Vegetation and soil quality effects from hydroseed and compost blankets used for erosion control in construction activities

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ABSTRACT: Soil erosion is one of the biggest contributors to nonpoint source pollution in the United States. Soil loss rates from construction sites are 10 to 20 times that of agricultural lands. The use of surface applied organic amendments has been shown to reduce runoff and erosion through enhanced vegetation growth and soil quality characteristics. The objective of this study was to evaluate the vegetation growth and soil quality effects from compost blanket and hydroseed applications to soils disturbed by construction activities. Four types of compost blankets, two hydroseeded treatments (silt fence and mulch filter berm) and a bare soil (control) were applied in field test plots. Treatments were seeded with common Bermuda grass (*Cynodon dactylon*). Vegetative growth (percent cover and biomass of weeds and grasses) and soil quality characteristics were evaluated periodically over one year and 18 months, respectively. Results showed compost blankets provided an average of 2.75 times more vegetative cover than hydroseed after three months. After one year, cover was similar, but hydroseed had significantly greater weed biomass than compost and a greater ratio of weed biomass relative to Bermuda grass biomass. One type of compost blanket increased surface soil extractable organic carbon, and another type increased organic matter in 0 to15 cm (0 to 6 in) soil depths relative to hydroseed treated soils. A one-time application of hydroseed that included mineral phosphorus (P) fertilizer elevated surface soil P after 18 months. On construction sites where disturbed soils are prone to erosion and vegetation establishment is required, compost applications will promote quicker vegetation cover with less weed growth than hydroseeding. Some compost erosion control blankets have the ability to increase soil quality characteristics relative to hydroseed applications within 18 months of application.

Keywords: Compost, erosion control, soil quality, vegetation quality

Sediment contamination of surface waters is one of the biggest threats to water resources in the United States according to the U.S. Environmental Protection Agency (USEPA). Soil loss rates from construction sites can be 10 to 20 times that of agricultural lands (USEPA, 2000). For example, forest lands lose an average of 0.36 metric t ha^{-1} (1 t ac^{-1}) per year; agriculture loses an average of 5.5 m t ha^{-1} (15 t ac^{-1}) per year while construction sites average 73.3 m t ha^{-1} (200 tac^{-1}) per year (GA SWCC, 2002). New National Pollution Discharge Elimination System Phase II regulations label development zones as "point sources" requiring best management practices (BMPs) for temporary and permanent vegetation establishment, storm water pollution prevention plans, increased monitoring, and more site inspections by government officials or certified professionals.

Construction and development projects where topsoil is disturbed or cleared of vegetation are particularly subject to erosion problems. These project zones often present a significant challenge in re-establishing vegetation to protect the soil due to reduced soil quality and fertility. In many cases the existing topsoil has been totally removed, making the challenge even greater. In addition, heavy machinery and constant traffic compact the soil creating a "hard pan" that decreases infiltration, increases runoff, and prevents plant establishment and growth (Brady and Weil, 1996).

Perhaps the best way to reduce runoff and control erosion is to establish permanent vegetation as quickly as possible. Densely grassed areas are nearly equal to undisturbed forests in preventing soil loss (Brady and Weil, 1996), which is why grasses are often specified for erosion control on construction sites (GA SWCC, 2002). The foliage of dense vegetative covers can intercept between five and 40 percent of total precipitation, never allowing it to touch the soil surface, thus reducing runoff and potential soil loss (Brady and Weil, 1996). In one study, grain sorghum reduced soil erosion compared to plots with no surface cover from 0.97 m t ha^{-1} (2.64 t ac^{-1}) to 0.34 m t ha^{-1} (0.92 t ac^{-1}), mainly because of raindrop interception by leaves and the binding actions of the fibrous roots near the soil surface (Adams, 1966).

On construction sites and highly disturbed soils where vegetation establishment is required to prevent accelerated erosion or to stabilize slopes, hydroseed and/or mulching are considered standard practices (GA SWCC, 2002). Hydroseed is a mixture that includes selected seed, fertilizer, lime, and wood or paper fiber to establish vegetation on disturbed soils. Tackifiers and green pigments are sometimes added to the hydroseed slurry to increase seed adherence to the soil and to help the installer achieve a uniform application. Often construction sites will not pass post-construction close out requirements until vegetation is established on all bare soil areas (Kentucky Erosion Prevention and Sediment Control Field Guide, 2005). Although wood mulches provide excellent temporary protection from soil erosion (Meyer et al., 1972), they are undesirable on soils where vegetation growth is required due to high nitrogen demand (Kentucky Erosion

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Prevention and Sediment Control Field Guide, 2005), which can stunt or prevent vegetation growth. In a University of Minnesota and Minnesota Department of Transportation study, wood fiber blankets used for erosion control exhibited 10 percent less vegetated cover and 30 percent less biomass than bare soil after two years (Benik et al., 2003). Limitations from hydroseeding include: a 24 hour drying period after application (Kentucky Erosion Prevention and Sediment Control Field Guide, 2005), high risk of nitrogen and phosphorus loading during storm events (Faucette et al., 2005), and low soil coverage before vegetation is established, which can lead to greater soil erosion (Faucette et al., 2005).

While both compost and mulch can effectively be used to control soil erosion (Faucette et al., 2004), it is important to recognize the advantage of compost over mulches in the ability to grow vegetation. Due to high carbon (C):nitrogen (N) ratios, mulches often have a detrimental effect on plant growth because of nitrogen immobilization (Meyer et al., 1972) while compost has a C:N ratio optimum for plant uptake and can provide a slow release of nutrients (Maynard, 2000; Granberry et al., 2001) that sustains prolonged healthy plant growth.

A layer of organic litter on the soil surface insulates the soil and reduces evaporation, creating a better environment for germination and root growth for establishing vegetation (Adams, 1966; Jordan, 1998). Field studies by the University of California found that compost out-performed conventional slow-release fertilizers in turf grass applications in the following areas: improved turf color throughout the year, delayed onset of dormancy, lower weed populations, and consistently higher quality turf grass ratings (Block, 2000). A project sponsored by the Federal Highway Administration and the USEPA reported superior vegetative growth of compost over hydromulch and fertilizer on highway construction embankments (USEPA, 1997). The Texas Department of Transportation and the Texas Natural Resources Conservation Commission (TNRCC) found that composted dairy and cattle manure substantially increased vegetative growth and reduced soil erosion on roadway slopes (Block, 2000; USEPA, 2000). When comparing vegetative growth and erosion, Storey et al. (1995) found compost-amended slopes outperformed synthetic chemical tackifiers and shredded wood on sandy soils. A study performed by Iowa State University found compost blankets applied to highly disturbed soils along highways established vegetation equal to topsoil while outperforming topsoil in weed control (Richard et al., 2002).

Due to the organic matter content present in most composts, it may increase soil organic matter and overall soil quality, therefore providing an added advantage in erosion control applications by sustaining vegetation *permanently*. Additionally, compost has been used as a disease suppressant (De Cuester and Hoitink, 1999; Graham, 1998), pH buffer (Maynard, 2000), and source of beneficial soil organisms (Zibilske, 1998). Soil erosion studies have also shown that soil quality characteristics such as bulk density and aggregate stability can affect soil loss (Bradford and Foster, 1996), and additions of organic amendments can increase aggregate stability (Piccolo and Mbagwu, 1990) over time, which will aid the soil complex in resisting the beating action of rain and reducing soil erosion even when runoff occurs (Adams, 1966; Brady and Weil, 1996; Gilley and Risse, 2000).

The goal of this study was to compare the effects of compost blankets and hydroseed (an industry standard practice), on vegetation and soil quality parameters as precursors to effective short and long term erosion control in construction activities. The specific objectives of the this study were to determine if 1) compost blankets, relative to hydroseed, provide quicker or greater vegetative establishment, and 2) compost blankets, relative to hydroseed, improve overall soil quality.

Materials and Methods

Site description. Research test plots were constructed at Spring Valley Farm in Athens/Clarke County, Georgia at 33°57' N latitude and 83°19' W longitude. The soil was originally classified as an eroded Pacolet Sandy Clay Loam (USDA-SCS, 1968) and has a high soil erodibility factor (K value) of approximately 0.36 (Wischmeier and Smith, 1978). Historically, the farm was used extensively for pasture and intensive cotton production for more than 100 years. These practices have left the research site area devoid of topsoil and low in soil fertility and overall soil quality. The research site was surrounded by open, unmanaged pasture with scrub vegetation. The area receives an average annual rainfall of 1214 mm (48 in), with January through March as the wettest period. The average annual high temperature for the area is 22°C (72°F); the average low is 11°C (52°F) with a mean annual temperature of 17°C (63°F) (Weather Channel, 2004).

In April 2002, the testing area was cleared of vegetation and uniformly graded to a 10 percent slope with a grading blade mounted skid steer, exposing a semi-compacted (from the skid steer) subsoil (Bt horizon) to simulate construction site conditions. On 21 test plots, plot borders were installed to prevent cross-contamination of plots. Fifteen cm (6 in) wide stainless steel borders were trenched 7.5 cm (3 in) into the soil with 7.5 cm (3 in) of the border extending above ground.

During the week prior to treatment application, (May 2002) the research site received no natural rainfall while 31 mm (1.22 in) of rain fell on the plots during the week of the first simulated storm events of a related study (Faucette et al., 2005). The average high temperature was 27°C (81°F), and the average low was 14°C (57°F) (Weather Channel, 2004). During the three months between treatment application and the first vegetation analysis (August 2002), the site received 90.7 mm (3.57 in) of natural rainfall with 16.8 mm (0.66 in) falling in the third month. For the three months between treatment application and first vegetation analysis the average high temperature was 30°C (86°F), and the average low was 19°C (66°F) (Weather Channel, 2004). Throughout the week before the final vegetation analysis (May 2003), the research site received 102.4 mm (4.03 in) of natural rain.

Treatments. Seven treatments, each in triplicate, were assigned randomly and manually applied to 21 1 m by 4.8 m (3.3 by 15.8 ft) plots on the cleared and graded sandy, clay loam surface. The treatments were a: 1) biosolids compost blanket; 2) a yardwaste compost blanket; and 3) a municipal solid waste compost (MSW) and mulch blanket (2:1 compost to mulch by volume); 4) a poultry litter compost, mulch, and gypsum blanket (2:1 compost to mulch by volume with five percent gypsum addition by volume); 5) hydroseed (with filter berm); 6) hydroseed (with silt fence); and 7) a bare soil (control) plot. The municipal solid waste and poultry compost were blended manually with mulch in accordance with the Texas Department of Transportation (TxDOT) specifications for erosion control compost as specified in Special Specifications 1058 (TxDOT, 2004). Specifications for compost erosion control blankets are relatively new and did not exist

Table 1. Selected physical, chemical, and biological characteristics of compost erosion control blankets at time of field application. All nutrients expressed in mg kg^{-1}.

Treatment	Bulk density (g/cm^3)	Stability - O_2 uptake (mg O_2/g VM hr^{-1})	Germination index (%)	Water (%)	pH	Soluble salts (mS/cm)	Organic matter (g kg^{-1})	C:N	C	N	NH_4-N	NO_3-N	P
Biosolids comp	0.51	0.02	96	31.3	7.0	1.62	202	17	100900	5830	2480	1960	4470
Yard waste comp	0.50	0.09	100	40.7	7.8	0.65	193	19	97500	5010	40	70	3240
Poultry litter comp/mulch	0.59	0.06	100	32.2	7.2	5.93	212	22	131500	5980	70	240	4290
MSW comp/mulch	0.32	0.10	100	45.7	8.1	4.96	360	20	175200	8660	140	180	1910
Soil	2.23	Nd	Nd	Nd	4.7	Nd	Nd	18	250	14	1	0	348

Nd = No data available.

Table 2. Particle size distribution by dry weight passing (%) specific dry sieve sizes for compost erosion control blankets at time of field application.

Sieve size	Municipal solid waste compost, % passing	Poultry litter compost, % passing	Yard waste compost, % passing	Biosolids compost, % passing
25 mm	100	99.5	100	100
16	99.8	98.8	99.6	100
9.5	91.6	97.0	97.2	98.1
6.3	84.4	93.0	91.0	80.7
4	77.0	87.2	81.4	59.1
3.35	72.9	84.7	77.3	53.1
2.36	63.2	79.6	69.2	44.1
2	56.5	76.2	64.1	40.6
1.4	43.6	68.4	51.6	33.9
1.18	37.8	64.6	48.7	30.8
1	30.6	60.1	43.6	27.1
850 µm	26.4	57.6	40.6	24.9
710	19.7	52.1	34.0	20.0
600	16.4	47.1	29.0	16.4
500	13.6	41.8	24.1	13.1
250	5.2	17.1	7.4	2.9
125	1.2	4.1	1.4	0.2

for Georgia at the time of this study, while TxDOT and AASHTO specifications were regarded by industry practitioners as the most up-to-date. Gypsum was blended manually to the poultry litter compost to evaluate the potential for reducing soluble phosphorus (P) loss in runoff as reported by Faucette et al. (2005). No additional amendments or fertilizers were added to the compost treatments. Hydroseed was chosen because it is an accepted best management practice for vegetation establishment (GA SWCC, 2002). The hydroseed mixture contained water, seed, paper fiber, lime, nitrogen, phosphorus, and potassium from 10-4.4-8.3 mineral fertilizer (commercially recognized as 10-10-10) that was applied to supply 10 g/m^2 (0.042 oz/yd^2) of total phosphorus. The two hydroseed treatments received different sediment control devices at the base of the plot for the purposes of sediment control evaluation as reported by Faucette et al. (2005), which should be irrelevant to effects on vegetation and soil as reported in this study. Other than the blending described above, the compost did not receive any special handling or treatment after delivery to the research site by the compost manufacturers.

Compost erosion control blankets were applied at 3.75 cm (1.5 in) depths over the entire area of the plot according to standard specifications by the American Association of State Highway Transportation Officials (AASHTO, 2003). Hydroseed treatments were mechanically mixed and applied with a hydraulic pump to completely cover the soil surface in accordance with, and by a commercial installer. Each treatment, excluding the control, was seeded during treatment application with a 1:1 mix of hulled and unhulled Common Bermuda (*Cynodon dactylon*) grass seed applied at 3.7 kg ha^{-1} (20 lbs ac^{-1}). This rate is specified by the Georgia Department of Transportation as an erosion control vegetative measure for slopes 3:1 (33 percent) or less for the Athens, Georgia region. Compost treatments were selected based on commercial availability in north Georgia and from positive results from previous research conducted at The University of Georgia (Faucette et al., 2004).

Three simulated storm events were conducted to evaluate runoff, nutrient loss, and soil erosion characteristics as part of a larger field research program (Faucette et al., 2005) at the beginning of the study after treatment application (no vegetation established), three months (vegetation establishing), and 12 months (vegetation mature). A Norton V-jet rainfall simulator was used to produce storms of 7.9 cm (3.1 in) per hour for one hour, which was applied equally to each treatment. No additional irrigation was applied.

Treatment characterization. The compost treatments were physically, biologically, and chemically characterized prior to application in the test plots (Tables 1 and 2). Physical and biological analyses of the treatments were performed at the University of Georgia's Bioconversion Research and Education Center (BREC) laboratory and followed the procedures outlined in the U.S. Composting Council's Test Methods for the Examination of Composting and Compost (TMECC) (USCC, 1997). Water content (method 07.09-A) was determined by the difference between wet and dry weight; germination rate (method 09.05-A) was determined by percent watercress (*Rorippa nasturtium-aquaticum*) seed germination in a water extract of the treatment; particle size distribution (method 02.02-B) was determined by percent dry weight passing reported sieve sizes (USCC, 1997). Bulk density was determined as dry weight per known volume of sample (USDA, 1998). To determine biological

Table 3. Average vegetation cover (%) at 3-months and 12-months; average biomass (dry weight, g/m^2) of Bermuda grass, weeds, and total vegetation at 12-months; and ratio of average Bermuda grass biomass to average weed biomass at 12-months, n = 3. Treatments with same letter are not significantly different at $\alpha = 0.05$ using Duncan's Multiple Range test.

	% Cover grass + weeds		Biomass at 12 months			
Treatment	**3 mo,** Pr>F = 0.008	**12 mo,** Pr>F = 0.006	**Bermuda,** Pr>F = 0.616	**Weed,** Pr>F = 0.0002	**Total,** Pr>F = 0.067	**Bermuda:** weed
Poultry litter compost/mulch	64a ± 28	73a ± 22	244a ± 230	81bc ± 25	325ab ± 206	3.03:1
Biosolids compost	57a ± 6	86a ± 15	129a ± 111	169b ± 74	297ab ± 173	0.76:1
MSW compost/mulch	59a ± 20	72a ± 16	192a ± 256	65bc ± 11	257ab ± 247	2.94:1
Yardwaste compost	62a ± 19	68a ± 17	148a ± 139	43c ± 13	191ab ± 150	3.43:1
Hydroseed 1 (filter berm)	22b ± 7	86a ± 2	200a ± 70	286a ± 71	486a ± 32	0.70:1
Hydroseed 2 (silt fence)	22b ± 16	81a ± 20	159a ± 106	287a ± 79	446a ± 27	0.55:1
Bare soil (control-no seed)	17b ± 14	24b ± 15	0a ± 0	77bc ± 63	77b ± 63	0

stability a screened compost sample at 50 percent moisture was incubated for 16 hours to bring microbes to a standard level and then placed in a aerated water bath at 37°C (99°F) for one hour. At this point, the oxygen source is removed, and oxygen concentration is measured every five minutes for 1 hr; the change in oxygen concentration is used to calculate oxygen consumption rate as described by Lannotti et al. (1993).

Chemical characterizations were performed at the University of Georgia Agricultural and Soil, Plant and Water Laboratory using USEPA or AOAC approved procedures (University of Georgia Soil, Plant and Water Analysis Lab, 2004). Total C and total N were analyzed on a Carlo Erba Analyzer and determined by thermal conductivity from Micro Dumas combustion to CO_2 and N_2 (Kirsten, 1983); organic matter was determined by weight difference after loss on ignition at 550°C (1,022°F) (Jackson, 1958). Nitrate-N and ammonium-N samples were first extracted using a 20 ml (0.06 in^3) solution of deionized water and KCl and then filtered with Whatman 42 filter paper (Keeney and Nelson, 1982) before analysis by continuous flow colorimetric assay on an Alpkem RFA300. After 1000 mg L^{-1} (1000 ppm) of colorimetric reagent was added to each sample, the chemical nutrient concentration in the solution was measured as a function of the amount of light absorbance at a particular wavelength. Acid digestion for total P used a persulfate, boric acid, and sodium hydroxide 1:5 solution (Qualls, 1989) after centrifugation and before being processed on an Alpkem RFA300 continuous flow colorimetric analyzer. After 1000 mg L^{-1} (1000 ppm) of colorimetric reagent was added to each sample, the P concentration in solution was measured as a function of the amount of light absorbance at a particular wavelength according to USEPA standard method 365.1 (colorimetric, automated, ascorbic acid) (USEPA, 1983). Nitrate-N was measured using USEPA standard method 353.2 (colorimetric, automated, cadmium reduction), ammonia N using EPA standard method 350.1 (colorimetric, automated phenate), and total P using EPA standard method 365.1 (colorimetric, automated, ascorbic acid) (USEPA, 1983). Soluble salts were determined by electrical conductivity (Jackson, 1958). Heavy metals in the compost were analyzed, and all of the treatments were below the pollutant concentration levels as specified in USEPA part 503 Table 4 (USEPA, 1993).

Vegetation sampling and analysis. Vegetative growth and weed analysis for each plot was performed at three months and 12 months after treatment application. Analysis included the percentage of vegetative cover of each plot area, total number of weed plants and species, and above ground biomass of the vegetation. Harvest for biomass analysis was only conducted at the end of the study (12 months).

Percent vegetative cover was measured using a one meter (3.3 ft) wide by 4.8 m (15.7 ft) long grid with string lines set 10 cm (4 in) apart on all sides. Vegetation was counted only if it was found directly under each intersect. A total of 480 intersects per plot were used in the calculation to obtain the percent cover.

Weeds (defined as any species other than Bermuda grass) may help control erosion and sediment loss but they are also regarded as a nuisance and undesirable in field applications. The total number of different weed species and the total number of weed plants were counted for each plot at three months and 12 months. Total number of weed species and number of plants were low enough at three months to manually count and identify for the plot as a whole. At 12 months, a grid measuring 9.3 dm^2 (1 ft^2) was randomly placed once in each third of each plot to sub-sample the number of weed species, the number of weeds and the percent cover of weeds (i.e. excluding Bermuda grass). The sub-samples were averaged to obtain a composite for each plot. Weeds established in the test plots were assumed to be from seeds blown in from the surrounding field, present in the imported compost, and/or present in the soil of the test plot; no action was taken to control this variable.

Composite samples for biomass analysis were harvested using a 9.3 dm^2 (1 ft^2) sampling area replicated three times, once in each third of each plot. Vegetation was clipped and harvested at the soil surface. Harvested biomass was sorted into weed biomass and Bermuda grass biomass before being oven dried separately. Biomass was calculated as dry weight divided by the area. The addition of the weed biomass and Bermuda grass biomass were used to calculate the total biomass.

Soil sampling and analysis. Soil samples were taken to evaluate the effects of the treatments on soil quality with special attention given to the Bt horizon (A was removed). Soil samples were taken at the beginning of the study (after clearing and grading but before application of treatments), at six months, and at 18 months. Soil core samples (the vegetation and compost layer was removed) were taken at 0 to 5 cm (0 to 2 in) and 0 to 15 cm (0 to 6 in) depths. Five randomly sampled replicates were taken for composite samples for each depth at each plot. Soil core samples taken at 0 to 5 cm (0 to 2 in) were analyzed for extractable organic carbon and total P, and samples taken at 0 to 15 cm (0 to 6 in) were analyzed for organic matter. Samples taken at the beginning of the study for extractable organic carbon were thrown out due to complications in processing and therefore are not reported.

Table 4. Results from correlation analysis for compost erosion control blanket treatments. This table lists all variables with significant correlation (r > 0.70, n = 12).

Response variable	Independent variable (correlation coefficient)
# of weed species at 3 months	NH_4 (0.81), NO_3 (0.82)
# of weed plants at 3 months	NH_4 (0.84), NO_3 (0.85)
Weed biomass at 12 months	C:N ratio (0.78)

Soil chemical characterizations were performed at the University of Georgia's Institute of Ecology Analytical Chemistry Laboratory (2004). Organic matter was determined by weight difference after loss on ignition at 550°C (1,022°F) (Jackson, 1958). Acid digestion for total P used a persulfate, boric acid, and sodium hydroxide 1:5 solution (Qualls, 1989) after centrifugation and before being processed on an Alpkem RFA300 continuous flow colorimetric analyzer. After 1000 mg L^{-1} of colorimetric reagent was added to each sample, the P concentration in solution was measured as a function of the amount of light absorbance at a particular wavelength according to USEPA standard method 365.1 (colorimetric, automated, ascorbic acid) (USEPA, 1983).

Extractable organic C has been used as a surrogate for chloroform fumigation extraction, as an indicator of soil microbial C (Ross, 1992; Christensen and Christensen, 1991). Soil samples were sieved prior to C extraction to remove excess organic material. Carbon extractions were performed by using 0.5 ml K_2SO_4 on a 1:4 basis (soil:extractant), agitated for one hour, centrifuged, and the resulting supernatant was filtered and analyzed for extracted total organic C (Ross, 1992; Christensen and Christensen, 1991). Total organic C analysis was performed with an ASI 5000A auto sampler according to EPA standard method 5310B (combustion-infared) (USEPA, 1983).

Statistical analysis. SAS version 8.2 (SAS Institute, 2001) was used for statistical analysis. Separation of means was determined by (PROC GLM and PROC ANOVA) using Duncan's Multiple Range test to determine any significant differences between treatments ($p \leq 0.05$). Prior to means separation using Duncan's Multiple Range test, Type 1 Error was controlled for at the ≤0.05 level, and any resultant Pr>F values >0.05 were not deemed to be significant. Correlation analysis (PROC CORR) was used to determine which of the independent variables including: physical, chemical, and biological treatment parameters of the compost erosion control blanket treatments (as expressed in Table 1 and 2) were correlated to the response variables.

Results and Discussion

Vegetation quality. *Percent cover.* Although the control was not seeded, there was no significant difference in percent cover at three months between the control and the hydroseed treatments, but the compost treatments had significantly more vegetation cover than the hydroseed treatments (Table 3). The compost treatments averaged 2.75 times more vegetation cover than the hydroseed treatments. Prior to plant establishment, it was likely that a greater proportion of seed, relative to the compost blankets, washed down the slope during rain events in the hydroseed treatments as runoff volume and rate were higher in the hydroseed treated plots (Faucette et al., 2005). Any vegetative cover found in the bare soil control plots was presumed to be from weed seeds blown in from adjacent fields. Percent cover results for all treatments at three months were lower than expected due to drought conditions over the three-month time period, where only 90.7 mm (3.6 in) of natural rain was recorded [historical average is 309 mm (12.2 in)] (Weather Channel, 2004). The greater percent cover observed on the compost treatments was likely due in part to their ability to hold more moisture or restrict evaporation than the hydroseed. This can be critical to plant growth during periods of drought, as experienced during the three months leading up to the first vegetation analysis.

After 12 months, vegetative cover in all treatments was significantly greater than the control. The hydroseed treatments improved remarkably after the initial three-month sampling period. There was no significant difference in percent cover between the hydroseed and compost. This may be due to the ability of Bermuda grass to spread rapidly over soil surfaces where vegetation is nonexistent (precisely why it is used for erosion control). Additionally, the low cover at three months allowed weeds to infiltrate the hydroseed plots, which affected the percent cover (see next section). Minor vegetation establishment in the bare soil was likely due to weed seeds blowing into the test plots between sampling periods or from seed exposure after clearing and grading the soil surface. These results indicate that in the short term, compost blankets may provide better erosion control in slope stabilization applications where vegetation establishment is required for post construction areas.

Aboveground biomass. Above ground biomass samples were harvested in May of 2003, 12 months after the test plots were seeded (Table 3). Although there were no differences between treatments for biomass of Bermuda grass, weed biomass was significantly higher in the hydroseed treatments relative to the compost treatments and the control. Similarly, Richard et al. (2002) reported that seeded compost blankets had significantly less weed biomass than seeded topsoil or bare soil although the biomass of planted species was the same. The slow establishment of the Bermuda grass on hydroseeded plots, relative to the compost plots, may have enabled more weeds to establish and proliferate. Additionally, the 3.75 cm (1.5 in) compost blanket acted as a mulch layer, physically suppressing and therefore preventing potential weed seeds in the soil from emerging through the compost. The composts do not prevent seed germination (Table 1).

Mineral N can have a positive affect on weed growth and proliferation. Although not directly tested in this study, fertilizer N additions may partly explain why the hydroseed plots had significantly more weed growth than the bare soil. In addition, the biosolids compost had significantly more weed biomass than the yard waste compost. This may be because the majority of the N content in the biosolids compost was in mineral form (76 percent) relative to the yard waste compost (two percent) (Table 1). Furthermore, ammonia N and nitrate N content of compost were positively correlated to the number of weed plants and the number of weed species at three months (Table 4), while low compost C:N ratio was negatively correlated to weed biomass at 12 months. It is interesting to note that three of the four composts had similar weed biomass as the bare soil. This could be that these composts have the ability to suppress weed growth although additional research is required to draw any conclusions. These results indicate that if weeds are a concern, compost blankets should be considered instead of hydroseeding.

Soil quality. Extractable soil organic carbon was evaluated at the 0 to 5 cm (0 to 2 in)

Table 5. Change in soil extractable organic carbon (mg kg^{-1}) at 0-5 cm soil depth from 6 to 18 months (n = 3); total P (mg kg^{-1}) at 0-5 cm soil depth from 0 to 18 months (n = 3); and change in soil organic matter (g kg^{-1}) at 0-15 cm soil depth from 0 to 18 months (n = 3). Treatments with same letter are not significantly different at $\alpha = 0.05$ using Duncan's Multiple Range Test.

	0-5 cm depth		0-15 cm depth
Soil characteristic	**Extractable organic C change, Pr>5 = 0.003**	**Total P change, Pr>F = 0.006**	**Organic matter change, Pr>F = 0.05**
Treatment	Avg	Avg	Avg
Poultry litter compost/mulch	38.31bc	63.67b	0.62ab
Biosolids compost	40.42ab	96.33b	1.10a
MSW compost/mulch	61.24a	135.67ab	0.17b
Yardwaste compost	14.18d	51.67b	0.02b
Hydroseed 1 (filter berm)	28.0bcd	286.33a	-0.04b
Hydroseed 2 (silt fence)	19.98bcd	288.67a	-0.10b
Bare soil (control-no seed)	17.04cd	-22.67b	-0.11b

horizon as an indicator in the change of the soil microbial carbon over 18 months. Two of the four compost blanket treatments significantly increased extractable soil organic carbon relative to the control and only one of the four relative to hydroseed between six months and 18 months (12 months total) after treatment applications (Table 5). Similarly, Fraser et al. (1988) reported that organic amendments increased soil microbial biomass. The increase in extractable soil organic carbon is likely a consequence of the addition of surface organic matter in some of the compost blankets, suggesting that unincorporated compost blankets may increase soil quality in poor soils common to construction sites. Soil microorganisms can increase nutrient cycling, increase nutrient availability to plants, improve soil structure through aggregate stability (Myrold, 1998), increase overall soil biodiversity (Wardle, 2002), and degrade petroleum hydrocarbons (Alexander, 1994) commonly spilled during construction activities.

At 0 to 15 cm (0 to 6 in) soil depths, organic matter in the hydroseed and control plots appeared to decrease over the 18-month sampling period whereas the compost blankets all appeared to increase. One of the composts (biosolids) was significantly greater than the hydroseed and bare soil treatments. Similarly, Sommerfeldt and Chang (1985) reported an increase in soil organic matter from 0 to15 cm (0 to 6 in) in a clay loam soil with addition of organic amendments, and Vitosh et al. (1973) reported an increase in organic matter from 0 to 23 cm (0 to 9.2 in) with the addition of manure. These slight differences may be the result of organic matter from the compost blankets slowly being incorporated into the soil via microbial migration from the soil surface into the soil profile (Wardle, 2002), but these differences may only occur at the soil surface. Additionally, 18 months may be an insufficient amount of time to detect sufficiently large changes in soil quality parameters if they are to occur. However, even slow and small improvements to soil quality resulting from an erosion control application are a step forward to sustainably managing vegetation, storm water, and soil erosion.

The total amount of phosphorus applied by each treatment was 95 g/m^2 (4.02 oz/yd^2) from the poultry litter compost, 85 g/m^2 (3.59 oz/yd^2) from the biosolids compost, 23 g/m^2 (0.97 oz/yd^2) from the MSW compost, 61 g/m^2 (2.58 oz/yd^2) from the yard waste compost, and 10 g/m^2 (0.042 oz/yd^2) from the hydroseeding. Total phosphorus levels of the soil sampled at the 0 to 5 cm (0 to 2 in) horizon prior to treatment application ranged from a high of 449 mg kg^{-1} (449 ppm) where the yard waste composts were to be applied to a low of 348 mg kg^{-1} (348 ppm) in the control. Differences were not statistically significant.

After 18 months, the change in total soil P levels from 0 to 5 cm (0 to 2 in) soil depth was significantly higher in the hydroseed treatments relative to the compost (except MSW/mulch) and control. The higher level of soil total P under the hydroseed treatments was probably due to the high level of soluble P fertilizer in the initial hydroseed mixture. Although the *total amount* of P applied by the compost treatments was much greater, relative to the hydroseed, nutrients in compost are generally in organic form and therefore are less mobile or likely to chemically adsorb to soil colloids. It is interesting to note that significant changes were observed from a one-time application of hydroseed as repeated applications are common industry practice when trying to establish vegetation to prevent soil erosion. This relatively high level of soil total P near the soil surface by the hydroseeded treatments over the 18-month period may contribute to prolonged P loss in runoff (Pierson, et al., 2001).

These results indicate that *some* compost erosion control blankets can contribute to increasing soil quality relative to hydroseed after only 18 months. There were positive trends for the remaining compost blanket types, but a longer-term study would be required to draw more definitive conclusions. Hydroseed can improve P fertility of P deficient soils, but where soils are prone to erosion, hydroseed application may have a negative impact on receiving waters.

Summary and Conclusion

Based on this study and under these environmental conditions, compost blankets provided a greater vegetative cover than hydroseed three months after application. Due to the invasion of weeds, there was no difference in percent of total vegetation cover (weeds + seeded grass) after one year. From a practical standpoint, to prevent soil erosion this may be desirable, but from an industry or commercial standpoint, invasive and/or exotic weed growth may be undesirable. This study provides evidence that compost blankets may suppress weed growth relative to hydroseed. However, composts with relatively high ammonia N and nitrate N contents and low C:N ratios may not provide as great a benefit for weed control.

One compost erosion control blanket increased soil extractable organic carbon and one increased organic matter relative to hydroseed treated soils, which may be an indication of soil quality improvement. However a long-term study may be needed to discern soil quality impacts. A *one-time application* of hydroseed generated elevated levels of surface soil phosphorus over the 18-month study period. Elevated levels of soil test P may provide a benefit to soil fertility; however, in some soils this may contribute to increased phosphorus loading to nearby surface water via storm runoff, contributing to eutrophication and long term water quality impairment.

On construction sites where disturbed soils are prone to erosion and vegetation establishment is required, compost applications will provide a greater vegetation cover in the short term and less invasive weed growth in the long term relative to hydroseeding. Additionally, increasing soil quality characteristics can decrease soil erosion. Although the results are limited, some compost erosion control blankets have the ability to increase soil quality characteristics relative to hydroseed applications.

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