced quality in fall, but otherwise, there were no differences among fungicide-treated plots. Summer and fall quality were poorest in nonfertilized turf.

Foliar mycelium, blight, and turfgrass quality, 1993

Plots without fungicide. Foliar mycelium cover again was more extensive in turf treated with Ringer (spring) when evaluated on 21 June and 4 July than in all other treatments

(Table 3). Spring-applied urea was associated with more mycelium cover (average = 52%) than urea applied in the fall (average = 26%) when examined on 4 and 15 July and 11 Aug. Higher amounts of mycelium were observed on 21 June and 4 July with spring vs. fall-applied Ringer. There was, however, only 0% to 6% mycelium cover in nonfertilized plots, again demonstrating that N encouraged foliar mycelium early in the season. After 15 July (data not shown), nonfertilized plots generally had foliar mycelium levels equivalent to plots receiving N.

Plots exhibited 61% to 86% of plot area blighted by 16 July (detailed data not shown). These RB levels generally were similar to the amount of foliar mycelium observed on 15 July. During July and August, turf receiving spring-applied urea generally had the highest RB ratings (44% to 84%), coinciding with higher foliar mycelium cover on those plots on 15 July and 11 Aug. RB had subsided somewhat by 11 Aug., and Ringer plots had RB levels (17% to 20%) statistically equivalent to fungicide-treated turf (30%). As was noted in 1992, residual RB (3% to 8%) on 27 Sept. 1993 was relatively low despite severe disease in late August. The AUDPC values show that RB was more severe in turf treated with urea (spring) than with Ringer (fall or spring) (Table 1). Plots fertilized with Ringer in the fall, however, had a lower AUDPC value than nonfertilized plots. There were no AUCRC differences among plots.

All fungicide-free plots exhibited unacceptable summer quality (i.e., ≤6.9), and only turf fertilized with Ringer (spring) had higher quality than nonfertilized turf (Table 2). Fall quality was in the fair range in plots fertilized with Ringer in spring, but these quality ratings were similar to plots fertilized with Ringer or urea in fall. Lowest summer and fall quality was again in nonfertilized turf.

Fungicide-treated plots. Iprodione effectively suppressed foliar mycelium cover (average ≤5%) when evaluated on 21 June, 4 July, and 11 Aug. (Table 3). On 15 July and 16 Aug. (data not shown), mycelium cover was 27% to 34% on spring-applied Ringer plots, whereas all other plots ranged from 1% to 8% cover. Data from both years suggest that the organic component of Ringer applied in recent months (i.e., May and June) was used as an *R. solani* substrate. There were, however, no significant increases in RB in the Ringer-treated (spring) plots (RB data not shown). Blighting was most extensive (>19%) on 24 Aug. (i.e., 15 days after iprodione was applied), again reflecting less residual control by the fungicide. Turf again demonstrated excellent recovery on 27 Sept. as residual RB ranged from 2% to 9% plot area damaged among all treatments.

There were no differences in AUDPC values among iprodione treatments, and these values were lower than those from fungicide-free plots. Recovery was best (i.e., lowest AUCRC values) in plots that received fall N or no fertilizer (Table 3). Poorest recovery was associated with spring-applied urea.

Despite late-season RB pressure, fair summer quality was maintained in all plots receiv-

Table 2. Influence of N source, N application timing, and iprodione fungicide on perennial ryegrass quality, 1992 and 1993.

N source	T ^y	Quality rating ^z			
		1992		1993	
		Summer	Fall	Summer	Fall
No fungicide					
Urea	F	5.8 de ^x	7.8 ab	6.3 cd	7.0 bc
	S	5.9 de	7.2 bc	6.2 cd	6.5 c
Ringer	F	6.1 cd	8.1 a	6.5 cd	7.2 a-c
	S	6.2 cd	7.8 ab	6.9 bc	7.9 ab
No fertilizer		5.7 de	5.8 d	5.8 d	5.0 d
Plus fungicide ^w					
Urea	F	7.0 b	7.8 ab	8.0 a	8.2 a
	S	7.2 ab	6.9 c	7.8 ab	6.5 c
Ringer	F	6.6 bc	7.8 ab	7.8 ab	8.0 ab
	S	7.8 a	7.6 ab	7.8 ab	7.5 a-c
No fertilizer		5.3 e	5.2 e	6.2 cd	5.3 d

^zTurf quality was assessed on a visual scale, where 0 = entire plot area brown or dead turf and 10 = optimum color and density. Turf quality ratings between 21 June and 20 Sept. were combined for summer, and ratings between 21 Sept. and 20 Dec. were combined for fall.

^yTiming (T) = N applied at 49 kg·ha⁻¹ per application in fall (F) or spring (S), where F = September, October, November, and May, and S = March, May, June, and September.

^xMean separation within columns by Fisher's protected least significant difference test at *P* ≤ 0.05.

^wThe fungicide iprodione was applied at 3.1 kg a.i./ha on 10 June, 1 and 22 July, and 11 and 31 Aug. 1992 and 7 and 28 June, 19 July, and 9 and 30 Aug. 1993.

Table 3. Influence of N source, N application timing, and iprodione on *R. solani* foliar mycelium, and *Rhizoctonia* blight development in perennial ryegrass as expressed by the area under disease progress and crop recovery curves (AUDPC and AUCRC, respectively) in 1993.

N source	T ^y	Plot area covered with mycelium (%) ^z				AUDPC ^x	AUCRC ^x
		21 June	4 July	15 July	11 Aug.		
No fungicide							
Urea	F	2 b ^w	19 c	35 c	24 bc	1890 a-c	1101 a
	S	1 b	36 b	85 a	36 a	2446 a	1235 a
Ringer	F	0 b	40 b	74 ab	13 cd	1487 c	989 ab
	S	20 a	62 a	86 a	20 bc	1675 bc	939 ab
No fertilizer		0 b	6 d	64 b	28 ab	2131 ab	961 ab
Plus fungicide ^v							
Urea	F	1 b	0 d	1 d	1 d	216 d	581 bc
	S	1 b	0 d	3 d	1 d	309 d	1152 a
Ringer	F	0 b	0 d	1 d	4 d	355 d	551 bc
	S	2 b	0 d	34 c	2 d	430 d	986 ab
No fertilizer		1 b	0 d	1 d	5 d	630 d	382 c

^zPercentage of plot area covered with mycelium was visually estimated on a 0% to 100% scale, where 0% = no visible mycelium and 100% = entire plot area covered with mycelium.

^yTiming (T) = N applied at 49 kg·ha⁻¹ per application in fall (F) or spring (S), where F = September, October, November, and May, and S = March, May, June, and September.

^xThe 1993 AUDPC data were collected between 10 July and 24 Aug., and AUCRC data were collected between 25 Aug. and 27 Sept.

^vMean separation within columns by Fisher's protected least significant difference test at *P* ≤ 0.05.

^wThe fungicide iprodione was applied at 3.1 kg a.i./ha on 7 and 28 June, 19 July, and 9 and 30 Aug. 1993.

ing N (Table 2). Unacceptable summer quality was associated with nonfertilized turf. Highest fall quality was in plots given fall N, but these means did not vary significantly from those of several other treatments. Turf treated with urea (spring) and nonfertilized plots had poorest fall quality.

Carbohydrate analyses and soil pH. There were no significant glucose, fructose, or sucrose concentration differences among treatments (data not shown). For most treatments, sucrose concentrations were higher than those for glucose or fructose. Soil pH (mean pH = 5.3) was similar regardless of N source or sampling depth (data not shown). No significant correlations were found between carbohydrate levels or soil pH and RB severity.

Discussion

No N source or application timing reduced RB compared to nonfertilized turf in 1992. In 1993, however, AUDPC values for fungicide-free plots fertilized with Ringer in fall were lower than those for nonfertilized plots. These 1993 results support observations by Nelson and Craft (1990) and Soika and Sanders (1991). Although fall-applied Ringer reduced the disease, summer turf quality was unacceptable because of high levels of blighting. In fungicide-free turf, blighting was generally higher when N was spring-applied, partly due to spring applications of N enhancing the development of foliar *R. solani* mycelium. In 1993, however, spring-applied Ringer enhanced growth for foliar mycelium, but the level of blighting was not increased significantly compared to fall-applied N or nonfertilized plots. The incidence of copper spot (*Gloeocercospora sorghi* Bain and Edgeton ex Deighton) is enhanced by N causing an increase in amino N in leaf exudates (Smith et al., 1989). Conceivably, therefore, enhanced growth of foliar *R. solani* mycelium may be attributed to increases in nutritive leaf surface exudates supplied by spring-applied N. Also, the organic component of Ringer possibly served as a substrate for *R. solani*.

Values for AUDPC were similar for Ringer and urea applied in the fall. RB levels, however, were reduced by fall-applied Ringer compared to spring-applied urea in both years in fungicide-free plots. The beneficial effects from Ringer might be attributed to its slow-release characteristics and its P and K constituents. The possibility of Ringer enhancing microbial activity or antagonism of *R. solani*, however, was not investigated.

Fungicide-free turf had unacceptable summer quality in both years. Iprodione reduced blighting compared to all fungicide-free plots on nearly all rating dates. Except for nonfertilized plots, fungicide-treated turf ex-

hibited fair summer quality in 1993, but Ringer (spring) plots had fair summer quality in both years. Blighting, however, was unacceptably severe in fungicide-treated turf by late August. Fortunately, this event coincides with the normal overseeding time in the mid-Atlantic region, which is performed in late August or early September. Our study showed that, when RB was severe, N and fungicide applications were required to reduce disease and improve summer quality. A more efficacious fungicide program, however, would be needed to provide for the high level of quality that is desirable for most golf course fairways. In regions where RB is not a chronic and severe disease problem, fungicide application frequency may not be as important as it was under the conditions of our study. Soil pH and plant carbohydrate concentration had no apparent effect on RB severity.

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