Environmental Effects of Applying Composted Organics to New Highway Embankments: Part 1. Interrill Runoff and Erosion

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Abstract. *Construction of new highways can lead to challenges when attempting to re–establish vegetation on right–of–ways. Lack of vegetation can leave soil exposed and subject to increased runoff and soil erosion. Therefore, the Iowa Department of Transportation and the Iowa Department of Natural Resources sponsored a study to evaluate the use of composts applied as mulch blankets to decrease runoff and erosion. This article evaluates interrill runoff and erosion between three types of compost (biosolids, yard waste, and bio–industrial byproducts) and two soil conditions (existing compacted subsoil (control) and imported topsoil) on a 3:1 highway embankment. Composts were applied as 5 and 10 cm blankets on the surface of the control, and topsoil was placed on the surface of the control at a depth of 15 cm. Treatments were replicated six times over a two–year period for both bare soil and six weeks following planting of an Iowa DOT–specified cover crop. Rainfall was applied at an average intensity of 95 mm h^{-1} using a rainfall simulator, and sampling was conducted for 1 h after runoff began. All compost treatments were effective at reducing interrill erosion rates under the conditions simulated in this study. In addition, the three compost media required 30 min or longer to produce runoff, while the two conventional soils produced runoff within the first 8 min. The depth of compost application was only a factor for the runoff rate on unvegetated treatments. In this case, the 5 cm depth had a significantly greater runoff rate than the 10 cm depth. Both 5 and 10 cm compost applications had similar effects on interrill erosion rates. Although the steady–state interrill erosion rates of all three composts were 3% to 24% of the steady–state interrill erosion rates of the two soils on unvegetated treatments, and 0.1% to 30% of the steady–state interrill erosion rates of the two soils on vegetated treatments, the type of compost was also a factor in interrill erosion control. The yard waste compost was the coarsest of the three compost materials, and on unvegetated plots had a steady–state interrill erosion rate that was 17% and 33% of the steady–state interrill erosion rates of biosolids and bio–industrial compost, respectively. Interrill erodibility factors were calculated for all treatments and fell within the range of experimental rangeland values (10,000 to 2,000,000 kg sec/m^4) that are used in the Water Erosion Prediction Project.*

Keywords. *Compost, Construction, Erodibility, Erosion, Interrill, Runoff.*

The Iowa Department of Transportation (Iowa DOT) has responsibility for construction and maintenance of Iowa's 180,000 km network of roadways. In the expansion and maintenance of this transportation system, the agency is also responsible for storm water management and erosion control during and after construction. The most widely used and effective erosion control practice has been the rapid establishment of a cover crop. However, in some cases, poor soil conditions result due to the removal of topsoil and the compaction of existing soil, which are necessary operations in highway construction.

Poor soil conditions make establishing a cover crop difficult, and may require use of temporary erosion control practices such as silt fences, straw mulch, and synthetic erosion control mats. At times, topsoil must be reapplied to provide adequate soil conditions for long–term cover crop growth.

A two–year study was conducted to evaluate the effect of compost application on cover crop establishment, runoff and soil erosion, and loss of nutrients and metals in runoff during the period from construction to vegetation establishment. The objective of this article is to present the results related to runoff and interrill soil erosion. Articles published as a part of this study are related to the effects of compost on cover crop establishment (Richard et al., 2002) and on loss of nutrients and metals in runoff (Glanville et al., 2004). A final report of all results associated with this two–year study was prepared and submitted to Iowa Department of Natural Resources (Glanville et al., 2003).

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LITERATURE REVIEW

Although few studies have evaluated the runoff and erosion control performance of compost blankets, several studies have measured the effectiveness of mulch covers on soils. Early work by Duley (1939) reported that a sandy loam soil covered with straw had an infiltration rate of 30.5 mm h^{-1} versus 6.4 mm h^{-1} on the same bare sandy loam soil. The same sandy loam soil had an infiltration rate of 40.6 mm h^{-1} with the addition of a burlap layer over the soil. Young (1968) suggested that 4.5 t ha^{-1} of grain straw would provide an adequate mulch layer. Watson and Laflen (1986) reported that straw mulch rates that protect the soil from sealing could greatly reduce the amount of runoff. Furthermore, they suggested that erosion was negligible at a straw application rate of 8 t ha^{-1}.

Compost, applied as a mulch blanket on the surface of the soil, is expected to have the same effect on erosion as straw mulch applications. However, composts have typically been viewed as soil amendments with goals of improving soil quality by increasing soil organic matter and nutrient content. Improved soil quality, especially on construction projects, is seen as an important tool for growing vegetation, the most commonly used erosion control practice.

More recently, several studies and demonstrations have been conducted to evaluate the erosion control characteristics of organic materials (table 1). A survey of state departments of transportation (DOTs) conducted by Mitchell (1997) reported that 19 state DOTs had compost specifications, and six had conducted erosion control experiments. Although many state DOT projects have provided little scientific data, there have been several studies evaluating the erosion control characteristics of different blanket applied composts.

All of these studies have shown potential erosion control benefits for compost applications of 1.9 to 7.6 cm depth. In addition to these studies, Stewart and Pacific (1993) suggested blanket applications of 7.5 cm, and Michaud (1995) suggested blanket applications of 10 cm. Michaud (1995) further explained that 10 cm applications would effectively control erosion on slopes up to 45% for 1 to 3 years.

MATERIALS AND METHODS

The study was conducted on a highway embankment in central Iowa after completion of construction. Three composts were used: a sewage biosolids and yard waste mixture (biosolids), a yard waste compost (yard waste), and a paper mill and grain processing sludge and yard waste mixture (bio–industrial). Two soil conditions were studied: a compacted subsoil (control) representing conditions typical after completion of a construction project and before any remedial activity, and the compacted subsoil described above but with the addition of a 15 cm topsoil layer representing a common Iowa DOT practice for establishing vegetation on poor soils. Physical and chemical characteristics of the composts and soils used in this study are shown in tables 2 and 3, respectively, and more detailed chemical characteristics are presented in Glanville et al. (2003, 2004).

Erosion measurements were made during application of rainfall using a rainfall simulator. The study was conducted during the summers of 2001 and 2002.

EXPERIMENTAL DESIGN

Research was carried out using a randomized complete block design in both years (fig. 1). Treatments consisted of the

Table 1. Experimental results of the effect of compost and mulch on soil erosion and runoff.

Citation	Conditions	Results
Meyer et al., 1971	Slope: 12%. Simulated rainfall: 63 mm h^{-1}. Straw mulch of 2.3 t ha^{-1}, 10 cm topsoil application.	Straw mulch soil loss <22 t ha^{-1}. Topsoil soil loss of 69 t ha^{-1}.
Storey et al., 1996	Slope: 33%. Simulated rainfall: 1, 2, and 5 year storms. Compost and wood mulch with synthetic chemical tackifiers applied between 76 to 101 mm depth.	Compost and wood mulch plots met Texas sediment loss standards on clay (12.21 kg/10 m^2) and sandy soil (0.34 kg/10 m^2).
Agassi et al., 1998	Slope: 5%. Simulated rainfall: 40 mm h^{-1}. Solid waste compost, soil control.	85% infiltration for compost, <52% for control.
Demars et al., 2000	Slope: 50%. Natural rainfall. Wood waste materials.	Effective at reducing runoff for storms <12.7 mm h^{-1}, effective at controlling erosion for mulch thickness of 1.9 cm or greater.
Block, 2000	Slope: 50%. Natural rainfall. Composted yard waste, wood mulch, straw thick.	Erosion more than 10 times any composted treatment on control plots.
Risse et al, 2002	Slope: 10%. Simulated rainfall: 167 mm h^{-1}. Compost, wood mulch, poultry litter at 5 cm depths compared to bare soil.	Total solids loss significantly less on compost treatments (between 96 and 215 g) and on mulch treatments (between 71 and 124 g) compared to soil (766 g).

Table 2. Physical and chemical characteristics of composts.

Year	Media	Moisture Content (%)	C:N Ratio	Bulk Density[a] (kg m^{-3})	Size Aggregate % Passing 22.2 mm	 % Passing 11 mm	 % Passing 6.35 mm
1	Biosolids	29	11	500	100	100	96
2	Biosolids	27	11	400	100	97	74
1	Yard waste	39	13	400	94	88	86
2	Yard waste	32	13	400	94	85	85
1	Bio–industrial	29	17	600	100	99	94
2	Bio–industrial	28	19	600	100	100	95

[a] Dry basis.

Table 3. Physical and chemical characteristics of soils.

Year	Media	Moisture Content (%)	Carbon (%)	Bulk Density[a] (kg m^{-3})	% Sand (0.05 to 2.00 mm)	% Silt (0.002 to 0.05 mm)	% Clay (<0.002 mm)
1	Control	5	3.4	1,300	58	28	14
2	Control	6	1.0	1,300	73	17	11
1	Topsoil	10	2.5	1,300	62	24	15
2	Topsoil	6	1.5	1,700	72	17	11

[a] Dry basis.

three compost media, applied at 5 and 10 cm depths (approximately 250 and 500 t ha^{-1} application rate) on top of the control, and the two soil treatments described above, the existing compacted subsoil and imported topsoil applied at 15 cm. All treatments were tested under bare conditions to simulate a construction site shortly after disturbance, and six weeks after vegetative growth began to simulate the performance after typical erosion control measures. Each treatment was replicated six times within each vegetative condition over the two years of the study, three replications per year. A total of 96 interrill rainfall simulator plots were used.

SITE CONSTRUCTION

Each interrill plot was constructed on a 3:1 (33% slope) highway embankment by placing compost (5 or 10 cm depth) and topsoil (15 cm depth) in 1.2 × 1.5 m plots in year 1 and in 1.2 × 1.2 m plots in year 2. The size varied between years because the available right-of-way area in year 2 was less. After compost or topsoil was applied, all plots were culti-packed twice, and vegetated plots were fertilized with 500 kg ha^{-1} of 13–13–13 (N–P_2O_5–K_20) and seeded into the compost or soil according to Iowa Department of Transportation specifications. The seed mixture was broadcast with oats, annual ryegrass, red clover, and timothy at rates of 108, 39, 6, and 6 kg ha^{-1}, respectively. Plots were hand–raked level after seeding. A galvanized frame 0.50 × 0.75 m was hand–driven into the middle of each plot to eliminate any edge effects. Galvanized collection troughs were installed prior to rainfall simulation at the downhill side of each plot.

FIELD DATA COLLECTION

Data collection procedures for interrill erosion were similar to those described in Liebenow et al. (1990). Rainfall was applied simultaneously to five treatments using an 8 m Norton rainfall simulator with operating characteristics (41 kPa, 3 m tall, Veejet 80100 nozzles) similar to the one outlined in Meyer and Harmon (1979). In year 1, rainfall was first applied at a target rate of 63 mm h^{-1}, but was subsequently increased on the unvegetated plots to a target rate of 100 mm h^{-1} to produce runoff within an hour of simulation. When runoff began, samples were collected in 1 L bottles at 5 min intervals for 1 h. Therefore, the total rainfall simulation time was generally longer than 1 h depending on the time required to initiate runoff, which represents a 100–year storm (or greater) for central Iowa at this intensity and duration (Iowa DOT, 2000). In the first year, runoff occurred off a collection trough and was corrected for this intercepted rainfall. In the second year, collection troughs were covered.

Slope and rainfall measurements were made for each plot. Slope measurements were made using a hand level and tape measure. Rainfall depth was measured at time intervals throughout the rainfall period at the top of each plot. Runoff samples were stored at −4°C until analysis.

LABORATORY SOLIDS ANALYSIS

Total solids (compost or soil) analysis was conducted on each runoff sample according to procedures outlined in *Standard Methods* (APHA, 2000). Each runoff sample collected was thoroughly mixed, and triplicate subsamples were removed and placed in 50 mL centrifugal tubes. The subsamples were centrifuged for 30 min to settle all solids. Dissolved solids analysis was determined by extracting a portion (20 to 30 mL) of the supernatant in the top of the centrifugal tubes and placing it in aluminum weighing dishes. The remaining subsample in the centrifugal tubes and the aluminum weighing dishes were placed in the oven and dried at 104°C until constant weight was achieved. The subsamples were corrected for the portion of dissolved solids that remained in the tube after extraction, yielding total suspended solids. This value of total suspended solids was used in all calculations of interrill erosion rates. Since compost was blanket applied, this value will either represent compost or soil eroding off of the plot.

DATA REDUCTION AND CALCULATIONS

The data reduction technique used in this research followed that of Liebenow et al. (1990). The last 20 min of sampling (or

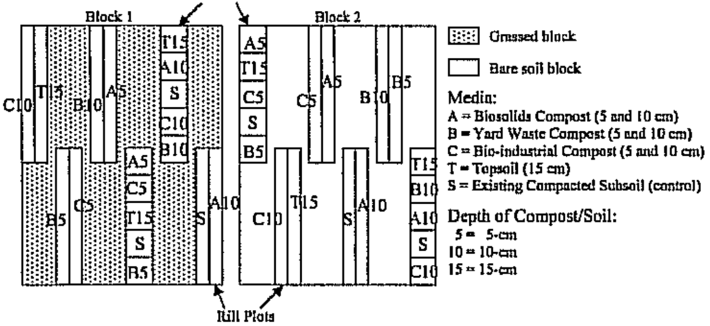

Figure 1. One complete replicate design as used in 2001. Also shown are rill plots for a companion study, which is not included in this paper.

four samples) were used to obtain steady–state conditions for interrill erosion and runoff rates.

Rainfall intensity was determined for each treatment by dividing the depth of collection by the time between measurements. An average rainfall rate for each plot was determined by averaging the individual rainfall intensities measured during the simulation period.

Runoff rates were determined based on the weight of runoff and the time over which a sample was collected. Runoff rates were converted into a depth per unit time based on a density of 1000 kg m^{-3} and the sampled plot area of 0.375 m^2.

INTERRILL ERODIBILITY FACTORS

The data collection procedure used in this study was adopted to determine interrill erodibility factors for each of the surface materials. Interrill erodibility factors have been used in soil erosion models such as the Water Erosion Prediction Project (WEPP). Erodibility factors are required to make soil erosion estimates for various materials, slopes and lengths, rainfall intensities and amounts, and managements.

Kinnell and Cummings (1993) developed the empirical relationship:

$$D_i = K_i I q S_f \tag{1}$$

to describe interrill erosion, which is a modification of equation 2, described in Liebenow et al. (1990):

$$D_i = K_i I^2 S_f \tag{2}$$

where

D_i = steady–state interrill erosion rate (mass of soil eroded/unit area/unit time)
K_i = interrill erodibility (mass–time/length^4)
I = rainfall intensity (depth per unit time)
q = steady–state flow discharge (depth per unit time)
S_f = $1.05 - 0.85 \exp(-4\sin\theta)$, where ϕ = slope angle (unitless).

Equation 1 was developed for situations where soils have high infiltration rates and was adopted in this study as the preferred method of calculating interrill erodibility factors. Composts, especially when applied as mulch blankets, are expected to have high infiltration rates.

STATISTICAL ANALYSIS

Statistical analysis was performed using SAS version 8.0 (SAS, 1999). Analysis of variance (ANOVA) using the generalized linear model procedure (PROC GLM) was used to determine significant differences among treatments under unvegetated and vegetated conditions. In all cases where significance existed among treatments, contrast statements were used to determine significance between compost types, compost depths, and treatment–to–treatment comparisons. The log transform was necessary on the interrill erosion rate, interrill erodibility factor, and time to initiate runoff data to satisfy the statistical assumptions of normally distributed data and constant variance. Significant differences were determined at the 0.05 level.

RESULTS AND DISCUSSION

RAINFALL INTENSITY AND SLOPE FACTOR

The overall mean intensity applied during the two–year study was 95 mm h^{-1}. The ramping of the rainfall intensity in year 1 on unvegetated plots did not significantly impact the results because of the blocking used in the experimental design and application of rainfall across all treatments within one rainfall simulation setup. The average slope factor over the two years of the study was 0.7. Any plot–to–plot variations in rainfall intensity and slope were normalized in the calculation of the interrill erodibility factor.

STEADY–STATE RUNOFF RATE

Unvegetated Plots

The difference in steady–state runoff rates between year 1 and year 2 was not a significant factor for unvegetated treatments ($p = 0.330$). The ANOVA showed that steady–state runoff rates were significantly different among treatments for the unvegetated plots ($p < 0.001$). Since there were significant treatment effects, analyses were conducted to determine the effect of the type of compost and compost depth on steady–state runoff rates.

The results of the analyses showed that the average steady–state runoff rate for 5 cm compost depths was statistically greater than for 10 cm compost depths on unvegetated plots ($p = 0.039$). Although there were significant differences in soil erosion between the two depths on the unvegetated plots, the interaction between the media and depth was not significant ($p = 0.203$). This allowed the soil erosion data from the 5 and 10 cm compost depths to be pooled for additional analyses.

Results from data pooled by depth showed significant differences in steady–state runoff rates among compost treatments for the unvegetated plots ($p < 0.001$). All compost media had steady–state runoff rates that were statistically lower than the control on the unvegetated plots (table 4). Furthermore, all compost media steady–state runoff rates in the unvegetated condition were statistically lower than the topsoil, except for the biosolids compost. Physical characteristics in tables 2 and 3 showed that the biosolids compost had the smallest particle size distribution in year 1 and appeared to be more soil–like. This smaller particle size distribution of the biosolids compost and the less compacted nature of the topsoil may suggest why performance was similar for these two media. On the other hand, yard waste compost generally had the lowest steady–state runoff rate and the largest particle size distribution.

Table 4. Mean steady–state runoff rate and erosion rate for three compost media, control, and topsoil on unvegetated plots (N = 12 for all media).

	Runoff		Interrill Erosion	
Media	Mean Steady–State Rate[a] (mm h^{-1})	SD[b]	Mean Steady–State Rate[a] (mg/m^2 sec)	SD[b]
Biosolids	39 b,c	22	28 b	27
Yard waste	14 a	8	4.7 a	5.3
Bio–industrial	27 b	21	14 b	16
Control	65 d	23	120 c	98
Topsoil	48 c	13	170 c	120

[a] Means followed by different letters within the same column are significantly different ($p < 0.05$).
[b] SD = standard deviation.

Vegetated Plots

The difference in steady–state runoff rates between year 1 and year 2 was not a significant factor for vegetated treatments ($p = 0.087$). The steady–state runoff rate interaction between the year and compost media was significant on the vegetated treatments ($p = 0.046$). The significance in this interaction term may be a result of different physical properties (bulk density and particle size distribution) and the quantity of vegetation grown on plots in each year. Richard et al. (2002) reported that year 1 planted vegetation germinated and emerged, but that year 2 vegetation germinated and did not emerge. In year 2, the soil treatments had native vegetation that emerged at significantly greater quantities than the three compost treatments.

Results showed that steady–state runoff rates were significantly different among vegetated treatments ($p < 0.001$). The average steady–state runoff rate for the 5 cm compost depths was not significantly different than for the 10 cm compost depths on the vegetated plots ($p = 0.215$), and runoff data from the two depths of compost were pooled. When the data were pooled, it was found that there were no significant differences in steady–state runoff rates among compost types for the vegetated data ($p = 0.108$). All compost media had steady–state runoff rates that were significantly less than both the control and topsoil on the vegetated plots (table 5).

STEADY–STATE INTERRILL EROSION RATE

Unvegetated Plots

There was not a significant difference in steady–state interrill erosion rates between years for unvegetated treatments ($p = 0.743$). However, there was a significant interaction between the year and compost media for the unvegetated treatments ($p = 0.003$). This may be a result of physical differences between materials in year 1 and year 2 and the greater rainfall intensity in year 2 as compared to year 1.

For unvegetated plots, there was not a significant effect of compost depth on steady–state interrill erosion rate for any of the compost media. Compost media depth was not considered in further analyses.

Steady–state interrill erosion rates for the three compost media and two soils are shown in table 4. Compost treatments had significantly lower steady–state interrill erosion rates compared to the topsoil and control. Among the compost types, the yard waste compost steady–state interrill erosion rate was significantly less than that of the biosolids and bio–industrial composts, which were not significantly different.

Table 5. Mean runoff rate and erosion rate for three compost media, control, and topsoil on vegetated plots (N = 12 for all media).

	Runoff		Interrill Erosion	
Media	Mean Steady–State Rate[a] (mm h^{-1})	SD[b]	Mean Steady–State Rate[a] (mg/m^2 sec)	SD[b]
Biosolids	20 b	20	6.0 b	10
Yard waste	3.4 a	5.0	0.1 a	0.1
Bio–industrial	15 a,b	25	4.0 b	7.8
Control	55 c	29	20 c	17
Topsoil (15 cm)	56 c	21	84 c	100

[a] Means followed by different letters within the same column are significantly different ($p < 0.05$).

[b] SD = standard deviation.

Another important distinction in the erosion rate data is how it relates to the steady–state runoff rate data. The steady–state runoff rate between the topsoil and biosolids compost was not significantly different for the unvegetated plots, but the steady–state interrill erosion rate was less (table 4). Biosolids is the finest textured compost of the three evaluated; however, it was observed that surface sealing was not prominent on all of the compost media. This may explain why the steady–state runoff rate was equivalent between the biosolids and topsoil, but the steady–state erosion rate was different.

Vegetated Plots

There was not a significant difference in steady–state interrill erosion rates between year 1 and year 2 for vegetated treatments ($p = 0.671$), despite the differences in emerging vegetation between the two years as reported by Richard et al. (2002). As with the unvegetated plots, there was not a significant effect of compost depth on steady–state interrill erosion, nor was there a significant effect of compost media type on erosion. As with the unvegetated plots, further analyses could be conducted without considering the application depth.

Compost media had significantly lower steady–state interrill erosion rates compared to the topsoil and control under vegetated conditions (table 5). Among the compost types, the yard waste compost steady–state interrill erosion rate was significantly less than that of the biosolids and bio–industrial composts, which were not significantly different.

INTERRILL ERODIBILITY FACTORS

Unvegetated Plots

The difference in interrill erodibility factors between year 1 and year 2 was not significant ($p = 0.447$). However, the interrill erodibility factor interaction between the year and media was significant ($p < 0.001$). This indicates that the difference in interrill erodibility factors between year 1 and year 2 were not the same for all treatments. Again, as discussed under the interrill erosion rate data, this may be due to physical differences in the materials, especially the difference in biosolids compost between year 1 and year 2.

There was no significant difference in average interrill erodibility factor for 5 and 10 cm compost depths, nor was there any significant effect of compost depth on the interrill erodibility factor for any compost media. Further statistical analyses were conducted without regard to compost depth.

Interrill erodibility factors for unvegetated plots on three compost media and two soil treatments are presented in table 6. Compost treatments had significantly lower interrill erodibility factors compared to the topsoil and control. Among the compost types, the yard waste compost interrill erodibility factor was significantly lower than the biosolids and bio–industrial composts. As discussed in the interrill erosion rate section, this may be attributed to larger particle size distribution of the yard waste compost.

Vegetated Plots

Interrill erodibility factors were calculated for treatments under vegetated conditions to normalize for any plot–to–plot differences; however, these factors are not corrected for vegetative cover and consolidation that may have occurred. Although these factors are useful for comparisons between treatments, they do not represent values that would be used in the WEPP model.

Table 6. Mean interrill erodibility factor and time to initiate runoff for three compost media, control, and topsoil on unvegetated plots (N = 12 for all media).

	Interrill Erodibility		Time	
Media	Mean Factor[a] (kg sec/m^4)	SD[b]	Mean Time[a] (min)	SD[b]
Biosolids	120,000 b	120,000	31 c	39
Yard waste	50,000 a	40,000	57 d	48
Bio–industrial	110,000 b	60,000	32 c,d	21
Control	340,000 c	220,000	4.7 a	2.0
Topsoil (15 cm)	720,000 d	390,000	7.8 b	3.8

[a] Means followed by different letters within the same column are significantly different ($p < 0.05$).

[b] SD = standard deviation.

The difference between year 1 and year 2 interrill erodibility factors was not a significant factor for vegetated treatments ($p = 0.891$). As with the unvegetated treatments, there was no significant effect of compost depth on average interrill erodibility, nor was there a significant effect of compost depth for any of the compost media. As with the unvegetated plots, further analyses disregarded compost application depth.

Interrill erodibility factors for unvegetated plots on three compost media and two soil treatments are presented in table 7. Compost treatments had significantly lower interrill erodibility factors compared to the topsoil. However, the biosolids compost interrill erodibility factor was not significantly different from the control. Among the compost types, the yard waste compost interrill erodibility factor was significantly lower than the biosolids.

TIME TO INITIATE RUNOFF

All evaluations of interrill erosion and runoff were based on data collection once runoff was initiated. Rainfall intensity was increased in the first year to initiate runoff within a reasonable sampling period (within 1 h). However, all treatments responded differently. Table 6 and table 7 show the mean time to initiate runoff on unvegetated and vegetated plots, respectively. The sampling year and application depth did not significantly affect the mean time to initiate runoff. Overall, the compost media required significantly longer times to produce runoff than either the topsoil or control on both the unvegetated and vegetated plots. The increased time for rainfall energy to be applied on compost media to produce runoff shows that composts have an immediate interrill erosion protection characteristic. This immediate protection was also realized applying a 100–year or greater design storm for central Iowa on the treatments.

Table 7. Mean interrill erodibility factor and time to initiate runoff for three compost media, control, and topsoil on vegetated plots (N = 12 for all media).

	Interrill Erodibility		Time	
Media	Mean Factor[a] (kg sec/m^4)	SD[b]	Mean Time[a] (min)	SD[b]
Biosolids	50,000 b,c	40,000	29 b	32
Yard waste	10,000 a	10,000	63 c	47
Bio–industrial	50,000 a,b	111,000	47 b,c	43
Control	60,000 c	30,000	5.6 a	4.9
Topsoil (15 cm)	320,000 d	380,000	4.3 a	2.9

[a] Means followed by different letters within the same column are significantly different ($p < 0.05$).

[b] SD = standard deviation.

CONCLUSIONS

All compost treatments were effective at reducing interrill erosion rates under the conditions simulated in this study. In addition, the three compost media required 30 min or longer to produce runoff, while the two conventional soils produced runoff within the first 8 min. The reduction in interrill erosion rates were achieved at an average applied rainfall intensity of 95 mm h^{-1}, which represents rainfall intensity greater than a 100–year design storm for central Iowa (Iowa DOT, 2000).

The depth of compost application (5 and 10 cm) was only a factor for the runoff rate on unvegetated treatments. In this case, the 5 cm depth had a significantly greater runoff rate than the 10 cm depth. Despite the one effect of depth as a factor for runoff rates, this effect did not carry over to the interrill erosion rate data. Both 5 and 10 cm compost applications had similar effects on interrill erosion rates. Since compost depths of 5 and 10 cm did not have significant effects on soil erosion, it can be concluded that for conditions similar to this study, the minimum application depth for erosion control will be 5 cm or less.

Although all three composts were effective interrill erosion control materials compared to the two soils, the type of compost was also a factor in the interrill erosion control performance. The yard waste compost was the coarsest of the three materials, and in most cases outperformed the biosolids and bio–industrial composts in reducing runoff rate and interrill erosion rate. As compost coarseness increases, its particle size distribution, and the potential for surface sealing and splash erosion, would be expected to decrease. This trend was shown to hold true for the three compost media in this study. Caution should be placed on the ability to plant a cover crop into very coarse material; however, this was not a factor for the three composts used in this study (Richard et al., 2002).

Interrill erodibility factors were calculated and compared among the treatments. The statistical outcomes were similar to those for the interrill erosion rates. In reality, the two performance indicators heavily influencing these factors were the interrill erosion rate and the runoff rate. Although rainfall and slope are important components that affect the interrill erosion rate and runoff rate, they were controlled in this experiment through the use of rainfall simulation and the experimental design. Runoff rates were identified as an important component in calculating interrill erodibility factors because the compost materials had significantly reduced runoff rates compared to the rainfall intensity applied. This phenomenon led to the adoption of equation 1 proposed by Kinnell and Cummings (1993). All erodibility factors calculated in this study fell within the range of 10,000 to 2,000,000 kg sec/m^4, which is the range of experimental rangeland soils (WEPP, 2002).

Future work might focus on incorporating the interrill erodibility factors into erosion models, such as the WEPP, to aid in erosion prediction at different site and climatic conditions. Additionally, the rill erodibility component must be incorporated to obtain total erosion estimates when using the WEPP model for construction sites.

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