FIELD EVALUATION OF COMPOST AND MULCHES FOR EROSION CONTROL

L. Mark Risse[1], L. Britt Faucette[2], Julia W. Gaskin[3], Carl F. Jordan[4], Miguel Cabrera[5], and Larry T. West[5]

AUTHORS: Associate Professor, Department of Biological and Agricultural Engineering[1], Research Director, Filtrex Inc.[2], Public Service Assistant, Department of Biological and Agricultural Engineering[3], Professor, Institute of Ecology[4], Professor, Crop and Soil Sciences Department[5], The University of Georgia, Athens, GA 30602.
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Abstract. Soil erosion is one of the largest contributors to nonpoint source pollution in Georgia. The use of surface applied organic amendments has been shown to reduce runoff and erosion and improve vegetative establishment on degraded soils such as those common to Georgia. In this study, four types of compost blankets, hydroseed, silt fence, and a bare soil (control) were applied in field test plots. Treatments were seeded with common bermuda grass. Simulated rainfall was applied at an average rate equivalent to a 50 yr one-hour storm event, and runoff samples were collected and analyzed for solids as well as runoff quantity. Three simulated rain events were conducted: immediately after treatment application, at vegetation establishment, and at vegetation maturity. In the short term, compost treatments produced significantly less runoff than the hydroseeded and bare soil plots. All treatments proved better than the control at reducing solids loss. Total solids loads were as much as 350% greater from the hydroseeded plots compared to the composts during the first storm and as much as 36 times greater during the second storm. Vegetative growth and nutrient loss data were also evaluated.

INTRODUCTION

Soil erosion is considered the biggest contributor to nonpoint source pollution in the United States according to the federally mandated National Pollution Discharge Elimination System (US EPA, 1997). Soil loss rates from construction sites can be 10-20 times that of agricultural lands (GA SWCC, 2002). In 2003, the federally mandated NPDES Phase II went into effect extending the storm water management plan requirement to any land-disturbing activity over 0.4 ha (1 acre) and effectively requiring all construction sites of this size to obtain permits and implement erosion control practices.

The use of surface applied organic amendments has been shown to reduce runoff and erosion (Meyer et al., 1972; Laflen et al., 1978; Vleeschauwer et al., 1978; Foster et al., 1985; Gilley and Risse, 2001). The mechanisms include interception and dissipation of the rainfall energy, reduction in soil surface crusting, creation of increased surface roughness and storage, and improvement of soil quality resulting in improvement of infiltration and reduced soil erodibility. Compost has been used successfully for slope stabilization, erosion and sediment control, storm water filtration, and vegetative establishment applications (Portland Metro, 1994; Ettlin and Stewart, 1993; Michaud, 1995). A study conducted by the Connecticut Department of Transportation found composts and mulches reduced soil erosion ten-fold compared to bare soil surfaces on a 2:1 slope and that composts were 99% more effective in retaining sediment than silt fences, and 38% more effective than hydroseeding. (Demars and Long, 1998). Faucette et al., (2004) compared twelve different commonly available composts and mulches in Georgia and found that all were effective in reducing soil erosion.

Many of the organic by-products used to create compost materials are low value materials that can create water quality concerns if improperly managed. Georgia generates approximately 1.36 million metric tons of poultry litter, over 1.81 million metric tons of food processing waste, 2.26 million metric tons of wood waste, and almost 362,000 metric tons per year of municipal biosolids (Faucette, 2004). Diversion of these organic materials from landfills and producing value added composts could eliminate pollution from disposal options. Diversion can also potentially improve soil quality by replacing organic matter and recycling nutrients to our highly depleted soils. The objective of this study was to perform a field evaluation using recycled organic materials compared to traditional soil erosion control technologies.

MATERIALS & METHODS

Research test plots were established at Spring Valley Farm in Athens, Georgia in the summer of 2002. The soil was originally classified as an eroded Pacolet Sandy Clay Loam and has a high soil erodibility factor (K value) of approximately 0.36. The area receives an average annual rainfall of 1,215 mm, with January through March as the wettest period. The land was cleared of vegetation and topsoil to simulate a construction site soil surface. A 10% grade was applied to the exposed subsoil (Bt horizon). Stainless steel test plot borders (15 cm wide) were installed to prevent cross contamination of plots. The borders were trenched 7.5 cm into the soil. The plots were 1.0 m wide by 4.8 m long, for an effective area of 4.8 m^2. A removable flume and nine rain gauges were installed at the base of each plot prior to each simulated rainfall event. Gauges were spaced evenly across the width and length of the plot.

Three replicates of seven treatments were randomly assigned to test plots: 1) a biosolids compost blanket with biosolids compost filter berm (BioC); 2) a yardwaste compost blanket with yard waste compost filter berm (YWC); 3) a mixture (1:1 by volume) of municipal solid waste compost and mulch blanket with mulch filter berm (MSWC); 4) a mixture of (1:3:1 by volume) poultry litter compost, mulch and gypsum blanket with a mulch filter berm (PLC); 5) a hydroseeded cover with a silt fence (Hsf); 6) a hydroseeded cover with a mulch filter berm (Hb); and 7) a bare soil (control) plot. Compost blankets were manually applied at 3.75 cm depths over the entire area of the plot. Filter berms were 60 cm wide by 30 cm high and situated at the base of the slope across the width of the plot. The hydroseeded cover was sprayed on the plots by a local commercial vendor and included fertilizer and lime. Each treatment, excluding the control plots, were seeded with a grass seed mix specified by the Georgia Department of Transportation as an erosion and sediment control vegetative measure for slopes 3:1. The compost treatments were physically, biologically and chemically characterized prior to application in the test plots (Some data in Table 1).

A Norton Rainfall Simulator was calibrated to produce a 7.75 cm per hour storm event for one-hour duration. This is equivalent to a 50yr one-hour storm event for the Athens region. Municipal tap water was used in the study. Three simulated rainstorms were conducted: at the beginning of the experiment, at 3 months, and at one year.

Runoff samples were collected from a flume placed at the base of each plot. Samples were taken beginning at runoff initiation at five minute intervals until the 60-min storm was finished. The total weight of runoff and the time over which it was collected was recorded for each sample. Each bottle was oven dried at 105° C until constant weight was achieved to determine the total solids content. From these data, the total runoff volume was calculated by summing the averages of each two time adjacent samples. Total solid loads were calculated

Table 1. Physical and chemical properties of materials.

Treatment Name	Bulk Density (g/cm^3)	C:N Ratio	Total C (ppm)	Total N (ppm)	Total P (ppm
BioC	0.51	17	100,900	5,830	4,470
YWC	0.5	19	97,500	5,010	3,240
PLC	0.59	22	131,500	5,980	4,290
MSWC	0.32	20	175,200	8,660	1,910
Mulch	0.18	101	268,900	2670	960
Soil	2.23	18	250	14	348

by summing the average of each two time adjacent concentration samples multiplied by the average of the same two samples for runoff volume. Nutrient analysis of the runoff water was conducted using separate volume weighted samples and EPA approved methods. This paper presents Total N and Total P data as collected from unfiltered samples. SAS version 8.2 analysis of variance (PROC ANOVA) using Duncan's Multiple Range test was used to determine any significant differences between treatments ($p \leq 0.05$).

RESULTS AND DISCUSSION

Selected results for all the treatments are presented in Tables 2 through 4.

Initially, the compost treatments tended to reduce runoff volume, and many of the compost treatments had significantly less runoff than hydroseeding with a silt fence or a bare soil for the three month and one year rainfall simulations. All of the treatments exhibited lower runoff than the control. During the first storm event, relative to the control, the MSWC and the YWC treatments allowed 51% more water to infiltrate the surface, the PLC allowed 43% more, the BioC 31%, the Hsf 24%, and the Hb 20%. By the final storm event,

Table 2. Runoff and erosion from various treatments .

	Day 1		Three months		One year	
Treatment	Runoff (mm)	Erosion (g/m^2)	Runoff (mm)	Erosion (g/m^2)	Runoff (mm)	Erosion (g/m^2)
PLC	32.0 ab	159 b	5.0 c	15 b	15.9 c	11 b
BioC	38.1 ab	106 b	9.6 c	19 b	21.6 bc	9 b
MSWC	22.5 b	192 b	1.8 c	6 b	21.9 bc	18 b
YWC	33.0 ab	89 b	8.1 c	14 b	25.0 abc	17 b
Hb	36.7 ab	265 b	20.2 bc	78 b	34.2 ab	11 b
Hsf	30.0 ab	308 b	32.3 ab	220 b	27.6 abc	15 b
Soil	42.3 a	6428 a	45.9 a	5464 a	40.8 a	1110a

relative to the control, the compost treatments allowed 61% to 65% more water to infiltrate the surface while the hydroseeded treatments allowed 43% to 47% more. The compost treatments tended to take longer for runoff to begin (probably due to the ability of the surface blanket to absorb and hold a portion of the rainfall) and tended to have higher steady state infiltration rates (data not shown) especially for the later simulations. Over the one-year study, all four compost treatments showed a reduction in runoff rate, while the Hsf runoff rate remained unchanged and the bare soil runoff rate increased. This may be the result of the compost blankets gradually improving soil structure and water infiltration in the soil surface, while the control may have experienced soil crusting.

All treatments had significantly less solids loss than the control for all three simulations. While not significant, the composts treatments tended to provide better erosion control than the hydroseeded plots, particularly in the short term, as solids loads were as much as 350% greater from these plots during the first storm event. This is probably a result of the immediate and more stable soil surface cover the compost blankets provided relative to the hydroseed treatments. The Hb treatment produced less solids loss than the Hsf treatment for all three simulations although these differences were not significant. Over time, the erosion rates dropped for all six treatments compared to the first storm event. This was probably due to the establishment of vegetation coupled with the drought that ensued between the first two storm events. After one year there were not differences between erosion rates on any of the treatments. This can be attributed to the establishment of vegetation on all of the plots.

The total amount of nitrogen applied to each treatment was 132, 111, 104, 94, and 10 g/m^2 from the PLC, BioC, MSWC, YWC, and hydroseeded treatments, respectively.

For the initial simulation, average total N concentrations and loads in the runoff were highest for the BioC treatment, followed by the MSWC and then by both hydroseeded treatments. Despite the fact that more total N was applied on the PLC and YWC treatments, these had lower N losses than the hydroseeded treatments indicating that these forms of N were probably less available to runoff. Seventy six percent of the original total N content of the BioC was inorganic N (ammonium-N and nitrate-N), which is more mobile and easily lost in storm water runoff relative to organic N. Comparatively, the yard waste compost had 2% of its total nitrogen as inorganic N, the MSWC had 4%, and the PLC had 5%. Mature composts generally have high organic N and low inorganic N contents. By the second and third simulated storm events, major reductions of total N concentration were observed in nearly all treatments and almost all N loads were lower than the control that did not have any N applied. Total N lost in the runoff, combined from all three storms, as a percent of the total applied by the treatments was 15.3% from the Hb, 12.2% from the Hsf, 3.9% for the BioC, 2% for the MSWC, and 0.7% for both the YWC and PLC treatments.

Table 3. Total N and P loads from various treatments over time. All loads in mg/m^2

	Day 1		Three months		One year	
Treatment	Total N	Total P	Total N	Total P	Total N	Total P
PLC	842 cde	87 c	25 b	16 a	40 b	17 ab
BioC	4061 a	157 bc	254 a	54 a	42 b	46 a
MSWC	2014 b	33 c	23 b	8 a	47 b	12 b
YWC	451 de	70 c	39 ab	10 a	34 b	13 b
Hb	1391 cb	925 a	90 ab	28 a	43 b	18 ab
Hsf	1008 cd	483 b	188 ab	41 a	40 b	21 ab
Soil	77 e	1 c	92 ab	22 a	103 a	27 ab

The total amount of phosphorus applied to each treatment was 95, 85, 23, 61, and 10 g/m^2 for the PLC, BioC, MSWC, YWC and hydroseeded treatments, respectively. The hydroseeded treatments had the highest total P runoff loads during the first storm event even though they had the least amount of P applied to them. This was probably due to the high degree of soluble P fertilizer in the initial hydroseed mixture. All treatments, including the four compost treatments, had higher concentrations of total P in the runoff than the control, although only the hydroseeded treatments were statistically different than the control. During the second storm event, three months after treatment application, all treatments had reductions in total P loads in runoff with the exception of the control and there were no significant differences between any of the treatments. After one year, the BioC continued to have the highest total P loads in the storm runoff while the MSWC and YWC continued to have the lowest total P loads. Total P lost in the runoff as a percent of the total P applied from the treatments for all three storms combined was 9.7% from the Hb, 5.4% from the Hsf, 0.4% from the BioC, 0.2% from the MSWC, and 0.1% for both the YWC and PLC.

Rapid vegetative establishment and permanent vegetative cover are perhaps the two most important factors in controlling erosion and sedimentation. Percent cover results for all treatments at three months were lower than expected due to extreme drought conditions over the 3-month summer time period (90.7 mm of rain). After three months, all of the compost treatments had significantly more vegetative cover than the hydroseeded or unseeded control plots. The bare soil control had the

Table 4. Vegetative cover and biomass from various treatments over time. All loads in mg/m^2

Treatment	3 month % cover	1 year % cover	Total biomass at 1 year (g/m^2)	Ratio of grass: weed biomass at 1 year
PLC	64 a	73 a	325 ab	3.0:1
BioC	57 a	86 a	297 ab	0.8:1
MSWC	59 a	72 a	257 ab	2.9:1
YWC	62 a	68 a	191 ab	3.4:1
Hb	22 b	86 a	486 a	0.7:1
Hsf	22 b	81 a	446 a	0.6:1
Soil	17 b	24 b	77 b	0:1

lowest cover, as it was the only treatment that was not seeded, followed closely by the hydroseeded treatments, as much of the seed washed off the plot during the first storm event. Any vegetative cover found in the control plots was presumed to be from weed seeds blown-in from adjacent fields. Increased percent cover results from the compost treatments may be due to their ability to hold moisture better than the hydroseeded or bare soil treatments. This can be critical to plant growth during periods of drought as experienced during the first three months of this study.

After twelve months the BioC and hydroseed treatments had the highest percent cover, although it had the lowest percent cover of the compost treatments at three months. Interestingly, while the YWC had nearly the highest percent cover after three months it had the lowest after twelve months, excluding the control. This may be due to the low nutrient content of the YWC. Both hydroseeded treatments improved remarkably from the three-month to the twelve-month sampling period. This may be due to the ability of Bermuda grass to spread rapidly over the soil surface, as it appeared that much of the hydroseed had washed down slope after the first rain event. The bare soil control remained the treatment with the lowest percent cover, although it did increase between the sampling periods. This was likely due to weed seeds blowing into the test plots between sampling periods. After twelve months only the control was significantly different from the remaining experimental treatments.

Above ground biomass samples were harvested in May of 2003, twelve months after the test plots were seeded with Bermuda grass. While the hydroseeded plots had the largest amount of total biomass, the compost treatments had more biomass of Bermuda grass. Weed biomass was significantly higher in the hydroseeded treatments than the control and compost treatments indicating that weeds were probably not brought in with the compost treatments. While it is more desirable to have a high biomass from the intended erosion control grass that is seeded, a high biomass of weeds can serve to reduce erosion and sedimentation as well. Results from correlation analysis (not shown) indicated that both percent vegetative cover and weed biomass were correlated to the initial N, P and K content of the treatments.

CONCLUSIONS

Under these experimental conditions, compost systems performed as well or better than the industry standards (silt fence and hydroseeding) in reducing storm runoff and solids loss. Compost blankets tended to produce less runoff and more infiltration than the control or hydroseeded plots. The compost blankets also produced less erosion initially, however, as vegetation was established, the differences between compost blankets and hydroseeded were not significant. The mulch berm trapped eroded sediment as well as the silt fence as there were no significant differences between the hydroseeded plots with silt fences or mulch berms. Materials high in total N and total P were likely to lose more of each nutrient to storm runoff; however, these nutrient concentrations diminished rapidly. Because hydroseed is applied with inorganic N and soluble P it is more likely that these nutrients will be lost to runoff in the initial storm events. Composts high in inorganic N are likely to generate higher concentrations of N in runoff, therefore it is recommended that composts have a high percentage of organic N as a portion of the total N content. The potential for high losses of P from hydroseeding applications needs to be addressed by the policy and regulatory community, particularly since it is one of the most ubiquitous erosion control best management practices in the United States. While the compost treatments initially produced more vegetative cover in the first three months due to the ability to conserve moisture, differences in vegetation were not evident after one year. Vegetative biomass was correlated to the amount of inorganic nutrients applied, and while this results in greater nutrient loss, it also promotes the growth of vegetative biomass for long term erosion control. Weed biomass was greater on the control and hydroseeded plots indicating that the introduction of weed seeds through the compost applications was not evident in this study.

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