RUNOFF AND SEDIMENT YIELD FOLLOWING MULCH AND SOIL STABILIZER TREATMENTS[1]

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Abstract.--This study provides a basis for comparing the effectiveness of 26 mulch and soil stabilizer treatments in reducing surface runoff and sediment yield. Square plots with no vegetative cover, a surface area of 4 square meters, and a slope of 10 degrees were used in this field study. Surface runoff and sediment yield were measured after rainfall events. The long fibered mulches--straw, shredded hardwood bark, Verdyol[3],--and composted municipal waste were the most effective treatments. Wood fiber, wood cellulose, shredded paper, and Agro-mulch, the short fibered mulches, were not as effective but did reduce runoff and sediment yield when applied at 1112 Kg ha^{-1}. When the rate of application for wood fiber was increased to 1668 Kg ha^{-1}, a further reduction in sediment yield occurred, but there was no effect on surface runoff. Short fibered mulches applied at a rate of 556 Kg ha^{-1} with 278 L ha^{-1} of a soil stabilizer are effective alternative treatments. Three polyvinyl acetate and three acrylic copolymer soil stabilizers were evaluated. The acrylic copolymers were more effective than the polyvinyl acetates at application rates of 562 L ha^{-1} and a 1 to 19 dilution rate. There was little difference between products when applied at 1124 L ha^{-1} and a 1 to 9 dilution rate. All soil stabilizer treatments reduced surface runoff and sediment yield. These results, and evidence from other research, indicate that treatments may increase plant available moisture, reduce moisture loss by evaporation, reduce surface soil temperatures, and reduce seed loss attributed to surface runoff or wind. These factors as well as the erosion control potential of the materials deserve equal consideration when selecting treatments for a specific site or reclamation objective.

INTRODUCTION

On sites disturbed by mining activities, mulches and soil stabilizers may be used to provide temporary site protection and aid vegetation establishment. Each material may be used individually or in combination and at varying rates of application to achieve specific objectives. Knowledge of the characteristics of available materials and their benefits and limitations will permit selection of treatments that mitigate potential environmental problems and enhance the opportunities for successful establishment of vegetation. These choices may be as critical as selecting plant species appropriate for anticipated site conditions.

One important function of mulch and soil stabilizer treatments is to control erosion and reduce sediment yield until an effective vegetative cover becomes established. Soil characteristics and site conditions determine the materials and application rates used. These treatments should be considered an integral part of the erosion control strategy. They will influence the design and capacity of sediment control structures.

Evidence from this study shows that mulch and soil stabilizer treatments will reduce runoff volume. This may determine the design and manage-

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ment of systems that physically control surface flow. In addition, the reduction in surface runoff may provide more plant available moisture. The actual increase will be determined by the materials used and the rate of application.

Some treatments reduce moisture loss by evaporation and modify temperatures at the soil surface. Therefore, selection of treatments that increase plant available moisture and modify the microenvironment may affect seed germination and provide a better opportunity for seedling survival. In some regions, conditions that accelerate germination may allow plants to benefit from seasonal precipitation patterns.

The primary objective of this study was to compare sediment yield and surface runoff from barren soils following 26 mulch and soil stabilizer treatments in a region having 100 to 130 cm of annual precipitation. Observations during the study identified supplemental benefits as well as limitations of the treatments. This information will be useful in selecting treatments appropriate for a specific site or reclamation plan.

METHODS

The basic experimental unit, which will subsequently be referred to as a plot, was a square plywood box having a surface area of 4 square meters and a slope of 10 degrees. Soil depth ranged from 30 to 76 cm. A particle size analysis by sieving air dry soil showed 67 percent of particles were 1/2 mm or less in size.

A row of six plots represented one replication. Each test included three replications of six erosion control treatments. Observation periods ranged from 6 to 8 weeks. This approximates the time required to establish an effective vegetative cover. Precipitation was documented by a recording rain gauge. No vegetation was seeded; all volunteer vegetation was removed when it was very small to avoid disturbance to the treated surface. The plots were essentially free of vegetation at all times. This maximized the impact of each precipitation event and reduced variation that could be attributed to vegetation density and species composition.

A covered gutter at the base of the slope on each plot drained into a 24-L container. Accurate measurement of surface runoff was possible for all but a few high volume storms. Surface runoff from these events exceeded the capacity of the container. Sediment yield represented the oven-dry weight of sediment deposited in the gutter and the sediment carried into the 24-L container by surface runoff. Samples of the runoff water were oven dried to estimate the weight of the sediment deposited in the container. Sediment yield was determined for several precipitation events during each of the 5 tests.

After each test all evidence of the treatment was removed. When required, additional soil was added. The soil was thoroughly scarified with a garden rake immediately before treatment. Mulches were applied by hand or with a 20-L hydromulcher. A 4-L garden sprayer or a 20-L hydromulcher was used to apply the soil stabilizer treatments.

TREATMENTS

Twenty-six erosion control treatments were field tested by this procedure during a 3-year period. This represents five independent tests, each of which compared six erosion control treatments. The treatments utilized long fibered mulches, short fibered mulches, and chemical soil stabilizers individually and in combination. The materials are being used in the region or were effective in previous experiments.

The long fibered mulches included: straw, bark, Verdyol, and compost (table 1). Wood fiber, wood cellulose, paper, Agro-mulch, and seed cleanings were considered short fibered mulches.

Table 1.--Long and short fibered mulches used in this study

Mulch	Commercial name	Description
Straw	--	Baled, wheat straw
Bark	--	Shredded hardwood bark
Verdyol	Verdyol mulch	Chopped straw, paper, and cotton
Compost	--	Municipal waste that was shredded and composted
Wood fiber	Conwed	Processed wood fibers
Wood cellulose	Superior mulch	Reprocessed cardboard
Paper	--	Shredded magazine paper
Agro-mulch	Agro-mulch	Wood chips, shredded paper, and other fibrous waste materials
Seed cleanings	--	Vegetative waste material from a seed cleaning operation, compressed into pellets

The soil stabilizers included polyvinyl acetate emulsions; acrylic copolymers, a byproduct of oil shale processing; and a vegetable gum (table 2). The oil shale recovery product was obtained from the Soviet Union (under a Soviet-American Scientific and Technical Cooperative Study Program). It contains resins from the semicoking of castobioliths, particularly oil shales.

Rates of application for the long and short fibered mulches conformed to the manufacturers recommendations, were consistent with regional practices, or were selected on the basis of past experience (table 3). The straw plus Verdyol treatment in 1977 represents a very intensive treatment that may not be practical for large acreages.

All soil stabilizers except Nerozin were diluted with water and applied as aqueous solutions. In 1978, the soil stabilizers were applied at a rate of 562 L ha^{-1}. The dilution rate was not controlled but was estimated to be 1 part stabilizer to 19 parts water. The stabilizer application rate in 1979 was 1124 L ha^{-1} and, the dilution rate was 1 part stabilizer to 9 parts water. Nerozin was applied undiluted at a rate of 3 mt ha^{-1} in 1978 and 1979. It was heated to permit spraying through conventional equipment.

RESULTS

Surface Runoff

The length and slope of all plots were the same and there was minimal variation in soil texture between plots. Characteristics of each precipitation event determined runoff volume. These include the volume of precipitation, the maximum intensity of the event, the duration of the event, the time interval since the last event, and the volume of the last event.

Each of the erosion control treatments affected the volume of surface runoff. Significant reductions in runoff volume may determine

Table 2.—2-soil stabilizers used in this study

Name	Description	Source
Aerospray 70	Polyvinyl acetate emulsion	American Cyanimid Company
Genaqua 743	Polyvinyl acetate emulsion	Delta Company
Curasol AH	Polyvinyl acetate emulsion	American Hoechst Corporation
Soil Seal	Acrylic copolymer emulsion	Soil Seal Corporation
DLR	Acrylic copolymer emulsion	Rohm and Haas Company
DLR-E	Acrylic copolymer emulsion	Rohm and Haas Company
Nerozin	Oil shale recovery product	Soviet Union
Complex 50	Vegetable gum	Verdyol Corporation

Table 3.—Mulching treatments

Year	Material and rate of application
1977	Straw (2.4 mt ha^{-1}) plus Verdyol mulch (2.2 mt ha^{-1})
	Bark (74 m^3 ha^{-1})
	Compost (2.2 mt ha^{-1})
	Verdyol (2.2 mt ha^{-1}) plus Complex 50 (143 Kg ha^{-1})
	Wood fiber (1112 Kg ha^{-1})
	Wood fiber (556 Kg ha^{-1}) plus Curasol AH (562 L ha^{-1})
1978	Wood fiber (1668 Kg ha^{-1})
	Wood fiber (1112 Kg ha^{-1})
	Wood cellulose (1112 Kg ha^{-1})
	Wood fiber (556 Kg ha^{-1}) plus Aerospray 70 (281 L ha^{-1})
	Paper (1112 Kg ha^{-1})
	Seed cleanings (1112 Kg ha^{-1})
1979	Straw (3.4 mt ha^{-1})
	Verdyol (1112 Kg ha^{-1})
	Wood fiber (1112 Kg ha^{-1})
	Paper (1112 Kg ha^{-1})
	Agro-mulch (1112 Kg ha^{-1})
	Wood fiber (556 Kg ha^{-1}) plus Genaqua 743 (281 L ha^{-1})

plant available moisture and strategies for controlling runoff from the site.

An analysis of variance and Duncan's multiple range test were used to analyze total runoff by treatment for each storm event. Table 4 provides the number, volume, and date of precipitation events during a test period. The date refers to the number of days after the start of the test. A few precipitation events produced large volumes of runoff and the 24-L containers on all treatments overflowed. These were excluded from the surface runoff analyses.

Mulches

1977 test: Significant differences occurred between treatments. This was attributed to the wide range in the physical characteristics of the materials used (table 5). The straw plus Verdyol treatment, which was the most intensive treatment evaluated, had significantly lower runoff than all other treatments. The runoff from the bark plots was significantly lower than compost Verdyol, wood fiber, and wood fiber plus Curasol AH. There were no significant differences in runoff for Verdyol plus Complex 50 and compost. When compared to the treatment with the highest runoff, straw plus Verdyol reduced runoff by 94 percent and bark by 74 percent.

1978 test: There was no significant difference between treatments in the volume of runoff. Similarities in the physical characteristics of these mulchea may have reduced the variation. Wood cellulose and wood fiber plus Aerosol 70 had consistenly lower runoff for all precipitation events. This represented 23 and 32 percent reduction when related to the treatment with the highest runoff.

1979 test: Although the mulches compared in 1979 had a wider variation in physical properties, there was no significant difference in runoff. The lower application rates for straw and Verdyol were more conventional. Straw, Verdyol, and wood fiber plus Genaqua 743 reduced runoff 29, 37, and 42 percent, respectively, when compared to the treatment with highest runoff.

Soil Stabilizers

1978 test: Variations in runoff volume among stabilizer treatments were significant in 1978 when stabilizers were applied at a rate of 562 L ha^{-1} and a 1 to 19 dilution rate. Runoff following the Nerozin treatment was significantly higher than all other treatments (table 6). Aerospray 70, Genaqua 743, and DLR were significantly higher than Soil Seal and DLR-E. A 72 and 79 percent reduction in runoff occurred when Soil Seal and DLR-E were compared to runoff from the Nerozin plots.

1979 test: In 1979, when the stabilizers were applied at 1124 L ha^{-1} and a 1 to 9 dilution rate, there were no significant differences in runoff. DLR-E and Genaqua 743 had the lowest runoff volume and Nerozin the highest. The reduction in runoff volume was 28 percent for both treatments.

Sediment Yield

Erosion occurs when soil particles are dislodged by rainfall impact or surface runoff. The smaller the particles, the more likely they will be dislodged. Transport of these particles in the runoff water continues until a barrier traps the sediment or it is carried into a defined channel. The function of an erosion control treatment is to

Table 4.--Precipitation events and sampling dates for each test period

1977 mulches			1978 mulches			1978 soil stabilizers			1979 mulches			1979 soil stabilizers		
Day	MM*	Sample	Day	MM*	Sample	Day	MM*	Sample	Day	MM*	Sample	Day	MM*	Sample
3	6.8		5	[1]29.8	S	4	9.5		8	[3]36.2	S	1	10.4	S
8	5.7	↓↓	13	3.8	↓	7	28.7	R	15	13.0	RS	5	4.7	↓↓
9	5.8	RS	14	4.0	R	13	14.0	R↓	21	12.8	R	8	5.7	RS
20	4.5		19	3.2	R↓	23	11.8	RS	26	[3]21.5	↓	10	2.2	↓
30	3.5		20	[2]14.4	S	29	3.2		29	[3]15.6	S	11	[3]22.5	S
31	6.0		23	9.5	↓	34	14.0	R	34	5.8	R	13	3.5	R↓
33	5.7		24	6.7	R↓	38	1.8	↓	39	1.2	↓	28	21.4	RS
34	10.6		27	8.2	RS	39	7.0	RS	43	28.5	RS	35	5.8	↓↓
38	9.6		39	3.4		45	[3]24.8					36	9.4	RS
50	12.0	RS				46	4.4	↓						
51	3.5					47	[3]32.3	S						
53	14.3	RS												
54	3.7													
57	4.8													

[1]14 of 18 24-L containers overflowed.
[2]16 of 18 24-L containers overflowed.
[3]All 24-L containers overflowed.

R = Runoff samples collected.
S = Sediment samples collected.
* = Precipitation

Table 5.--Average liters of runoff per plot by treatment and precipitation event--mulching evaluations

Year	Treatment	Sample Number (1)	(2)	(3)	(4)	[1]Total
		----- liters -----				
1977	Straw-Verdyol	1.20	.27	.11		1.58a
	Bark	1.20	5.19	2.42		8.81b
	Compost	1.93	9.35	8.89		20.17c
	Wood fiber	3.26	12.26	17.60		33.12d
	Verdyol + Complex 50	3.29	8.67	4.84		16.80c
	Wood fiber - Curasol AH	5.87	8.18	19.72		33.70d
1978	Wood fiber (1668 Kg ha^{-1})	3.37	.98	17.79	18.77	40.91a
	Wood fiber (1112 Kg ha^{-1})	2.27	1.10	18.77	16.20	38.34a
	Wood cellulose	1.10	.45	16.77	15.37	33.69a
	Wood fiber + Aerospray 70	1.51	.64	16.43	11.43	30.01a
	Paper	4.12	1.93	18.70	18.82	43.57a
	Seed cleanings	3.29	1.74	17.82	17.11	39.96a
1979	Wood fiber + Genaqua 743	6.70	4.13	.02	19.00	29.85a
	Verdyol	10.41	5.94	.06	20.33	36.74a
	Wood fiber	18.02	8.78	2.23	23.13	52.16a
	Paper	11.05	7.27	.02	19.68	38.02a
	Agro-mulch	11.81	9.35	.61	21.95	43.72a
	Straw	8.48	3.18	.02	21.65	33.33a

[1]Totals followed by the same letter are not significantly different.

Table 6.--Average liters of runoff per plot by treatment and precipitation event--soil stabilizers

Year	Treatment	Runoff Sample Number (1)	(2)	(3)	(4)	(5)	[1]Total
		----- liters -----					
1978	Aerospray 70	6.74	1.36	2.57	10.83	2.57	24.07b
	Genaqua 743	2.61	1.74	1.85	8.40	1.63	16.23b
	Soil Seal	2.35	.83	.87	6.81	1.17	12.03c
	DLR	2.95	1.06	1.40	8.97	2.27	16.65b
	DLR-E	1.48	.87	.49	5.45	.83	9.12c
	Nerozin	11.17	2.50	3.56	20.33	5.94	43.50a
1979	Aerospray 70	2.23	6.66	16.05	13.55		38.49a
	Genaqua 743	1.93	7.65	14.65	12.53		36.76a
	Curasol AH	3.44	7.65	14.19	14.95		40.23a
	DLR	4.31	8.14	19.19	19.34		50.98a
	DLR-E	3.75	6.32	13.32	13.44		36.83a
	Nerozin	2.31	8.48	21.65	20.93		53.37a

[1]Totals followed by the same letter are not significantly different.

mitigate rain drop impact, slow runoff, and trap sediment particles.

Sediment yield in this study represents the oven dry weight of sediment collected in the gutters plus estimates of the total sediment in the runoff water. The dates for sediment collection are shown in Table 4. In some cases, this represents more than one storm event. An analysis of variance and Duncan's multiple range test were used to compare sediment yield for treatments evaluated in each of the five tests.

Mulches

1977 test: Significantly lower sediment yields resulted from straw plus Verdyol and bark (table 7). There was no significant difference between compost and Verdyol plus Complex 50. In comparison to the treatment with the highest sediment yield, the straw plus Verdyol and bark treatments represent a 98 and 97 percent reduction. Compost and Verdyol plus Complex 50 represent an 80 percent reduction.

1978 test: Wood fiber at 1668 Kg ha^{-1} and wood fiber plus Aerospray 70 significantly reduced sediment yield. There was no significant difference between wood fiber, wood cellulose, and paper when applied at 1112 Kg ha^{-1}. Wood fiber at 1668 Kg ha^{-1} resulted in a sediment reduction of 77 percent and wood fiber plus Aerospray 70 a reduction of 66 percent when compared to the treatment with the highest sediment yield.

1979 test: There were no significant differences between treatments. Wood fiber plus Genaqua 743 and straw had the lowest sediment yields. The reduction in sediment yield for these two treatments was 54 and 47 percent respectively.

Soil Stabilizers

1978 test: There were no significant differences between treatments (table 8). The acrylic copolymers--Soil Seal, DLR, and DLR-E--were the most effective treatments. In comparison to the treatment having the highest sediment yield, these reduced sediment yield by 63, 63, and 71 percent, respectively.

1979 test: The treatments applied in 1979 had a higher rate of application and a controlled dilution rate. Sediment yield following the Nerozin treatment was significantly higher than all other treatments. When compared to sediment yield following the Nerozin treatment, reductions for the other treatments ranged from 78 to 84 percent; Curasol AH and DLR-E were the most effective.

SUMMARY AND DISCUSSION

The results of this study provide a basis for comparing the effectiveness of several mulch and soil stabilizer treatments in reducing surface runoff and sediment yield. Evidence from previous experience and research was used to identify factors that could contribute to differences between treatments. Since the tests were conducted on plots essentially free of vegetation, no specific conclusions may be made regarding the effect of the treatments on seed germination or seedling survival and growth. However, results from this study and data from similar studies provide evidence that can be used to speculate on potential benefits to plant establishment.

Table 7.--Average kilograms of sediment per plot by treatment and sampling date--mulching evaluations

Year	Treatment	Sediment Yield				
		Sample Number				[1]Total
		(1)	(2)	(3)	(4)	
		- - - - kilograms - - - -				
1977	Straw-Verdyol	.045	.036	.005		.086a
	Bark	.073	.045	.009		.127a
	Compost	.204	.231	.109		.544b
	Wood fiber	.422	2.381	1.170		3.973c
	Verdyol + Complex 50	.245	.272	.027		.544b
	Wood fiber + Curasol AH	.572	2.232	.653		3.457c
1978	Wood fiber (1668 Kg ha^{-1})	3.874	1.751	1.334		6.959b
	Wood fiber (1112 Kg ha^{-1})	8.224	2.708	2.340		13.272b
	Wood cellulose	8.428	3.257	2.123		13.808b
	Wood fiber + Aerospray 70	5.792	2.581	2.096		10.469a
	Paper	9.244	3.438	2.794		15.476b
	Seed cleanings	17.491	7.530	5.484		30.505c
1979	Wood fiber + Genaqua 743	.277	.045	.141	.082	.545a
	Verdyol	.644	.045	.141	.077	.907a
	Wood fiber	.744	.091	.209	.132	1.176a
	Paper	.583	.064	.168	.082	.899a
	Agro-mulch	.717	.059	.227	.109	1.112a
	Straw	.390	.018	.150	.068	.626a

[1]Totals followed by the same letter are not significantly different.

Table 8.--Average kilograms of sediment per plot by treatments and sampling date--soil stabilizers

Year	Treatment	Sediment Yield					[1]Total
		Sample Number					
		(1)	(2)	(3)	(4)	(5)	
		- - - - - kilograms - - - - -					
1978	Aerospray 70	.272	.095	13.767			14.134a
	Genaqua 743	.122	.050	8.904			9.076a
	Soil Seal	.086	.032	5.171			5.289a
	DLR	.100	.063	5.026			5.189a
	DLR-E	.118	.027	3.905			4.050a
	Nerozin	.363	.109	7.625			8.097a
1979	Aerospray 70	.322	.032	.268	.045	.023	.690b
	Genaqua 743	.372	.068	.200	.050	.027	.717b
	Curasol AH	.249	.082	.191	.050	.032	.604b
	DLR	.367	.032	.322	.059	.045	.825b
	DLR-E	.249	.127	.191	.045	.023	.635b
	Nerozin	1.783	.132	1.597	.145	.050	3.707a

[1]Totals followed by the same letter are not significantly different.

The discussion will consider long fibered mulches, short fibered mulches, and soil stabilizers separately. Results from all tests are summarized, comparisons of materials will be noted, and the potential effects on plant establishment are reviewed. Alternatives to improve the effectiveness of the treatments are discussed.

Long Fibered Mulches

Straw, shredded hardwood bark, Verdyol, and composted municipal waste were compared in these tests. These materials were the most effective of all treatments evaluated for reducing surface runoff and sediment yield.

Straw is widely used for site protection and vegetation establishment. In these tests it was applied at a conventional rate (3.4 mt ha^{-1}). Verdyol, a commercial product utilizing chopped straw, paper, and cotton was also evaluated. This material was applied at a minimum rate (1112 Kg ha^{-1}) and at the manufacturers recommended rate (2.2 mt ha^{-1}) with the vegetable gum soil stabilizer, Complex 50. The most intensive treatment tested was Verdyol (2.2 mt ha^{-1}) with a top dressing of straw (2.4 mt ha^{-1}).

The results indicate the straw-Verdyol treatment was the most effective and reduced surface runoff and sediment yield by 90 percent or more. Verdyol mulch with Complex 50 reduced runoff by 50 to 75 percent and sediment yield by 80 percent. Straw at the conventional rate and Verdyol at the minimum rate reduced runoff by 20 to 30 percent. Verdyol reduced sediment yield by 40 to 50 percent and straw by 20 to 30 percent.

All straw and Verdyol treatments effectively mitigate rainfall impact. Therefore, their primary function is to slow runoff and trap sediment. Verdyol may be more effective in trapping sediment under the test conditions as the pieces of straw are smaller, and there is greater probability of the material having intimate contact with soil. The addition of Complex 50 stabilizer contributes a soil binder that apparently increases the resistance of soil particles to movement by surface runoff.

The effectiveness of straw mulches for erosion control may be increased by rolling, crimping, or punching the straw into the soil with specially designed equipment (Kay 1978). This also increases the resistance to movement by wind or surface runoff.

The reduction in runoff does not necessarily mean more moisture is available to plants. The straw absorbs some moisture and the percentage retained increases with an increase in the rate of application and the time interval since the last precipitation event. It is believed, for precipitation events of 10 mm or less, little if any moisture reaches the soil.

Straw retards evaporation and creates a moist microenvironment to aid seed germination (Meyer et al. 1971). There is also evidence that it modifies surface temperature.

Straw and hay provide similar qualities with regard to mulching potential. Straw is often preferred to hay as it usually contains few weed seeds and there is less likelihood of transmitting disease. An advantage in using hay is the seed of desirable plant species contributed by the mulch. This is particularly important in the Western United States where wild-grass hay may be used when the seeds are ripe but not shattered (Kay 1978).

There are reports that hay and straw mulches provide habitat for rodents. These mammals may utilize seeded or planted vegetation as a food source. It is possible they would cause extensive damage. This is particularly true for planted tree and shrub seedlings.

Shredded hardwood bark was not as effective as the straw-Verdyol treatment but more effective than the Verdyol-Complex 50 and composted municipal waste treatments. Bark reduced runoff by 75 percent and sediment yield by 97 percent. The 74 m ha^{-1} rate of application is recommended for regions with high annual rainfall (Vogel 1981). Volumetric rates of application are preferred as the moisture content of bark is extremely variable and applications by weight may not provide reproducible soil coverage.

Shredded hardwood bark is preferred to wood chips or pine bark. The variable size of the bark fragments, its stringy characteristics, and the bristly edges contribute to its effectiveness (Yocum et al. 1971). The density or weight of the material is also important. Wood chips and pine bark are lighter and tend to float in surface runoff or are blown by wind (Vogel 1981). No mechanical treatments are required to assure hardwood bark is in intimate contact with the soil.

Bark itself will mitigate rainfall impact but the variability in fragment size may not provide uniform coverage of the soil surface. The material is effective in slowing runoff and trapping sediment particles.

The physical properties of the hardwood bark indicate it would absorb less moisture than straw during a precipitation event. Therefore, a higher percentage of the water retained on the site will be available for plant use. There is evidence bark reduces moisture loss by evaporation and modifies surface temperature (Graves and Carpenter 1979). Research has shown no risk to plants from bark leachate for the more common hardwood species (Plass 1978).

Denitrification, caused by micro-organisms associated with the decomposition of wood, may occur when a high percentage of the bark mulch is sawdust or other small wood particles. This nutrient deficiency may be corrected by applications of nitrogen fertilizer.

Composted municipal waste was the least effective of the long fibered mulches. This treatment reduced surface runoff by 40 percent and sediment yield by 50 percent. The 2.2 mt ha^{-1} application is adequate but higher rates may be more effective.

Composted municipal waste has a high percentage of wood cellulose from paper and cardboard waste. It may also contain fragments of glass, plastic, wood, and metal. This material before application has a light, fluffy appearance and a low moisture content. Conventional spreaders or blowers could be used to apply the mulch. The exclusion of industrial wastes from the raw material reduces the risks of plant toxicity.

Composted municipal waste will mitigate rainfall impact to some degree. The reductions in surface runoff and sediment yield indicate moderate effectiveness in slowing runoff and trapping sediment. The variation in the size of particles in this material may contribute to its effectiveness for erosion control.

Benefits to seed germination and plant survival would occur from a reduction in moisture loss by evaporation and modification of surface soil temperatures. The nutritive value of any organic materials in the waste probably are so low there would be little or no benefits to plants.

Short Fibered Mulches

The materials used in these tests included: wood fiber, wood cellulose, shredded paper, Agro-mulch, and pelleted seed screenings. All are applied by hydromulching.

The 1978 tests permit comparisons between four products when applied at 1112 Kg ha^{-1}. Pelleted seed cleanings were the least effective. This material has very small particles and after the pellets dissolve there is little chemical or physical cohesion. The effect of wood fiber, wood cellulose, and shredded paper on surface runoff was minimal. However, all three products reduced sediment yield by about 50 percent when compared to the results for pelleted seed cleanings.

The 1979 test used the same application rate and compared wood fiber, shredded paper, and Agro-mulch. In comparison to the long fibered mulches, Verdyol and straw, all short fiber treatments had higher surface runoff and sediment yields.

The evidence from these tests shows wood fiber, wood cellulose, shredded paper, and Agro-mulch, when applied at a rate of 1112 Kg ha^{-1} reduce sediment yield but have minimal effect on runoff. There appears to be little difference between products. When the rate of application for wood fiber is increased to 1668 Kg ha^{-1}, a reduction in sediment yield occurs but there is no apparent effect on surface runoff. In all tests, the long fibered mulches were more effective than any short fibered mulch treatment in reducing surface runoff and sediment yield.

Treatments combining wood fiber and a soil stabilizer are promising alternatives. Wood fiber was applied at a rate of 556 Kg ha^{-1} with 281 L ha^{-1} of a stabilizer in 1978 and 1979. In both cases, surface runoff and sediment yield were reduced. The results in 1979 were comparable to those for straw or Verdyol.

The short fibered mulches apparently provide little resistance to rain drop impact and surface runoff. After a rainfall, ridges of mulch developed where runoff carried the mulch to an obstruction. This creates an uneven distribution of mulch and some areas may be unprotected. Failure of the short fibered mulches to reduce runoff suggest these fibers may reduce soil porosity and restrict infiltration. Their ability to trap sediment is improved when the rate of application is increased from 1112 Kg ha^{-1} to 1668 Kg ha^{-1}. The addition of a soil stabilizer glues the fibers together, binds the fibers to the soil, and provides greater cohesion between soil particles.

When seed is applied with the short fibered mulches, some become entangled in the fibers and may be suspended above the soil. The wide variations in moisture and temperature that occur in the web of mulch may prevent germination or kill the emerging seedling (Plass 1978). An alternative is to sow the seed then apply the mulch.

Chemical Soil Stabilizers

A number of soil stabilizers have been evaluated. The polyvinyl acetates and acrylic copolymers are considered the most effective. In these tests, Complex 50 was effective while Nerozin was not. Laboratory and greenhouse tests showed no adverse effects on seed germination or plant growth (U.S. Department of Interior 1982). All treatments used in these tests were effective for 8 weeks, and the crusts displayed minimum breakdown at the end of the test periods. Laboratory tests have shown stabilizers are most effective on sandy soils and a decrease in soil particle size reduces their effectiveness (U.S. Department of Interior 1982). The high percentage of small sized particles in the test soils indicates less than optimum conditions for soil stabilizer use.

All treatments using the polyvinyl acetates and acrylic copolymers reduce sediment yield and surface runoff. When these stabilizers were applied at 562 L ha^{-1} and a 1 to 19 dilution rate, the acrylic copolymers were more effective than the polyvinyl acetate emulsions. Rates of 1124 L ha^{-1} and a 1 to 9 dilution rate reduced the variation between treatments. Reductions in surface runoff varied by treatment and ranged from 28 to 79 percent. Less variation occurred for sediment yield as the percentage reduction ranged from 63 to 84 percent.

Since the crust formed by the stabilizer retains little if any moisture, any reduction in surface runoff will increase plant available moisture. This is particularly important for low volume precipitation events. It is believed chemical soil stabilizers maintain soil porosity during precipitation events by binding the soil particles together (Buxton et al. 1979). On untreated soils, particles detached by rain drop impact and surface runoff fill pores, restrict infiltration, and cause surface runoff (Hendrickson) 1938).

Increases in soil moisture will benefit germination and plant growth. There is also evidence soil stabilizer treatments reduce moisture loss by evaporation (U.S. Department of Interior 1982). These treatments probably have little effect on soil temperature. Seed loss, by wind or water movement, will be reduced as the soil stabilizer glues the seed to the soil surface (Plass 1978).

All of the soil stabilizers used in this study, except Nerozin, may be used with the long and short fibered mulches. The polyvinyl acetate and the acrylic copolymers are effective at a rate of 281 L ha^{-1}. Complex 50 should be applied at a rate of 143 Kg ha^{-1}. When used with a soil stabilizer, the short fibered mulches are effective at 561 Kg ha^{-1}. Soil stabilizers may be used at similar rates as tackifiers for all long fibered mulches except shredded hardwood bark. The tackifier is applied after the long fibered mulch is in place. Soil stabilizers bind the mulch fibers together and anchor them to the soil. This reduces the potential for movement by surface runoff and wind. The stabilizer reaching the soil tends to bind the soil particles together, retains soil porosity, and increases the resistance of soil particles to movement by surface runoff and wind.

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