A Review of Mulches to Control Wind Erosion

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ABSTRACT

THE need to increase food production and improve the quality of our environment has prompted a search for materials to control wind and water erosion. This paper is a review of research and development associated with application, methods, and amounts of mulch types—crop residues, chemical soil stabilizers, and feedlot wastes (manure)—required to control wind erosion. An effective wind erosion control treatment is one that can resist a 38.0 m/s wind as measured at 15.2 m.

Any crop residue, either grown in place or hauled in and spread, can control wind erosion. Hauled-in residues must be spread and anchored to the soil surface by a packer or an anchoring agent, i.e., cutback asphalt or asphalt emulsion. Depending on residue type, minimum amounts needed to control wind erosion are 4.5 to 11 t/ha. Chemical soil stabilizers, i.e., asphalt, polyvinyl alcohol, styrene-butadiene latex emulsions, and resins-in-water emulsions control wind erosion effectively if properly diluted and applied to cover the total soil surface at volumes of at least 3785 L/ha. Wet feedlot manure applied to a highly-erodible sand controlled erosion with 31.8 t/ha surface-applied or 52.3 t/ha tilled-in with a tandem disk.

INTRODUCTION

Many hectares of intensively farmed, coarse-textured soils in the Great Lakes Region (Drullinger and Schmidt, 1968), the Southern Coastal Plains (Carreker, 1966), Atlantic Coast Flatwoods (Carreker, 1966), Northern Coastal States, and the Great Plains have a wind erosion problem. Michigan and Ohio have 0.7 million ha of potentially wind-erodible land. The Soil Conservation Service estimates that 1.4 million ha of land are damaged each year in the 10 Great Plains States. Another 2.5 million ha of crops were damaged, ranging from complete loss to lowered crop quality, yields, and prices due to delayed maturity.

The need to increase food production while improving the quality of our environment has prompted a search for materials to protect the soil surface from wind and water erosion until vegetation emerges. This paper reviews the use of mulches to control wind erosion.

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Applying mulches to soil is possibly as old as agriculture itself (Jacks, Brind, and Smith, 1955). The ancient Romans and Chinese placed rocks and pebbles on the soil to conserve water. Today mulches are used for many reasons: temperature modification, nutrient effects, soil salinity control, soil structure improvement, moisture conservation, crop quality control, weed control, and erosion control.

A mulch is defined as any material at the soil surface that was grown in place, grown and modified before placement, and any material processed or manufactured and then placed. Examples include crop residues, tree limbs, woodchips, gravel, plastic films, asphalt, and livestock manure. Wind erosion control is defined as any mulch treatment that resists the erosive force of a 38.0 m/s wind velocity measured at 1.52 m (85 mph at 50 ft).

DISCUSSION

Research on the amount of mulch material needed to control wind erosion began in 1959 with a study testing wheat straw and prairie hay (Chepil et al., 1960, 1963a, 1963b). Methods of anchoring the material to the surface also were investigated. Mulches were spread with a blower-type spreader with nozzles mixing asphalts into the mulch as it left the spreader to bind the mulch particles together and to the soil surface. Other treatments were packed with various implements to keep the mulch in place (Chepil et al., 1960).

Results indicated that 5 t/ha of prairie hay or 6 t/ha of wheat straw well-anchored with a disk packer or with 2840-6615 L/ha asphalt controlled wind erosion and allowed grass seedlings to emerge. Packer disks should be spaced 10 to 20 cm apart and penetrate the soil 5 to 7 cm.

In conjunction with the vegetative mulch study, several organic and inorganic materials were tested for direct application to the soil surface. Effective materials, rates, and costs are given in Table 1.

Ammonium lignin sulfonate, sodium silicate, calcium chloride, and sodium silicate-calcium chloride mixtures also were effective until the first rain, when the materials dissolved and left the soil surface. Gelatinized starch decomposed rapidly after the rain and produced a more erodible surface than the original untreated surface.

Data from these two studies indicate the following characteristics desirable for surface mulches: (a) indispersible in water, durable yet porous to allow rainfall percolation; (b) weak enough to allow seedling emergence; (c) remain sticky indefinitely if used alone; and (d) easy to apply.

Cotton gin trash was applied to untilled, listed, or chiseled soil at rates of 0, 2.5, 7, 11, 16, and 21 t/ha

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TABLE 1. MATERIALS, RATES, AND COSTS OF SOME NONVEGETATIVE MATERIALS TO CONTROL WIND EROSION*

Material	Rate/ha	Cost/ha†
Fine gravel (0.2 to 0.6 cm diameter)	45 t	$136
Medium gravel (0.6 to 1.3 cm diameter)	112 t	494
Coarse gravel (1.3 to 3.8 cm diameter)	224 t	926
Cutback asphalt	11.2 m^3	610
Asphalt emulsion	11.2 m^3	827
Resin emulsions‡	5.6 m^3	556
Latex emulsions‡	11.2 m^3	4,742
Cellulose fiber	1.12 t	235

*From Chepil et al. (1963b)
†Cost of materials and labor, 1960 prices.
‡Dilution 1:1.

(Fryrear and Armbrust, 1968). One treatment involved chiseling of untilled soil after mulch was applied. Seven MT/ha reduced wind erosion 63 percent and 11 t/ha reduced it 87 percent as compared to untilled and unmulched plots. Eleven t/ha covered the soil surface, and tilling it after application did not improve its effectiveness. Tillage on lesser amounts of gin trash did improve wind erosion control.

During the 1960's, many commercial products became available to control wind erosion. Four products were tested in Californai (Letey et al., 1963). Three of the four performed well but costs were high: $475 to $4,750 per ha.

An English company developed and tested a styrene-butadine latex in mineral oil liquid material throughout the world on sandy soils and dune sands (Haas and Steer, 1964; Simmons and Armstrong, 1965; Weymouth, 1967). Tests indicated 360 L/ha of 30 percent solids of 9:1 oil/rubber blend ideal to control wind erosion.

A resing-in-water emulsion material effectively stabilized sand dunes in California (Rostler and Kunkel, 1964). A liquid plastic developed by a German firm controlled wind erosion on a sandy soil until grass was established (Gorke and Hulsmann, 1971).

The increase in the number of commercial products designed to control erosion prompted field and laboratory studies at the USDA-ARS Wind Erosion Laboratory, Kansas State University, Manhattan, KS. The first study was in the field to evaluate rates, areal coverage, dilutions, and spray atomization to reduce the cost and still control wind erosion (Lyles et al., 1969). Four materials were used and results indicated that 25 percent of the recommended rate effective if: (a) total soil surface was covered; (b) diluted and applied at recommended rate with coarse-spray nozzles; or (c) applied with fine-spray nozzles at the recommended dilution.

A laboratory study evaluated 34 materials to establish rates that would prevent wind erosion, resistance of that rate to weathering, and the effect of that rate on germination and emergence (Armbrust and Dickerson, 1971). Characteristics required for materials to be acceptable were: (a) cost less than $123/ha; (b) no adverse effect on plant growth and emergence; (c) prevent erosion initially and reduce it for 2 months; and (d) be easy to apply. Twelve materials exceeded the cost criteria; three affected plant growth; seven did not reduce erosion for 2 months; and six were difficult to apply. The six which met all criteria are shown in Table 2.

TABLE 2. MATERIALS THAT MET CRITERIA FOR TEMPORARY WIND-EROSION CONTROL*

Product†	Manufacturer
Coherex	Golden Bear Oil Co.
DCA-70	Union Carbide
Petroset SB	Phillips Petroleum Co.
Polyco 2460	Bordon Chemical Co.
Polyco 2605	Bordon Chemical Co.
SBR Latex S-2105	Shell Chemical Co.

*From Armbrust and Dickerson, 1971.
†Material names and manufacturers, included for benefit of readers, imply no endorsement or preferential treatment by the USDA.

The six materials in Table 2 plus the 11 in Table 3 were further evaluated in the laboratory and field (Lyles, Schrandt, and Schmeidler, 1974). Dilution ratios and rates were established in the laboratory to control wind erosion before and after 1.62 and 5.44 cm/hr simulated rainfall. Selected materials and rates were tested in the field at three highly wind-erodible sites. Tests indicated that: (a) higher volumes and lower dilutions were needed for wind erosion control after rainfall; (b) a minimum of 3785 L/ha of low dilution (1:1 or 1:2) was needed in the field; (c) 6 to 7 wks is the maximum protection time if rainfall occurs; and (d) laboratory tests did not establish rates for the field.

Feedlot wastes have been tested to determine amounts necessary to prevent wind erosion of sandy soils (Woodruff et al., 1974). Feedlot manure (66 percent water) from concrete-floored lots was applied at rates of 4.5, 11.0, 22.7, and 34.1 t/ha surface applied and at rates of 34.1, 68.2, and 136.4 t/ha surface applied and tilled in with a lightweight tandem disk. Plots were exposed to wind tunnel testing in the fall 2 days after application and in the spring 234 days after application.

Surface-applied and tilled-in manure at rates of 31.8 and 52.2 t/ha, respectively, were required to keep soil loss below 11 t/ha in the fall. Fifty percent of the manure was lost to weathering during the winter. Twice as much manure must be applied in the fall to prevent wind erosion in the spring.

CONCLUSIONS

Any mulch material can prevent wind erosion if applied at a sufficiently high rate to the total soil surface. Costs become prohibitive for many materials, particularly the petroleum-based products.

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TABLE 3. PRODUCTS TESTED FOR TEMPORARY WIND EROSION CONTROL*

Product†	Manufacturer
Ammonium lignosulfonate (TREX-LTA)	Scott Paper Co.
C.A.N.E. AR 105	Armour Industrial Chemicals
Cationic asphalt emulsion	HyWay Asphalts, Inc.
CMC-7H	Hercules, Inc.
CMC-7HC	Hercules, Inc.
Deepgard concrete cure agent RW-4913	PPG Industries, Inc.
Huls 801 emulsion	Henley and Co., Inc.
Rezosol 5411-13	E.F. Houghton and Co.
TRI-DAR 33/1	Darling and Co.
TRI-DAR 100	Darling anc Co.
Wicaloid Latex 7035 (AO)	Wica Chemicals

*From Lyles et al., 1974.
†Material names and manufacturers, included for benefit of readers, imply no endorsement of preferential treatment by the USDA.

Mulches for Wind Erosion

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For cropland we need information on methods to apply large volumes of liquid mulches rapidly, stabilized surfaces strong enough to withstand raindrop impact but still allow percolation, and reliable weed control chemicals for coarse-textured soils.

Prairie hay, wheat straw, feedlot wastes, and other well-anchored vegetative materials apparently are the best mulch materials and the least expensive to control wind erosion.

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