Use of Vermicomposted Waste Materials as a Turfgrass Fertilizer

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SUMMARY. Vermicomposting is the process of fragmenting organic wastes with certain species of earthworms. A variety of vermicomposts are being marketed as fertilizer materials for turfgrass management, particularly in the golf course industry. In 2002 and 2003, field trials were conducted on established kentucky bluegrass (*Poa pratensis*) in Columbus, Ohio, to evaluate the use of vermicomposted animal, food, paper, and turfgrass clipping waste materials as a turfgrass fertilizer under home lawn maintenance conditions. Visual quality of the plots was significantly higher for 2 weeks after application of paper vermicompost, regardless of application rate. Few other differences in either turfgrass visual quality of clipping yields were observed during a 6-week period after application, regardless of application rate or source of vermicompost. Based on the results of these studies, the use of vermicompost as a fertilizer material on established turfgrass is not warranted.

Highly maintained turfgrass used on golf courses, sports stadiums, and other areas requires 146.5 to 292.9 kg·ha⁻¹ (3–6 lb/1000 ft²) of nitrogen fertilizer in order to maintain acceptable color, quality, and density (Beard, 1973; Turgeon, 1991). Concern over the use of nitrogen fertilizers, and environmental contamination due to runoff and leaching of nitrate nitrogen has resulted

in efforts to reduce the amount of nitrogen applied to turfgrass (Liu et al., 1997). At the same time, there has been an increase in the use of fertilizer materials derived from natural sources, such as poultry manure and corn gluten meal (Gardner et al., 1997), due to the perception that use of these materials reduces leaching risks.

Large volumes of organic wastes are produced by a variety of industries, creating serious disposal problems, as well as a major source of environmental pollution (Fletcher, 1991). Vermicomposting is the process of fragmenting organic wastes with certain species of earthworms (*Eisenia* sp.) (Atiyeh et al., 2000c). Ingestion of the waste by earthworms fragments the waste substrate, accelerates organic matter decomposition, and alters the properties of the parent material (Atiyeh et al., 2000c). Vermicomposts are finely divided peat like materials. They have high porosity, aeration, drainage, and water-holding capacity and contain nutrients in forms readily taken up by plants (Atiyeh et al., 2000b). The ability of earthworms to consume a range of organic wastes, such as animal manure, crop residues, and industrial refuse, has been previously established (Edwards et al., 1985; Mitchell et al., 1980).

When used as a soil additive or a component of horticultural media, vermicomposts usually enhance seedling growth and result in an overall increase in productivity of a wide variety of crops (Atiyeh et al., 1999, 2000b, 2000c). However, previous research suggests that distinct differences exist between vermicomposts in terms of their chemical properties, nutrient content, and effect on plant growth (Atiyeh et al., 2000d).

A variety of vermicomposts are being marketed for use as fertilizer materials for turfgrass management, particularly in the golf course industry. Positive increases in flower and fruit production resulting from the use of vermicompost as an incorporated soil amendment has been established in certain crops (Atiyeh et al., 2000a). However, the effects of vermicomposts as a surface-applied fertilizer material for turfgrass have not been well established. Also, most studies on the use of vermicompost have involved incorporation of the material into the soil or potting media. This is not practical in most turfgrass management situations, except at time of establishment.

Therefore, if vermicomposts are to be utilized in turfgrass, they must, in most cases, be applied as a fertilizer or a surface-applied topdressing amendment to the turfgrass. The objective of this study was to evaluate the effects of vermicomposted waste materials applied as a fertilizer on the growth and quality of kentucky bluegrass.

Materials and methods

Vermicomposts from three commercial sources and a turfgrass vermicompost produced at the Ohio State University were tested in trials established on 20 June 2002 and 2 July 2003 at the Ohio State Turfgrass Foundation Research and Education Center, Columbus. The soil was a Brookston silty clay loam with a pH of 7.5 and 90 g·kg⁻¹ (9%) of organic matter. Soil test results indicated a high phosphorus (P) level for turfgrass [107.6 kg·ha⁻¹ (96 lb/acre) of P], and a medium level of potassium (K) for turfgrass [280.2 kg·ha⁻¹ (250 lb/acre) of K], using the Bray-P1 extraction method for phosphorus and the ammonium acetate extraction method for potassium (Christians, 2004; Guillard and Dest, 2003; Tisdale et al., 1993). Field trials were conducted on three replicate plots in kentucky bluegrass. Each plot was 1.9 m² (20 ft²). Treatments were applied in a randomized complete-block design.

The chemical properties of the paper vermicompost (American Resource Recovery, Stockton, Calif.), food vermicompost (Oregon Soil Corp., Portland, Ore.), animal waste vermicompost (Pacific Garden Co., Ferndale, Wash.) and the turfgrass vermicompost are listed in Table 1. The turfgrass vermicompost was produced by adding 45.4 kg (100 lb) partially composted turfgrass clippings and wood chips (3:1 v/v) to a compost bin adjacent to the field plots with 22.7 kg (50 lb) earthworms, *Eisenia andrei* in July 2002. The vermicompost was periodically turned over, and new clippings and wood chips added periodically for 10 months. The earthworms were separated by hand from the vermicomposted clippings in May 2003. The vermicompost was then analyzed to determine pH, organic matter content, conductivity, and nutrient levels (Table 1).

Vermicomposted waste materials were applied to the plots using a shaker can. No other fertilizer was applied.

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Table 1. Chemical properties of vermicomposted waste materials utilized in turfgrass field trials in Columbus Ohio in 2002 and 2003.

Vermicompost	pH	Conductivity (mmhos·cm ⁻¹)	OM ^z	Macronutrients ^y						
				N		P	K	Ca	Mg	S
				Total	NO ₃ ⁻					
				----- % -----						
Paper waste	5.9	11.00	34.7	1.06	0.07	0.42	0.40	17664	5473	6237
Food waste	8.0	4.05	50.8	1.35	0.06	0.26	1.09	13507	3808	1748
Animal waste	6.3	33.60	57.9	2.91	0.35	0.58	1.36	35221	6728	6588
Turfgrass waste	6.4	4.80	36.4	2.91	0.14	0.57	0.61	62674	10760	5095
				Micronutrients ^x						
				B	Cu	Fe	Mn	Mo	Zn	
				----- µg·g ⁻¹ -----						
				70	137	12301	362	4	333	
				22	49	23375	626	<1	357	
				62	187	2554	214	1	252	
				31	216	4983	241	7	193	

^zTotal organic matter

^yN = nitrogen; NO₃⁻ = nitrate nitrogen; P = phosphorus; K = potassium; Ca = calcium; Mg = magnesium; S = sulfur.

^xB = boron; Cu = copper; Mn = manganese; Mo = molybdenum; Zn = zinc.

Four separate field trials were initiated. A rate response study was conducted using paper waste vermicompost in 2002 and 2003. The rates applied supplied 12.2, 24.4, 48.8, or 97.6 kg·ha⁻¹ (0.25, 0.5, 1, or 2 lb/1000 ft²) of total nitrogen. A second study comparing the same nitrogen rates, but with vermicomposted turfgrass clippings, was conducted in 2003.

The third study was conducted in 2002 and 2003 to compare the response of turfgrass to application of various vermicomposted waste products (animal waste, food waste, and paper) to urea, and three commercially available organic fertilizers [Milorganite (Milorganite, Milwaukee), Sustane (Natural Fertilizer of America, Cannon Falls, Minn.), and Nature Safe, Griffin Industries, Cold Spring, Ky.], all applied at rates to supply 48.8 kg ha⁻¹.

A fourth study conducted in 2003 investigated the response of turfgrass to application of N from different ratios of vermicomposted turfgrass clippings and urea. The treatments in this study included an untreated control and plots that received 48.8 kg·ha⁻¹ from 100% turfgrass vermicompost, 20% urea and 80% vermicompost, 40% urea and 60% vermicompost, 60% urea and 40% vermicompost, 80% urea and 20% vermicompost, or 100% urea.

For all studies, clippings were collected weekly or twice monthly, depending on growing conditions, at a 6.35-cm (2.5 inches) height. Before

Table 2. Visual quality and yield response of kentucky bluegrass to increasing rates of paper vermicompost in field trials in Columbus, Ohio. Data are pooled means from 2002 and 2003

Nitrogen rate [kg·ha ⁻¹ (lb/acre)]	Clipping wt (g ^z)			Visual quality ^y		
	2 WAT ^x	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT
0 (0)	9	25	9	5	6	6
12.2 (0.25)	10	9	9	6	6	6
24.4 (0.5)	6	10	9	6	6	6
48.8 (1)	23	14	10	6	7	7
97.6 (2)	12	11	9	6	7	6
Linear contrast	NS	NS	NS	***	NS	NS
CV	75	79	9	5	10	15

^z28.4 g = 1 oz.

^yTurfgrass visual quality was evaluated on a scale of 1–9, where 1 = poorest quality, 6 = acceptable turfgrass, and 9 = best quality based on overall color, cover, and density. Values are the average of visual estimates of three replicate plots for each cultivar evaluated.

^xWAT = weeks after treatment.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.0001, respectively.

collection of clippings, strips at the front and the rear of each plot were mowed to ensure a consistent clipping collection area. Clippings were collected for the whole 1.2 × 1.5 m (4 × 5 ft) plot area. Clippings were dried in an oven at 60 °C (140.0 °F) for 4 d and weighed. Irrigation was supplied as necessary to maintain the grass in good growing condition. No pesticides were applied to the plots.

Estimates of turfgrass visual quality were taken twice monthly for 6 weeks after treatment (WAT). Turfgrass visual quality was evaluated on a scale of 1–9 where 1 = poorest quality, 6 = lowest acceptable quality, and 9 = best quality based on overall color and density. Clipping yield and visual quality data were analyzed using the general

linear models (GLM) procedure of SAS (SAS Institute, 1990). Fishers's least significant difference (LSD) test was used to compare means among fertilizer treatments. Linear contrasts were used to analyze fertilizer rate response.

Results

RATE RESPONSE STUDIES. Visual quality of the plots was significantly ($P \leq 0.05$) higher for 2 weeks after application of paper vermicompost, regardless of application rate (Table 2). However, the visual quality of the plots was similar to the control 4 and 6 WAT. Clipping yield 2 WAT was higher on the plots that received 48.8 kg·ha⁻¹ of N from paper vermicompost. However, the plots that received 97.6 kg·ha⁻¹ of N

from paper vermicompost had clipping yields similar to the control 2 WAT. No significant differences in clipping weights were observed either 4 or 6 WAT (Table 2). In addition, no differences in either turfgrass visual quality or clipping yields were observed after application of vermicomposted turfgrass, regardless of rate (Table 3).

FERTILIZER COMPARISON STUDY. Urea produced the highest visual quality 2 WAT, followed by Milorganite®, Sustane®, and Nature Safe®. However, the visual quality of the vermicompost treated plots was similar to the control 2 WAT (Table 4). Plots that received food or animal waste vermicompost had higher visual quality 4 WAT compared to the control, but was similar to Milorganite and Sustane and was lower than either Nature Safe or urea. At 6 WAT the quality of the vermicompost treated plots was similar to the control, and lower than Milorganite or Nature Safe.

Clipping yields on the vermicompost treated plots were similar to the control 2, 4, and 6 WAT. Clipping yields on the vermicompost treated plots were significantly lower than those of the urea treated plots 2 and 4 WAT and those of the Milorganite and Nature Safe treated plots 4 and 6 WAT.

TURFGRASS VERMICOMPOST/UREA RATIO STUDY. Application of a higher percentage of nitrogen as urea produced progressively higher quality turf 2 WAT (Table 5). Application of 48.8 kg·ha⁻¹ of N, 80% from urea and 20% from vermicompost, produced more clippings than the untreated control on all dates. The 60% urea/40% vermicompost application produced significantly ($P \leq 0.05$) higher clippings 4 and 6 WAT. However, there was no difference in visual quality 4 or 6 WAT, regardless of urea to vermicompost ratio.

Discussion

Although studies where vermicomposted materials were incorporated into the soil showed positive effects on turfgrass growth (Gardner, unpublished data), the results of these studies suggest that surface application of vermicomposted waste materials does not result in visual quality or clipping yield response that would lend them to use as a fertilizer on established turfgrass. In an established turfgrass there would be little benefit to using

Table 3. Visual quality and yield response of kentucky bluegrass to increasing rates of turfgrass vermicompost in field trials in Columbus, Ohio, in 2003.

Nitrogen rate [kg·ha ⁻¹ (lb/acre)]	Clipping wt (g ²)			Visual quality ²		
	2 WAT ³	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT
0 (0)	19	31	57	7	7	7
12.2 (0.25)	28	35	76	7	8	7
24.4 (0.5)	24	26	62	7	7	7
48.8 (1)	23	30	61	6	7	7
97.6 (2)	30	27	64	7	7	7
Linear contrast	NS	NS	NS	NS	NS	NS
CV	28	27	14	9	9	8

²28.4 g = 1 oz.

³Turfgrass visual quality was evaluated on a scale of 1–9 where 1 = poorest quality, 6 = acceptable turfgrass, and 9 = best quality based on overall color, cover, and density. Values are the average of visual estimates of three replicate plots for each cultivar evaluated.

³WAT = weeks after treatment.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.0001, respectively.

Table 4. Visual quality and yield response of kentucky bluegrass to different organic fertilizers compared to vermicomposted waste materials in field trials in Columbus, Ohio. Data are pooled means from 2002 and 2003

Product	Clipping wt (g ²)			Visual quality ²		
	2 WAT ³	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT
Control	36 B ^w	33 B	38 CD	5 C	6 C	7 B
Urea	64 A	45 A	48 BC	7 A	8 A	7 B
Paper waste						
vermicompost	37 B	29 B	39 CD	5 C	6 C	7 B
Food waste						
vermicompost	39 B	29 B	36 D	5 C	7 B	6 C
Animal waste						
vermicompost	34 B	29 B	39 CD	5 C	7 B	7 B
Milorganite	45 B	44 A	55 AB	6 B	7 B	8 A
Sustane	36 B	34 B	40 CD	6 B	7 B	7 B
Nature Safe	45 B	52 A	61 A	6 B	8 A	8 A
LSD _(0.05)	16	9	11	1	1	1
CV	32	21	21	7	14	13

²28.4 g = 1 oz.

³Turfgrass visual quality was evaluated on a scale of 1–9 where 1 = poorest quality, 6 = acceptable turfgrass, and 9 = best quality based on overall color, cover, and density. Values are the average of visual estimates of three replicate plots for each cultivar evaluated.

³WAT = weeks after treatment.

^wMeans followed by the same letter are not significantly different according to Fishers protected least significant difference (LSD) test ($P = 0.05$, $n = 3$).

Table 5. Visual quality and yield response of kentucky bluegrass to different ratios of urea and vermicomposted turfgrass in field trials in Columbus, Ohio, in 2003.

Vermicompost (%)	Urea (%)	Clipping wt (g ²)			Visual quality ²		
		2 WAT ³	4 WAT	6 WAT	2 WAT	4 WAT	6 WAT
Untreated control		13 B ^w	30 B	41 C	5 C	6	7
100	0	14 B	20 B	36 C	5 C	6	7
80	20	13 B	22 B	35 C	5 C	6	7
60	40	25 AB	25 B	44 BC	6 BC	7	7
40	60	29 AB	41 A	57 A	7 AB	7	7
20	80	39 A	41 A	56 AB	8 A	8	7
0	100	26 AB	28 B	41 C	7 AB	7	7
LSD _(0.05)		17	11	13	2	NS	NS
CV		41	22	16	20	18	0

²28.4 g = 1 oz.

³Turfgrass visual quality was evaluated on a scale of 1–9 where 1 = poorest quality, 6 = acceptable turfgrass, and 9 = best quality based on overall color, cover, and density. Values are the average of visual estimates of three replicate plots for each cultivar evaluated.

³WAT: weeks after treatment

^wMeans followed by the same letter are not significantly different according to Fishers protected least significant difference (LSD) test ($P = 0.05$, $n = 3$).

vermicompost beyond simply returning the clippings to the turf (Kopp and Guillard, 2002).

The vermicomposts tested in this study contained 1.06% to 2.91% N. However, a relatively small percentage of this was in the form of nitrate nitrogen (Table 1). Some differences in overall quality 2 weeks after application could be attributed to the nitrate nitrogen being utilized by the turf. However, because significant biological immobilization of applied nitrogen in turfgrass thatch has been observed in previous studies (Miltner et al., 1996), the remaining nitrogen may have been tied up in organic forms not readily available for plant uptake throughout the duration of these studies. In the present studies involving both turfgrass and paper vermicompost, no significant differences in quality or clipping yields were observed more than 2 weeks after application.

Even if all of the nitrogen becomes available for plant uptake, application of a normal 48.8 kg·ha⁻¹ rate would require as much as 4.6 t·ha⁻¹ (94 lb/1000 ft²) of vermicompost if using the paper vermicompost. Previous research has shown highest increases in yield response when vermicompost constituted 5% of the plant growth medium (Atiyeh et al., 2001). The vermicompost/urea ratio study was designed to investigate if any differences in yield and quality of turfgrass could result from the addition of smaller ratios of N from vermicompost. While some differences were observed, they could be attributed to the urea application and no differences were observed in this study due to the addition of turfgrass vermicompost.

Based on the results of these studies, the use of vermicompost as a fertilizer material on established turfgrass is not warranted. However, most previous research on the use of vermicompost that produced favorable yield results occurred when vermicompost was added as a soil amendment. The results of these studies and a long term greenhouse trial (Gardner,

unpublished data) suggest that much of the nitrogen contained in the vermicompost does not become available immediately, but rather over a term of 2–3 months. Also, leaching losses of nitrogen from turf systems have been attributed to several factors, including turfgrass establishment (Bowman et al., 2002). Because of this, future studies in turfgrass should address the use of vermicompost as an incorporated soil component at the time of establishment.

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