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CHEMICAL SOIL STABILIZERS FOR SURFACE MINE RECLAMATION

Successful stabilization of surface mine spoils and other drastically disturbed areas depends on the establishment of a grass and legume cover. Mulches and soil stabilizers may be used on these sites to help establish vegetation and reduce erosion. The selection of an appropriate mulch or soil stabilizer is complicated by the number of products that are commercially available and by the scarcity of information on their effectiveness. Two cooperative demonstrations compared vegetation establishment and erosion loss following 30 treatments with six mulches and 12 soil stabilizers. There is no evidence that these materials are necessary for vegetation establishment; they are used primarily to control erosion. Mulch, soil stabilizer, and soil stabilizer-mulch treatments were effective.

Successful stabilization of surface mine spoils and other drastically disturbed areas requires establishment of a grass and legume cover. A high degree of skill is needed to select and apply treatments appropriate for the varied conditions that occur on these areas. The selection of plant species adapted to the site and the application of adequate amounts of a suitable fertilizer are fundamental treatments. Complementing these basic requirements are a variety of materials and treatments that may aid vegetation establishment and growth.

Among the options are various materials for mulching and soil stabilization. This facet of revegetation technology has experienced rapid growth during the past few years. Much of the interest in these new products may be related to our growing concern about the environment. Interest also comes from the belief that mulches are the solution to our revegetation problems and that they will eliminate the frustrations and hard work often experienced today. Evidence indicates that mulches and soil stabilizers are useful for erosion control, but neither is considered necessary for vegetation establishment in the eastern United States.

There is little well-documented information on appropriate rates of application. The effects of a mulch or soil stabilizer on erosion losses and the factors affecting the site protection provided by various treatments have not been clearly established.

The problems that may occur in prescribing and using mulches are illustrated by the West Virginia statute regulating surface mining. One section in this law states that all slopes of 20 deg or more created by surface mining will be mulched. Acceptable materials and rates of application were not specified; it was left to the designated regulatory agency to develop and enforce technical requirements. A wide variety of products would satisfy the intent of the law, but the scarcity of well-documented information about product acceptance, rates of application, methods of application, and limitations on use made it difficult to prepare specific regulations.

Recognizing the need for more specific information, the West Virginia Department of Natural Resources asked the U.S. Forest Service to initiate a cooperative project to evaluate mulches and soil stabilizers for areas disturbed by surface mining. This paper describes the results of two demonstrations conducted during a 2-year period.

DEMONSTRATION NO. 1

An exploratory study was initiated in June 1971 to compare various commercial products by measuring vegetation establishment and growth on sample plots. Mulches and soil stabilizers were evaluated (Table 1). These were applied to plots established along a steep fill slope composed of uncompacted, gray to black shale. The pH of the spoil ranged from 2.5 to 5.8. However, most of the site would support vegetation when the appropriate kinds and amounts of seed and fertilizer are applied. Twenty-two of the plots were a quarter acre each, and six were 1,000 sq ft each. Half of the quarter-acre plots had a western exposure; the remainder and the 1,000-sq ft plots had a northern exposure. All plots were seeded with a mixture of Kentucky 31 fescue, sericea lespedeza, Korean lespedeza, and sudum, a hybrid of sudan grass and sorghum. Ammonium nitrate and diammonium phosphate were applied at rates sufficient to provide 85 lb of nitrogen and 50 lb of P_2O_5 per acre.

Each product was assigned to one plot with a western exposure and one plot with a northern exposure, except the Genequa products, which were applied to six 1,000-sq ft plots. All treatments were selected by the manufacturers' representatives. In most cases, the same treatments were applied on the western and northern exposures. A few manufacturers applied a different treatment to each of their assigned plots. The mixing and application were supervised by the manufacturers' representatives.

Normal seasonal weather occurred during the study period. Conditions were favorable for germination, and adequate precipitation maintained vegetation growth.

It was apparent that all these materials can be classified under two broad categories: mulches and soil stabilizers. A mulch can be described as any organic or inorganic material applied to the soil surface to protect the seed, maintain more uniform soil temperatures, reduce evaporation, enrich the soil, or reduce erosion by absorbing raindrop impact and intercepting surface runoff. A soil stabilizer is any organic or inorganic material applied in an aqueous solution that will penetrate the soil surface and reduce erosion by physically binding the soil particles together. These materials can also reduce evaporation and protect the seed.

Mulches appeared to be more effective than soil stabilizers in aiding the establishment of the sudum hybrid. The wide range in mean height at the end of the first growing season indicates that some treatments improved the growth and vigor of the sudum hybrid.

The excellent growth of the sudum hybrid on the untreated check plots indicates that a mulch or soil stabilizer is not necessary to establish a vegetative cover.

DEMONSTRATION NO. 2

The results of the first demonstration indicated that mulches may be superior to soil stabilizers for establishing vegetation and that treatments affected vegetation growth. A second demonstration was established in May 1972 to verify these results and to compare sediment loss among several treatments.

Nineteen treatments using 15 products were applied to a slope with a southern aspect. The slope varied from 16 to 25 deg. No mulch or soil stabilizer was applied to one plot; erosion was controlled on this plot by the grass and legume cover. The spoil was a mixture of light-colored brown sandstone and gray shale that had been partially compacted as it was regraded. Spoil pH ranged from 5.2 to 6.5.

Runoff subplots were established on each plot. Each subplot was 15 ft wide along the contour and 74.5 ft long at right angles to the contour. At the lower end, two strips of 30-in. belting were fitted into a trench to form a V-shaped runoff trough. The trough emptied into a piece of gutter that drained into a 34.9-cu ft wooden box (Figs. 1 and 2). These boxes were designed to release the runoff slowly while retaining the sediment.

Representatives of the participating companies selected and applied treatments to assigned plots (Table 2). It is interesting to note that many of the soil stabilizer manufacturers recognized the value of wood fiber as a mulch and included it as part of their treatment. This contrasted with the practice in the previous year, when all soil stabilizers were applied with little or no mulch.

The grass-legume mixture included Kentucky 31 fescue, perennial ryegrass, sericea lespedeza, weeping love grass, and Japanese millet. Ammonium nitrate and diammonium phosphate were applied at rates to provide 85 lb of nitrogen and 50 lb of P_2O_5 per acre, as in the previous demonstration.

Because of frequent rain showers, the soil was at or above field capacity the week before the treatments were applied. During the week of treatment, rain kept the soil moist, and air temperatures remained unseasonably cool. These conditions emphasized differences among the soil stabilizers. One product required a 2- to 3-hour warm, dry curing period after application. A rain shower after this product was applied caused concern, and the manufacturer's representative had the plot re-treated during a period of dry weather. Other soil stabilizer treatments may have been affected to a lesser extent by the high moisture content of the soil. These products depend on infiltration to carry the binder into the soil. The depth of penetration and the effectiveness of the treatment depend on the soil moisture at the time of treatment. On a few plots the surface soil became saturated during the treatment, causing some of the solution to run off. This loss may have reduced the effectiveness of the treatment. On other plots the solution puddled in small depressions and remained on the surface for several hours. It was assumed that the rate of infiltration was slow and the zone of treatment shallow. Therefore, the layer of treated soil may have been thin and easily destroyed by rainfall and erosion. Runoff and puddling can be controlled to some extent by reducing the amount of water used to mix the solution.

Vegetation germinated and grew much more rapidly on plots treated with a mulch or a combination of soil stabilizer and wood fiber. Straw tacked with Curasol AH, hardwood bark, Curasol AH with wood fiber, Aerospray 70 with wood fiber, and Aquatain resulted in an acceptable, uniform cover 8 weeks after treatment. The Japanese millet on the plots treated with Aerospray 70 had a healthy green color. Some yellowing of the millet foliage occurred on the plots treated with straw tacked with Curasol AH, Curasol AH with wood fiber, and Aquatain. Hardwood bark caused extreme yellowing of the foliage. The yellowing occurred along the leaf margins near the tip of the leaf blade and resembled the symptoms of nitrogen deficiency.

Plots treated with soil stabilizers without wood fiber did not have so dense a cover, nor was the vegetation so tall as on the plots treated with mulch or a soil stabilizer with wood fiber. This is consistent with results obtained the year before.

The treatments were expected to have their greatest effect on sediment loss during the time from application until a vegetative cover was established. On many spoils, a protective ground cover can be established in 8 to 10 weeks with a suitable seed mixture and adequate fertilization. The vegetation becomes more effective for erosion control as the plants grow and the ground cover density increases. At the same time, the effectiveness of the mulch or soil stabilizer may decrease as it deteriorates by weathering.

The straw tacked with Curasol AH was considered one of the most effective erosion control treatments. It was used as a standard with which to compare sediment loss on the other plots. This proved to be a valid basis for comparison, inasmuch as sediment loss from this plot was the lowest of all treatments. Sediment loss was very low on plots treated with hardwood bark, Curasol AH with wood fiber, experimental wood fiber No. 2, and Aquatain. At the end of 8 weeks, four mulches, three soil stabilizers, and three soil stabilizers with wood fiber had produced low sediment losses.

Table 1. Treatments tested in demonstration No. 1.

Treatment	Rate per Acre	Northern Exposure: Est. Mean Height[a] (ft)	Northern Exposure: Plant Vigor	Western Exposure: Est. Mean Height (ft)	Western Exposure: Plant Vigor
Control					
No mulch or soil stabilizer	—	5 to 6	Good	5 to 6	Good
Mulches					
Hardwood bark	27 cu yd	5 to 6	Good	—	—
Straw tacked with asphalt	1½ to 2 tons with 80 gal	5 to 6	Good	—	—
Hay tacked with Curasol AH	1½ to 2 tons with 40 gal	6 to 7	Good	—	—
Hay tacked with Aerospray 52	1½ to 2 tons with 20 gal	—	—	5 to 6	Good
Wood fiber	1,200 lb	5 to 6	Good	5 to 6	Good
Erocom	2 tons	1 to 2	Poor	1 to 2	Poor
Soil stabilizers					
Aquatain	5 lb	3 to 4	Good	2 to 3	Fair
Terra-Tack	40 lb	4 to 5	Good	3 to 4	Fair
Curasol AH with wood fiber	60 gal with 200 lb	—	—	3 to 4	Fair
Curasol AE with wood fiber	22 gal with 200 lb	4 to 5	Fair	—	—
Aerospray 70	30 gal	3 to 4	Poor	—	—
Aerospray 70 with wood fiber	20 gal with 200 lb	—	—	3 to 4	Poor
Genequa 743	100 gal	3 to 4	Fair	—	—
Genequa 743	50 gal	4 to 5	Good	—	—
Genequa 743 with Genequa 8	50 gal with 50 lb	3 to 4	Fair	—	—
Genequa 169	50 gal	4 to 5	Good	—	—
Genequa 555	50 gal	3 to 4	Fair	—	—

[a]Height was estimated at several points where plant density was the highest; estimates were checked occasionally by measuring the height of several plants.

Figure 1. In demonstration No. 2, runoff from 1,000-sq ft subplot is channeled into the collection box to measure sediment yield.

Figure 2. In demonstration No. 2, a trough of belting channels the runoff into a gutter; gutter empties into a 34.9-cu ft box.

Table 2. Treatments tested in demonstration No. 2.

Treatment	Rate per Acre	Average Height of Japanese Millet[a] (ft)	Foliage Color[b]	Ground Cover Density[c]	Sediment Loss per Acre (cu ft)
Control					
No mulch or soil stabilizer	—	1.6	G	L	309.5[d]
Mulches					
Straw with Curasol AH	1¼ tons with 40 gal	2.6	F	H	10.5
Hardwood bark	27 cu yd	2.1	P	M	52.3
Erocom	2 tons	1.4	G	M	183.0
Erocom	½ ton	1.7	F	M	172.6[d]
Conwed No. 1	1,000 lb	1.6	F	H	52.3[d]
Conwed No. 2	1,000 lb	1.5	P	H	94.2
PFM	500 lb	1.8	F	M	313.8
Soil stabilizers					
Aquatain	10 lb	2.7	F	M	52.3
Terra-Tack	20 lb	1.6	F	L	204.0
Terra-Tack with wood fiber	20 lb with 400 lb	1.5	F	M	962.2[d]
Curasol AH with wood fiber	40 gal with 800 lb	2.2	F	H	15.7
Aerospray 70 with wood fiber	80 gal with 800 lb	2.6	G	H	88.9
Aerospray 70 with wood fiber	40 gal with 400 lb	1.0	G	L	287.7[d]
M-145	72 gal	1.8	G	M	83.7
M-145	18 gal	1.8	F	M	209.2[d]
Genequa 743	55 gal	2.8	G	L	73.3
Genequa 169 with wood fiber	40 gal with 1,000 lb	1.9	F	L	109.8
XB-2386	114 gal	2.7	G	L	172.6
XB-2386 with wood fiber	75 gal with 600 lb	1.0	G	L	407.9[d]

[a]Measured at 10 randomly selected points on each plot.
[b]Subjective evaluation of the vegetation on the entire plot: G = no yellowing; F = slight yellowing; P = pronounced yellowing.
[c]Estimated on each plot: H = 75 to 100 percent; M = 50 to 74 percent; L = (50 percent.
[d]Subplots with a slope of 20 deg or more.

CONCLUSIONS

There is no evidence that mulches or soil stabilizers are necessary for vegetation establishment, but some of these treatments affected the rate of germination and the growth of sudum hybrid and Japanese millet. This may or may not affect total sediment loss.

Sediment loss was reduced by several of the treatments evaluated in these demonstrations. This is the most important reason for recommending mulches or soil stabilizers. No one group of products had any apparent advantage over another. Mulches, soil stabilizers, and soil stabilizers with wood fiber were all effective; however, some treatments within each category were more effective than others.

All of the products tested can be mixed easily without danger to personnel involved. All can be applied with a conventional hydroseeder. Seed, fertilizer, and other additives may be included in the mix.

There is a growing trend toward including a mulching material such as wood fiber with a soil stabilizer. This combination may hasten the germination of the vegetative cover on some sites. A dye in the wood fiber colors the slurry and provides a means of determining what areas have been completely and uniformly treated.

High soil moisture and cool weather may limit the use of some soil stabilizers. The depth of penetration depends on infiltration, so treatments may be more effective on soils with a moisture content below field capacity. The bond between the soil particles determines their resistance to erosion. The strength of this bond can depend on the proper curing of the soil stabilizer. It is believed that warm, dry weather after the application will encourage rapid and complete curing of these stabilizers.

Much research with soil stabilizers is needed to determine how to use them most effectively. There is a need to document differences in sediment loss from plots treated with several rates of application at different soil moisture levels, to evaluate soil stabilizers combined with other mulching materials, and to compare sediment losses for soils with specific chemical and physical properties. It may also be advisable to establish standard methods of evaluating the new products that enter the market each year.