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Evaluation of Fungicides, Nozzle Type, and Spray Volume on Control of Typhula Blight on Cool Season Turfgrass

Taehyun Chang[1]*, Seogwon Chang[2], and Geunhwa Jung[3]*

[1]*Plant Resources and Environment Major, College of Ecology & Enviromental Sciences, Kyungpook National University, Sangju-city, Gyeongsang Buk-Do, 742-711, South Korea*

[2]*Department of Golf Course Management, Korea Golf University, Hoengseong 225-811, Kore*

[3]*Department of Plant, Soil & Insect Sciences, University of Massachusetts, Amherst, MA 01003,USA*

ABSTRACT. Commercial formulation of fungicides was studied *in vitro* for sensitivity against *Typhula* species causal agents of Typhula blight. Efficacies of fungicides application, spray volume, nozzle types and fungicides applied time (early fall and late fall) were evaluated for their influence on the chemical control of Typhula blight of turfgrass during the winter season in Wisconsin. All fungicides effectively reduced the mycelial growth of eight isolates of *Typhula* spp. *in vitro* on potato dextrose agar (PDA) media. For inhibitory effects on mycelial growth of eight isolates, propiconazole was the most effective at 1.0 μg active ingredient (a.i) / ml of PDA. *Typhula incarnata* two isolates were significantly more sensitive to all fungicides of PDA than six isolates of three varieties of *T. ishikariensis.* For 2 years in field experiment, unsprayed control has significantly more disease severity than seven fungicides were applied to field plots at two locations. Propiconazole was the most effective for controlling Typhula blight, at two locations in both years. The level of disease control was not dependent on fungicides spray volume or nozzle types at two locations. The disease damage treated with triadimefon applied time (early fall and late fall) was not significantly different at two location for two years.

***Key words*:** Nozzle, Propiconazole, Spray volume, Typhula blight

Introduction

Typhula Blight, Gray snow mold, is a major disease of turfgasses in areas where there are over 90 days of continuous snow cover (Smith and Reiter, 1976; Smith, 1987). On turfgrasses, Typhula blight is caused by *Typhula incarnata* Lasch ex Fr. and three varieties of *Typhula ishikariensis* (var. *ishikariensis*, var. *idahoensis* and var. *canadensis*) Imai complex (Årsvoll and Smith, 1978; Smith and Reiter, 1976; Stienstra, 1980). These pathogens are economically important diseases on golf courses in Wisconsin (Steve, 1999), Minnesota (Stienstra, 1980; Sweets and Stienstra, 1976), southern Ontario (Fushtey, 1980), northern Idaho, and northeastern Washington (Gould et al., 1977). Of *Typhula* spp, *T ishikariensis* var. *canadensis* is a common pathogen at golf courses in Northern British Columbia (Dahl, 1934; Hsiang et al., 1999). In contrast, *T. incarnata,* which can cause snow mold in the absence of a snow cover, is very uncommon in the Canadian Prairies (Smith and Reiter, 1976). Three varieties of *T. ishikariensis* have a circumpolar distribution in Asia, Europe and North America that is considered to be a more aggressive pathogen than *T. incarnata*. *T. ishikariensis* var. *ishikariensis* and var. *canadensis* are reported to have wider host ranges than *T. ishikariensis* var. *idahoensis* (Årsvoll and Smith, 1978). Some isolates of *T. phacorrhiza* (Fr.) has been found pathogenic on winter wheat (Årsvoll and Smith, 1978) but others are non-pathogenic on *Poaceae* (Burpee, 1994). A virulent isolate from turfgrass in Ontario has been shown antagonistic to *T ishikariensis* in field tests (Burpee, 1994).

Typhula spp. survives as sclerotia and mycelium in soil or turfgrass thatch (Smith and Reiter, 1976). Sclerotia ermine dormant during spring, summer and early fall that germinate carpogenically, usually under snow, serve as primary inoculum (Hsiang et al., 1999). The mycelium penetrates leaf sheaths and blades through stomata or wounds (Burpee and Goultry, 1984). In addition, mycelium of *T. incarnata* may infect roots (Hsiang et al., 1999). The disease occurs often severely in the spring during the snow melt (Smiley, 1983), but Typhula blight damages is generally governed environment conditions during the autumn, depth and duration of winter snow cover, availability of disease inoculum and dominance (Smith and Reiter, 1976). Dominance of a particular *Typhula* spp. may change with the season (Smith et al., 1989).

*Corresponding author; Tel: +82-54-530-1204
E-mail : thchang@knu.ac.kr
*Corresponding author; Tel: +1-413-545-2243
E-mail: jung@psis.umass.edu
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The optimum temperature for disease development is 9ºC - 15ºC, though the fungus will grow over a wider range, -7ºC to 21ºC. On high height turf such as fairways, the symptoms of infected plants appear as round or irregularly shaped, yellow-brown (*T. incarnata*) and gray-white (*T. ishikariensis*) colored patches approximately 2-10 cm in diameter. Under a snow cover the patches increase in size and may become quite large. On emergence from the snow the bleached grass leaves may be covered with fairly sparse to dense white or grayish-white mycelium (Smith and Reiter, 1976).

The general turf management methods used for the cultural control and resistant cultivars of snow mold should be used. Typhula blight damage to turfgrass is aggravated by excessive or unbalanced nitrogenous fertilizer, but the application of inorganic fertilizer, especially calcium nitrate, reduced snow mold disease severity on bentgrass (*Agrostis*) species (Tyson, 1936). The bentgrass is often severely damaged by *T. incarnate*. Within species, there can be very large differences in susceptibility among cultivars (Smith and Reiter, 1976). Vargas et al. (1972), Most of the common cultivars of *Poe pratensis* were susceptible in Michigan. Fungicide application is the primary method of disease control on turfgrass. Typhula blight diseases have been historically controlled with synthetic fungicides containing mercury, thiram (Hsiang, 1999; Smiley, 1983), PCNB, chlorothalonil, iprodione, propiconazole, tridimefon and flutolanil (Burpee, 1994; Smith et al., 1989; Stienstra, 1980). Since 1994, mercury fungicides have no longer been available for sale in the Unite State (Vargas, 1994). These fungicides usually controlled Typhula blight diseases with a single application late in the fall prior to snowfall. However, chemical control has been reported as inconsistent (Smith et al., 1989; Stienstra, 1980). Successful chemical control depends on which fungus dominates (Smith et al., 1989). Typhula blight caused by the varieties of *T. ishikariensis* generally is more difficult to control with fungicides than *T. incarnata* (Taylor, 1976; Stienstra, 1980). Recently, the first commercial strobilurin fungicide, azoxystrobin, has been evaluated to be effective for controlling Typhula blight (Årsvoll and Smith, 1978). However, azoxystrobin has been not compared with PCNB and another fungicides class to control Typhula blight *in vitro* and *in vivo*.

Currently used fungicides are applied once just prior to snowfall to protect the grass against Typhula blight throughout the winter. If applied too far in advance of permanent snow cover, rainfall and continued leaf growth may dilute the effectiveness of the fungicide. Of fungicides to Typhula blight control, are better able to persist and provide protection during the winter, but even with the proper conditioning of turfgrass for winter and the use of normally efficacious fungicides, abundant Typhula blight may still occur (Wolf, 1988). Effective methods and time of fungicide application are of practical importance to control Typhula blight. Evaluation of spray volume (Matsumoto and Sato, 1982) and effective nozzle types (Matsumoto and Sato, 1982; Mueller et al., 2002) are important, but have not been evaluated on Typhula blight. Fungicides application technologies are spent on considerable time and money.

The purpose of this study is designed *in vitro* and *in vivo* with three objectives. First goal was to compare effects of fungicides sensitivity on the mycelial growth of *Typhula* spp. isolates in vitro. A second goal is to evaluate and compare among fungicides for control of Typhula blight in the field. A third objective is to assess the most effective spray volume, nozzle types and fungicides applied time to efficiently control Typhula blight.

Materials and Methods

Fungal isolates

Two isolates from each of T. *ishikariensis* var. *ishikariensis* (Z1.93, Z2.181), var. *idahoensis* (Z3.122, Z3.116), var. *canadensis* (Z3.127, Z2.105) and *T. incarnata* (Z3.279, Z1.35) were randomly selected from a collection of isolates obtained from Wisconsin golf courses in the early spring of 1997 (Smith, 1987). All sclerotia were surface-disinfected with 1% NaOCl for 10 minutes and placed on PDA amended with 100 μg/ml each of chloroamphenicol and chlorotetracycline HCl to inhibit growth of bacteria (Smith, 1987). The eight isolates were maintained and propagated on potato dextrose agar (PDA; Difco Laboratories) plates at 4ºC.

Fungicides sensitivity *in vitro*

To evaluate fungicide sensitivity, the following fungicides were used: pentachloronitrobenzene (PCNB), chlorothalonil, propiconazole and azoxystrobin (Table 1). For agar plate tests, each fungicide were suspended in sterile distilled water with concentration of 1.0, 10.0 and 100.0 μg a.i./ml. Fungicides were added to autoclaved PDA cooled to 60ºC. The medium was stirred during addition of fungicide and for 2 minutes thereafter to ensure uniform mixing. The medium was then dispensed at 20 ml per Petri dish (60 mm diameter). Non–amended agar was used as a control. A 5 mm diameter plug of agar was cut from the margins of two week-old colonies with a cork borer, inverted, and placed in the center of treatment plates. The Petri plates were incubated for two weeks in a growth chamber at 10ºC with no light.

Fungal colony growth was measured along the diameter. Radial mycelial growth measurements (plus the diameter of the inoculation plug) were made at two weeks post-inoculation. The results were expressed as percentage of mycelial relative growth. Mycelial relative growth were calculated as the mean adjusted colony diameter on

Table 1. List of fungicides used in this study.

Common Name	Trade Name and Rates	Mode of action	Fungicide group (Family)	Manufacturer
PCNB	Turfcide400 4F - 40% (10.17 kg a.i./ ha)	Contact	Halogenated nitrobenzene	Uniroyal, Chemical Co, Inc., Middlebury, CT
Chlorothalonil	Daconil Weatherstik 6F - 54% (9.05 kg a.i./ ha)	Contact	Nitrile	Syngenta Corp Protection Inc., Greensboro NC
Propiconazole	Banner Maxx - 14.3% (0.91 kg a.i./ ha)	Acropetal Systemic	Triazole	Syngenta Corp Protection Inc., Greensboro NC
Triadimefon	Bayleton - 50% (4.12 kg a.i./ ha)	Acropetal Systemic	Triazole	Bayer Corperation, Kansas City, MO
Azoxystrobin	Heritage - 50% (0.61 kg a.i./ ha)	Acropetal Systemic	Strobilurin	Syngenta Corp Protection Inc., Greensboro NC
Iprodione	Chipco26GT 2SC - 23.3% (2.96 kg a.i./ ha)	Local Penetrant	Dicarboximide	Aventis Environmental Science, Montvale, NJ
Flutolanil	ProStar - 70% (9.60 kg a.i./ ha)	Acropetal Systemic	Carboximide	Aventis Environmental Science, Montvale, NJ

fungicide amended medium / the mean adjusted colony diameter on non-amended medium × 100 % for each isolate and fungicide concentration.

Field evaluation of fungicides

Field fungicides trials to evaluate the efficacy of seven fungicides against Typhula blight, were conducted for 2 years at Sentry world Golf Course (SGC), Stevens Point Wisconsin (WI) in USA, on a “Penneagle”, creeping bentgrass (*Agrostis stolonifera* L.) fairway, and at Gateway Golf Course (GGC), Land O’ Lakes WI, on an annual bluegrass (*Poa annua* L.) fairways. This experiment was repeated at the same location for both trials and seven fungicides were evaluated for disease control of Typhula blight on fairways maintained at a height of 19 mm. Individual plots were designed 90 cm wide × 300 cm long. The experimental design for effects of fungicides application timing, spray volumes and nozzle types were arranged in randomized complete block designs with three or four replications using Agriculture Research Management 6.0 (Gylling Data management, Inc.).

The fungicides PCNB, chlorothalonil, propiconazole, triadimefon, azoxystrobin, iprodione and flutolanil were used and are listed in Table 1. All fungicides were suspended in water and sprayed within 2 hr of mixing. Fungicides were applied one time prior to snowfall on November at SGC, and at GGC in WI, USA. All fungicides were applied using a CO_2- powered boom sprayer, XR Teejet 8005 VS nozzles (Spraying System co., Wheaton IL) at 2.1 kg/cm^2 (30 psi) that applied 7.5 L/93 m^2 of fungicides. The experimental area was not inoculated with *Typhula* species; all disease development was of natural occurrence.

Spray volume

In this study, the effect of spray volumes equivalent to 3.75 L, 7.5 L and 15 L/93 m^2 on disease fungicides efficacy were investigated. The fungicides PCNB, triadimefon and iprodione were used. All fungicides were suspended in water and sprayed within 2 hr of in mixing. Applications were one time prior to snowfall in late autumn (October) at SGC on a “Penneagle”, creeping bentgrass and October 28 at GGC on an annual bluegrass. Fungicides were applied with a CO_2 – powered boom sprayer, using XR Teejet 8005 VS, at 2.1 kg / cm^2 (30 psi). The experimental area was not

Table 2. List of nozzle types used in this study.

Nozzle	Spraying pressure	Nozzle types	source
DG Teejet	30-60 psi	drift guard flat fan spray	Spraying Systems CO, Wheaton IL
Floodjet	10-40 psi	wide angle flat fan spray	
RA Raindrop	20-50 psi	wide angle hollow cone	
Turbo Teejet	15-90 psi	wide angle flat fan spray	
Twinjet	30-60 psi	twin flat fan spray	
XR Teejet	15-60 psi	extended range flat fan spray	

inoculated with *Typhula* spp.; all disease development was of natural occurrence.

Nozzle types

Identical fungicide treatments were applied using the following 6 nozzle types (Table 2); DG Teejet, Floodjet, RA Raindrop, Turbo Teejet, Twinjet and XR Teejet to use operated CO_2 - power, at 30 psi (2.1 kg/cm^2) in water equivalent to 7.5 L/ 93 m^2. The fungicides PCNB, triadimefon, and iprodione were used. were one time prior to snowfall in late autumn (October) at SGC on a "Penneagle", creeping bentgrass and GGC on an annual bluegrass. The experimental area was not inoculated with *Typhula* spp.; all disease development was of natural occurrence.

Fungicides applied time

Of seven fungicides, triadimefon applied in early fall and in late fall at two locations for two years. Early (5 Oct.) applications were made at SGC, and at GGC. Late (25 Oct.) applications were made at SGC, on a "Penneagle", creeping bentgrass and at GGC, on an annual bluegrass. Fungicides application was applied with a CO_2 – powered boom sprayer, using XR Teejet 8005 VS, at 2.1 kg/cm^2 (30 psi). The experimental area was not inoculated with *Typhula* spp.: all disease development was of natural occurrence.

Assess disease severity

Typhula blight damage ratings were taken two times for all plots after snowmelt in each year for 2 years. Most diseased areas were almost circular and gray or gray-white in color. Plots were visually rated as percentage of diseased area in each plot (Stienstra, 1980). By subtracting the area of healthy grass from the total area of the dead spot, the diseased area of each plot was obtained. Plots were rated for diseases on March 24 to April 15 at two locations SGC and GGC) for two years after snow melting.

Statistical analysis

Whole data analysis was performed using the Fit Y by X (ANOVA on means, compare means- All Pairs Student's t) and Fit model on means, platform of the JMP5 statistical (program, SAS Institute Inc., 2002). Fit Y by X, ANOVA analysis was used to calculate analysis ANOVA of variance, means of ANOVA and means comparisons of groups and were visually represented by comparison circles. Fit model and whole model were calculated analysis of variance and effect tests.

Table 3. Percent mean of relative mycelial growth of eight *Typhula* species isolates on potato dextrose agar (PDA) amended with four fungicides at three concentrations.

Fungicide	Concent-ration (μg a.i./ ml)	Relative mycelial growth (%) [a]								*F* value
		Typhula ishikariensis						T. incarnata		
		var. *idahoensis*		var. *canadensis*		var. *ishikariensis*				
		Z3.122	Z3.116	Z3.127	Z2.105	Z1.93	Z2.181	Z3.279	Z1.35	
PCNB	1.0	97.7ab [b]	75.1b	44.7c	124.5a	101.5ab	113.8a	76.6b	84.0b	17.617*
	10.0	41.7ab	26.3b	31.1b	47.5a	31.4b	39.7ab	9.4c	0.0c	22.567*
	100.0	1.6bc	13.8a	14.5a	20.1a	6.6b	3.4bc	0.0c	0.0c	29.609*
Propiconazole	1.0	3.3d	23.7b	23.2b	30.0b	11.7c	25.4b	38.9a	38.7a	58.871*
	10.0	0.8bc	3.6b	8.8a	2.9bc	0.0c	0.0c	1.2bc	0.0c	18.146*
	100.0	0.0b	0.0b	0.0b	2.3a	0.0b	0.0b	0.0b	0.0b	9.995*
Azoxystrobin	1.0	38.1bc	32.4c	50.7ab	60.4a	47.0abc	10.0d	47.5abc	45.0abc	17.384*
	10.0	36.7a	14.8bc	30.8ab	36.1a	40.9a	0.0c	14.5bc	0.0c	19.760*
	100.0	4.3b	0.0c	2.6b	5.3b	35.4a	0.0b	0.0b	0.0b	52.466*
Chlorothalonil	1.0	1.5c	68.0a	18.5bc	88.5a	72.4a	69.8a	27.6b	20.9bc	31.403*
	10.0	1.4e	74.5a	24.4d	45.6c	60.2b	63.3b	0.0e	0.0e	239.020*
	100.0	11.7c	25.0b	16.7bc	11.0c	10.8c	55.9a	0.0d	0.0d	87.239*

Colony diameters were determined 3 weeks after plating.
Relative mycelial growth: diameter on fungicides amended medium / the corresponding diameter on unamended medium ×100.
[a] values of 6 replicated plates.
[b] Within rows, Values followed by the same letters are not significantly difference according to comparisons all pairs using ANOVA (P=0.05). ANOVA used 576 observations.
* The mark are significantly difference according to comparisons all pairs using ANOVA (P < .0001).

Results

Fungicides sensitivity *in vitro*

The sensitivity of *Typhula* spp. to four fungicides is given in Table 2. The efficacies of four fungicides were compared using mycelial relative growth of eight isolate of *Typhula* spp. on fungicide amended PDA. For all isolates, significant inhibition of mycelial growth (P = 0.05) was observation media amend with each fungicide at 1.0, 10 and 100 μg a.i. / ml (Table 1). Propiconazole was the most active, propiconazole at 1.0 or 10.0 μg a.i. / ml of agar significantly inhibited mycelial growth of all isolates when compared with all fungicide amended PDA at 1.0 (P <.0001) or 10.0 μg a.i. / ml (P <.0001). Azoxystrobin was not significant differently when compared with PCNB all Isolates of *Typhula* spp. Chlorothalonil were inhibited *T. incarnata* isolates with at 10.0 μg a.i. / ml, while the isolate Z3.122 of *T. ishikariensis* var. *idahoensis* was the most variable (P = <.0001). Of isolates, *T. incarnata* isolates was more sensitivity than isolates of *T. ishikariensis* varieties to eight fungicides.

Significant main effects of fungicides, isolate, concentration, and a fungicide x isolate or concentration x isolate interaction were detected for the inhibition of mycelial growth (Table 3).

Field evaluation of fungicides

The percentage of disease incidence in the field plots at two locations in Wisconsin after 2 years of chemical treatment, are presented in Table 3. The Typhula blight Disease damages varied significantly at two locations between years. Propiconazole was reduced the most effectively disease damages at both locations for the second years when compared with other fungicide treated plots (P = 0.05). In first year (Exp. 1) at both locations, all fungicides treatments did not significantly suppress the development of Typhula blight among fungicides (Table 4). In second year (Exp. 2), there were significantly different among fungicide. At SGC, propiconazole were shown results of same that significantly suppressed disease incidence, while were effectively difference at GGC for two years.

ANOVA analysis revealed significant interaction between years and locations. The analysis of variance on Typhula blight control for two years was detected with respect to the percent value for the location factor of the incidence of Typhula blight (Table 5). No location x fungicide interaction was detected for first year (Exp. 1), but in second year (Exp. 2), location x fungicide interaction was detected.

Spray volume, Nozzle types and Fungicides applied time

Spray volumes and nozzle type study, Significant main effects were not detected with respect to the percent value for spray volumes factor and nozzle types (Table 7). Spray volumes, there is no statistical difference between the three different spray volumes (Table 8). However, we were found trends of increased disease control with higher spray volume. When efficacies of fungicides from six different nozzles were compared, none of the nozzle types were found to significantly increase of Typhula blight control (Table 9). However, we were found to difference between locations and fungicides. On fungicides applied time for two years, the Typhula blight damage severity was not significant different with fungicide applied time (Table 9).

Discussion

Fungicides were tested for their ability to inhibit mycelial

Table 4. Significance level from analysis of variance for the effects fungicides on eight isolates of *Typhula* species that differ in sensitivity *in vitro* to four fungicides.

Source of variation	Df [a]	Sum of squares	F value	P value [b]
Fungicide	3	84504.42	455.879	<.0001
Isolate[c]	7	38067.52	88.013	<.0001
Concentration[d]	2	183035.60	1481.143	<.0001
Fungicide × Isolate	21	76497.26	58.955	<.0001
Concentration× Isolate	14	22253.29	25.725	<.0001
Fungicide × Concentration	6	60891.41	164.247	<.0001
Fungicide × Concentration × Isolate	42	35303.38	13.604	<.0001
Error	480	29658.54	…	…

[a] Degree of freedom
[b] P = 0.05: Significant at the 0.05 level
[c] Isolates: Z3.122 or Z3.116 of var. *Idahoensis,* Z3.127 or Z2.105 of var. *Canadensis,* Z1.93 or Z2.181 of var. *ishikariensis* and Z3.279 or Z1.35 of *T. incarnata*
[d] Concentration: 1.0, 10.0 and 100.0 μg a.i. / ml.

Table 5. Efficacies of chemical control of Typhula blight and three varieties at two golf courses in Wisconsin for two years.

Treatment	Rate (g a.i./ 93 m²)	Application	Typhula blight damages (%)[a]					
			Exp. 1 (First year)			Exp. 2 (Second year)		
			SGC [b]	GGC	Mean	SGC	GGC	Mean
Untreated[c]	-	Late	52.5a [d]	54.2a	53.3	62.5a [e]	75.5a	69.0
PCNB	94.6	Late	18.3b	29.2bc	23.8	16.7def	46.7de	31.7
Propiconazole	8.5	Late	10.8b	14.2c	12.5	10.0f	45.9e	27.9
Azoxystrobin	5.7	Late	17.5b	20.0bc	18.8	22.6bcd	48.8cde	35.7
Chlolothalonil	84.2	Late	20.0b	30.8b	25.4	18.9cde	66.3ab	42.6
Iprodione	27.6	Late	15.8b	21.7bc	18.8	26.8bc	48.4cde	37.6
Flutolanil	89.3	Late	10.8b	20.8bc	15.8	30.1b	58.8bc	44.4
Triadimefon	28.4	Late	8.3b	15.0bc	11.7	12.8ef	57.9bcd	35.4

[a] Disease damage (%) was least square means of diseased area in microplots.
[b] SGC: Sentryworld Golf Course, Stevens Point, GGC: Gateway Golf Course, Land O' Lakes.
[c] Nothing was applied on the turfgrass for the nontreated (water was applied).
[d,e] Within columns for the First year, Values followed by the same letters are not significantly difference according to comparisons all pairs using ANOVA (P = 0.05).ANOVA used 24 possible observations

growth on PDA. In agar–plate tests, ranking suppression of mycelial growth by four fungicides was detected a good predictor of field disease control. The eight isolates of *Typhula* spp. showed arrange sensitivities among concentration to four fungicides *in vitro*. Propiconazole was the most effective suppressor of mycelial growth at all concentration for all isolates of *Typhula* spp. (Table 2). The inhibition of mycelial growth appeared to be similar sensitivity to azoxystrobin with mean mycelial relative growth (%) at 10.0 μg a.i. / ml when compared with PCNB at 10.0 μg a.i. / ml, respectively. There were a lot of variation among isolates, the isolate Z1.93 of *T. ishikariensis* var. *ishikariensis* was not affected by azoxystrobin amended PDA at 1.0, 10.0, and 100.0 μg a.i. / ml (Table 2). There were varied sensitivities of fungicides between *T. incarnata* isolates and the varieties of *T. ishikariensis* isolates. The significant differences observed all concentration to fungicide, and there were detected interaction among fungicide and isolates, isolates and concentrations (Table 3)

Results of field studies indicate that azoxystrobin at 5.67 g a.i./ m² applied in late fall, can provide control of Typhula blight of creeping bentgrass and annual bluegrass that is almost same level to the control achieved with PCNB at 94.62 g a.i./ m² for two years. A result of *In vitro* supports this result. Control value of fungicides showed higher suppression of Typhula blight at two locations in the first year (Exp. 1) than the second years (Exp. 2). During the second year, SGC showed higher suppression than GGC liked due pathogen activity under the longer snow cover duration in winter season. These results are of importance for developing methods of snow mold management. Weather conditions, including days of snow cover during the winter seasons of this study varied greatly (Steve, 1999). For two years, propiconazole and triadimefon treatments at SGC were effective when compared with other fungicides, and significantly suppressed disease incidence by 10.8 -

Table 6. Significance level from analysis of variance and effect tests of Typhula blight control with seven fungicides at two locations for two years.

Source	Df [a]	Exp. 1 (First year)			Exp. 2 (Second year)		
		SS	*F* value	*P* value [b]	SS	*F* value	*P* value
Fungicide (treatment)	7	7504.2	12.9656	<.0001	6755.6	28.6734	<.0001
Location	1	500.5	6.0535	0.0195	11516.5	342.1612	<.0001
Fungicide × Location	7	149.5	0.2583	0.9656	1407.9	5.9758	0.0002
Error							

[a] Degree of freedom.
[b] P = 0.05 ; Significant at the 0.05 level

Table 7. Analysis of variance of spray volume using XR Teejet 8005 VS nozzle type and six different nozzle types at two locations in field trail.

Source	Df [a]	SGC			GGC		
		S S	*F* value	*P* value [b]	S S	*F* value	*P* value
Spray Volume							
Fungicide [b]	2	8543.1	11.5984	0.0002	4134.7	19.1242	<0.0001
Volume [c]	2	134.7	0.1829	0.8339	84.7	0.3919	0.6796
Fungicide × Volume	4	669.4	0.4544	0.7683	286.1	0.6617	0.6240
Error	27	9943.8					…
Nozzle types							
Fungicide	2	7248.1	30.8189	<0.0001	36448.2	121.1200	<0.0001
Nozzle [d]	5	974.5	1.6575	0.1700	796.8	1.0591	0.3990
Fungicide × Nozzle	10	735.2	0.6252	0.7823	1079.6	0.7175	0.7025
Error	36	4233.3					…

[a] Degree of freedom. $P = 0.05$: Significant at the 0.05 level
[b] fungicide : PCNB, Triadimefon, Iprodione.
[c] Spray volume : 3.75 L, 7.5 L and 15 L / 93 m^2.
[d] Nozzle : DG Teejet, Floodjet, RA Raindrop, Turbo Teejet, Twinjet and XR Teejet.

10.0% (P = 0.05) and 8.3 - 12.8% (P= <.0001). At GGC, propiconazole more effectively suppressed disease development at 14.2-45.9%, while chlorothalonil was the least effective at 30.8-66.3% for two years (P = 0.05). Efficacies of propiconazole and triadimefon were similar for control of Typhula blight. However, triadimefon failed to control high disease incidence at GGC in second year (Exp. 2). Therefore, variability of disease control in relation to different locations is difficult to explain. Most Typhula blight fungicides show selective activity against particular groups of fungi. This study supports the conclusions of other (Steve, 1999).

On previous study showed a little different trend on same species of turfgrass when compared with our results. In New York showed that *T. incarnata,* on bentgrass and annual bluegrass was effectively controlled with chlorothalonil, iprodione and triadimefon (Mueller et al., 2002). In New Hampshire, iprodione and triadimefon (Nutter et al., 1979), chlorothalonil, iprodione and triadimefon (Smiley and Craven, 1980) controlled gray snow mold (*Typhula* spp.). To successfully Typhula blight control, it was important the dominant of *Typhula* species. In case of GGC, was less controlled of Typhula blight than SGC. At GGC, *T. ishikariensis* var. was dominates (Steve, 1999). Otherwise, application time and snow cover days is important to Typhula blight development. Spray of fungicides in late autumn are recommended to protect turfgrass from infection by snow mold fungi (Smiley, 1983), however, few chemicals provide acceptable control (< 3% disease) when inoculums levels are high and turfgrass is covered with snow for 3 months or longer (Burpee, 1994). Gould et al. (1977), obtained best control of the disease with early autumn, late autumn and spring treatments with benomyl and chlorothalonil, benomyl and chlorothalonil and mancozeb, thiophanate methyl and chloroneb formulations.

The optimum spray volume for a turfgrass fungicide is the one of which it gives the highest dilution volume of disease control. In recent years, it has been conducted to determinative extent various dilution levels affect the effectiveness of spray formulation of various turfgrass fungicides, however there have been no studies on comparative affective of spray volume on Typhula blight in turfgrass. Typically, fungicides are applied from 5 L to 20 L / 93 m^2, which is equivalent to 0.05 mm to 0.2 mm of precipitation (Hossfeld, 1974). In this spray volumes study, although diseases control values were not statistically significant (P = 0.05) in Table 7, PCNB and tridimefon showed trends of improved disease control with high volumes. Iprodione had erratic results with the 7.5 L / 93 m^2 treatment having more disease damage than with the 3.75 L / 93 m^2 and 15 L / 93 m^2 (Table 6). Couch (1985), showed a result of similar on turfgrass when compared with our results, Iprodione (Chipco 26019) was equally effective in the control of dollar spot at dilution of 1.4 L, 3.75 L, 7.5 L and 15 L of water / 93 m^2. Triadimefon (Bayleton) was clearly much better 7.5 L than 1.4 L or 3.75 L of water / 93m^2 applied with a nozzle 8002 tip. Other study, disease control was less effective when the volume of spray was reduced from 550 L /ha to 243 L / ha (Morton and Hall, 1989).

Table 8. Effects of spray volume applied with three fungicides to Typhula blight damages at two locations.

Spray volume (L)	Typhula blight damage (%)					
	PCNB (94.6g a.i. / 93 m^2)		Iprodione (27.6g a.i. / 93 m^2)		Triadimefon (28.4g a.i. / 93 m^2)	
	SGC	GGC	SGC	GGC	SGC	GGC
3.75	33.8a [a]	22.5a	35.0a	27.5a	11.3a	7.5a
7.50	32.5a	13.8a	47.5a	35.0a	3.8a	3.8ab
14.0	23.8a	16.3a	45.0a	28.8a	1.3a	1.3b
Mean	30.0	17.5	42.5	30.4	5.4	4.2

[a] Within columns, Values followed by the same letters are not significantly difference (n = 4) according to comparisons each pairs using ANOVA (*P*=0.05).

Table 9. Effects of nozzle types applied with three fungicides to Typhula blight damages at two locations.

Nozzle types	Typhula blight damage (%)					
	PCNB (94.6 g a.i./ 93 m^2)		Iprodione (27.6 g a.i./ 93 m^2)		Triadimefon (28.4 g a.i./ 93 m^2)	
	SGC	GGC	SGC	GGC	SGC	GGC
RA Raindrop	33.3a [a]	18.3ab	41.7a	83.3a	6.7a	10.0a
DG Teejet	23.3a	28.3a	16.7b	63.3a	1.7ab	8.3a
Twinjet	26.7a	26.7ab	18.3b	70.0a	1.7ab	5.0a
Turbo Teejet	33.3a	18.3ab	16.7b	66.7a	3.3ab	5.0a
XR Teejet	33.3a	15.0b	23.3ab	55.0a	0.0b	5.0a
Floodjet	28.3a	15.0b	21.7ab	66.7a	1.7ab	8.3a
Mean	29.7	20.3	23.1	67.5	2.5	6.9

[a] Within columns, Values followed by the same letters are not significantly difference (n = 4) according to comparisons each pairs using ANOVA (*P*=0.05).

Table 10. Effects of application time to Typhula blight during at two locations two years in Wisconsin.

Treatment	Rate (g a.i./ 93 m^2)	Application	Exp. 1 (First year)			Exp. 2 (Second year)		
			Typhula blight damages (%)[a]					
			SGC	GGC	Mean	SGC	GGC	Mean
Triadimefon	28.4	Early (5 Oct.)	12.5a[a]	36.7a		20.5a	40.5a	
		Late (25 Oct.)	8.3b	15.0a		12.8a	35.4a	

[a] Within columns, Values followed by the same letters are not significantly difference (n = 4) according to comparisons each pairs using ANOVA (*P*=0.05).

Comparison efficacies of fungicides from six nozzles type, disease control were not significantly (P = 0.05) affected by six nozzles type (Table 8). These results were consistent at two locations. However, Teejet (flat fan) nozzles performed better than the Raindrop (whirl chamber) nozzles with of the chemical modes of action. Couch and Smith (Couch and Smith, 1987), a different trend has been noted by the observation of sclerotinia dollar spot of creeping bentgrass. It was significantly inferior to treatment made with either Teejet (flat fan) nozzle or Raindrop (whirl chamber) nozzle. The effectiveness of iprodione was 50 percent less when it was applied with the Floodjet than when applied with the Teejet (flat fan) nozzle. On previous reports, a similar trend has been noted by the observations of different crops when compared with our results, were not effective using two different nozzle types (Mueller et al., 2002). This study supports the conclusion of other (Morton and Hall, 1989) that has found little difference in nozzle type in disease control. With a fungicide applied time, there was a not significantly difference at two location for tow years.

However, we founded better trends with applied in late than in early to Typhula blight control.

The success of Typhula blight control in Wisconsin depends on which species dominates, amount of inoculums, snow covered days and species of turfgrass. Any year, some chemical that may be effective on Typhula blight control may be discarded because they did not control of snow mold that caused by all *Typhula* spp. In addition, Typhula blight disease management may emphasize choosing chemicals.

The results of the *in vitro* and in the field demonstrated that propiconazole were most active against mycelial growth inhibition and for Typhula blight control. The *Typhula* spp. isolates examined all had similar sensitivity to propiconazole in the assay performed. In the field, propiconazole at 0.91 kg a.i. / ha was the most effective of Typhula blight at SGC and GGC for two years in Wisconsin golf courses. Therefore, For Typhula blight control in the field in Wisconsin, is important this fungicide, but for increasing effects of fungicide should be examined further. Spray volumes, nozzle types and fungicide applied time may affect disease control is need be examined further.

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한지형잔디에 설부병 방제에 대한 살균제, 노즐타입 및 살포약량의 평가

장태현[1]* · 장석원[2] · 정근화[3]*

[1]경북대학교 생태환경대학 식물자원환경전공, [2]한국골프대학교 골프코스관리학과
[3]메사츄세츠대학교 식물, 토양, 곤충학과

요 약: 설부병에 원인이되는 *Typhula* species 대하여 살균제의 감수성을 실내에서 연구하였다. 살균제, 노즐타입 및 살포약량에 대한 효과와 살균제의 살포시기(이른가을과 늦가을)에 대한효과 위스콘신에서 겨울동안 설부병에 대한 약제의 방제 효과에 대한 영향을 평가하였다. 모든 살균제는 *Typhula* spp.의 8균주에 대하여 실내 PDA 배지상에서 균사생장을 효과적으로 억제하였다. 8균주에 대한 균사생장 저지효과는 propiconazole 1.0 μg (a.i) / ml에서 가장 효과적이었다. *Typhula incarnata* 2균주는 *T. ishikariensis* 6균주(3품종)보다 모든 살균제에서 더 감수성을 보였다. 2년 동안 포장시험에서 7개 농약을 2지역에서 살포하였으나, 무처리구에서만 병 발생이 심각하였다. Propiconazole이 설부병 방제에 2년 동안 2곳에서 가장 효과적이었다. 약제 살포용 노즐타입이나 살포약량은 두 곳 시험에서 모두 통계적으로 유의성이 없었다. 살제 살포시기도 설부병 방제에 통계적으로 유의성이 없었다.

주요어: 노즐, Propiconazole, 살포약량, 설부병