SUPPRESSION OF DOLLAR SPOT DISEASE OF CREEPING BENTGRASS WITH COMPOST

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ABSTRACT

The use of composts in turfgrass disease management allows for a reduction in pesticide use in chemical control practices. In 1998, five composts were evaluated for effectiveness in suppression of dollar spot in field experiments with compost prepared in 1997-8. Multiple applications of compost (every 3 weeks) throughout the season suppressed dollar spot (*Sclerotinia homoeocarpa* F. T. Bennett) of turf to levels not significantly different than applications of fungicide every 2 weeks (*P*#0.05). Compost applied in a single application at the start of the season was not effective in reducing disease. Field experiments in 1999 evaluated two selected compost formulations reproduced in 1998-9 and evaluated the influence of storage on suppressiveness of the 1997-8 compost formulations. Compost formulations that were reproduced were effective in suppressing disease to levels not significantly different than the fungicide controls (*P*#0.05). Storage of compost for up to one year did not affect its ability to reduce dollar spot severity (*P*#0.05). In addition, the affect of nitrogen, a known cultural control method of dollar spot, was evaluated as a potential mechanism of disease suppression. Compost applications were significantly better at suppression of dollar spot than nitrogen treated plots (*P*#0.05), even though all nitrogen controls were applied at rates equivalent to, or greater than, the highest compost application rate.

INTRODUCTION

Dollar spot (*Sclerotinia homoeocarpa)* is an important turfgrass disease (5,33,37). Although fungicides are commonly used for its management, 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 the need for other methods of disease management (6,25). An exciting 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 disease (2). The use of composts and other organic amendments for disease suppression has the potential to be beneficial both ecologically and economically. Although compost may not control turfgrass diseases to a level that will replace fungicides, its integration into current disease management practices may reduce the use of fungicides 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 or in soil root-zone mixtures. Dollar spot is one of the more commonly studied diseases for suppression with composts, sludges and other organic materials (15,17,20,26,28). Composts are known to suppress plant diseases through a combination of biological and physiochemical characteristics (13). Biological characteristics include microbial populations in compost, competition for nutrients with pathogens, antibiotic production, lytic and other extracellular enzyme production, parasitism and predation, and induction of host-mediated resistance in plants. Compost can be a beneficial material where a high proportion of organic matter may offset sand content and increase or restore microbial populations (1). High levels of microbial activity in composts was postulated as the primary mechanism of disease control (7,8,23,24,26,27,28,30). Several bacterial and fungal species (e.g. *Fusarium heterosporum*, *Acremonium* spp., *Rhizoctonia* spp., *Enterobacteria cloacae, Pseudomonas fluorescens*, *Pseudomonas lindbergii*) are known to be highly suppressive to dollar spot (10,12,24). 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 (3,16,21,26,32,34).

Physiochemical characteristics include any physical or chemical aspects of composts that reduce disease severity by directly or indirectly affecting the pathogen or host capacity for growth, such as: nutrient levels, organic matter, moisture, colour, pH and other factors (11,38). There are a number of examples where nutrient competition was a factor in suppression of plant pathogens (4,7,9,14,18,22,29,36,38). For example, nitrogen, a known cultural control method for dollar spot, is considered partially or even completely responsible for dollar spot control with composts and other natural organic fertilizers (17,20).

The objectives of this research were to: 1) evaluate the ability of selected compost formulations to suppress dollar spot in field trials; and 2) to evaluate the effects of storage on compost suppressive capabilities.

MATERIALS AND METHODS

Field plots were established on a creeping bentgrass (*Agrostis palustris)* green in 1998 and 1999 at the Guelph Turfgrass Institute, Guelph, ON, to evaluate the ability of compost to suppress dollar spot.

Preparation of composts: Five mature composts were provided by All Treat Farms, Ltd., Arthur, ON. Composts 4, 5, 6, 8, and 9 were prepared in 1998, and composts 6 and 9 were prepared a second time in 1999. Composts used in plant disease suppression assays were produced using proprietary blends of selected feedstocks combined in proportions that would result in acceptable C:N ratios and moisture levels. Feedstock components are listed in Table 1. The beginning of the composting process was defined as day 0, which ranged from June 19, 1997 to July 4, 1997, and September 22, 1998, to September 24, 1998 for 1998 and 1999 experiments, respectively. All composts were passively aerated,

Table 1. Composition of compost batches.

	Compost				
Feedstocks	4	5	6	8	9
Horse manure				x	
Chicken manure	x	x	x	x	x
Paunch manure[1]					x
Bone meal ash[2]			x	x	
Bark mix	x	x	x	x	x
Soybean Meal		x	x	x	
Milorganite		x	x	x	

[1] Paunch manure refers to feed remaining in the rumens of slaughtered cattle.

[2] Bone meal ash refers to the mineral remains of animal bone materials.

and mechanically turned once to re-mix materials. No composting piles were harvested until the average core compost temperature declined to at least 45°C. All composts were screened to 3.8 mm average particle size before application.

Pathogen growth: *S. homoeocarpa* (Sh48B) was maintained on PDA (potato dextrose agar) (Bacto® Difco Laboratories, Detroit, MI) at 4°C. For preparation of field inoculum, *S. homoeocarpa* was initially grown on agar plates of PDA at 22 ± 2°C for 9 days and transferred (20 plugs of 5 mm diameter from the colony margin) into 1000 mL Erlenmeyer flasks containing 250 mL of sterile chicken scratch (corn, barley, oats) mix plus 100 mL deionized water (2.5:1 w/w). Inoculated flasks were incubated at 21 ± 2°C until thoroughly colonized at 21 days. Seventy-two hours before field inoculation, the medium was removed from the flasks, placed on paper towels in a laminar flow cabinet, and air dried for 48 h. Inoculum was then ground in a Waring blender (Waring Commercial Blender, Model 5011, Waring Products Division, New Hartford, Conn, USA), weighed, and placed in individual envelopes for field application. Inoculum was applied to plots at a rate of 1 g/ m^2 prior to compost topdressings.

Experiment 1, 1998: Field plots (1 x 2 m) of creeping bentgrass were maintained under golf course putting green conditions, and mowed daily to 4 mm. In 1998, the factorial experiment (composts and rates of application) with four replications per treatment included a split block design (19) to evaluate single and multiple applications of compost. As a result, the 1 x 2 m plots were subdivided into two 1 x 1 m plots: one half received a single compost application, while the other half had compost applied every 3 weeks for the duration of the experiment. The five composts were topdressed at 48.7, 24.4, and 12.2 kg (dry weight) / 100 m^2 (100, 50 and 25 lbs/ 1000 ft^2). There were three controls: control (untreated), pathogen control (pathogen only), and fungicide control (fungicide only). The commercial fungicide Daconil 2787® (chlorothalonil, tetrachloroisophthalonitrile 40.4%) (ISK Biotech, Reg. No. 15 724, U. S. Patent 3 948 636) was applied every 14 d at the manufacturer's recommended preventative rate of 95 mL/100 m^2 (38.4 mL active ingredient/ 100 m^2) with a portable compressed CO_2 sprayer at 301.2 kPa, using a TeeJet 8002VS nozzle.

Experiment 2, 1999: In 1999, a factorial experiment with four replications per treatment was used to evaluate composts 6 and 9, prepared in 1998, as well as composts 6 and 9, prepared in 1999, for dollar spot suppression. Experiments in 1999 evaluated the reproducibility of preparation methods of composts 6 and 9, as well as evaluated the storage effects on suppressive capabilities. Composts were applied every 3 weeks for the duration of the experiment. The four composts were topdressed at 48.7, 24.4, and 12.2 kg (dry weight) / 100 m^2 (100, 50 and 25 lbs/ 1000 ft^2). There were three controls: control (untreated), pathogen control (pathogen only), and fungicide control (fungicide only). The commercial fungicide Daconil 2787® (chlorothalonil, tetrachloroisophthaloni-trile 40.4%) (ISK Biotech, Reg. No. 15 724, U. S. Patent 3 948 636) was applied every 14 days at the manufacturer's recommended preventative rate of 95 mL/100 m^2 (38.4 mL active ingredient / 100 m^2) with a portable compressed CO_2 sprayer at 301.2 kPa, using a TeeJet 8002VS nozzle. There were two nitrogen controls: one was equivalent to nitrogen levels in composts, and the level of nitrogen applied was equivalent to that of the highest nitrogen level in compost batches, when compost was applied at the heaviest rate (48.7 kg/100 m^2). Sulphur coated urea was the nitrogen source used, applied at a rate of 37.3 g/2m^2. The second nitrogen control was chosen to be representative of nitrogen applied in a golf course setting at 2 kg/100m^2, which was applied as sulphur coated urea in four equal applications during the season (10 g/2 m^2 per application). Nitrogen control plots were inoculated with the same level of pathogen inoculum as the compost treated plots.

Rating and Data Analysis: Plots were rated visually for dollar spot severity on a percent scale with 0 = no disease and 100 = 100% of the plot area affected. Data were analysed using Statistical Analysis Software (SAS Institute Inc., Cary, NC) as a factorial experiment, reducing the full model by the removal of non-significant terms (*P*# 0.05). Means were compared with Tukey's adjustment for multiple comparisons. Dunnett's test was used to compare each treatment to the pathogen and fungicide controls. For the 1998 field experiment, single and multiple applications (split block) were analyzed separately as these factors were significantly different. For 1998 and 1999 experiments, an area under the disease-progress curve (AUDPC) was calculated for each treatment as a measure of cumulative disease incidence for the season using the equation; AUDPC = $3 [(y_i + y_{i+1})(t_{i+1} - t_i) /2]$ for i = 1, 2, 3, ..., n-1, where y_i is the cumulative disease incidence, expressed as a proportion at the ith observation, and t_i is the time (days after first compost treatment) at the ith observation (32,34).

RESULTS AND DISCUSSION

Experiment 1, 1998: The results of single and multiple applications of compost on the severity of dollar spot for 1998 are presented in Tables 2 and 3, respectively.

Single applications of compost did not provide any significant suppression of disease compared to the pathogen control for most of the season (Table 2), while compost treatments applied every three weeks reduced dollar spot severity on 6 of 7 rating dates (Table 3). On some rating dates there were differences among composts and application rates in both single and multiple applications but, overall, this was uncommon. Because the fungicide showed little control of disease until 63 DAT, selected multiple application treatments showed significantly better control of disease than the fungicide.

The AUDPC values indicated that all compost-rate single applications provided significantly less control of dollar spot than the fungicide control, and were not significantly different from the pathogen control. For multiple application treatments, AUDPC values showed that compost-rate treatments suppressed disease severity at a level that was not significantly different from the fungicide control but was significantly lower than the pathogen control (except for 3 treatments). In addition, there were no significant differences (*P*# 0.05) among the compost piles when applied either in single or multiple applications. This indicated that applications of compost every 3 weeks reduced dollar spot severity as effectively as applications of a fungicide every 2 weeks.

Experiment 2, 1999: Plots treated with compost developed significantly less dollar spot compared to the pathogen control plots for most of the 1999 season (Table 4). As observed in the 1998 field season, treatments that suppressed disease at levels significantly lower than the pathogen control plots for most of the season included those having

Table 2. Dollar spot severity in creeping bentgrass plots amended with five composts applied once at three rates in 1998. Each point is the average of n=4.

Compost [b]	Rate [c]	Single application [a] Days After Treatment (DAT) [d]							
		28	42	49	56	63	70	77	AUDPC
4	1	15.3 a [e]	30.0 a	36.3 a	37.5 a	43.8 a †	42.5 ab †	42.5 a †	1828.9 a †
4	2	23.0 a †	33.8 a	42.5 a	36.3 a	41.3 a †	50.0 ab †	52.5 a †	2072.1 a †
4	3	18.5 a	33.8 a	38.8 a	36.3 a	45.0 a †	43.8 ab †	50.0 a †	1963.6 a †
5	1	14.5 a	33.8 a	37.5 a	35.0 a	43.8 a †	45.0 ab †	51.3 a †	1911.0 a †
5	2	18.0 a	33.8 a	41.3 a	36.3 a	45.0 a †	47.5 ab †	50.0 a †	2005.9 a †
5	3	18.8 a	38.8 a	45.0 a	36.3 a	50.0 a †	47.5 ab †	55.0 a †	2150.0 a †
6	1	14.3 a	25.0 a	35.0 a	23.8 a	36.3 a †	43.8 ab †	50.0 a †	1652.1 a †
6	2	14.3 a	37.5 a	37.5 a	37.5 a	50.0 a †	51.3 ab †	55.0 a †	2075.9 a †
6	3	20.0 a	38.8 a	42.5 a	38.8 a	48.8 a †	48.8 ab †	50.0 a †	2141.9 a †
8	1	16.8 a	33.8 a	38.8 a	38.8 a	40.0 a †	48.8 ab †	52.5 a †	1979.0 a †
8	2	14.5 a	33.3 a	38.8 a	37.5 a	45.0 a †	40.0 abc †	50.0 a †	1895.1 a †
8	3	15.3 a	30.0 a	37.5 a	30.0 a	40.0 a †	46.3 a †	45.0 a †	1800.1 a †
9	1	19.5 a	32.5 a	41.3 a	33.8 a	40.0 a †	26.3 bc ‡	53.8 a †	1962.9 a †
9	2	15.8 a	31.3 a	40.0 a	36.3 a	40.0 a †	23.8 c ‡	45.0 a †	1799.8 a †
9	3	15.8 a	30.0 a	42.5 a	35.0 a	45.0 a †	52.5 a †	53.8 a †	1999.8 a †
Pathogen [f]		13.3	30.8	33.8	31.3	38.8	37.5	38.8	1781.6
Fungicide [g]		9.3	26.7	33.3	28.3	4.7	11.7	16.7	1029.3

[a] Single application refers to the portion of the split plot experimental design that received one compost application.
[b] Compost refers to compost 4, 5, 6, 8 or 9.
[c] Compost application rate: 1= 12.2 kg / 100 m2, 2 = 24.4 kg / 100 m2, 3 = 48.7 kg / 100 m2.
[d] DAT (days after treatment) refers to rating date when disease severity was assessed, after initial experimental set up. Disease was rated in percent of total plot area diseased.
[e] Values followed by the same letter(s) within individual columns are not statistically different at P# 0.05.
[f] Values followed by the same symbols († and ‡) within individual columns represent treatments that are statistically different (P# 0.05) from the fungicide and pathogen controls, respectively.
[f] Pathogen refers to the level of disease in control plots inoculated with the pathogen only.
[g] Fungicide refers to the level of disease in control plots treated with the pathogen and a fungicide only.

Table 3. Dollar spot severity in creeping bentgrass plots amended with five composts applied every three weeks at three rates in 1998. Each point is the average of n=4.

Compost [b]	Rate [c]	Multiple applications [a] Days After Treatment (DAT) [d]							
		28	42	49	56	63	70	77	AUDPC
4	1	6.0 a [e]	18.0 a	28.8 a	25.0 a	30.0 a †	28.8 ab †‡	35.0 a †	1285.5 a
4	2	2.5 a ‡ [f]	21.3 a	22.5 a	22.5 a	22.5 a †	22.5 a ‡	32.5 a	1109.4 a ‡
4	3	2.0 a ‡	20.0 a	15.0 a	20.0 a	25.0 a †	16.3 a ‡	32.5 a	982.4 a ‡
5	1	4.5 a	18.8 a	20.0 a	18.8 a	25.0 a †	23.8 a ‡	33.8 a	1082.1 a ‡
5	2	3.0 a	24.5 a	20.0 a	18.8 a	27.5 a †	21.3 a ‡	32.5 a	1127.4 a ‡
5	3	3.0 a	22.5 a	16.3 a †‡	18.8 a	27.5 a †	17.5 a ‡	30.0 a	1059.9 a ‡
6	1	5.0 a	13.8 a ‡	23.8 a	15.0 a	22.5 a †	30.0 ab †‡	28.8 a	1036.1 a ‡
6	2	6.3 a	26.3 a	17.5 a †	22.5 a	31.3 a †	28.8 ab †‡	32.5 a	1299.4 a
6	3	7.0 a	26.3 a	12.5 a †‡	21.3 a	27.5 a †	21.3 a ‡	30.0 a	1157.3 a ‡
8	1	6.5 a	22.5 a	25.0 a	28.0 a	28.8 a †	27.5 a †‡	35.0 a †	1298.9 a
8	2	4.3 a	22.5 a	26.3 a	22.5 a	30.0 a †	21.3 a ‡	35.0 a †	1185.4 a ‡
8	3	2.5 a ‡	13.0 a ‡	12.5 a †‡	12.5 a †‡	17.5 a †‡	16.3 a ‡	22.5 a	759.8 a ‡
9	1	4.5 a	20.5 a	24.5 a	21.3 a	26.3 a †	46.3 ab †	33.8 a	1179.1 a ‡
9	2	4.3 a	19.5 a	20.0 a	18.8 a	27.5 a †	30.0 ab †‡	26.3 a	1015.9 a ‡
9	3	2.3 a ‡	20.8 a	15.0 a †‡	17.5 a	26.3 a †	15.0 a ‡	27.5 a	958.6 a ‡
Pathogen f		13.3	30.8	33.8	31.3	38.8	37.5	38.8	1781.6
Fungicide [g]		9.3	26.7	33.3	28.3	4.7	11.7	16.7	1029.3

[a] Multiple application refers to the portion of the split plot experimental design that received compost applications every three weeks.
[b] Compost refers to compost 4, 5, 6, 8 or 9.
[c] Compost application rate: 1= 12.2 kg / 100 m2, 2 = 24.4 kg / 100 m2, 3 = 48.7 kg / 100 m2.
[d] DAT (days after treatment) refers to rating date when disease severity was assessed, after initial experimental set up, rated in percent of total plot area diseased.
[e] Values followed by the same letter(s) within individual columns are not statistically different at P#0.05.
[f] Values followed by the same symbols (†, ‡) within individual columns represent treatments that are statistically different (P#0.05) from the fungicide and pathogen controls, respectively.
[f] Pathogen refers to the level of disease in control plots inoculated with the pathogen only.
[g] Fungicide refers to the level of disease in control plots treated with the pathogen and a fungicide only.

higher rates of compost application (*i.e.* 48.7 kg /100 m^2). Almost all compost treated plots suppressed dollar spot severity to levels not significantly different than the fungicide controls for the season. Fungicide treated plots showed a similar trend in disease control compared to 1998 data, where an apparent lack of control at the start of the season was followed by an improvement in dollar spot control by the end of the season. Most compost treatments had significantly less disease severity than the nitrogen controls.

The AUDPC values indicated that all compost applications suppressed disease severity to levels not significantly different than the fungicide control (except 1 treatment) and provided significantly increased control compared to pathogen controls. In addition, all compost treatments applied at a rate of 48.7 kg /100 m^2 and 3 of 4 compost treatments applied at 24.4 kg/100 m^2 provided significantly better disease control than that of either nitrogen control. No compost treatments applied at 12.2 kg/100 m^2 were significantly different from the nitrogen controls. These results indicate that applications of compost every 3 weeks reduced dollar spot severity as effectively as applications of fungicide every 2 weeks, and more effectively than nitrogen applied as sulphur-coated urea. In addition, storage of compost for up to one year does not appear to alter its ability to control dollar spot of turf.

Field experiments in 1998 and 1999 were effective in identifying multiple applications (every 3 weeks) of compost as a suppressant to dollar spot. Lack of consistent significance among compost application rates to suppress dollar spot in individual rating dates may have resulted from levels being applied above those necessary to either adequately inoculate the localized environment with antagonistic or competitive microorganisms, or encourage the growth and activity of resident communities in the turf.

Calculation of the AUDPC was a valuable method for determining cumulative disease as it allowed the sum of effects which may not be detected on individual rating dates to be expressed as a single value for the entire epidemic. This method of comparing seasonal disease values may be more useful for assessing disease control methods where effects on pathogens may be more subtle, additive or cumulative, or require a time period to become adequately active. AUDPC may be especially useful with compost amendments, where time is likely a factor in suppression, which may require growth and adaptation of highly competitive or antagonistic microorganism populations to new environmental conditions, or release of nutrients and/or incorporation into soil systems to improve plant health and disease resistance abilities.

Some composts and natural organic fertilizers have been found to be highly suppressive to dollar spot when applied preventatively as topdressings on putting greens (28). The sphagnum peat currently used as a top-dressing and organic amendment material in the turf industry is an excellent candidate for replacement as it is a non-renewable resource from ecological zones described as “the most delicate areas of interaction of vegetation and hydrology on the planet” (35). Covering 3% of the Earth’s surface, these areas are crucial to the world’s biosphere, and are considered to be on the same scale as the tropical rainforests in importance (35).

Although disease suppression with composts has been established, the mechanisms of action responsible are still under debate. Previous studies have shown several bacterial and fungal species to be suppressive to dollar spot, but nitrogen application is still considered an implicating factor in control (10,12,24). Nitrogen is a cultural control method of dollar spot, known to stimulate turf to outgrow pathogen symptom damage and promote rapid recovery from disease injury. As a result, it is normally considered partially or even completely responsible for dollar spot control with composts and other natural organic fertilizers (17,20). However, in this study, when compost was compared to nitrogen fertilizers, compost displayed higher levels of dollar spot control. The nitrogen fertilizer controls only suppressed dollar spot to levels equivalent to that of compost applied at the lightest rate (12.2 kg/ 100 m^2), although the fertilizer applications were equivalent to nitrogen levels in the heaviest compost rate applied (48.7 kg/100 m^2). This data suggests that although nitrogen does control dollar spot to a certain level, compost contains other variables which allow it to suppress disease significantly better when applied at the same rate of nitrogen. Other than fertilizer effects, nitrogen is known to increase fungal and bacterial populations in turf and play a major role in microbial population dynamics (20). It is essential for the production of many compounds involved in host resistance, including phenolics, phytoalexins, growth hormones, cellulose and carbohydrates (16).

The modes of action by which natural organic fertilizers suppress dollar spot are assumed to include increases in plant growth from nutrient availability, and increased microbial populations from those present in the fertilizers themselves, and/or those stimulated in turf through their application which may compete with or antagonize pathogens and protect plants from infection (20,31). Other researchers have concluded that compost suppression of dollar spot was due to microbial effects of the material which are suspected to directly interfere with pathogen growth as well as competition (24,28). Another suggested role of bacteria in dollar spot suppression is the metabolic provision of nitrogen nutrition to turf (24). A relatively low amount of dollar spot suppression by a synthetic organic nitrogen source (Nitroform™ 38-0-0) compared to organic fertilizers was indicative that nitrogen assimilation alone is not solely responsible for control (17).

Antagonistic activity of composts relies on a number of factors, and although their relative importance varies, microbial activity, population dynamics, nutrient concentrations, and other associated chemical and physical factors all have an influence in turfgrass disease suppression. The lack of information 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 of compost to act as a suppressant has led to increased research on improving the consistency of control, and increased knowledge of, or at least awareness of, the large number of factors in composts that play an integrated role in pathogen suppression.

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