Evaluation of Phosphonate Fungicides for Control of Pythium Blight on Creeping Bentgrass and Perennial Ryegrass

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Introduction

Phosphonate fungicides are used by golf course managers to control Pythium diseases, suppress anthracnose basal rot, alleviate summer stress, and improve turf quality. In many areas of the northeast, phosphonate products are applied at regular intervals throughout the summer as part of a fairway and putting green management program. Currently, over a dozen phosphonate fungicides and fertilizers are available on the golf turf market. Although these products have similar active ingredients and modes of action, they differ in trade name, formulation, label terminology, uses, and price. Understanding the different phosphonate products and how they perform in the field should help superintendents decide which product is most suitable for their particular need.

The objective of this study was to determine if active ingredient and formulation of phosphonate fungicides [potassium phosphite (Alude) or fosetyl Al (Aliette and Chipco Signature)] provide similar control of Pythium blight when applied at equivalent rates of phosphorous acid, the active compound for controlling this disease.

Materials and Methods

This study was conducted at the Joseph Valentine Turfgrass Research Center, University Park, PA during 2004 and 2005. The soil at the test site is a Hagerstown silt loam with a pH of 6.8, 150 lb Mehlich-3 P/acre (75 ppm Mehlich-3 P), 0.54 meq K/100 g soil (210 ppm K), and a CEC of 13.4 meq/100 g soil. The turfgrasses used in this study were ‘Integra’ perennial ryegrass and ‘Penncross’ creeping bentgrass. Both species were established on the test site from seed (4.0 lb perennial ryegrass seed/1000 ft^2 and 1.0 lb creeping bentgrass seed/1000 ft^2) during Sep, 2003 and in Sep, 2004. The turf was mowed at 1.0 inch every other day with a rotary mower (clippings returned), and fertilized twice per year (spring and summer) with 1.0 lb N as IBDU/1000 ft^2 per application.

Prior to treatment application in 2004 and 2005, a 30 ft by 48 ft chamber constructed of an aluminum frame and covered with clear polyethylene plastic was placed over the test site (Fig. 1). An automatic misting system designed to increase humidity and cool the turf was suspended from the chamber frame. After treatments were applied, the two open ends of the chamber were sealed with preassembled wooded frames covered with clear polyethylene plastic. Each end was equipped with a hinged window that could be opened or closed to facilitate heating or cooling. Two electric heaters equipped with fans and thermostats were placed on either side of the chamber to aid in heating when nighttime temperatures dropped below 60°F.

Fig. 1. Pythium chamber with plastic-covered wooden frames sealing the ends of the chamber.

Treatments included commercial formulations of three phosphonate fungicides; Alude (Cleary Chemical Corp., Dayton, NJ), Aliette (Bayer Environmental Science, Montvale, NJ), and Chipco Signature (Bayer Environmental Science, Montvale, NJ); a 1.0 M solution of reagent-grade phosphorous acid (H_3PO_3) adjusted to a pH of 6.2 with 10.0 M potassium hydroxide (KOH); a solution of reagent-grade phosphoric acid (H_3PO_4) adjusted to a pH of 6.2 with 10.0 M potassium hydroxide; Subdue MAXX, a commercial formulation of mefenoxam (Syngenta Crop Protection, Inc., Greensboro, NC); and an untreated control. All phosphonate fungicides and the reagent-grade phosphorous acid/potassium hydroxide treatment were applied at equivalent amounts of phosphorous acid (based on the phosphorous acid equivalent listed on the Alude label and according to the chemical formula and amount of fosetyl Al listed on the Aliette and Chipco Signature labels). The rate of phosphorous acid used in this study was based on the intermediate product rate (7.4 fl oz/1000 ft^2) listed on the Alude label for Pythium diseases. The rates of product and phosphorous acid for all phosphonate treatments are provided in Table 1. The rates of the reagent-grade phosphoric acid/potassium hydroxide treatment and Subdue MAXX are also listed in Table 1.

The experimental design was a split block design with fungicide treatments serving as whole plots and grass species as sub plots. Each treatment was replicated four times. The whole plots were 3 ft by 8 ft and sub plots were 3 ft by 4 ft.

Prior to inoculation and treatment application, 3336 F (thiophanate methyl, Cleary Chemical Corp., Dayton, NJ) was sprayed at 4 fl oz/1000 ft^2 to prevent brown patch and dollar spot. Previous studies have shown that benzimidazole fungicides suppress brown patch and dollar spot and sometimes enhance Pythium blight development.

Treatments were applied on 30 Aug, 2004 and 18 July, 2005 with a CO_2-powered backpack sprayer equipped with a single boom and 11008E nozzle. Applications were made at 40 psi with a dilution rate equivalent to 2 gal water/1000 ft^2. On 31 Aug, 2004 and 19 July, 2005, the open ends of the chamber were sealed with the plastic-covered end frames. The entire test area was inoculated on 1 Sep, 2004 and 20 July, 2005 with 36 qt of a mycelia and rye grain slurry made from a five-isolate pool (P-3, P-20, P-38, P-40, and P-41) of *Pythium aphanidermatum*. The slurry was distributed over the test area by hand using a jar with a perforated lid. To insure uniform coverage, four passes were made over the entire test area in different directions.

Immediately following inoculation, the misting system was activated for approximately five minutes and the chamber was sealed to maintain high temperatures and humidity. The misting system was activated periodically during the test period to cool turf and increase humidity. Test plots were not mowed between the day of treatment application and disease assessment (12 d).

Disease assessments were made on both grass species on 10 Sep, 2004 (10 d after inoculation and 12 d after treatments were applied) and 29 July, 2005 (9 d after inoculation and 11 d after treatments were applied). Visual assessments were based on the percentage of plot area showing Pythium blight symptoms (% blighting). Data were subjected to analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test at the 0.05 level of significance.

Table 1. Treatments and rates used in the Pythium blight phosphonate fungicide study in 2004 and 2005.

Treatment	Rate/1000 ft^2	H_3PO_3 equivalent/1000 ft^2
Control	----	---
H_3PO_4/KOH solution	4.0 oz	---
H_3PO_3/KOH solution	43.6 fl oz	89.4 g
Alude	7.4 fl oz	89.4 g
Aliette	5.7 oz	89.4 g
Chipco Signature	5.7 oz	89.4 g
Subdue MAXX	1.0 fl oz	----

Results

Results for 2004: Analysis of variance of 2004 percent blighting data indicates that the main effects of turf species and fungicide treatment were significant ($P \leq 0.01$) (Table 2). Disease symptoms (expressed as percent blighting) were more severe on perennial ryegrass than creeping bentgrass and fungicides provided better control of Pythium blight on creeping bentgrass than on perennial ryegrass (Fig. 2 & 3). All fungicide treatments (including the reagent grade phosphorous acid/potassium hydroxide solution) provided good control (> 89%) of Pythium blight on creeping bentgrass and perennial ryegrass relative to the untreated control. The phosphoric acid/potassium hydroxide treatment did not differ in percent blighting from the untreated control on either species, indicating that plant-available phosphorus and potassium were not responsible for disease inhibition.

On creeping bentgrass, no differences in percent blighting were detected among any of the fungicides used in this test (Fig. 2). However, on perennial ryegrass, Subdue MAXX provided better control of Pythium blight than the phosphorous acid/potassium hydroxide treatment and Alude; but was not different from the Aliette and Chipco Signature treatments (Fig. 3). No differences in percent blighting were detected among any of the phosphonate treatments on either turfgrass species in 2004, regardless of active ingredient or formulation.

A significant treatment by species interaction ($P \leq 0.001$) indicates that differences in blighting occurred between perennial ryegrass and creeping bentgrass in the untreated control and phosphoric acid/potassium hydroxide treatment; whereas no differences in percent blighting occurred between the two species when treated with any phosphonate treatment or Subdue MAXX (Table 2).

Results for 2005: Analysis of variance of 2005 data show that the main effect of turf species was not significant, but the main effect of fungicide treatment was significant at $P \leq 0.001$ (Table 2). In contrast to 2004, percent blighting in 2005 was similar on both species (Fig. 4 & 5). All fungicide treatments (including the reagent grade phosphorous acid/potassium hydroxide treatment) provided better control of Pythium blight than the untreated control and phosphoric acid/potassium hydroxide treatment on creeping bentgrass and perennial ryegrass. Although Pythium blight control with the phosphonate fungicide treatments was not as pronounced in 2005 as in 2004, no differences in percent blighting occurred among these fungicides (regardless of active ingredient or formulation) on either turfgrass species.

On creeping bentgrass, Subdue MAXX provided better control of Pythium blight than the Alude treatment, but was not different from the Aliette, Chipco Signature, and phosphorous acid/potassium hydroxide treatments (Fig. 4). On perennial ryegrass, Subdue MAXX provided better control of Pythium blight that all other treatments (Fig. 5).

A significant treatment by species interaction ($P \leq 0.05$) indicates some differences in efficacy occurred among fungicide treatments on the two grass species (Table 2). Whereas no differences in percent blighting were detected between perennial ryegrass and creeping bentgrass for the untreated control, phosphoric acid/potassium hydroxide, Alude, and Subdue treatments; blighting was more severe in perennial ryegrass than creeping bentgrass in the Aliette, Chipco Signature, and phosphorous acid/potassium hydroxide treatments.

Conclusions

Results of this study showed that when phosphonate fungicides with different active ingredients and formulations [potassium phosphite (Alude and the phosphorous acid/potassium hydroxide treatment) and fosetyl Al (Aliette and Chipco Signature)] were applied at the same rate of phosphorous acid, no differences in Pythium blight control occurred among these products.

Differences in the degree of *overall* Pythium blight control between 2004 and 2005 was detected with the phosphonate fungicides, with much better control occurring in 2004. Differences between years may be explained by variation in the temperature and humidity levels inside of the chamber between the 2004 and 2005 test periods. Previous studies by Nutter and associates in Pennsylvania found that Pythium blight was more likely to occur when the maximum daily temperature was greater than 86°F, followed by at least 14 hours of relative humidity greater than 90%, and the minimum nighttime temperature was 68°F. In 2004, there were only 57 hours with temperatures over 86°F and 59 hours under 68°F inside of the chamber; whereas in 2005, there were 75 hours over 86°F and only 42 hours under 68°F in the chamber. This suggests that conditions in 2005 were more conducive for Pythium blight development than in 2004, and may explain the breakdown in control during 2005.

The Pythium chamber described in this report provides a severe test of fungicide performance. The chamber was used to sustain temperatures and humidity levels that would ensure maximum sustained disease development over a short period. Such conditions are unlikely to occur in Pennsylvania; thus, we believe that these data are more meaningful for comparing fungicide performance under extreme disease-conducive conditions than predicting the overall level of disease control in the field.

Table 2. Analysis of variance of % blighting data as influenced by fungicide treatments and turfgrass species.

		Mean squares of % blighting of turf	
Source	df	2004	2005
Replication (R)	3	223.06 ^{NS}	115.35^{NS}
Species (S)	1	4305.02 **	2046.11^{NS}
R x S	3	104.73 ^{NS}	275.49^{NS}
Treatment (T)	6	9903.82 ***	8632.25***
T x S	6	796.06 ***	484.03*
Error	18	82.82	141.10
Corrected total	55	-----	-----

^{NS} = Non-significant; * = significant at $P \leq 0.05$; ** = significant at $P \leq 0.01$; *** = significant at $P \leq 0.001$

Fig. 1. Alude-treated perennial ryegrass plots compared with Chipco Signature plots and the untreated control.

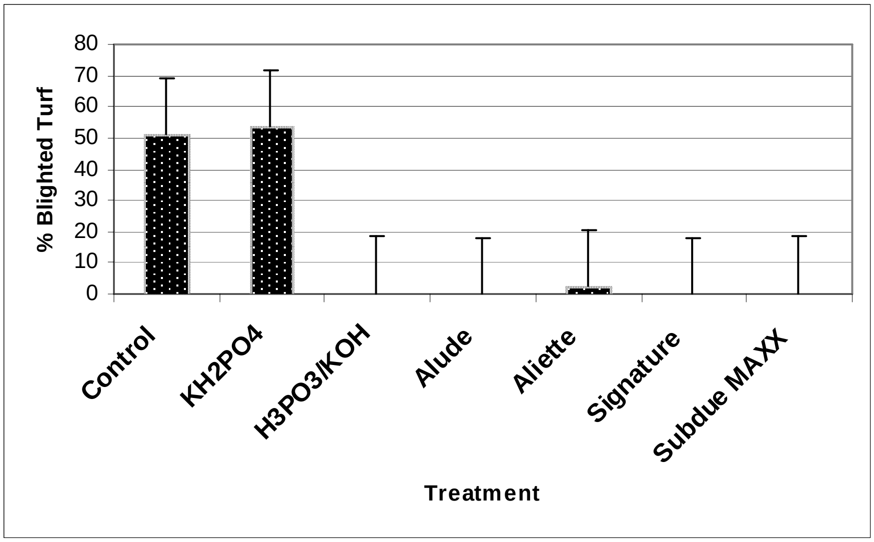

Fig. 2. Effect of phosphonate fungicides on Pythium blight development of 'Penncross' creeping bentgrass in 2004, expressed as % blighted turf. Bars above columns indicate LSD at 0.05 level of significance (LSD = 18.0)

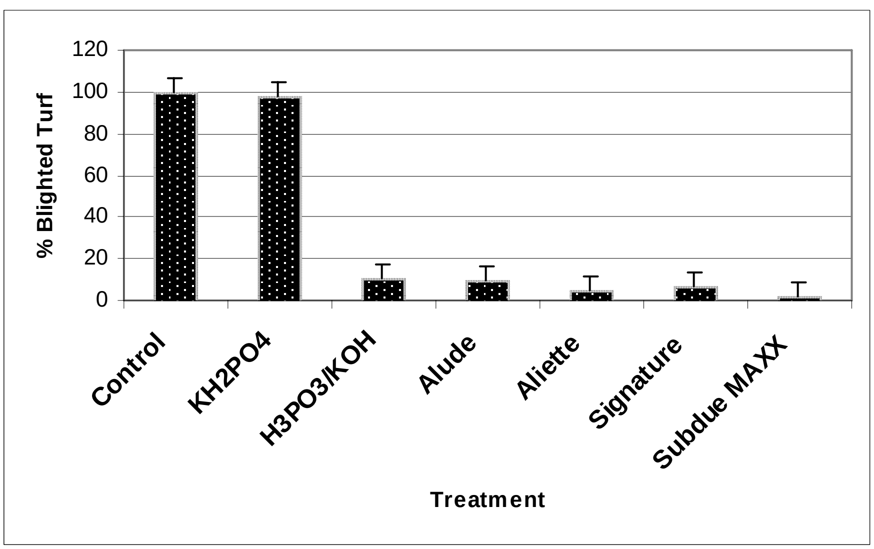

Fig. 3. Effect of phosphonate fungicides on Pythium blight development on 'Integra' perennial ryegrass in 2004, expressed as % blighted turf. Bars above columns indicate LSD at 0.05 level of significance (LSD = 6.9)

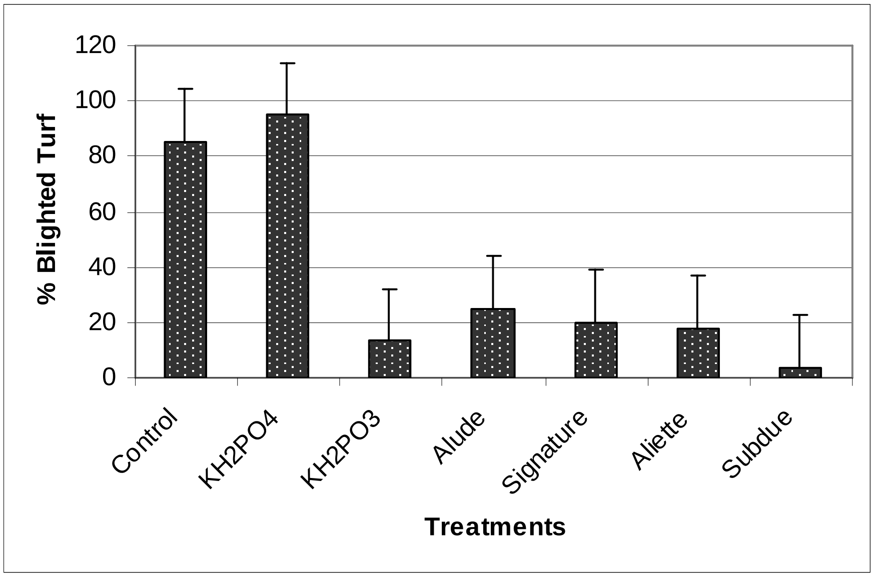

Fig. 4. Effect of phosphonate fungicides on Pythium blight development of ‘Penncross’ creeping bentgrass in 2005, expressed as % blighted turf. Bars above columns indicate LSD at 0.05 level of significance (LSD = 18.6)

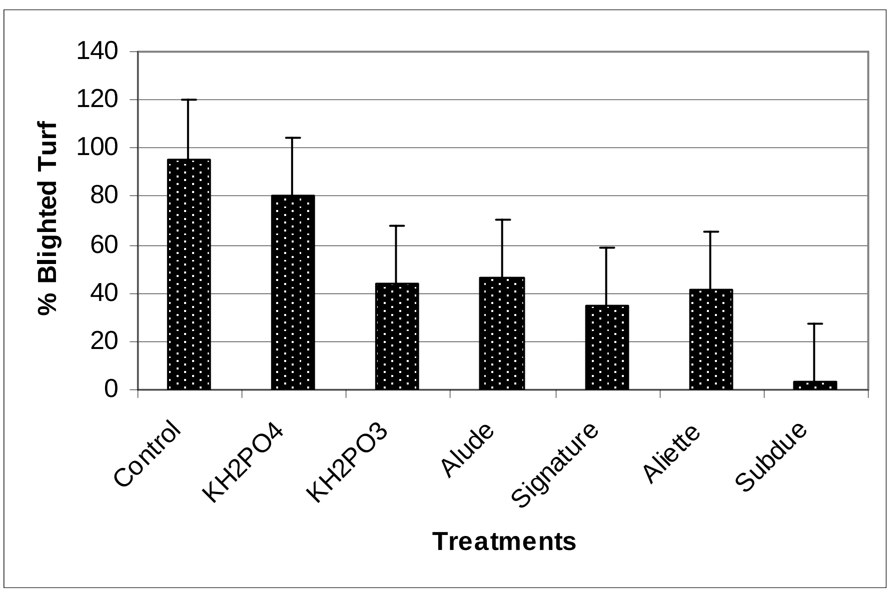

Fig. 5. Effect of phosphonate fungicides on Pythium blight development on ‘Integra’ perennial ryegrass in 2005, expressed as % blighted turf. Bars above columns indicate LSD at 0.05 level of significance (LSD = 24.2)