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Spray-on Adhesives for Temporary Wind Erosion Control

Commercially available soil stabilizers, given certain application techniques, application rates, and areal coverages, are an economical means of temporarily controlling wind erosion on cropland.

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WIND erosion is a serious problem on intensively farmed, coarse-textured soils in the Great Lakes Region, the Southern Coastal Plains, Atlantic Coast Flatwoods, and Northeastern Coastal States (*1, 5*). About 1.7 million acres of potentially wind-erodible soils exist in Michigan and Ohio alone (*5*),

Vegetables are easily damaged by blowing soils, especially during the seedling stage (*9*). Crop damage ranges from complete loss to lower yields, quality, and prices—the latter because of market timing. A continuing need exists for effective, economical materials to eliminate or reduce the adverse effects of blowing soil on crops.

Many commercially available products from chemical, animal, and petroleum industries are recommended for soil stabilization and erosion control. Some have not been tested extensively; those studied have been used primarily to control water and/or wind erosion on newly seeded areas, such as golf courses, road rights-of-way, military installations, and dunes (*3, 4, 6, 7, 10, 11, 12*). Generally, recommended rates of the materials are too high to be economically practical for farm crops. However, intensively farmed, high-income crops may justify use of spray-on adhesives, particularly if application techniques can be found that substantially reduce per-acre costs.

Our field study was made to evaluate four materials soon after they were applied.

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Procedure

Field plots were established near Manhattan, Kansas, on a highly wind-erodible soil containing 89.6 percent sand, 5.9 percent silt, and 4.5 percent clay. A split-plot design with three replications was used. Main plots, 35 feet by 104 feet, involved four soil stabilizers (Table 1). The stabilizers were applied to 8-foot by 35-foot subplots at four rates, one being zero as a check. The areal coverages, called methods of application, were (a) stabilizers sprayed in 8-inch bands on 40-inch centers (20 percent coverage), (b) 24-inch bands on 40-inch centers (60 percent coverage, and (c) 100 percent coverage (Figure 1).

On plots totally covered, stabilizers were applied with a spray boom from a power-take-off-driven gear pump through wide-angle, square-spray, full-jet industrial nozzles at 35- to 60-pounds-per-square-inch pump pressure. Bands were applied with a single teejet, even-spray agricultural nozzle at 30- to 40-pounds-per-square-inch pump pressure. Asphalt emulsion was omitted from the band applications because solids in the emulsion were too large to pass through the teejet nozzles (*2*). Asphalt also gummed up the gear pump.

Results from the original tests prompted other tests of 100 percent coverage with the teejet even-spray nozzle and 100 percent coverage with the full-jet industrial nozzles at the low rate of soil stabilizer, R_1, diluted with water and applied at high rate volume, R_3 (R_{13}).

All plots were tested 4 minutes with a portable wind tunnel at 35 miles per hour 1 foot above the soil surface (*13*) (Figure 2). A proportionate amount of soil moved by the wind was caught in modified Bagnold catchers and weighed. All plots were tested within 16 to 24 hours after stabilizers were applied. The soil surface was made highly erodible by tandem disking and hand raking or smoothing with a seeder before stabilizers were applied.

A comparative test was made to evaluate field bean emergence through the stabilizers. This test involved a completely random design with three replications of each stabilizer at three rates, with 15 beans planted per 10-foot row.

Results and Discussion

Coarse-spray Industrial Nozzles

The interaction between stabilizer and application rate was highly significant, indicating that rate of application must be specified for comparisons between stabilizers. All stabilizers at all rates tested reduced soil movement (Table 2). Each increase in rate of application at recommended dilutions significantly reduced soil movement. The R_1 amount of stabilizer diluted with water and applied at the R_3 total volume markedly reduced soil movement compared with the same rate of stabilizer at the manufacturer's recommended dilution. This was especially true with the resin adhesive, a thick, viscous material. The R_1 application with coarse-spray industrial nozzles was insufficient for good areal coverage. Although R_{13} treatments reduced soil movement as effectively or better than R_3 treatments, protection from R_3 treatments lasted longer. Four weeks after testing, the R_{13} treatments, except for asphalt emulsion, were beginning to fail. Apparently, surface films were too thin to withstand raindrop impact; inspection of surfaces revealed numerous holes in the material. The asphalt emulsion, because

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Table 1. Soil stabilizers, with manufacturer's recommended dilution and application rates.

Stabilizer[a]	Dilution with Water	Rates[b] (gal./acre)
Swift's soil erosion control resin adhesive Z-3876	2:1	870 (R_3)
		435 (R_2)
		218 (R_1)
		0 (R_0)
Coherex: resin-in-water emulsion	4:1	1,210 (R_3)
		605 (R_2)
		303 (R_1)
		0 (R_0)
Anionic asphalt emulsion	1:1	1,210 (R_3)
		605 (R_2)
		303 (R_1)
		0 (R_0)
Oil/latex polymer emulsion	3:1	1,200 (R_3)
		800 (R_2)
		400 (R_1)
		0 (R_0)

[a]Trade names and company names are included for the benefit of the reader; they do not imply any endorsement or preferential treatment of named products by the U. S. Department of Agriculture.

[b]Highest rate of each stabilizer is manufacturer's recommended rate.

of its low recommended dilution (1:1), was only 7:1 after diluting the R_1 amount of emulsion to the R_3 volume. That corresponds to 11:1, 12:1, and 19:1 for the oil/latex polymer, resin adhesive, and resin-in-water, respectively. Apparently enough asphalt was still present to resist raindrops. All stabilizers at the recommended dilution and application rates were holding well against natural winds 7 weeks after testing, which agrees with Chepil's results *(2)*.

The properties of the various stabilizers changed after they were applied. The resin adhesive dried rapidly and became hard and brittle, though it softened again when wetted. The asphalt emulsion hardened rapidly and became somewhat brittle after a few days. The resin-in-water emulsion dried slowly, penetrated well, and did not form a hard crust. The oil/latex polymer emulsion dried slowly and remained flexible. It had fine weblike strands that bound soil particles.

Fine-spray Agricultural Nozzles

Results of the different application methods are presented in table 3. Because the asphalt emulsion could not be sprayed through the fine-spray teejet nozzles, it could not be compared.

The 8-inch bands on 40-inch centers did not reduce soil movement. In general, the bands stabilized the soil immediately beneath them, but the exposed area between bands eroded as much as the check plots (Figure 3).

Each of the three stabilizers tested in 24-inch bands on 40-inch centers greatly reduced soil movement. There were no significant differences between rates of application for either band width. Soil movement with the 24-inch bands was not significantly different among stabilizers. However, soil movement for individual tests ranged from .04 to 4.0 tons per acre for the same stabilizer and application rate. When exposed soil grains between bands began moving, they impacted with other grains or aggregates which, in turn, continued the motion.

The 100-percent-coverage treatments with fine-spray nozzles at the low application rate effectively reduced soil movement (Table 3). The effect of spray atomization is shown by comparing the low rates of application between the industrial and agricultural nozzles (Table 4). The fine spray was considerably more effective than the coarse spray at the same rate of stabilizer, especially for the resin adhesive. Chepil *(2)* reported similar results with asphalt emulsion.

Bean Emergence

None of the stabilizers adversely affected field bean emergence (Table 5). Average final emergence was slightly higher with stabilizers than without them. Stabilizers also decreased emergence time, especially those that deepened the color of the surface, probably because they raised temperatures during the somewhat cool days of the germination and emergence period.

Practical Considerations

Quantitative interpretation of the data requires information on rates of soil movement considered damaging for a particular problem in question and the degree of control to be attained. Schmidt *(8)* speculated that where highly susceptible vegetable crops are grown it may be necessary to reduce soil movement to 1

Figure 1. Adhesives applied in, left, 8-inch bands on 40-inch centers; center, 24-inch bands on 40-inch centers; and, right, complete coverage.

ton per acre or less annually. Skidmore *(9)* reported that relatively low rates of sand movement and short periods of exposure can severely damage plant seedlings and substantially reduce greenbean yields, as did Armbrust and his colleagues[1] with tomatoes.

Assuming that a treated soil surface stabilizes within 5 minutes, one can deduce from Skidmore's data *(9)* that about 0.4 ton per acre of soil movement would be tolerable for greenbeans. This was the criterion used in our study. Apparently 100 percent coverage of the surface is needed for the soil tested. For less erodible soil, lower coverage rates might suffice.

Economic considerations will largely determine the use of spray-on adhesives for agricultural purposes. Our study suggests two ways to lower per-acre costs, provided only temporary protection is required. One is to use higher dilutions with the stabilizers and apply the stabilizers at high volumes. Another is to use recommended dilutions of stabilizers but to apply them at lower rates with fine-spray atomizing nozzles.

Stabilizer costs, excluding transportation, are presented in table 6. Among the stabilizers tested for which cost figures are available, the resin-in-water emulsion was the most economical, comparing favorably (if sprayed at low rates with fine nozzles) with the use of vegetative strips, such as rye or barley *(5)*.

Low rates of stabilizers offer only temporary protection against wind erosion. However, if the stabilizers were used as a pre-emergence spray, they should protect long enough for a crop to establish a canopy that could protect the soil surface. A herbicide must be included with the stabilizers to control weeds until plants become established; any mechanical stirring of the soil would destroy the effectiveness of the stabilizers.

Other considerations in using spray-on adhesives must include costs of storage and spraying equipment, extra labor for handling large volumes, and extra time required during seeding operations, the feasible time to apply the stabilizer. For example, applying 1,200 gallons per acre with 4-row equipment would require a 730-gallon tank to make one round through a 40-acre field, ¼-mile long. Such large volumes suggest that atomizing nozzles to permit lower application rates would be more practical and economical.

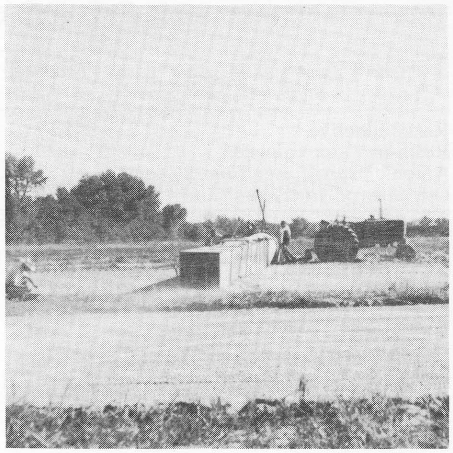

Figure 2. Portable wind tunnel in operation during soil stabilization tests.

Figure 3. Appearance of plot with 8-inch bands after testing.

Summary

Four spray-on adhesives were field tested on a highly wind-erodible soil with a wind tunnel. Results indicate

Table 2. Average soil movement as affected by application rates and dilutions of stabilizers—full-jet industrial nozzles and 100 percent areal coverage.[a]

	Soil Movement (tons/acre)					
Stabilizer	R_0	R_1	R_2	R_3	R_{13}[b]	*Mean*[c]
Resin adhesive	13.14	8.43	4.21	0.74	0.14	5.34*
Resin-in-water emulsion	13.14	2.11	0.46	0.18	0.06	3.20†
Anionic asphalt emulsion	13.14	2.00	0.98	0.19	0.03	3.28†
Oil/latex polymer emulsion	13.14	1.75	0.24	0.09	0.05	3.06†
Mean[c]	13.14*	3.58†	1.47‡	0.30δ	0.07δ	

[a]Treatments considered effective if soil movement was less than 0.4 ton per acre.
[b]Rate 1 amount of stabilizer applied at Rate 3 volume.
[c]Means followed by the same symbols are not significantly different at the 95-percent level by Duncan's multiple range test.

Table 3. Average soil movement as affected by method of applying soil stabilizers—even-spray teejet agricultural nozzles.[a]

	Soil Movement (tons/acre)			
Stabilizer	*Check*	*8-inch bands (20% coverage)*	*24-inch bands (60% coverage)*	*R_1 only (100%[1] coverage)*
Resin adhesive	12.19	11.17	1.09	0.24
Resin-in-water emulsion	12.19	13.78	0.94	0.24
Oil/latex polymer emulsion	12.19	13.31	0.60	0.13

[a]Treatments considered effective if soil movement was less than 0.4 ton per acre.

Table 4. Effect of spray atomization on average soil movement with three soil stabilizers, 100 percent areal coverage at R_1 application rate.

	Soil Movement (tons/acre)	
Stabilizer	*Industrial Nozzle (Coarse spray)*	*Agricultural Nozzle (Fine spray)*
Resin adhesive	8.43	0.24
Resin-in-water emulsion	2.11	0.24
Oil/latex polymer emulsion	1.75	0.13

[1]"Effect of Soil Moisture on the Recovery of Sandblasted Tomato Seedlings" by D. V. Armbrust, J. D. Dickerson, and J. K. Greig. (To be published in the Proceedings of the American Society for Horticultural Science.)

that for temporary control about one-fourth of the manufacturers' recommended amount of stabilizer will reduce soil movement to 0.4 ton per acre, provided (a) 100 percent of the soil surface is covered and (b) the stabilizers are diluted with water to the recommended application rate and sprayed on with coarse-spray industrial nozzles or (c) provided they are sprayed with fine-spray agricultural nozzles without additional dilution. Practical considerations favor the latter. Of the stabilizers tested for which cost figures are available, the resin-in-water emulsion was the most economical.

Table 5. Effect of soil stabilizers on bean emergence.

Stabilizer	Emergence (%) Initial	Emergence (%) Final
Resin adhesive	19[b]	93[ab]
Resin-in-water emulsion	36[ab]	96[a]
Anionic asphalt emulsion	30[ab]	87[b]
Oil/latex polymer emulsion	44[a]	88[b]
Check	14	83

Note: Small letters indicate statistical difference at 95 percent level by Duncan's multiple range test. Checks not included in analysis.

Table 6. Stabilizer product costs and costs of various applications, 1968.

Stabilizer	Product ($/gal.)	Stabilizer Cost ($/acre) Manufacturer's Recommended Rate	R_{13} Dilution	R_1 Spray Atomization
Resin adhesive	1.57	452	113	113
Resin-in-water emulsion	0.20	48	12	12
Anionic asphalt emulsion	0.35	210	53	——
Oil/latex polymer emulsion[a]	——	——	——	——

[a]No cost figures available; product currently being considered for market by a major U. S. oil company.

REFERENCES CITED

1. Carreker, J. R. 1966. *Wind erosion in the southeast.* J. Soil and Water Cons. 21(3): 86-88.
2. Chepil, W. S. 1955. *Effects of asphalt on some phases of soil structure and erodibility by wind.* Soil Sci. Soc. Am. Proc. 19(2): 125-128.
3. Chepil, W. S., N. P. Woodruff, F. H. Siddoway, and D. V. Armbrust. 1963. *Mulches for wind and water erosion control.* ARS 41-84. U. S. Dept. Agr., Washington, D. C. 23 pp.
4. 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(1): 86-89.
5. Drullinger, R. H., and B. L. Schmidt. 1968. *Wind erosion problems and controls in the Great Lakes Region.* J. Soil and Water Cons. 23(2): 58-59.
6. Haas, J. A., and J. A. Steers. 1964. *An aid to stabilization of sand dunes: Experiments at Scolt Head Island.* Geog. J. 130: 265-267.
7. Rostler, F. S., and W. M. Kunke, Jr. 1964. *Soil stabilization.* Ind. and Eng. Chem. 56(4): 27-33.
8. Schmidt, B. L., and G. B. Triplett, Jr. 1967. *Controlling wind erosion.* Ohio Rpt. of Res. and Dev. 52(3): 35-37.
9. Skidmore, E. L. 1966. *Wind and sandblast injury to seedling greenbeans.* Agron. J. 58: 311-315.
10. U. S. Army Corps of Engineers. 1960. *Report on wind erosion control for G/M Training Facility, 75-1.* U. S. Army Engineer District, Los Angeles, California. 40 pp.
11. Weymouth, N. F. 1966. *Soil stabilization—analysis of the problem, the market, and a method using synthetic rubber latices.* International Synthetic Rubber Co. Ltd., Southhampton, England.
12. Zak, John M. 1967. *Controlling drifting sand dunes on Cape Cod.* Bul. 563. Mass. Agr. Exp. Sta., Amherst. 15 pp.
13. Zingg, A. W. 1951. *A portable wind tunnel and dust collector developed to evaluate the erodibility of field surfaces.* Agron. J. 43: 189-191.