Soil Stabilizers to Control Wind Erosion[1]

7

D.V. ARMBRUST and LEON LYLES[2]

ABSTRACT

The maintenance of our environment and the need to increase food production has prompted a search for materials and methods to stabilize soil surfaces against wind and water erosion. This paper discusses investigations on surface-applied materials to control soil movement by wind.

Field and laboratory studies have established the following criteria for surface soil stabilizers: (i) 100% of the soil surface must be covered, (ii) the stabilizer must have no adverse effect on plant growth or emergence, (iii) prevent erosion initially and reduce erosion for at least 2 months, (iv) be easy to apply without special equipment, and (v) cost must be low enough for profitable use. Five polymers and one resin-in-water emulsion were found to meet all these requirements.

Before soil stabilizers can be used on agricultural lands, methods must be developed for applying large volumes rapidly. Also, reliable pre-emergent weed-control chemicals for use on coarse-textured soils must be developed and we must have films strong enough to resist raindrop impact and still allow water and plant penetration with no adverse effects on the soil-water-air environment.

INTRODUCTION

In the United States, wind erosion is a problem on intensively farmed, coarse-textured soils in the Great Lakes Region (Drullinger & Schmidt, 1968), the Southern Coastal Plains (Carreker, 1966), Atlantic Coast Flatwoods (Carreker, 1966), Northern Coastal States, and the Great Plains. Michigan and Ohio have 0.7 million ha (1.7 million acres) of potentially wind-erodible land. The Soil Conservation Service has estimated the amount of land damaged in the 10 Great Plains States for each year since 1935. An average of 1.4 million ha (3.6 million acres) have been damaged each year, with a high of 6.4 million ha (15.9 million acres) in 1954–55 and a low of 0.4 million ha (995,000 acres) in 1968–69. The estimates are for 1 November to 31 May, when the wind erosion hazard is greatest.

---

[1]Contribution from the Agricultural Research Service, U. S. Department of Agriculture, in cooperation with the Kansas Agricultural Experiment Station, Dep. of Agronomy Contribution no. 1383.

[2]Soil Scientist and Agricultural Engineer, North Central Region, ARS, USDA, Manhattan, KS 66506.

Vegetables, wheat (*Triticum aestivum* L.), and grasses and alfalfa (*Medicago sativa* L.) are easily damaged by blowing soils, especially during the seedling stage (Armbrust, Dickerson & Greig, 1969; Skidmore, 1966; Woodruff, 1956; Lyles & Woodruff, 1960, respectively). Damage ranges from complete destruction to lowered crop quality, yields, and prices due to delayed maturity.

The construction of military installations, airports, highways, houses, shopping centers, and industrial plants has exposed vast areas to the ravages of wind and water erosion. Many such facilities are constructed in areas where climate and soil type foster wind erosion.

The need to increase our food supply while maintaining the quality of our environment has prompted a search for materials to stabilize the soil surface against wind and water erosion until a permanent vegetative cover can be established. This paper discusses investigations on surface-applied materials to control wind erosion.

LITERATURE REVIEW

Field and Laboratory Studies

In 1959 investigations were begun to determine the amount of prairie hay and wheat straw needed to prevent wind erosion on extremely sandy areas and on finer textured soils (Chepil et al., 1960, 1963). The residues were spread with a blower-type spreader with nozzles to mix asphalts into the mulch as it left the blower. Cutback asphalt and asphalt emulsion were used

Table 1. Materials, rates, and costs of some nonvegetative materials to control wind erosion*.

Material	Rate†		Cost‡	
	per hectare	per acre	per hectare	per acre
			$	
Fine gravel (0.2 to 0.6 cm diameter)	45 metric tons	20 tons	136	55
Medium gravel (0.6 to 1.3 cm diameter)	112 metric tons	50 tons	494	200
Coarse gravel (1.3 to 3.8 cm diameter)	224 metric tons	100 tons	926	375
Cutback asphalt	11.2 kl	1,200 gallons	610	247
Asphalt emulsion	11.2 kl	1,200 gallons	827	335
Resin emulsion §	5.6 kl	600 gallons	556	225
Latex emulsion§	11.2 kl	1,200 gallons	4,742	1,920
Cellulose fiber	1.12 metric tons	0.5 ton	235	95

* Information from Chepil et al. (1963).
† To control wind erosion on sandy loams and loamy sands.
‡ Cost of materials and labor, 1960 prices.
§ Dilution, 1:1.

to bind individual pieces of mulch to each other and to the soil surface, but the emulsions were not used on the soil surface directly.

In conjunction with that study, several inorganic and organic materials were examined for their effectiveness when applied directly to the soil surface (Chepil et al., 1963). Effective materials, rates, and costs are given in Table 1. Ammonium lignin sulfonate, sodium silicates, calcium chloride, and sodium silicate-calcium chloride mixture also were effective until the first rain when they dissolved and were removed from the soil surface. Gelatinized starch decomposed rapidly after the rain, making the soil more erodible than the untreated surface.

The data gathered in those two studies indicates the following characteristics as desirable for surface soil stabilizers: (i) indispersible in water, durable, yet porous enough to allow percolation of water; (ii) weak enough for seedling penetration; (iii) sticky indefinitely when used as permanent wind-erosion-control covers; and (iv) easy to apply (Chepil & Woodruff, 1963).

In 1963 four surface-applied materials were tested for their abilities to control wind erosion over the winter months (Letey et al., 1963). Three of the four performed well when rates and dilutions were correct. Costs for materials ranged from $475 to $4,750 per ha ($190 to $1,900/acre) for effective treatments.

An emulsion of polymerized styrene-butadiene latex in mineral oil was developed by an English company and tested extensively in the early 1960's. It effectively stabilized sand dunes and increased grass growth on Scolt Head Island, England (Haas & Steer, 1964). Rates of 172 kg/ha (151 pounds/acre) of solids provided an adequate surface film.

Laboratory tests established that 357 liters/ha (150 gallons/acre) of 30% solids of a 9:1 oil/rubber blend was ideal to control wind erosion with no adverse effect on plant germination or growth (Simmons & Armstrong, 1965). Field trials at a Lancashire resort and in the Negev Desert proved that rate and dilution could withstand severe climatic conditions and control wind erosion until a vegetative cover could be established. The same material was used to control sand movement of active dunes on the Mornington Peninsula, Victoria, Australia (Weymouth, 1967). Roughly leveled dunes planted to rye

Table 2. Stabilizers evaluated in laboratory study*.

Material type	Number of products
Asphalt	3
Latex	8
Plant or animal byproduct	5
Polymers	5
Polyvinyls	3
Powders	5
Resins	3
Others	2

* From Armbrust and Dickerson (1971).

(*Secale cereale* L.) and lucerne (*Medicago sativa* L.) were sprayed with the latex-oil material. Sixteen hectares (40 acres) of 32 hectares treated were successfully stabilized the first year. The material withstood winds of 36 m/second (80 miles/hour) before grass emerged.

During the same period, a California firm developed a resin-in-water emulsion that has proved effective against wind erosion of dune sands (Rostler & Kunkel, 1964). A German firm has developed a liquid plastic material that also controls wind erosion effectively (Gorke & Hulsmann, 1971).

PROCEDURE

Field and Laboratory Studies

The increase in the number and types of materials commercially available to stabilize soil against wind erosion prompted us to evaluate some of the materials in field and laboratory studies at Manhattan, Kansas.

In the field study we used four materials to determine rates, areal coverage, dilutions, and spray atomization that would reduce costs and still give adequate temporary wind erosion protection until a plant canopy could protect the soil surface (Lyles, 1969). The results showed that 25% of the recommended amount of stabilizer would give adequate control if: (i) 100% of the soil surface was covered, and (ii) stabilizer was diluted and applied at the recommended rate with coarse-spray nozzles, or (iii) applied with fine-spray nozzles at the recommended dilution.

In the laboratory study, we evaluated 34 commercially available products for rates that prevented wind erosion, for resistance to natural weathering, and for effects on plant germination and emergence (Armbrust & Dickerson, 1971). The types of stabilizers evaluated are listed in Table 2. Except for asphalts, all materials were sprayed with atomizing nozzles on 20 by 152

Table 3. 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	Borden Chemical Co.
Polyco 2605	Borden 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 U. S. Department of Agriculture.

Table 4. Products being tested for temporary wind-erosion control.

Product*	Type
Ammonium lignosulfonate	Plant byproduct
C.A.N.E. AR-105	Asphalt-rubber
Cationic asphalt emulsion	Asphalt
CMC-7HC	Powder
Coherex	Resin-in-water emulsion
Huls Latex 801	Latex
Rezosol S411-B	Polymer
Tri-Dar 100	Unknown
Wicaloid Latex 7035 (AO)	Latex

* Material names, includes for benefit of readers, imply no endorsement or preferential treatment by the U. S. Department of Agriculture.

by 5-cm (8 by 60 by 2-inch) trays with fine-screen bottoms filled with a highly erodible soil, 89.6% sand, at the manufacturers' recommended dilutions and at six rates ranging from 1/8 to 4 times the rates recommended. When films were dry, they were exposed to a 13.4-m/second (30-mile-per-hour) wind at 30.5 cm (1 foot) above the tray surface. After determining the rate of soil stabilizer that prevented wind erosion, we sprayed soil trays at that rate, let the material dry, then exposed it to natural weathering for 60 to 120 days. The same stabilizer rate was used in plant germination and emergence studies.

To be acceptable, a material had to meet four criteria: (i) cost < $123/ha ($50/acre); (ii) have no adverse effect on plant growth or emergence; (iii) prevent erosion initially and reduce erosion for at least 2 months; and (iv) be easy to apply without special equipment. Twenty-two of the thirty-four materials passed the cost criterion. Of these 22, 3 adversely affected plants, 7 did not reduce erosion for 2 months, and 6 were difficult to apply. The six remaining products that met all four criteria are listed in Table 3. Five are polymers and one is a resin-in-water emulsion.

Products listed in Table 4 are now being laboratory and field tested.

CONCLUSIONS

Any of the soil stabilizers tested will prevent wind erosion if applied to the total soil surface at a sufficiently high rate, but costs then become prohibitive for many products. Before soil stabilizers can be used on agricultural lands, we must develop (i) methods for applying large volumes rapidly, (ii) reliable pre-emergent weed-control chemicals for use on coarse-textured soils, (iii) films strong enough to withstand raindrop impact and still allow water and plant penetration, and (iv) films that have no adverse effects on the soil-water-air environment.

LITERATURE CITED

Armbrust, D. V., and J. D. Dickerson. 1971. Temporary wind erosion control: Cost and effectiveness of 34 commercial materials. J. Soil Water Conserv. 26(4):154-157.

Armbrust, D. V., J. D. Dickerson, and J. K. Greig. 1969. Effect of soil moisture on the recovery of sandblasted tomato seedlings. J. Am. Soc. Hort. Sci. 94(3):214-217.

Carreker, J. R. 1966. Wind erosion in the Southeast. J. Soil Water Conserv. 21:86-88.

Chepil, W. S., and N. P. Woodruff. 1963. The physics of wind erosion and its control. Adv. Agron. 15:211-302.

Chepil, W. S., N. P. Woodruff, F. H. Siddoway, and D. V. Armbrust. 1963. Mulches for wind and water erosion control. Agric. Res. Serv., USDA. p. 41-84.

Chepil, W. S., N. P. Woodruff, F. H. Siddoway, D. W. Fryrear, and D. V. Armbrust. 1963. Vegetative and nonvegetative materials to control wind and water erosion. Soil Sci. Soc. Am. Proc. 27:86-89.

Chepil, W. S., N. P. Woodruff, F. H. Siddoway, and L. Lyles. 1960. Anchoring vegetative mulches. Agric. Eng. 41(11):754-755, 759.

Drullinger, R. H., and B. L. Schmidt. 1968. Wind erosion problems and controls in the Great Lakes Region. J. Soil Water Conserv. 23:58-59.

Gorke, K., and J. Hulsmann. 1971. Soil stabilization. Int. Soc. Soil Sci., Bull. No. 38.

Haas, J. A., and J. A. Steer. 1964. An aid to stabilization of sand dunes: Experiments at Scolt Head Island. Geog. J. 130(2):265-267.

Letey, J., D. E. Halsey, A. F. Van Maren, and W. F. Richardson. 1963. Wind erosion control with chemical sprays. Calif. Agric. 17(10):4-5.

Lyles, L., D. V. Armbrust, J. D. Dickerson, and N. P. Woodruff. 1969. Spray-on adhesives for temporary wind-erosion control. J. Soil Water Conserv. 24(5):190-193.

Lyles, L., and N. P. Woodruff. 1960. Abrasive action of windblown soil on plant seedlings. Agron. J. 52:533-536.

Rostler, F. S., and W. M. Kunkel, Jr. 1964. Soil stabilization. Ind. Eng. Chem. 56:27-33.

Simmons, P., and W. J. Armstrong. 1965. A new method of soil stabilization. Sci. Ind. 3(4):282-291.

Skidmore, E. L. 1966. Wind and sandblast injury to seedling green beans. Agron. J. 58:311-315.

Weymouth, N. 1967. Soil stabilization. Rubber Plast. Age 48(3):253-255.

Woodruff, N. P. 1956. Wind-blown soil abrasive injuries to winter wheat plants. Agron. J. 48(11):499-504.

DISCUSSION

Q (Anonymous)–Which products have done the best up until now? Are any economical?

A (Dr. Armbrust)–None.

Q (D. J. Hoyle, vegetable crops specialist, University of California)–Does rain water or a sprinkler penetrate through the latex film to the seed zone? Do latex films increase soil temperature in the seed zone?

A (Dr. Armbrust)–Yes, water will penetrate. We have not measured soil temperature, but because of dark color when applied, we expect some temperature increase. This increase will be small as compared to asphalts.