Montana Department of Transportation April 2011
RESEARCH PROGRAMS

Project Summary Report 8196
Authors: Robert Ament Western Transportation Institute, Montana State University - Bozeman, MT
Stuart Jennings and Pam Blicker, Reclamation Research Group, LLC, Bozeman, MT

Steep Cut Slope Composting: *Field Trials and Evaluation*

http://www.mdt.mt.gov/research/projects/env/organic_matter.shtml

Introduction

This project is a continuation of earlier work performed by Montana State University (Jennings *et al*. 2007) evaluating compost application on, and incorporation into, soils on steep cut slopes for the Montana Department of Transportation (MDT). The earlier work evaluated compost application at rates of 2.54 cm (1 in) and 5.08 cm (2 in). It also evaluated the relative effectiveness of surface-applied compost blankets versus compost incorporated into the surface soil. In this project, the research objectives were:

- Evaluate vegetation performance on seeded plots using surface-applied compost with thicknesses between 0.32 cm (1/8 in) and 1.27 cm (1/2 in);
- Assess the effectiveness of various tackifiers, erosion control fabric and netting in retarding loss of compost from wind and water erosion;
- Conduct a cost–benefit analysis of the various rates of compost applied in conjunction with the various compost retention techniques; and
- Make final recommendations for compost application rates and preferred stabilization techniques.

What we did

Twenty-two test plots of varying sizes were constructed on steep north- and south-facing roadside cuts along Montana (MT) Highway 84 approximately 25 kilometers (15 miles) west of Bozeman in southwest Montana. Slopes varied between 64 and 71 percent. At this location, MT Highway 84 is aligned on an east-west axis and provided the opportunity for the establishment of test plots on both north-facing and south-facing slopes (Figure 1). The test site is typified by semi-consolidated sand, silt, clay, and intermittent fine gravel deposits. Laboratory analyses determined the slopes had a silt loam texture. Analyses before treatment confirmed the site soils exhibited low levels of organic matter, nitrogen (N) and phosphorus (P) consistent with a road cut through fresh parent material lacking soil horizon development. In this report the rooting zone materials will be called "soil," recognizing these materials have little, if any, soil horizon development characteristic of an entisol.

A grass seed mix appropriate for the environmental conditions and geologic materials at the research site was broadcast prior to application of compost and/or compost retention treatments. The seed mix contained six native bunchgrass species. The compost used for the experiment was a wood-based reclamation compost, slightly basic (reactivity (pH) of 7.9), and was screened so that

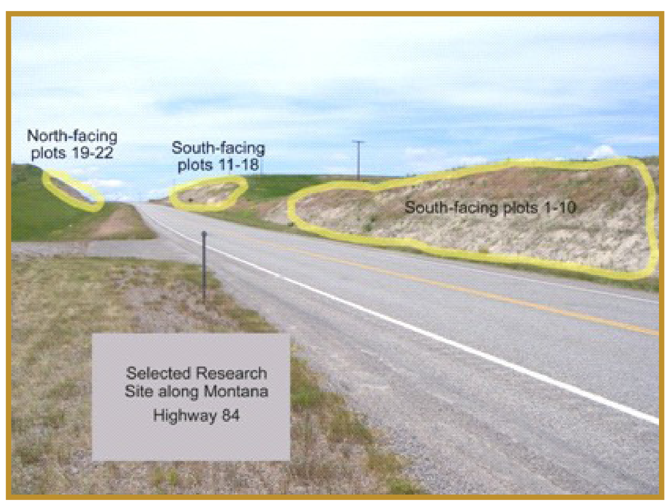

Figure 1: Roadside overview of research site location along MT Highway 84.

pieces were smaller than 1 cm (3/8 in). A chemical analysis of the compost indicated high total levels of N, P and potassium (K), macronutrients that generally support plant response when applied to nutrient-poor soils like those found at the research site. Three depths of compost were selected to be placed on seeded plots on both south-facing and north-facing cut slopes: 0.32 cm (1/8 in), 0.64 cm (1/4 in) and 1.27 cm (1/2 in). The five compost retention methods were employed only on the environmentally harsher south-facing slopes, with a compost depth of 1.27 cm. The five retention measures were coconut-straw fiber erosion control blanket, lightweight plastic netting and three commercially available tackifiers (Figure 2). The three tackifiers were 1) polymer emulsion liquid, 2) guar-based water dispersible formulation and 3) *Plantago*-based seed husk powder. These treatments were compared to seeded control plots.

Figure 2: View of eight south-facing plots that are across highway from the four north-facing plots (western plots). Plot 11 is shown furthest to the left in the image while plot 18 is most distant (to the right or east).

What we found

Nutritional value of compost addition: The addition of compost improved soil chemical characteristics at the test site. Soil samples were collected before construction of the research plots in November 2008 and again following the last monitoring event in August of 2010 to evaluate the nutritional effects of compost blankets on the test plots. Organic matter content increased as well as the plant macronutrients N, P and K. Only a portion of the total nutrient pool was available to plants during the final soil monitoring event, suggesting a long-term supply of nutrients would be available for plant growth over a period of many years.

Physical compost retention techniques: Compost retention treatments employing physical retention of compost such as coconut-straw fiber fabric or lightweight plastic netting were effective in limiting the loss of applied compost. The two treatments using coconut-straw fiber fabric and plastic netting had the highest compost retention rates at the end of the project. Treatments lacking a physical method of retention were more subject to wind removal.

Tackifier compost retention techniques: The three tackifiers evaluated for compost retention yielded confounding results. This was due to a severe wind gradient from the top (western side) to the bottom (eastern side) of the study site (left and right side of Figure 1, respectively). Two replications of each treatment were implemented and dissimilar compost retention values were recorded for the same treatment depending on the test plot's location.

Erosion control: The research site was not regraded prior to test plot construction and a dense network of rills several inches deep were present. Rills formed due to steep slopes, erosive surface material and limited vegetation cover over a six-year period after MT Highway 84 construction and before the research project was initiated. Erosion indices were qualitatively estimated during the 2009 growing season and again in June 2010. It was anticipated the treated plots would become less erosive over time due to the application of compost, erosion control methods and the resulting improved vegetation conditions. Erosion decreased from critical to moderate due to the retention of compost and establishment of vegetation on many of the test plots. Some rills have begun to fill in as a result of the various compost treatments and new vegetation establishment combining to slow the velocity of water movement down the slopes. However, the steep slopes are still erosive and it is difficult to determine if on-going erosion can be correlated with conditions existing prior to the project versus what erosion has occurred since the inception of the project.

Native perennial grass establishment: The application of compost can be directly correlated to increased establishment and vigor of both seeded and colonizing plants. Too little compost may result in persistent erosion and lack of vegetation establishment, while too much compost results in higher reclamation costs. The amount of perennial grass cover that can be reasonably expected on south-facing steep cut slopes with a semi-arid climate receiving 250–500 mm (10–20 in) of annual precipitation was calculated by combining the results of this study's three compost depths (0.32 cm, 0.64 cm and 1.27 cm) with two compost depths (2.54 cm and 5.08 cm) from the 2003-2006 MDT study (Jennings *et al.* 2007). The expected perennial grass cover response for various compost depths can be approximated using the linear regression in Equation 1, and is displayed in Figure 3.

Equation 1: Perennial Grass Cover (%) = 7.66 • (Compost Depth (cm), x) + 6.64

Cost Benefit Analysis: Recognizing costs for each project are unique and vary, approximate unit costs were obtained from multiple industry sources to facilitate the analysis. The results of the cost benefit analysis are shown in Table 1.

What the researchers recommend

Treatments with good vegetation response and costs of less than $100,000 per hectare (ha) ($40,469 per acre (ac)) are recommended. Specifically, compost rates between 1.27 and 2.54 cm are recommended and can be expected to yield approximately 16–26 percent live perennial grass cover in a semi-arid climate in Montana. These are the recommended rates since they balance erosion control, vegetation establishment and cost.

Erosion control blankets or mesh netting are recommended for use in windy areas. Both physical retention treatments - coconut-straw fiber erosion control blanket or lightweight plastic netting - were effective in limiting the loss of applied compost. Plastic netting is recommended since it is more cost effective. Although not used in this study, biodegradable mesh netting could also be used. The 1.27 cm compost application with plastic netting utilized for retention at this project site is estimated to cost $65,069/ha ($26,333/ac).

The three tackifiers evaluated - polymer emulsion liquid, guar-based water dispersible formulation and *Plantago*-based seed husk powder - gave confounding results so no recommendation can be made.

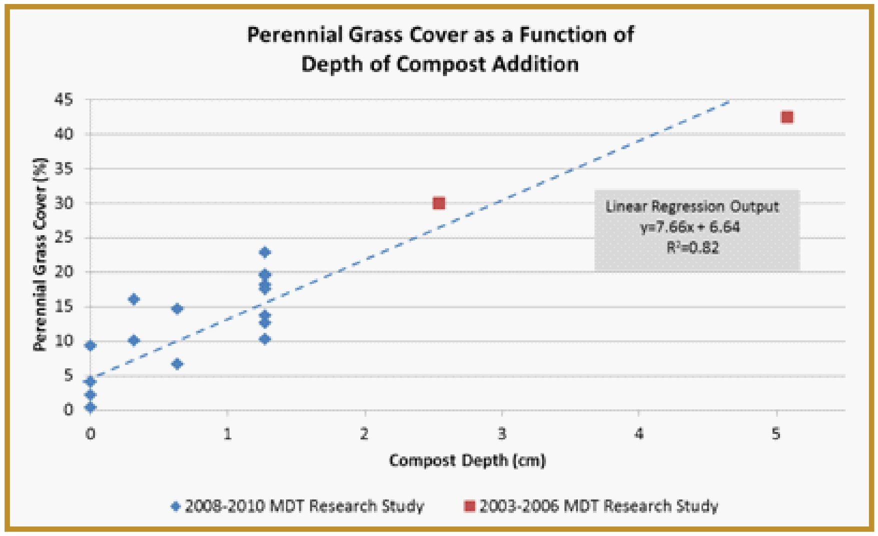

Figure 3: Linear regression of compost depth versus perennial grass cover resulting from varying depths of compost addition from two combined MDT steep slope reclamation studies.

Table 1: Cost–benefit analysis for varying rates of compost and multiple methods to retain compost against erosion. Costs are based on typical Montana compost procurement and delivery costs plus installation of compost on-slope using a blower truck and two laborers at this project site.

Compost Depth (cm)	Predicted Native Grass Cover (%)	Predicted Erosion	Broadcast Seed ($/ha)	Compost Blanket[1] ($/ha)	Compost Blanket[1] + Coconut Straw Fiber Plastic ($/ha)	Compost Blanket[1] + Plastic Netting ($/ha)	Compost Blanket[1] + Water Applied Tackifier ($/ha)
0	6.6	Very High	$325	-	-	-	-
0.32	9.1	Very High	-	$10,401	$58,220	$34,311	$11,389
0.64	11/5	High	-	$20,654	$68,473	$44,564	$21,642
1.27	16.4	Moderate-High	-	$41,160	$88,979	$65,069	$42,148
2.54	26.1	Low	-	$82,171	$129,990	$106,081	$83,159
5.08	45.6	Very Low	-	$164,194	$212,013	$188,104	$165,182

[1] All compost blankets include the cost of broadcast seeding

Compost application rates of 1.27–2.54 cm are recommended for establishment of sufficient vegetation cover to control erosion. These recommended application rates are estimated to cost between $41,160/ha ($16,657/ac) and $82,171/ha ($33,254/ac) based on the plot construction methods from this study using a blower truck. Costs may vary in other locations and by using other methods.

References

Jennings, S. J., Goering, J.D., and P. S. Blicker. 2007. Evaluation of Organic Matter Addition and Incorporation on Steep Cut Slopes, Phase II Test Plot Construction and Monitoring. MDT Research Division, Technical Report, Helena, MT.

For More Details . . .

The research is documented in Report FHWA/MT-10-008/8196*, Steep Cut Slope Composting: Field Trials and Evaluation.*

MDT Project Manager:
Sue Sillick, ssillick@mt.gov, 406.444.7693

Western Transportation Institute Project Manager:
Robert Ament, rament@coe.montana.edu, 406.994.6423

To obtain copies of this report, contact MDT Research Programs, 2701 Prospect Avenue, PO Box 201001, Helena MT 59620-1001, mdtresearch@mt.gov, 406.444.6338.

MDT Implementation Status
April 2011

Compost currently plays an integral role in the development of plant cover on steep roadside slopes that lack sufficient topsoil for proper plant establishment and growth. The results of the two research studies that evaluated the performance of compost on MDT roadsides clearly shows the benefit of its use. As a matter of standard procedure, MDT now incorporates compost as a component of the mulch applied on reseeded slopes steeper than 3:1. Application rates can range from 15 cubic yards [1/8th inch depth] to 65 cubic yards [1/2 inch depth] per acre, depending on soil and slope conditions. Based upon the successes achieved to date, we anticipate that compost will continue to be utilized as a necessary component of MDT's reclamation activities.

For more information contact Phil Johnson, phjohnson@mt.gov, 406.444.7657.