SUPPRESSION OF PINK (*Microdochium nivale*) AND GREY (*Typhula ishikariensis*) SNOW MOULDS OF CREEPING BENTGRASS WITH COMPOST

J.I. BOULTER, G.J. BOLAND, J.T.TREVORS

Department of Environmental Biology, University of Guelph, Guelph, ON, N1G 2W1

ABSTRACT

When incorporated into turfgrass disease management programs, composts can significantly reduce the use of pesticides and fertilizers. Two composts were evaluated for suppression of pink (*Microdochium nivale*) and grey (*Typhula ishikariensis*) snow moulds in field experiments conducted in 1998-1999 in two distinct areas of turf management. Fall applications of compost applied at either 48.7 kg/100 m^2 or 97.4 kg/100 m^2 reduced snow mould severity to levels not significantly different ($P \leq 0.05$) from fungicide controls. There were no significant differences between the two composts in their ability to suppress disease. However, most plots that received the higher application rate of compost had significantly less disease than those that received the lower application rate on most rating dates ($P \leq 0.05$). In addition, a significant increase in green-up of turf (recovery from disease and/or winter dormancy) compared to fertilizer and fungicide controls ($P \leq 0.05$) was observed at both turf management locations. These differences in green-up among treatments diminished over a four week rating period, after which, the controls approached or were not significantly different from the compost treated plots ($P \leq 0.05$). There were no significant differences between composts at either experimental location, on any rating dates ($P \leq 0.05$).

INTRODUCTION

More money is spent annually per acre of turfgrass for disease control than on any other commodity (22). An alternative in turfgrass disease management is the development and use of organic amendments such as composts, organic fertilizers, and sludges, or inoculation of turf with specific bacterial or fungal species known to suppress diseases (3). Snow mould diseases such as typhula blight (*Typhula ishikariensis, Typhula incarnata*) and fusarium patch (*Microdochium nivale*) are important turfgrass diseases. Although fungicides are commonly used for management of these diseases, the high frequency of chemical use, associated costs, nontarget effects, development of fungicide resistant populations, and health risks to humans and the surrounding environment has stimulated development of alternative methods for disease management (7; 22).

The use of composts and other organic amendments for disease suppression has potential benefits both ecologically and economically. Although the use of compost may not control turfgrass diseases to a level which may replace the use of fungicides, their integration into current disease management practices may reduce fungicide use and associated problems. Naturally suppressive (antagonistic) composts can be incorporated into normal golf course maintenance by replacing sphagnum peat or other organic materials used in topdressing mixtures. Composts are known to suppress plant diseases through a combination of physiochemical and biological characteristics. Physiochemical characteristics include any physical or chemical aspects of composts which reduce disease severity by directly or indirectly affecting the pathogen or host capacity for growth, such as: nutrient levels, organic matter, moisture, pH and other factors (11; 29). Biological characteristics include compost-inhabiting microbial populations in competition for nutrients with pathogens, antibiotic production, lytic and other extracellular enzyme production, parasitism and predation, induction of host-mediated resistance in plants, and other interactions which decrease disease development.

The ability of selected composts to suppress disease in turfgrass has been reported. For example, an 80 - 90 % reduction in disease was obtained with a late spring application of yard trimmings compost (2). Compost has been suggested as a beneficial material where a high proportion of organic matter may offset sand content and increase or restore soil microbial populations (1). A compost of yard trimmings did not suppress snow mould but did increase the rate of recovery of turf from disease during the spring (2). High levels of microbial activity in composts have been postulated as the primary mechanism of disease control (8; 9; 20; 21; 23; 24; 25; 27). However, physiochemical factors, which include colour, fertilizer effects, and other factors are often implicated in control. Researchers have generally supported the proposal that microbial populations in compost provide nutrients and other chemical compounds to competing microorganisms and plant hosts through continual breakdown of composted material (14; 23). There are also a number of examples where nutrient competition has been a factor in suppression of plant pathogens (6; 8; 10; 13; 15; 17; 26; 28; 29).

The objectives of this study were to: 1) evaluate the ability of selected compost formulations to suppress snow moulds; and 2) to increase the green-up of turf (recovery from disease and/or winter dormancy).

MATERIALS AND METHODS

Field plots were established in November 1998 on a creeping bentgrass green maintained in summer at 4 mm height, and a creeping bentgrass range maintained in summer at a 25 mm height at the Guelph Turfgrass Institute, Guelph, ON, to evaluate the ability of composts to suppress grey (*Typhula ishikariensis* Imai) and pink (*Microdochium nivale* Fr. Samuels and Hallett) snow mould.

Preparation of composts: Mature composts were provided by All Treat Farms, Ltd., Arthur, ON. Composts designated 6 and 9, prepared in 1998, were produced using proprietary blends of selected feedstocks combined in proportions that would result in acceptable C:N ratios and moisture levels (13; 18). Feedstock components are listed in Table 3[1]. The beginning of the composting process was defined as day 0, which ranged from June 19, 1997 to July 4, 1997. Composts were passively aerated over a period of approximately 32 weeks, during which they were mechanically turned once to re-mix materials. No composting piles were harvested until the average core compost temperature declined to 45°C. All composts were screened to 3.8 mm average particle size before application.

Table 1. Composition of compost batches 6 and 9.

Feedstocks	Compost	
	6	9
Chicken manure	x	x
Paunch manure[1]		x
Bone meal ash[2]	x	
Bark mix	x	x
Soybean Meal	x	
Milorganite	x	

[1] Paunch manure is remains in the rumens of slaughtered cattle.

[2] Bone meal ash is mineral remains of animal bone materials.

Pathogen growth and inoculum preparation: *T. ishikariensis* (isolated from the Cambridge Research Station, Cambridge, ON; courtesy of Dr. T. Hsiang) and *M. nivale* (courtesy of Dr. Bruce Gossen, Saskatoon, SK) were maintained as sclerotia, and on PDA (Bacto® Difco Laboratories, Detroit, MI) at 4°C, respectively. Surface sterilized sclerotia of *T. ishikariensis* were placed on agar plates (10 ± 2°C) and grown for 12 weeks. *M. nivale* was initially grown on agar plates of PDA (10 ± 2°C) for 3 weeks. Following germination and growth of mycelium, 15 plugs of 5 mm diameter from the colony margin were removed from the plates and transferred to a liquid culture of 200 mL PDB (Bacto® Difco Laboratories, Detroit, MI) at 10 ± 2°C in three 250 mL Erlenmeyer flasks, on a shaker (Orbit Shaker, Lab-Line Instruments, Inc., Model 3520, Melrose Park, IL, 60160) at 40 rpm, in the dark for 4 wk (*M. nivale*) and 10 wk (*T. ishikariensis*). Following this period, excess liquid was removed (approximately 70 mL) and the remaining flask contents (approximately 130 mL) were homogenized in a sterile blender (Waring Commercial Blender, Model 5011, Waring Products Division, Hew Hartford, CT) for 30 sec. The resulting homogenate (approximately 130 mL) was added to a sterile (autoclaved 3 times at 121°C) 1000 mL Erlenmeyer flask containing 125 mL of chicken scratch (corn, barley, oats (1.25:1 w/w)) mix plus 100 mL deionized water. Inoculated flasks were incubated at 10 ± 2°C in the dark until thoroughly colonized (30 d for pink mould and 45 d for grey mould). Seventy-two hours before field inoculation, the colonized chicken scratch medium was removed from the flasks, placed on paper towels in a laminar flow cabinet and air dried for 48 hr. Inoculum was then ground in a blender (Waring Commercial Blender, model 5011, Waring Products Division, New Hartford, Conn, USA) weighed and placed in individual envelopes for field application.

Experiments: The experiments were conducted as factorial designs with three pathogen treatments, and two composts applied at 2 rates: 48.7 and 97.6 kg / 100 m^2 (dry weight) over inoculated plots, on

December 1, 1998. Treatments included plots treated with *M. nivale* (2 g inoculum / m^2), *T. ishikariensis* (2 g inoculum / m^2), and a mixture of *M. nivale* and *T. ishikariensis* (1 g inoculum of each pathogen / m^2). Controls included a fungicide treatment of PCNB Quintozene (Plant Products Co. Ltd., Bramalea, ON., Quintozene 75%, wettable powder) applied at the manufacturers recommended rates (318 g / 100 m^2, or 6.36 g / 2 m^2 plot) with a portable compressed CO_2 sprayer at 310.2 KPa using a TeeJet 8002VS nozzle, and a fertilizer control of sulphur coated urea (25-0-0) applied at 33.3 g/ m^2. Fertilizer was applied at a rate equivalent to the amount of nitrogen in the compost batches when applied at the 48.7 kg / 100 m^2 (dry wt.) rate. This rate was equivalent to the nitrogen content in compost 6 (1.83 (N)-2.00 (P)-0.96 (K)) which was higher than the nitrogen content of compost 9 (1.71 (N)-1.29 (P)-0.81 (K)).

Rating and Data Analysis: Plots were rated visually for *M. nivale* and *T. ishikariensis* disease severity on a percent scale with 0 = no disease and 100 = 100% of the plot area affected. Beginning on April 14, plots were rated weekly until May 4, 1999 for green up (recovery from winter dormancy) and rated for disease severity on April 14, and 21, 1999. All data were analyzed using Statistical Analysis Software (SAS Institute Inc., Cary, NC). Normality was checked with the univariate procedure using Wilk's test. A log transformation was used in to restore normality for data not normally distributed. However, if normality could not be restored, the mean, variance and standard deviation were reported. [(Table 2)]. Data were analyzed statistically as a factorial experiment, reducing the full model by the removal of non-significant terms ($P \leq 0.05$). All non-significant compost x rate treatment data were pooled for comparison of means using Tukey's Studentized Range adjustment for multiple comparisons. Dunnett's test was used to compare each treatment to the pathogen, fungicide, and fertilizer controls.

RESULTS

Disease data: The development of grey and pink snow mould on creeping bentgrass at green (4 mm) and range (25 mm) mowing heights was low in the spring of 1999. As a result, data from four of eight rating date/location/disease combinations were not normally distributed, even after log transformation. These data were not included in the statistical analyses, however, the means, variance and standard error are summarized in Table 2. Data that were normally distributed included Apr. 14 for pink snow mould on the golf green (Figure 1) and for grey snow mould on the range location (Figure 2), and Apr. 21 for grey (Figure 3) and for pink snow mould (Figure 4) on the range location. Because the interaction between compost x rate was not significant, data were pooled into two data sets of composts 6 and 9 (application rate 1 and 2 pooled), and compost application rates (composts 6 and 9 pooled).

In all ratings where the data were normally distributed, the fungicide control was not significantly different from composts at either application rate 1 (48.7 kg/100 m^2) or 2 (97.4 kg/100 m^2) except for Apr. 21 where rate 1 had significantly higher disease severity compared to the fungicide treatment on the range plot. Fertilizer treatments had significantly higher disease severity compared to compost treatments on the creeping bentgrass green ($P \leq 0.05$), and showed a trend towards having higher disease severity on the creeping bentgrass range. Untreated control plots had significantly higher disease compared to all compost treatments on most ratings. Composts 6 and 9 were not significantly different in disease suppression, although compost application rate 2 had significantly lower disease than rate 1 for most ratings.

Green-up data: In these assessments, green up referred to the degree to which turfgrass commenced new growth and was a measure of the percent area of the plot that had recovered from a dormant brown colour to green (as a result of recovery from disease and/or winter dormancy). Although the two experiments were located in distinct areas of turf management, the assessments of green up were similar. In the analysis of green up data, the interaction between compost x rate was not significant and, therefore, rate data were pooled into compost data and compost data were pooled into rate data (Table 3,4).

For both the creeping bentgrass green (mowing height 4 mm) and the creeping bentgrass range (mowing height 25 mm), there were significant increases in green-up in compost treated plots compared to the fungicide and untreated plots at both locations, and the fertilizer treatment on the range on April 14 ($P \leq 0.05$). These differences in green-up among treatments diminished over the four week rating period, after which, the controls approached

Table 2. Results of the determination of mean, variance and standard error for data not normally distributed for two composts applied at three rates of topdressing on snow mould severity in 1999.

Rating Date	Disease	Experiment Location	Treatment	Mean	Variance	Standard Error
April 14	grey	green	fertilizer[1]	6.25	12.50	1.77
	snow		fungicide[2]	2.25	13.36	1.83
	mould		untreated[3]	4.38	24.55	2.48
			compost 6, rate 1[4]	2.25	10.50	1.62
			compost 6, rate 2[4]	0.00	0.00	0.00
			compost 9, rate 1	2.50	21.48	2.32
			compost 9, rate 2	1.25	5.35	1.16
April 14	pink	range	fertilizer	5.00	28.57	2.67
	snow		fungicide	0.00	0.00	0.00
	mould		untreated	6.88	56.70	3.77
			compost 6, rate 1	0.63	3.13	0.88
			compost 6, rate 2	0.63	3.13	0.88
			compost 9, rate 1	1.25	12.50	1.77
			compost 9, rate 2	1.88	28.13	2.65
April 21	grey	green	fertilizer	7.00	5.14	1.13
	snow		fungicide	0.00	0.00	0.00
	mould		untreated	3.38	12.55	1.77
			compost 6, rate 1	1.63	9.70	1.56
			compost 6, rate 2	0.63	3.13	0.88
			compost 9, rate 1	1.88	13.84	1.86
			compost 9, rate 2	0.25	0.50	0.35
April 21	pink	green	fertilizer	31.88	13.84	1.86
	snow		fungicide	0.63	3.13	0.88
	mould		untreated	5.38	22.55	2.38
			compost 6, rate 1	2.25	6.21	1.25
			compost 6, rate 2	1.00	8.00	1.41
			compost 9, rate 1	1.88	6.70	1.29
			compost 9, rate 2	0.88	3.27	0.90

[1] Fertilizer refers to plots treated with sulphur coated urea fertilizer (25-0-0) applied at 33.3 g/m^2.

[2] Fungicide refers to plots treated with PCNB Quintozene (Plant Products Co. Ltd., Bramalea, ON., Quintozene 75%, wettable powder) applied at the manufacturers recommended rates (318 g / 100 m^2) with a portable compressed CO_2 sprayer at 310.2 KPa using a TeeJet 8002VS nozzle.

[3] Untreated refers to plots that received no treatments of any kind.

[4] Rate 1 refers to compost applied at 48.7 kg/100 m^2, rate 2 refers to compost applied at 97.4 kg/100 m^2.

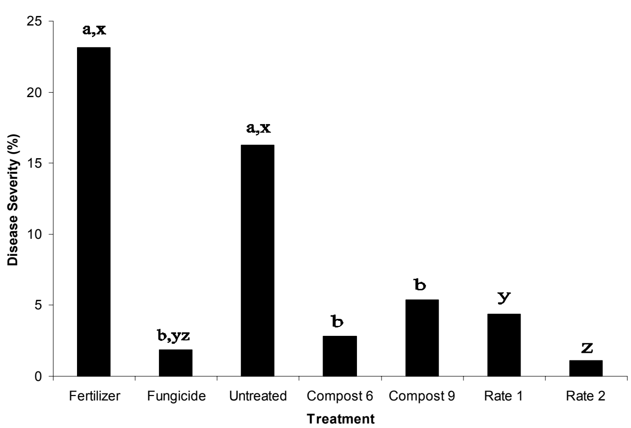

Figure 1. Pink snow mould (*Microdochium nivale*) disease severity was assessed on a creeping bentgrass (*Agrostis palustris*) green (mowing height 4mm) as percent of total plot area affected on April 14, 1999. Compost refers to compost 6 or 9. Rate refers to compost application rate: 1=48.7kg/100 m^2 and 2=97.4 kg/100 m^2. Untreated refers to plots which did not receive any treatments of compost, fertilizer, or fungicide. Bars with the same letters (a, b) refer to control treatments which were not significantly different from compost treatments (6 or 9), and bars with the same letters (x,y,z) refer to control treatments not significantly different from compost application rate treatments (1or 2) ($P<0.05$).

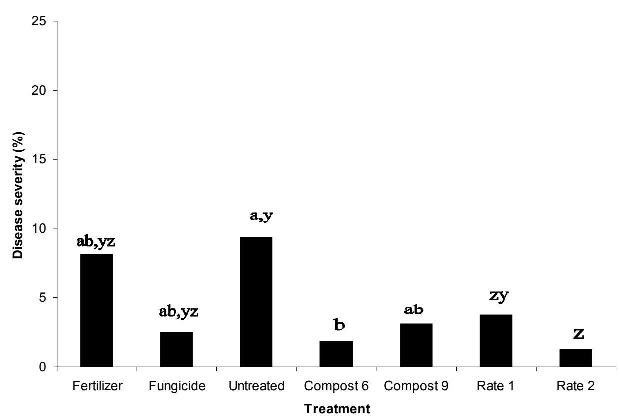

Figure 2. Pink snow mould (*Microdochium nivale*) disease severity was assessed on a creeping bentgrass (*Agrostis palustris*) green (mowing height 25mm) as percent of total plot area affected on April 21, 1999. Compost refers to compost 6 or 9. Rate refers to compost application rate: 1=48.7kg/100 m^2 and 2=97.4 kg/100 m^2. Untreated refers to plots which did not receive any treatments of compost, fertilizer, or fungicide. Bars with the same letters (a, b) refer to control treatments which were not significantly different from compost treatments (6 or 9), and bars with the same letters (x,y,z) refer to control treatments not significantly different from compost application rate treatments (1or 2) ($P<0.05$).

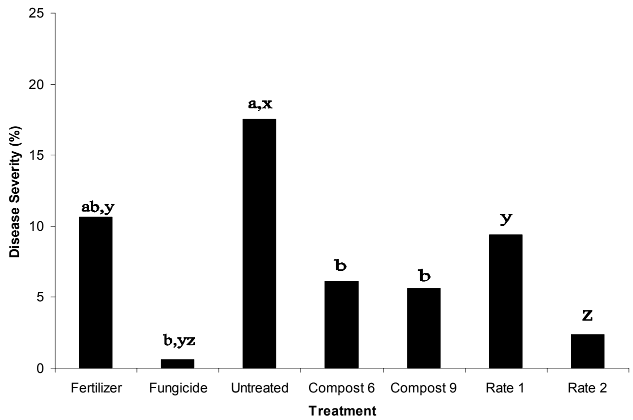

Figure 3. Grey snow mould (*Typhula ishikariensis*) disease severity was assessed on a creeping bentgrass (*Agrostis palustris*) green (mowing height 25mm) as percent of total plot area affected on April 14, 1999. Compost refers to compost 6 or 9. Rate refers to compost application rate: 1=48.7kg/100 m^2 and 2=97.4 kg/100 m^2. Untreated refers to plots which did not receive any treatments of compost, fertilizer, or fungicide. Bars with the same letters (a, b) refer to control treatments which were not significantly different from compost treatments (6 or 9), and bars with the same letters (x,y,z) refer to control treatments not significantly different from compost application rate treatments (1or 2) ($P<0.05$).

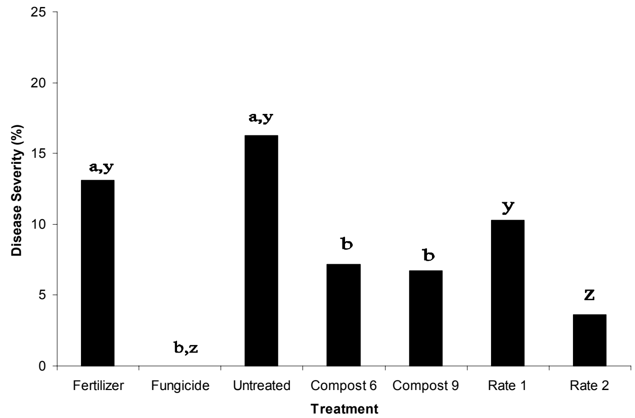

Figure 4. Grey snow mould (*Typhula ishikariensis*) disease severity was assessed on a creeping bentgrass (*Agrostis palustris*) green (mowing height 25mm) as percent of total plot area affected on April 21, 1999. Compost refers to compost 6 or 9. Rate refers to compost application rate: 1=48.7kg/100 m^2 and 2=97.4 kg/100 m^2. Untreated refers to plots which did not receive any treatments of compost, fertilizer, or fungicide. Bars with the same letters (a, b) refer to control treatments which were not significantly different from compost treatments (6 or 9), and bars with the same letters (x,y,z) refer to control treatments not significantly different from compost application rate treatments (1or 2) ($P<0.05$).

Table 3. Influence of treatments on green-up, or winter recovery, on a creeping bentgrass (*Agrostis palustris*) green (mowing height 4 mm) from Apr. 14 to May 4, 1999, as percent of total plot area recovered from winter dormancy. Compost refers to compost 6 or 9, averaged across compost application rates 1 (48.7 kg / 100 m^2) and 2 (97.4 kg / 100 m^2). Rate refers to rates 1 (48.7 kg / 100 m^2) and 2 (97.4 kg / 100 m^2), averaged across composts 6 and 9. On individual rating dates, treatments with the same letters are not significantly different (*P*<0.05). Dates with data that were not normally distributed do not include statistical calculations.

Treatment	Rating Date							
	14 Apr			21 Apr	28 Apr			4 May
Compost 6	88.13	a		90.83	99.38	a		99.58
Compost 9	87.29	a		91.25	98.13	a		99.17
Rate 1	79.8		b	83.75	97.5		a	98.96
Rate 2	95.63		a	98.33	100		a	99.8
Fertilizer	41.25	b[1]	c	61.25	83.33	b	b	81.25
Fungicide	32.5	c	d	54.58	78.75	b	b	97.5
Untreated	32.5	c	d	54.58	77.92	b	b	97.5

[1] There are two statistical analyses: one compares the controls (fertilizer, fungicide, untreated) to the composts (pooled across rates), the other compares the controls to the rates (pooled across composts).

Table 4. Influence of treatments on green-up, or winter recovery, on a creeping bentgrass (*Agrostis palustris*) range (mowing height 25 mm) from Apr. 14 to May 4, 1999, as percent of total plot area recovered from winter dormancy. Compost refers to compost 6 or 9, averaged across compost application rates 1 (48.7 kg / 100 m^2) and 2 (97.4 kg / 100 m^2). Rate refers to rates 1 (48.7 kg / 100 m^2) and 2 (97.4 kg / 100 m^2), averaged across composts 6 and 9. On individual rating dates, treatments with the same letters are not significantly different (P<0.05).

Treatment	Rating Date											
	14 Apr			21 Apr			28 Apr			4 May		
Compost 6	56.25	a		53.54	a		79.58	a		91.88	a	
Compost 9	55.21	a		54.80	a		76.88	a		88.54	a	
Rate 1	52.08		a	45.63		b	74.58		b	85.42		b
Rate 2	59.38		a	62.71		a	81.88		a	95.00		ab
Fertilizer	45.00	a[1]	a	56.67	a	ab	87.50	a	a	97.50	a	a
Fungicide	18.33	b	b	16.25	b	c	65.83	b	c	74.58	b	c
Untreated	21.25	b	b	18.33	b	c	57.50	b	c	70.00	b	c

[1] There are two statistical analyses: one compares the controls (fertilizer, fungicide, untreated) to the composts (pooled across rates), the other compares the controls to the rates (pooled across composts).

or were not significantly different from the compost treated plots. There were no significant differences between composts 6 and 9 at either experimental location, on any rating date ($P \leq 0.05$).

On the creeping bentgrass green, the fungicide treated plots had a significantly lower percent of green-up compared to compost treatments at every normally distributed rating date ($P \leq 0.05$). In addition, fertilizer treated plots did not display the same level of green-up as compost treated plots although this difference showed a trend towards diminishing over time. The fungicide and untreated plots were not significantly different for the duration of the rating period ($P \leq 0.05$). Plots treated with rate 2 showed a significantly higher level of green up compared to the rate 1 on Apr. 14. However, there was an overall trend for the level of green-up from the lower application (rate 1) to approach levels attained by the higher application (rate 2) by the end of the assessment period. Plots treated with compost applied at the higher application rate showed a higher level of green-up on Apr. 14 compared to those treated with compost applied at the lighter application rate ($P \leq 0.05$) (Table 3). However, this difference diminished through time.

On the creeping bentgrass range, the fertilizer controls were not significantly different from the compost treated plots on any rating date (Table 4). The fungicide and untreated plots, which were not significantly different for the duration of the rating period, had a significantly lower level of green-up when compared to compost and fertilizer treatments on every rating date ($P \leq 0.05$). In general, the results of this experiment were similar to those observed on the creeping bentgrass green. However, the fungicide and untreated controls did not attain the same amount of green up by the end of the rating period. On the range, there was no consistent difference in green-up between plots treated with the two application rates of compost, although on two of four rating dates, the plots which received the higher application rate of compost showed significantly higher levels of green-up compared to those which received the lower application rate (Table 4).

DISCUSSION

Results from these experiments report on the use of mature composts from selected feedstocks as suppressants to two important diseases of turfgrass, pink and grey snow moulds, in field conditions.

In this study, field disease assays were effective in identifying fall applications of compost as a suppressant to pink and grey snow moulds, at least under low disease pressure. In addition, turf that received compost applications displayed a more rapid rate of spring green-up than turf which was treated with fertilizer or fungicide. The higher rate of compost (97.4 kg/100 m^2), had a greater ability to suppress disease compared to the lower rate (48.7 kg/100 m^2) on some rating dates. This may have been a result of a combination of increased nutrient availability, increased antagonistic or competitive interactions among microorganism populations or their metabolites, or the darker colour of the higher compost application rate may have increased ground heating and promoted more rapid recovery of turf. However, Hoitink (12) found higher rates of compost application to be no better than lower rates in disease suppression, suggesting that smaller amounts of organic matter were sufficient to stimulate the microbiota.

In this study, some fertilizer controls were not statistically different from compost treatments in some ratings. As a result, it is unclear as to the effect that the nutrient levels in the compost were having on turf. However, where compost treatments were different from the fertilizer controls, they consistently had less disease. The effect that composts had on snow mould was likely due to factors other than nitrogen only. Since most fertilizer controls were not different from untreated plots, nutrients may not be dominant factors in control of snow mould disease.

Other than fertilizer effects, nitrogen is known to increase fungal and bacterial populations in turf and play a major role in microbial population dynamics (16). It is essential for the production of many compounds involved in host resistance, including phenolics, phytoalexins, growth hormones, cellulose and carbohydrates (14). Autoclaving of composted material destroyed or reduced suppressive effects on *Pythium*; suggesting microbial antagonists and their metabolites had an important role (25). However, for composts with higher levels of nitrogen and other available nutrients, disease suppression may also have been a result of enhanced turfgrass nutrition allowing for more rapid recovery from disease (8).

Compost applications on the creeping bentgrass green increased the rate of green-up and playability more quickly than fertilizer applications. As a result, nutrients are not postulated to have played a significant role in green-up at the green location. However, turf height and increased available water on the green surface may have encouraged microbial activity compared to the range area, allowing for breakdown and release of nutrients and other antagonistic compounds. Additional ratings earlier in the season may have given more insight into this question. Fertilizer control plots seemed to have an upper limit in their ability to green-up turf, after about 78% green, bentgrass did not become more green for the duration of the rating dates. This may have been a result of more rapid release of nitrogen from the fertilizer, thus becoming exhausted more rapidly. Other than fertility, the darker colour of the compost may have had an impact on spring soil warming, increasing turfgrass growth rate or stimulating microorganism growth and activity. A heating effect may have stimulated earlier activity of mycorrhizae, thus increasing nutrient availability to turf. In addition, the heavy compost layer may have held more water than the lighter rate, increasing availability to turf.

In contrast to the green height creeping bentgrass experimental location, fertilizer treatments on range height creeping bentgrass were not significantly different from compost treatments in their ability to green-up turfgrass on most rating dates. In this case, the effect of compost on green-up may have been more of a nutrient effect. A heating effect may have been less of a factor as compost may have been more rapidly incorporated into thatch, falling deeper into the stand (25 mm), which may have shaded it from early spring sunlight. Compared to the green location, the range was exposed to winds and also developed increased ice cover, which may have increased dessication and lessened microbial competitive capabilities.

Other researchers have reported that although compost did not prevent the occurrence of snow mould, it increased the recovery of grasses from the disease (2). It was postulated that the dark colour of the composted material increased radiant heat absorption, increased nutrient levels and stimulated growth (2). Most research on snow moulds has focused on biological control of *Typhula* spp. with antagonistic microorganisms. The reduction of populations of sclerotia with hyperparasites and limiting of mycelial growth prior to infection with low temperature-tolerant antagonists are common approaches (4). *T. phacorrhiza*, initially assumed to be an unreported pathogen of turfgrass, was found to be suppressive to development of *T. ishikariensis* (5; 19; 31). The mechanism of suppression likely involved competition for nutrients and space or production of inhibitory compounds (5; 15; 30). There has, however, been significant variance in the ability of *T. phacorrhiza* to act as a biological control over grey snow mould development over a three-year field study (31).

In these experiments no results were indicative of consistent differences among composts in their ability to suppress turfgrass pathogens. It may be acceptable for compost producers wishing to create a suppressive product to base all composts on a single feedstock, which would form the majority of batch material and, subsequently, add various other feedstocks without altering biological control capacity. Because research has found compost to decrease the incidence and severity of diseases, Hoitink (12) suggested that a broad mechanism of action is responsible for suppression rather than a specific chemical action against pathogens.

A lack of interest in research on biological controls for turfgrass diseases in the past has resulted in many potential antagonists still in the development stage and/or recently marketed agents with unknown/unidentified mechanisms of control. The recently established ability for compost to act as a suppressant has led to increased research on the development of consistency in control and increased knowledge, or at least awareness of, the large number of factors in composts which play an integrated role in suppression of plant pathogens.

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