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Response of Vegetation to Various Mulches Used in Surface Mine Reclamation in Alabama and Kentucky— 7-Year Case History

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Abstract

Five different mulches and one mulch-amendment combination were evaluated in the reclamation of two different mine spoils, one in western Kentucky and one in northern Alabama. The treatments evaluated were bark, hardwood chips, straw, hay, hydromulch, and hydromulch plus Petroset SB emulsion. Test plots, approximately 1 acre, were instrumented with flumes to monitor discharge, erosion transects to measure erosion, suction lysimeters for sampling groundwater, and devices to sample the runoff water. In the first years of the study, bark, hay, and straw generally produced the best vegetative cover. Mulches high in biomass tended to favor the establishment of legumes over grass. After 7 years, the effects of the different mulch treatments were readily apparent at the Alabama site where the hardwood-chip plot had strikingly superior cover. Differences were not so apparent at the Kentucky site.

Acknowledgments

This study would not have been possible without the cooperation and support of the coal companies that made land available for the study sites and loaned heavy equipment and operators to smooth the plots and form the berms, and in one instance supplied the fertilizer. Cooperators at the Fabius Mine in northern Alabama were Robertson and Associates and the Tennessee Valley Authority. The cooperator in western Kentucky was the Amax Coal Company at the Ayrgem Mine.

Introduction

About 200 thousand acres in the United States are disturbed by surface mining each year. All of this disturbed land is at least temporarily bare of vegetation and exposed to erosion. Miners are now required to reclaim and revegetate the land they have disturbed. Mulches and/or chemical stabilizers or adhesives are frequently applied to the spoil surface to help reduce erosion and to speed the revegetation process. Mulches and soil stabilizers generally are considered useful in spoil reclamation; however, the true value and long-term effects on different spoils and under different conditions of slope, aspect, and climate have not been investigated extensively. In this study we evaluated the long-term effects of six mulches (bark, wood chips, straw, hay, hydromulch, and Petroset plus hydromulch) on growth of selected grasses and legumes and on runoff and erosion from approximately 1-acre plots on two highly different types of spoils.

Experimental Design

In the spring of 1976, two research sites were established: the Fabius site in northern Alabama and the Ayrgem site in western Kentucky (Fig. 1). The spoil at the Ayrgem site was a gravelly sandy loam to sandy loam and at the Fabius site was a very gravelly borderline sandy loam to loam. At each site seven mulch plots, each approximately 1 acre, were delineated. Table 1 gives the plot treatment, slope, length, LS factor, and aspect. Berms were constructed to separate the plots and to direct runoff water into flumes instrumented with continuous discharge recorders and automatic water-sampling devices. Four suction lysimeters were installed on each plot so water for chemical analysis could be extracted periodically from the spoil at a depth of about 24 inches. Fifteen erosion transects, 48 inches across, of the type described by Curtis and Cole (1972) were installed on each plot in five rows of three with each row offset so that no gully would cross more than one transect.

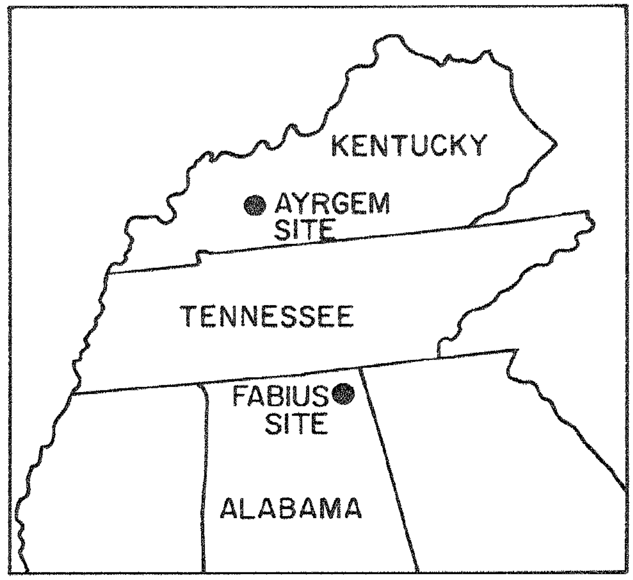

Figure 1.—Map showing site locations.

Table 1.—Plot treatment, slope, length, LS factor, and aspect

Treatment[a]	Slope	Length of plots	LS[b] factor	Aspect[c]
	Percent	*Feet*		*Degrees*
		AYRGEM		
Petroset	12.8	400	4.00	48
Chips	12.6	400	3.90	48
Straw	12.3	400	3.76	48
Control	11.7	405	3.49	49
Hydromulch	12.3	415	3.83	47
Bark	11.4	410	3.38	46
Hay	12.3	390	3.71	46
		FABIUS		
Petroset	13.2	322	3.77	326
Chips	13.2	290	3.58	328
Straw	16.7	278	5.14	332
Control	17.6	286	5.69	335
Hydromulch	15.8	296	4.84	337
Bark	10.7	306	2.65	339
Hay	14.6	266	4.03	318

[a]Plot sequence is from left to right when viewed looking uphill.

[b]Computed product of slope (L) and gradient (S) from Wischmeier and Smith (1965, p. 9) using the equation $LS = \sqrt{\lambda}\,(0.0076 + 0.0053s + 0.0076s^2)$ wherein λ is the field slope length in feet, and s is the gradient expressed as slope percent. The LS factors presented here indicate the computed ratio of plot erodibility to that of a "standard" plot 72.6 feet long with a 9% slope.

[c]Aspect is viewed looking downslope from top of plots to the bottom.

Table 2.—Vegetative yields from the Ayrgem and Fabius sites, 1979, 1980, and 1982, in pounds per acre (dry matter)

Treatment	Grass + Legumes			Grass			Legumes		
	1979	1980	1982	1979	1980	1982	1979	1980	1982
				AYRGEM					
Petroset	4,810	5,080	12,970	—	220	540	—	4,860	12,420
Chips	4,510	5,130	9,590	—	750	610	—	4,380	8,990
Straw	4,960	6,170	12,740	—	100	400	—	6,060	12,340
Control	4,090	5,470	14,020	—	300	550	—	5,160	13,480
Hydromulch	5,330	6,020	14,430	—	730	1,020	—	5,290	13,410
Bark	5,030	7,470	9,420	—	1,310	1,230	—	6,170	8,200
Hay	4,580	6,640	9,040	—	610	910	—	6,030	8,130
				FABIUS					
Petroset	4,140	—	8,060	3,070	—	2,160	1,080	—	5,980
Chips	6,180	—	23,100	210	—	40	5,970	—	23,060
Straw	2,540	—	8,290	350	—	940	2,200	—	7,350
Control	3,100	—	11,670	2,540	—	1,740	560	—	9,920
Hydromulch	4,000	—	14,920	1,640	—	990	2,360	—	13,940
Bark	4,450	—	21,980	2,220	—	190	2,230	—	21,790
Hay	8,650	—	18,270	1,310	—	410	7,340	—	17,860

Third season. Live vegetative cover was down severely the third year compared to the second-year cover on most plots partly because the legumes had lost most of their leaves just before measurement either from frost or drought. Nevertheless, vegetative cover increased on the control and Petroset plots. Despite this partial leaf loss, the legumes were still strongly predominant on all plots. If all litter, including mulch on the ground, was counted as a part of the total cover, then it is evident that the spoil surface is largely protected on all sites and ranged from 97 percent cover for the bark mulch to a minimum of 56 percent for the chip mulch.

Fourth season. Live cover was nearly double what it had been at the end of the third season. Legumes were still strongly predominant on all plots. There were no important differences in legume cover or total yields attributable to the mulches applied to any of the seven plots. The hydromulch, hay, and Petroset plots had appreciably more grass cover than the remaining plots.

Fifth season. Legumes were strongly predominant on all plots. There was no appreciable difference in the legume harvest between plots, but the grass harvest was nearly thirteenfold higher on the bark plot than on the straw plot. The total vegetation harvested ranged from 6 to 48 percent greater than the year before on all treatments.

Sixth season. No observations were made.

Seventh season. Legumes were still strongly predominant on all plots. Neither grass nor legume harvests were appreciably different on any of the seven plots. The total vegetation harvested in this seventh season (1982) ranged from 26 to 156 percent greater than that harvested in the fifth season. Grass yields were slightly higher in 1982 on the chip and bark plots than they had been in 1980, but had declined appreciably on the remaining five plots during the same interim.

Fabius Site

First season. Total vegetative growth was best on the hay plot (61 percent live cover), the bark plot (41 percent), and the straw plot (36 percent). Live cover on the chip, Petroset, hydromulch, and control plots was 25, 19, 19, and 16 percent, respectively. Legumes accounted for less than 12 percent of the live cover on all plots, but were most in evidence on the hay and bark plots.

Second season. Live vegetative cover increased through the second season on all except the straw plot where it decreased from 36 to 7 percent. The decline in live vegetation on the straw plot can be attributed to the wheat seed contained in the straw mulch. This seed germinated ahead of the planted seeds and produced a quick-growing lush cover that crowded out the seeded species. This dense cover of wheat died having produced little or no seed. Almost none of the planted seeds ever produced viable plants so the straw plot remained almost void of living vegetation, but with an even heavier accumulation of straw mulch than had initially been applied. At the end of the second season, grass was still the predominant vegetation on all plots, though legumes had increased appreciably on the bark and hay plots.

Third season. By the end of the third season, the bark, hay, and chip plots had the heaviest live cover (58, 55, and 52 percent, respectively). Live cover had increased on all except the hay and bark plots, both of which decreased from the previous season. The chip and straw plots both showed remarkable increases in live cover over the previous season, in both cases an increase almost totally attributable to the sudden establishment of a good stand of legumes which now was the dominant vegetation, 94 and 79 percent, respectively, of the total live cover. The other five plots were still predominantly grass, though the hay plot showed an appreciable legume concentration (47 percent of the live cover). The steep decline in grass on the chip and hay plots may have been caused by competition from the decomposers for the available nitrogen.

Fourth season. There was no appreciable change in grass cover on any of the seven plots during the fourth season, but legume cover increased markedly on all plots. Legumes predominated on five of the plots by the end of this season: 97 percent of the vegetative cover on the chip plot, 89 percent on the straw, 71 percent on the hay, 66 percent on the hydromulch, and 51 percent on the Petroset plots. Total yields and cover were highest on the hay plot.

Fifth and sixth seasons. No observations were made.

Seventh season. Legumes strongly predominated on all plots at Fabius by the end of the seventh season (1982). Legumes as a percent of total yield increased on all plots over that recorded for the fourth season and ranged from 72 percent on the Petroset plot to essentially 100 percent on the chip plot. The grass yield was lower than it had been 3 years earlier on all except the straw plot.

Erosion and Transport of Suspended Solids

Erosion on the study plots was evaluated for a period of about a year and a half starting in the spring of 1976. The two methods of evaluation were: (1) erosion transect measurements, and (2) suspended solids measured in the runoff water.

In theory, the erosion transects should give a direct measurement of erosion from each plot. The data obtained from these transects are presented in Table 3 and seem to indicate that they sometimes measured something other than erosion. At both sites, the control had the most erosion as indicated by the transect measurements as would be expected. During measurements it was noted that the metal measuring pins frequently rested on clumps of sod, so did not penetrate all the way to the ground, thus sometimes causing the appearance of deposition when none had occurred.

Table 3.—Erosion as indicated by erosion transects and by suspended solids in surface runoff

Mulch[a]	Change in surface elevation[b]		Suspended solids[c]		Theoretical[d] suspended solids on standard plot	
	mm	*Rank*[e]	*mg/l*	*Rank*	*mg/l*	*Rank*
			AYRGEM			
Petroset	−7.8	6	2,334	4	584	3
Chips	−1.1	3	3,422	5	877	5
Straw	−0.7	1	4,225	7	1,124	7
Control	−12.3	7	1,765	2	506	2
Hydromulch	−0.9	2	3,612	6	943	6
Bark	−5.6	5	2,066	3	611	4
Hay	−2.6	4	1,681	1	453	1
			FABIUS			
Petroset	−5.4	6	8,834	5	2,343	6
Chips	−2.9	4	5,212	3	1,456	3
Straw	−2.1	3	1,178	2	229	2
Control	−10.3	7	9,257	6	1,627	4
Hydromulch	−3.9	5	13,280	7	2,744	7
Bark	+4.9	1	5,572	4	2,103	5
Hay	−0.5	2	868	1	215	1

[a]Mulches are listed in sequence from left to right, looking uphill.

[b]Change in surface elevation relative to tops of erosion transect posts driven into the spoil. Negative values indicate erosion, positive values indicate deposition, swelling of spoil, or settling of the erosion transect posts into the spoil. These elevation changes are for the period May 19, 1976, to October 5, 1977, at Ayrgem and May 27, 1976, to May 3, 1977, at Fabius.

[c]Suspended solids samples were effluent from small holes drilled in the side of each flume. These outlets were at elevations of 1-3/8, 2-3/8, 6, and 12 inches from the bottom of the flume. Suspended solids values presented here are average values for samples taken at all outlets during the major floods from August 4, 1976, to September 13, 1977, (2 to 8 samples per flume). Suspended solids concentrations averaged about the same from the four outlets at each flume.

[d]Theoretical suspended solids that would have been found on a "standard" 9% slope, 72.6 feet in length. The adjustment to standard slope was made by dividing the measured suspended solids concentration by the LS factor in table 1. It is assumed that the ratio of suspended solids to erosion would remain the same on "standard" slopes as that observed for actual slopes—a rather debatable assumption.

[e]Ranked in order of increasing erosion or suspended solids.

The suspended solids content of water samples collected at the flumes was determined and should provide an independent, though indirect, measure of the relative rates of erosion on each plot. Average suspended solids concentrations are given in Table 3 and were collected in accordance with the procedure described in Table 3, footnote c.

Slope and length of plot vary enough to significantly affect erosion and, in turn, the suspended solids concentrations that were measured during the course of this study. If it is assumed that the suspended solids concentrations observed in runoff water are proportional to erosion on the watershed (not a completely valid assumption), then it is possible to adjust the observed suspended solids concentrations to what should have been present from plots of uniform slope and length. Using methods described by Wischmeyer and Smith (1965, p. 9), we corrected the observed suspended solids concentrations using the LS factors (Table 1) to give the theoretical concentrations shown in Table 3 to be expected from a "standard plot" 72.6 feet in length with a 9-percent slope.

At the Ayrgem site, the erosion transects indicated that the least erosion was on the straw, hydromulch, and chip plots, while the unadjusted suspended solids data indicated the least erosion had been on the hay, control, and bark plots—or almost the reverse. Erosion deduced from the theoretical suspended solids concentrations expected on standard plots would have this same ranking, except that Petroset would replace the bark for third place. We believe that the suspended solids data are a better measure of erosion than the erosion transect data; but erosion as measured at the Ayrgem site by either of these methods cannot be explained in terms of physical characteristics of the mulches. However, the relatively dense vegetation on the bark and hay plots in 1976 and 1977 could account for the lower levels of suspended solids concentrations observed on these plots.

At the Fabius site the erosion transects showed an average of 4.9 mm deposition (or growth of sod) on the bark plot, while the hay, straw, and chip plots showed the least measured erosion. The unadjusted suspended solids data indicated that the least erosion was on the hay, straw, chip, and bark plots—pretty much in agreement with the erosion transect measurements, and in accord with what would be expected from erosion reducing mulches. Erosion deduced from the theoretical suspended solid concentrations expected on standard plots would have this same ranking except that the control would replace bark for fourth place.

Discussion

The response to a given mulch was not uniform from site to site. Numerous factors can contribute to this. In essentially all situations it seems likely that mulches help control erosion. In most instances, mulches help establish vegetation, but mulches can hinder, or even prevent vegetative growth. A discussion of the more important variables affecting mulch responses follows.

Variations Within a Given Mulch

Some mulches such as hydromulch may be uniform everywhere, yet most will vary greatly according to source. Bark, wood chips, and leaves can be from either hardwood trees or softwood trees, and they can be from either one tree species or from a mix of numerous tree species. Bark, wood chips, and leaves from some trees such as walnut may contain phytotoxic substances that actually repress plant growth. Allison and others (1963) found that finely ground wood or bark from 6 of the 28 species tested exhibited some degree of toxicity to garden peas. It is believed that the bark used at the Fabius site was predominantly softwood (conifer), while that used at the Ayrgem site was predominantly hardwood. Hardwood chips were used on both sites.

Hay used for mulch in the study area is usually a tall fescue hay that often contains mature seed of fescue and possibly some legume and weed seed. Seed from the hay would add to that which was deliberately sown and may account for the especially dense stand of fescue that quickly became established on the hay plot at the Fabius site.

The wheat straw used at the Fabius site contained much seed that produced plants that almost totally crowded out those that were deliberately seeded to reclaim the spoil.

Weathering of Mulch Materials

Fresh mulch materials may have different effects from mulches that are allowed to weather or age for a year or two prior to application. The weathering of mulch materials may cause partial decomposition and thus reduce their erosion retarding properties somewhat, but at the same time, it may reduce nutrient demand from the mulch material or promote release of nutrients from the mulch, thus improving the value of the mulch to growing vegetation. Weathering may gradually leach away any toxic components that may be in the mulch. Weathering also will likely reduce viability of seeds contained in the mulch materials. Wood bark used at Fabius had weathered only a few months, while that used at Ayrgem had been exposed at a dump for more than a year. Straw and hay had weathered in the bales for only a few months at both sites. Wood chips were applied the day they were chipped at the Ayrgem site, and were only a few days old when applied at the Fabius site.

Time of Application of Mulch and Seed

The effects of mulches on growth of vegetation may vary according to the season of seeding and time of mulch application relative to the date of seeding. Mulches tend to conserve moisture in the soil and to prevent extremes of temperature in the soil. Consequently, plants seeded in the hot or dry season are likely to benefit more from mulches than those seeded in a cool or moist season. Mulches applied in a cool or moist season may hinder the establishment of vegetation, though there is no evidence they did so at either of the sites investigated in this study.

Mulches were applied from 1 to 23 days after seeding in this study, and germination of seeds may have been different had each mulch been applied at a different time. Most seeds should have germinated by the time the bark and chips were applied to the Ayrgem plots 23 days after seeding, so only a post-germination effect due to these mulches could be observed. At Fabius, bark and chips were applied the day after seeding, so both pre- and post-germination effects of these mulches should have been observed here. Jim Powell[3] surmises that the natural organic substances produced by bark or wood chips will scarify the seeds of hard seeded legumes such as the lespedezas, thus speeding up their germination. Therefore, at Fabius we may be observing the chemical effects as well as physical effects of these mulches.

[3]Jim Powell, Peabody Coal Co., Greenville, Kentucky. Personal communication August 4, 1983.

Effect of Applied Fertilizers on Observed Plant Growth

The initial heavy application of nitrogen fertilizer would be expected to favor growth of grasses over legumes. After a year or two when the nitrogen is leached from the spoil or tied up in organic material, legumes, because of their ability to supply their own nitrogen, would have a distinct advantage over the grasses. The first year's growth on all plots at the Fabius site and on three plots at the Ayrgem site was predominantly grass as had been expected. Grasses still predominated at all Fabius plots the second year. Legumes predominated the first year on four of the Ayrgem plots; namely, bark, chips, straw, and hay—those with the greatest mass of added organic materials. These four mulches not only seemed to retard the growth of grasses, perhaps by competing for nutrients as discussed in the next section, but they also generally promoted a growth of legumes more than adequate to compensate for any possible suppression of grasses.

Demand of Mulch Decomposers for Nutrients

All organic mulch materials will eventually decompose, and as they do so, the microorganisms that digest them extract nutrients from the spoils they contact. Partially decomposed mulches and coarse textured mulches are likely to be less demanding of nutrients than are unweathered or finely divided mulches. Mulch-decomposing bacteria demand nutrients, especially nitrogen, and are in direct competition with growing plants; and plant growth may be severely retarded by this competition. In the reclamation of mine spoils, it is common practice to apply enough fertilizer to supply the needs of growing plants for the first year or two, but not necessarily enough for the needs of mulch-decomposing bacteria. Eventually a shortage of nitrogen is likely to develop on spoils that are being mulched during reclamation, unless they have been seeded to nitrogen fixing legumes. At the Fabius site, a severe shortage of nitrogen seems to have developed on the woodchip and straw plots by the third year. This may account, at least in part, for the great increase in legume cover on these sites during the third year and the relative or absolute decline in grass cover.

Aspect

The potential value of a given mulch depends greatly on the aspect of the slope to which it is applied. A slope facing south or west is much more likely to benefit from the cooling and moisture retaining characteristics of a mulch than one facing north or east. The greater insolation on southerly and westerly slopes generates higher soil temperatures and causes the slopes to be much more droughty. A heavy mulch applied to a northerly or easterly slope may retard the establishment of vegetation, especially during the cooler or damper months.

The aspect of each plot is given in Table 1. The Ayrgem plots slope in a northeasterly direction; nevertheless, mulches still had a beneficial effect at this location because the Ayrgem spoils were very sandy and tended to be droughty. They were seeded late enough in the season for moisture to be less than optimum, so the moisture conserved by the mulches was beneficial in establishing a good plant cover.

The Fabius plots face west toward a high wall that shields the lower portions of the plots from the full effect of the late evening sun. Mulches at Fabius had a beneficial effect.

Spoil Physical Characteristics

Data on particle-size distribution, spoil texture, and moisture retention characteristics are given in Table 4. Despite the striking differences in available water, Figure 2 and Table 2 show that overall vegetative growth was similar at the Ayrgem and Fabius sites. The Ayrgem spoils perhaps compensated for the lower percentage of available water with a deeper root zone and greater permeability. The greater percentage of coarse fragments in the Fabius spoil would also have been a compensating factor.

Spoil Chemical Characteristics

A summary of selected spoil chemical characteristics is given in Table 5 for the years 1976, 1977, and 1982–83. Specific conductance and sulfate measurements indicate that both the Ayrgem and Fabius sites contain relatively low and decreasing concentrations of dissolved solids.

Median pH values (from Table 5) of all seven plots at the Ayrgem site averaged 6.9 in all three sets of spoil samples. Median pH values from the Fabius site averaged 5.0, 4.8, and 5.3, respectively, for the 1976, 1977, and 1982 spoil samples. The pH shifts over time in the Fabius spoil cannot be readily explained, but may be attributable largely to the difficulty in obtaining samples fully representative of these highly variable spoils. After almost 7 years, the chip plot at Fabius had the highest biomass as shown in Table 2; yet, it had one of the lowest pH levels (Table 5), a pH that in agronomic circles is considered just barely adequate for good plant growth. Data in Table 5 indicate that appreciable increases in exchangeable acidity and exchangeable aluminum occurred on the Fabius plots between 1977 and 1982 and that the site might benefit from a light application of lime.

Table 4.—Summary of spoil texture, particle-size distribution, and moisture retention characteristics at 0-6 inch depth, 1982-1983 samples, in percent

Treatment[a]	Coarse fragments	Particle-size distribution of soil fraction			Spoil texture	Moisture retention by soil fraction		Available water in soil fraction[b]
		Sand	Silt	Clay		⅓ bar	15 bars	
					AYRGEM			
Petroset	21	82	12	6	Gravelly sandy loam	8	2	6
Chips	20	81	13	6	Gravelly sandy loam	8	2	6
Straw	16	82	12	6	Gravelly sandy loam	8	2	6
Control	25	80	12	8	Gravelly sandy loam	8	2	6
Hydromulch	19	82	11	7	Gravelly sandy loam	8	2	6
Bark	10	84	11	5	Sandy loam	7	2	5
Hay	16	82	11	7	Gravelly sandy loam	8	2	6
					FABIUS			
Petroset	38	58	33	9	Very gravelly sandy loam	20	7	13
Chips	38	58	31	11	Very gravelly sandy loam	18	9	9
Straw	40	54	35	11	Very gravelly sandy loam	18	7	11
Control	45	52	35	13	Very gravelly sandy loam-loam	17	7	10
Hydromulch	40	52	37	11	Very gravelly sandy loam-loam	18	8	10
Bark	36	55	34	11	Very gravelly sandy loam	21	8	13
Hay	47	48	39	13	Very gravelly loam	18	7	11

[a]Plot sequence is from left to right when viewed looking uphill.
[b]Water available for plant use was assumed to be equal to the difference in moisture retained at ⅓ bar and at 15 bars pressure.

Table 5.—Summary of spoil chemical characteristics at 0-6 inch depth: March to April 1976; August 1977; October 1982 to March 1983

Treatment	Median pH[a]			pH[a] extremes Low			pH[a] extremes High			Mean specific conductivity[a]			Mean sulfate[b]			Mean exchangeable acidity			Mean exchangeable aluminum		
	1976	1977	1982-83	1976	1977	1982-83	1976	1977	1982-83	1976	1977	1982-83	1976	1977	1982-83	1976	1977	1982-83	1976	1977	1982-83
										micromhos/cm			*mg/kg*			*me/100 g*			*me/100 g*		
AYRGEM																					
Petroset	7.4	7.7	7.4	6.2	5.9	7.1	8.1	8.5	7.7	337	251	204	160	184	108	0.2	0.2	0.0	0.0	0.0	0.0
Chips	6.2	5.6	6.65	4.6	3.8	4.0	7.3	7.9	6.8	724	484	208	695	855	110	.3	.4	.8	.0	.1	.3
Straw	6.9	7.1	7.2	4.7	4.0	7.2	7.4	8.1	7.2	596	475	190	478	318	111	.2	.4	.0	.0	.1	.0
Control	7.2	7.65	7.0	6.5	5.1	6.1	8.0	8.2	7.1	768	403	367	675	490	157	.3	.3	.2	.0	.0	.0
Hydromulch	6.45	6.2	6.7	4.9	4.4	6.2	7.9	8.2	7.1	709	434	216	692	479	119	.2	.2	.0	.0	.0	.0
Bark	7.25	7.55	6.8	3.4	4.3	6.4	8.0	8.2	7.8	561	275	207	597	275	125	.2	.3	.3	.0	.0	.0
Hay	6.6	6.7	6.4	3.9	3.6	5.5	8.2	8.4	6.5	343	146	114	283	132	113	.2	.4	.8	.1	.2	.1
FABIUS																					
Petroset	5.2	4.95	5.0	4.7	3.9	4.6	5.9	6.3	5.0	305	292	102	323	334	112	0.4	0.1	1.6	0.0	0.0	0.6
Chips	5.0	4.6	4.8	4.6	3.7	4.7	5.7	5.2	5.1	182	263	208	238	333	122	.5	.2	1.8	.2	.0	.4
Straw	5.15	4.6	4.6	4.8	3.8	4.5	6.2	5.2	4.7	207	213	159	218	184	104	.4	.3	1.9	.1	.0	.8
Control	5.0	4.75	5.0	4.3	3.9	4.6	5.9	5.1	5.0	277	222	154	305	259	99	.6	.1	1.5	.2	.0	.5
Hydromulch	5.5	4.85	5.1	5.1	4.3	5.0	6.2	6.0	5.3	243	286	167	253	361	117	.3	.1	1.1	.0	.0	.2
Bark	5.7	5.1	5.3	5.2	3.6	5.3	6.3	6.3	5.3	343	170	166	342	237	104	.2	.2	1.0	.0	.0	.2
Hay	5.5	4.9	5.2	4.6	4.0	4.9	7.0	5.9	5.6	237	190	224	305	232	126	.4	.2	.8	.1	.0	.2

[a]Determined on 1:2 spoil to water extracts (air-dry basis).
[b]Determined on 1:10 spoil to water extracts.

Conclusions

1. In general, bark mulch was the most satisfactory of the six mulches and hay mulch followed closely. Petroset and hydromulch plots generally differed little from the control.
2. No one mulch is best for all spoils and for all purposes.
3. The great variability within certain types of mulch materials such as straw, hay, leaves, and wood bark must be taken into consideration when selecting a mulch.
4. An inappropriate mulch may have negative effects on some or all forms of vegetation.
5. The use of mulches high in organic matter such as bark, chips, hay, and straw tends to encourage the growth of legumes more than grasses.

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