



Influence of a PGR on the efficacy of fungicides for control of dollar spot on creeping bentgrass

During a three-year study, Primo Maxx appeared to have a neutral effect on the increase and decrease of dollar spot disease.



Dollar spot is arguably the most serious disease of creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) on golf courses in the Midwestern and northeastern U.S. The disease threatens creeping bentgrass and annual bluegrass fairways, tees and putting greens throughout the growing season. Damage is limited by repeated applications of effective, but costly fungicides.

The severity of dollar spot outbreaks is influenced by a variety of factors including temperature, moisture, fertility and turf maintenance practices such as application of plant growth regulators (PGRs). Because PGR use has become a conventional turf management practice, it is reasonable to consider whether or not they influence disease development and/or fungicide performance against common diseases of golf course turf.

Previous research

Most of the investigations on the effects of PGRs on disease development have involved dollar spot. An early report described improved fungicide efficacy with use of Primo Maxx (trinexapacetyl, Syngenta) against dollar spot on creeping bentgrass maintained at fairway height in Ohio (5). Several research briefs addressed combinations of Primo Maxx and various fungicides for

dollar spot control. They described a neutral effect of Primo Maxx on fungicide performance (3,4).

A more thorough investigation addressed the interaction of PGRs with fungicides for dollar spot control (2). In this case, the effects of PGRs on fungicide efficacy against dollar spot varied among PGR active ingredients and fungicides for each year of the research. In general it showed that Primo Maxx, unlike two other PGRs (Cutless [flurprimidol, SePro] and Trimmit 2SC [paclobutrazol, Syngenta]), is not fungistatic to *S. homoeocarpa* and was less likely to affect fungicide performance.

Another study (7) reported increased antioxi-



Dollar spot is a troublesome disease on putting greens. Photos by R. Latin

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dant (superoxide dismutase) levels in response to Primo Maxx applications and suggested that the growth regulator increased host plant resistance to the dollar spot fungus.

Research on the influence of PGRs is not limited to their effects on dollar spot development. Results are mixed, but the majority of cases showed that Primo Maxx did not influence disease development or fungicide efficacy against *Rhizoctonia* blight of tall fescue (1). A more recent investigation of the effects of Primo Maxx on anthracnose of annual bluegrass demonstrated reduced disease severity where the PGR was applied (6).

Some of the previous research was conducted on fairway-height turf, whereas other research focused on turf maintained at putting green height. Most reports involve research conducted in only one year. None of the investigations addressed the effects of PGRs, and specifically Primo Maxx, on disease progress and fungicide efficacy after outbreaks had already occurred. Because the growth reduction effects of PGRs may delay recovery from disease symptoms, the effects of Primo Maxx on post-outbreak disease suppression and restoration of fine turf should be examined.

The objective of this research was to conduct a comprehensive study of the effects of Primo Maxx on the performance of Daconil Ultrex (chlorothalonil, Syngenta) and Banner Maxx (propiconazole, Syngenta) against dollar spot on creeping bentgrass greens and fairways, including the effects on fairway turf where disease was well established.

Materials and methods

Research was conducted in 2004, 2005 and 2006 on swards of Pennncross creeping bentgrass maintained as putting greens mowed at 0.13 inch (3.3 millimeters) and as fairway turf mowed at 0.5 inch (12.7 millimeters). The turf plots were located at Purdue University's Daniel Turfgrass Research and Diagnostic Center in West Lafayette, Ind.

General plot maintenance was similar for each year of the research. Fertilizer was broadcast at a rate of 130.6 pounds nitrogen/acre (146.4 kilograms/hectare) for putting greens and 152.4 pounds/acre (170.8 kilograms nitrogen/hectare) for fairways, with approximately 70% of the nitrogen applied from September through November. Remaining nitrogen was applied equally between the months of April and June. These applications were designed to simulate a standard fertilizer program on golf courses in Indiana where at least 50% of the total nitrogen is not soluble in water.

Irrigation was applied as needed throughout



The experimental plots were located at the Purdue University Daniel Turfgrass Research and Diagnostic Center in Indiana.

the course of the experiments to prevent drought stress and to promote conditions favoring the dollar spot pathogen. Dollar spot was allowed to develop through natural infection.

Treatments

All experiments involved six treatments as described in Table 1. Fairway treatments were tested under two regimes defined by disease status at the time treatments were initiated (pre-outbreak



Treatments

Treatment no.	Chemical name	Product name	Application rate	
			Per acre	Per hectare
1	no treatment			
2	trinexapac-ethyl	Primo Maxx	11 fluid ounces	0.8 liter
3	propiconazole + trinexapac ethyl	Banner Maxx	2.75 pints	3.2 liters
		+ Primo Maxx	11 fluid ounces	0.8 liter
4	propiconazole	Banner Maxx	2.75 pints	3.2 liters
5	chlorothalonil + trinexapac ethyl	Daconil Ultrex 82.5WG	8.72 pounds	9.8 kilograms
		Primo Maxx	11 fluid ounces	0.8 liter
6	chlorothalonil	Daconil Ultrex 82.5WG	8.72 pounds	9.8 kilograms

Table 1. Each experiment included the same six treatments. Influence of Primo Maxx on disease progress and fungicide efficacy was examined by statistical comparisons of treatment 1 vs. treatment 2, treatment 3 vs. treatment 4, and treatment 5 vs. treatment 6.



Dollar spot near a golf course green.

or post-outbreak). For experiments in the pre-outbreak regimes, dollar spot symptoms were absent from plots when Primo Maxx treatments were initiated. For the post-outbreak regime, Primo Maxx was first applied after dollar spot symptoms were observed in all creeping bentgrass fairway plots. Only pre-outbreak trials were conducted on putting greens because tolerance for damage on greens is so low that experiments allowing more than 1% disease on greens are unrealistic.

Treatment applications

Fungicide and PGR treatments were applied to field plots using a customized boom sprayer that delivered a spray volume of 87.0 gallons/acre (813.9 liters/hectare) at 40 pounds/square inch (276 kilopascals). Primo Maxx was applied at a rate of 11 fluid ounces of product/acre (0.8 liter/hectare) beginning seven days before the start of each experimental run. A second application was made 14 days after the first, except in the season-long experiments in which the PGR was applied six times at 14-day intervals through the entire season. Daconil Ultrex was applied at 8.72 pounds of product/acre (9.8 kilograms/hectare), and Banner Maxx was applied at 2.75 pints/acre (3.2 liters/hectare). Both were applied as single applications of product seven days after the initial Primo Maxx treatment, except in the season-long experiments, where they were repeated at 21-day intervals during the course of the experiment.

Assessments

We conducted a total of 15 experiments over three growing seasons. Dollar spot severity was assessed at seven-day intervals for the season-long experiments and at two- to three-day intervals for all other trials. AUDPC (area under the disease progress curve) values were calculated from dollar spot infection center counts in pre-outbreak trials, and from disease percentage estimates for post-outbreak and season-long experiments.

To estimate the influence of Primo Maxx on disease development and fungicide performance, the same treatment pairs were compared statistically in all experiments. Untreated plots were

compared with plots treated with Primo Maxx alone. Chlorothalonil-treated plots were compared with plots treated with Daconil Ultrex plus Primo Maxx. Banner Maxx treatments were compared with treatments of Banner Maxx plus Primo Maxx.

Results

Based on AUDPC values, Primo Maxx had little effect on the severity of dollar spot in pre-outbreak experiments on greens and fairways (Table 2). There were a few cases where treatments with and without Primo Maxx resulted in statistically different disease severity values (highlighted in red and green, Table 2), but there was no consistent pattern and all other comparisons showed negligible effects associated with the PGR. In the post-outbreak experiments, Primo Maxx reduced the efficacy of Banner Maxx in 2004 and 2005 and reduced the efficacy of Daconil Ultrex in one trial in 2005 (highlighted in blue, Table 2).

In the season-long experiments, the only significant effect of Primo Maxx was found in 2005 when it increased the efficacy of Daconil Ultrex

(highlighted in yellow, Table 2), but significant differences were not observed in 2006.

Pre-outbreak experiments

Results from the pre-outbreak experiments on putting greens and fairways suggest a net neutral effect of Primo Maxx on dollar spot development and fungicide performance. In most cases there were no differences in disease severity among relevant comparisons. In the few cases where differences were observed, applying Primo Maxx was not consistently associated with an increase or a decrease in disease severity. These results support other published research demonstrating that dollar spot was not suppressed and fungicide efficacy was not affected by the use of Primo Maxx (2,3,4).

Our conclusions differ from reports suggesting that Primo Maxx contributes to a reduction in dollar spot severity (5,7). However, in one report (7), conclusions were based on results from a single experiment where differences were not constant throughout the experimental period. While their observations are certainly valid, and we did

Disease severity

Year.trial	Treatment 1 No Treatment	Treatment 2 Primo Maxx	Treatment 3 Banner Maxx+ Primo Maxx	Treatment 4 Banner Maxx	Treatment 5 Daconil Ultrex + Primo Maxx	Treatment 6 Daconil Ultrex
Pre-outbreak (green)						
2004.1	1,078.0	1,310.3	312.3	478.8	478.8	358.5
2004.2	1,752.3	1,188.8	469.0	581.8	426.3	1060.8
2005.1	175.8	150.5	97.5	146.0	87.0	107.5
2005.2	127.3	86.5	63.5	105.8	61.0	80.5
Pre-outbreak (fairway)						
2004.1	132.8	438.3	24.6	13.0	39.0	16.3
2004.2	1,914.5	1,672.5	408.8	230.5	393.0	292.8
2005.1	253.1	202.0	63.9	229.8	88.5	135.3
2005.2	154.3	147.3	119.4	46.0	58.9	47.1
2006	465.4	44.5	31.1	52.0	91.5	80.8
Post-outbreak (fairway)						
2004	1,283.1	1,325.3	750.4	515.0	710.2	657.0
2005.1	379.1	436.1	372.3	140.2	363.7	134.6
2005.2	999.7	1,086.2	219.1	192.4	335.4	334.1
2006	187.8	239.0	101.4	119.8	126.8	124.1
Season-long (fairway)						
2005	2,471.7	2,301.7	302.4	479.1	671.8	945.0
2006	915.4	610.5	143.2	126.4	236.4	442.5

Table 2. Disease severity, described in terms of the area under the disease progress curve (AUDPC), for each treatment and all experiments during three years of research. Influence of Primo Maxx on disease progress and fungicide efficacy was examined by statistical comparisons of treatment 1 vs. treatment 2, treatment 3 vs. treatment 4, and treatment 5 vs. treatment 6. A few statistically significant differences (highlighted) appeared in comparisons of disease severity in plots treated with and without Primo Maxx.



Season-long experiments, 2005

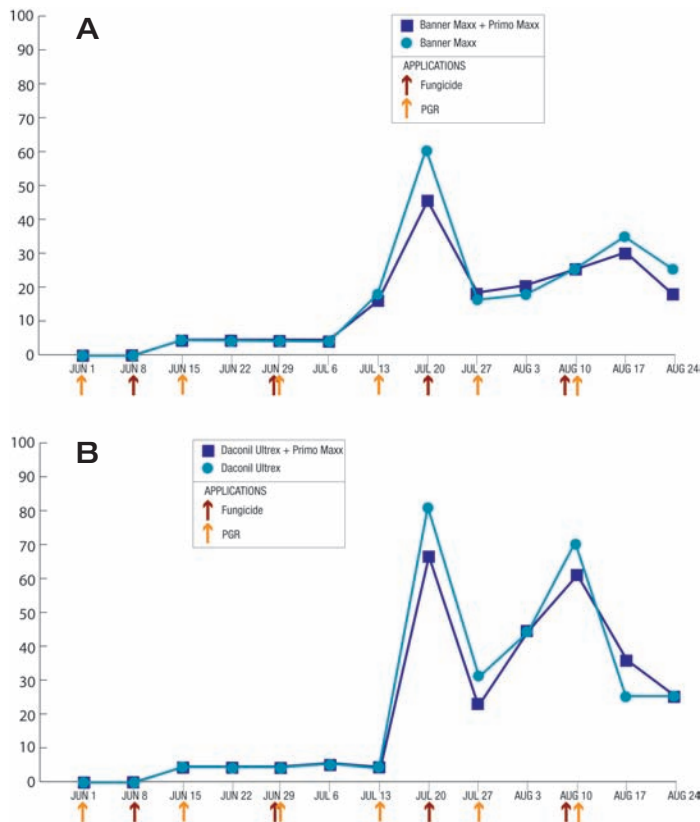


Figure 1. Season-long (June 1-Aug. 24) data from 2005 for both fairways and greens show that dollar spot disease severity when only Primo was applied does not differ significantly from disease severity when Primo Maxx was applied with either Banner Maxx (A) or Daconil Ultrex (B). From a practical standpoint, using Primo Maxx over an entire season had negligible effects on fungicide performance, although some differences in disease progress were observed.

observe this effect on a few occasions, differences appear to be the exception rather than the rule.

Season-long experiments

The influence of Primo Maxx and fungicides on dollar spot over several years on both putting greens and fairways showed few significant differences, but strong evidence of anything other than a neutral effect was not apparent. Negligible effects of Primo Maxx on dollar spot development are further supported in season-long experiments. Although a significant difference in AUDPC occurred when Primo Maxx was combined with Daconil Ultrex in 2005, disease progress curves indicate that the difference is probably not important in terms of disease control (Figure 1).

Post-outbreak experiments

In the post-outbreak experiments, disease progress curves reveal the basis for concern over using PGRs when disease is already present. In 2004, there was a delay in turf recovery after the Banner Maxx application in plots also treated with Primo Maxx (Figure 2A). This result suggests that diminished turf growth reduced fungicide uptake and limited the suppressive effect of the active ingredient, thereby delaying recovery from the outbreak. Although only one penetrant fungicide (Banner Maxx) was tested, we would expect the same results for all demethylation-inhibitor (DMI) fungicides. Such a delay was not apparent for the Daconil Ultrex comparisons (Figure 2B), most likely because it is a contact fungicide and therefore not vulnerable to the consequences

Post-outbreak experiments, 2004

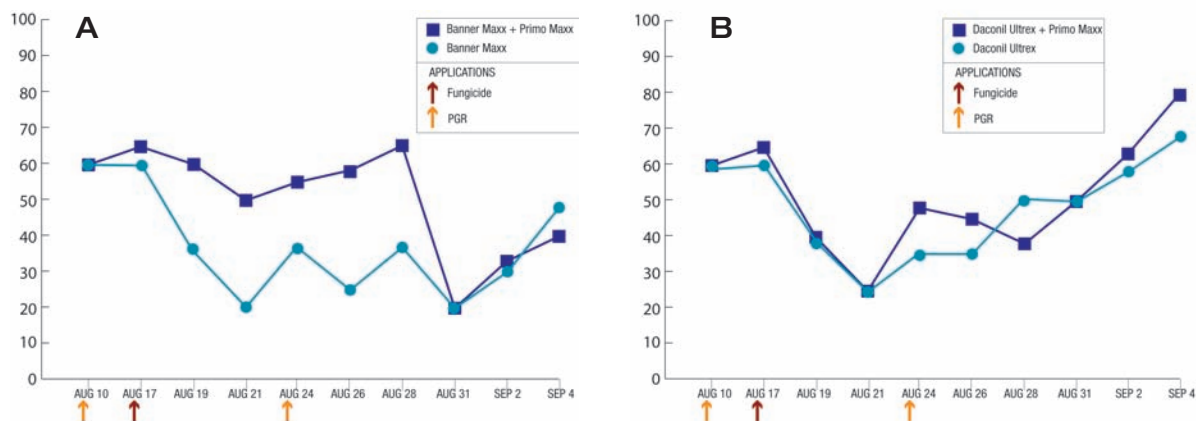


Figure 2. Data from Aug. 10 to Sept. 4, 2004, show the results of applying Primo and Primo plus Banner Maxx (A) or Daconil Ultrex (B) after a serious disease outbreak. When applied in combination with Banner Maxx, Primo Maxx delayed turf recovery, but the combination of Primo Maxx and Daconil Ultrex did not have the same effect. A likely reason for the difference in the results is that, unlike Banner Maxx, Daconil Ultrex is a contact fungicide and not vulnerable to the consequences of reduced uptake into the plant.

of reduced uptake into the plant. Considering all of the post-outbreak trials, Primo Maxx had little effect on disease progress except when dollar spot outbreaks were especially severe.

Conclusions

This research represents a comprehensive investigation of the effects of Primo Maxx on the development and control of dollar spot on creeping bentgrass greens and fairways. Significant effects were observed in only a few experimental situations, indicating that in most cases Primo Maxx did not contribute to an increase or decrease in fungicide efficacy against dollar spot.

The significant differences between treatments in the post-outbreak experiments, however, represent a legitimate concern because superintendents may encounter occasional severe dollar spot outbreaks on fairways and question the continued use of Primo Maxx while disease levels remain high. Because we lack consistent evidence that Primo Maxx contributes to improved disease control, it may be prudent to suspend such treatments to fairways until turf has fully recovered from the disease-related damage.

Given that fungicide performance is influenced by numerous interacting factors including disease pressure, chemical deposition and depletion phenomena, and fungicide sensitivity of the pathogen population, neutral results associated with a single factor should not be unexpected.

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GCM

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The presence of mycelium indicates dollar spot activity.



The research says

→ The objective of the research was to determine whether Primo Maxx, a PGR, influenced disease development and/or the performance of the fungicides Daconil Ultrex and Banner Maxx against dollar spot of fairways and putting greens.

→ Significant effects were observed only a few times, indicating that, in most cases, Primo Maxx did not contribute to an increase or decrease in fungicide efficacy.

→ Because delay in recovery was seen in a few cases when Primo Maxx was applied to turf after a serious disease outbreak and because we lack consistent evidence that Primo Maxx contributes to improved disease control, it may be prudent to suspend such treatments to fairways until turf has fully recovered.

→ Because fungicide performance is influenced by numerous interacting factors, neutral results associated with a single factor should not be unexpected.