Commercial Soil Stabilizers for Temporary Wind-Erosion Control

Leon Lyles, R. L. Schrandt, N. F. Schmeidler
MEMBER
ASAE

AGRICULTURAL crops are most vulnerable to damage by blowing soil immediately after seeding and during early growth (Lyles and Woodruff 1960, Skidmore 1966). Damage ranges from "blowouts" before emergence to complete destruction by abrasion after emergence.

The risk of damage from windblown soil prevents direct seeding of tomatoes in some areas. (Wittmeyer 1974) One feasible approach toward preventing wind erosion for 5 to 7 wks (or until the crop establishes a canopy to protect the soil surface) is to spray the soil surface at seeding time with commercially available stabilizers.

In a field study Lyles et al. (1969), evaluating four materials soon after application, showed that per-acre costs could be reduced by using higher water-dilution ratios at manufacturers' recommended total volumes, or by using lower total volumes at recommended dilution ratios and applying the material with fine-spray nozzles.

Armbrust and Dickerson (1971), who tested 34 materials in the laboratory, used recommended water-dilution ratios but tested lower total volumes applied through fine-spray nozzles. Because of plugging, fine-spray nozzles could not be used with some of their products. They suggested six stabilizers, based on certain criteria, that would cost $50 or less per acre (material cost only) and provide temporary wind-erosion control.

Our study extends previous research by including rainfall effects in laboratory-screening tests and by including field trials of selected soil stabilizers found effective in laboratory tests.

Article was submitted for publication in April 1974; reviewed and approved for publication by the Soil and Water Division of ASAE in August 1974. Presented as ASAE Paper No. 74-2036.

Contribution from the Agricultural Research Service, USDA, in cooperation with the Kansas Agricultural Experiment Station. Dept. of Agronomy Contribution No. 1398.

The authors are: LEON LYLES, Agricultural Engineer, R. L. SCHRANDT, former Engineering Technician, and N. F. SCHMEIDLER, former Research Assistant, North Central Region, ARS, USDA, Manhattan, Kans.

PROCEDURE

Laboratory Tests

Laboratory tests were made to determine maximum water-dilution ratios and minimum total volumes that would prevent soil movement by wind. "Water-dilution ratio" is defined as the parts of water we added to each part of the material received from the supplier, regardless of the material's water content when manufactured. Test materials are given in Table 1. The first six stabilizers are those recommended by Armbrust and Dickerson (1971). All the products are liquids except CMC-7H and CMC-7HC, which are dry powders.

The test soil, a highly erodible sand (90 percent sand, 6 percent silt, and 4 percent clay), was placed in trays 6.5 in. wide, 58.5 in. long, and 1.75 in. deep. After smoothing the surface, stabilizers were applied through a single tee jet, even-spray nozzle. Application volume was controlled by nozzle size and height above tray and by varying the tray speed as it passed under the fixed nozzle. After air drying, the soil trays were exposed for 5 min in a wind tunnel at a free-stream velocity of 31 mph, and soil loss was determined by weighing.

To test effects of rainfall on the persistence of the stabilizers, soil trays were sprayed with stabilizer, air-dried, and exposed in a raintower for 1 hr to rainfall intensities of 0.69 and 2.14 in. per hr. After oven drying at 120 F, the trays were exposed in the wind tunnel as before.

We conducted emergence tests using four stabilizers and 10 bean or alfalfa seeds per greenhouse pot. After seeding, soil in pots was sprayed with stabilizers, and soil was allowed to wet by capillarity.

TABLE 1. TEST MATERIALS

Product name*	Manufacturer (supplier)*	Product type (composition)
Coherex	Witco Chemical	Petroleum resin-in-water emulsion
DCA-70	Union Carbide	Modified vinyl polymer
Petroset SB-1	Phillips Petroleum Co.	Rubber emulsion
Polyco 2460	Borden Chemical Co.	Styrene-butadiene copolymer
Polyco 2605	Borden Chemical Co.	Vinylchloride-vinylidene chloride copolymer
SBR Latex S-2105	Shell Chemical Co.	Styrene-butadiene latex
Ammonium Lignosulfonate (TREX-LTA)	Scott Paper Co.	High molecular weight polyelectrolytes and wood sugars
C.A.N.E. AR 105	Armour Industrial Chemicals	Asphalt neoprene emulsion
Cationic asphalt emulsion	HyWay Asphalts, Inc.	Asphalt emulsion
CMC-7H	Hercules, Inc.	Sodium carboxymethyl cellulose
CMC-7HC	Hercules, Inc.	Sodium carboxymethyl cellulose
Deepgard concrete cure agent RW-4913	PPG Industries, Inc.	Linseed oil curing compound
Huls 801 emulsion	Henley & Co., Inc.	Liquid plastic
Rezosol 5411-B	E.F.Houghton & Co.	Organic polymer
TRI-DAR 33/1	Darling & Co.	Linseed oil-based emulsion
TRI-DAR 100	Darling & Co.	Linseed oil-based emulsion
Wicaloid Latex 7035(AO)	Wica Chemicals	Carboxylated Styrene-butadiene latex

* Trade names and company names are included for the benefit of the reader; they do not imply any endorsement of preferential treatment of named products by the U.S. Depart of Agriculture.

This article is reprinted from the TRANSACTIONS of the ASAE (Vol. 17, No. 6, pp. 1015, 1016, 1017, 1018, 1019, 1974)
Published by the American Society of Agricultural Engineers, St. Joseph, Michigan

TABLE 2. WATER DILUTION RATIOS AND TOTAL VOLUMES REQUIRED IN LABORATORY TESTS FOR ZERO SOIL LOSS OF SEVERAL SOIL STABILIZERS APPLIED WITH OR WITHOUT FIRST BEING EXPOSED TO RAINFALL

Product	Recommended water-dilution ratio	Maximum water-dilution ratio†	Required water-dilution ratio‡	Required water-dilution ratio§	
Ammonium Lignosulfonate (TREX-LTA)	5:1	10:1	2:1	2:1	(200)‖
C.A.N.E. AR 105	*	200:1	50:1	25:1	(200)
Cationic asphalt emulsion	1:1	100:1	25:1	10:1	(200)
CMC-7H	2.65 g/l	0.5 g/l	1 g/l	2.5 g/l	(400)
CMC-7HC	2.65 g/l	1 g/l	2 g/l	2 g/l	(200)
Coherex	4:1	100:1	4:1	4:1	(400)
DCA-70	12.5:1	200:1	100:1	12.5:1	(200)
Deepgard concrete cure agent RW-4913	*	4:1	2:1	**	
Huls 801 emulsion	*	25:1	9:1	9:1	(200)
Petroset SB-1	19:1	400:1	100:1	25:1	(200)
Rezosol 5411-B	9 to 50:1	10:1	10:1	10:1	(400)
TRI-DAR 33/1	*	2:1	1:1	**	
Wicaloid Latex 7035(AO)	12.5:1	200:1	100:1	50:1	(200)

† No prior rainfall exposure; 100 gal per acre total volume.

‡ Exposed to 0.69-in. per hr rainfall for 1 hr; 100 gal per acre total volume.

§ Exposed to 2.14-in. per hr rainfall for 1 hr.

‖ Number in parenthesis is required total volume in gal per acre.

* Unknown.

** Not tested.

Selected soil stabilizers were used in field tests at site 1, near Abilene, Kansas, in 1971 and 1972; at site 2, near Wamego, Kansas, in 1971; and at site 3, near Manhattan, Kansas, in 1972 and 1973. Soil at site 1 was loamy sand (84 percent sand, 9 percent silt, and 7 percent clay); at site 2, sand (90 percent sand, 4 percent silt, and 6 percent clay); and at site 3, loamy sand (82 percent sand, 14 percent silt, and 4 percent clay). The crop involved at site 1 (both years) and at site 3 in 1972 was Crimson Sweet watermelons; that at site 2 was alfalfa. Recommended preemergence herbicides for weed control in melons, bensulide and naptalam (Morrison et al. 1972), were applied 7 to 10 days before seeding, and soil stabilizers were applied immediately after seeding.

Soil stabilizers were applied with an agricultural sprayer using a fairly high volume centrifugal pump and 8040 tee jet nozzles operating at 40 psi pump pressure or with a pressurized tank and boom using the same nozzles and pressure. Stabilizer treatments at sites 1 and 2 were not replicated. We used three replications per treatment in a randomized complete block design in the field tests at site 3.

To determine soil losses from each treatment, we made portable wind-tunnel tests at site 3 (6 or 7 wks after application), using 4-min runs at free-stream velocities of 36 mph. Amounts lost were determined from two modified Bagnold catchers, each sampling a 3/8-in. width of soil flow from the 30-ft-long wind-tunnel test section. No wind-tunnel tests were made at sites 1 and 2.

RESULTS AND DISCUSSION

Laboratory tests

The near minimum needed to cover a smooth, flat surface when using fine-spray nozzles is 100 gal per acre total volume. Maximum water-dilution ratios that prevented soil movement are presented in Table 2. The Polyco products and the SBR Latex are not included because, when diluted with city water, some of the solids precipitated, gummed the roller pump, and plugged the nozzles. We did not encounter this problem when we used distilled water.

When the stabilizers (except Rezosol) were exposed to low-intensity rainfall, lower water-dilution ratios were required to prevent erosion (Table 2). When the stabilizers were exposed to high-rainfall intensity, either lower water-dilution ratios or higher total volumes (or both) were required to prevent erosion (Table 2).

The water-repellency characteristics of some stabilizers are shown in Table 3. Although petroleum-based products repelled waterdrops applied directly at the surface, falling raindrops penetrated all stabilizer-treated surfaces on impact. Water does not "clean up" the substance that deposits and adheres to the walls of containers, pumps, etc from C.A.N.E. AR 105, asphalt emulsion, Coherex, and Petroset. CMC-7H and 7HC (dry powders) do not dissolve readily, which severely restricts their use in agricultural field applications.

Emergence of beans and alfalfa from pots treated with several stabilizers was not significantly different from that from untreated (control) pots (Table 4).

TABLE 3. TIME FOR PENETRATION OF 0.8 ml OF DEIONIZED DISTILLED WATER (APPLIED DIRECTLY TO THE TREATED SURFACES) FOR VARIOUS SOIL STABILIZERS

Product	Water-dilution ratio	Total volume, gal per acre	Time of penetration, min
C.A.N.E. AR 105	25:1	200	194
Cationic asphalt emulsion	10:1	200	177
CMC-7H	2.5 g/l	400	*
CMC-7HC	2 g/l	200	*
Coherex	4:1	400	0.6
DCA-70	12.5:1	200	0.1
Petroset SB-1	25:1	200	4.2
Rezosol 5411-B	10:1	400	0.2
Wicaloid Latex 7035(AO)	25:1	200	1.5

* Too fast to measure

Field Tests

Because preemergence herbicides failed, no valid tests of the stabilizers were obtained at site 1. The herbicides used gave excellent control of grassy weeds, but poor control of broadleaf weeds. They had no effect on puncturevine (*Tribulus terrestris* L.) which almost covered the soil surface and necessitated mechanical cultivation to save the melon crop. That terminated our tests.

TABLE 4. EMERGENCE OF BEANS AND ALFALFA FROM SOIL TREATED WITH STABILIZERS INDICATED. TOTAL APPLICATION VOLUME: 400 GAL PER ACRE

Stabilizer	Water-dilution ratio	Average emergence, percent*	
		Beans	Alfalfa
C.A.N.E. AR 105	25:1	100	77
Coherex	4:1	—	73
Rezosol 5411-B	10:1	87	80
Wicaloid Latex 7035(AO)	25:1	100	87
Control	—	97	63

* Means do not differ at the 5 percent level.

TABLE 5. WIND-TUNNEL SOIL LOSSES AT SITE 3, 1972. TEST PERIOD: 7 WEEKS WITH 3.88 IN. OF RAINFALL DURING PERIOD. TOTAL VOLUME: 400 GAL PER ACRE

Product	Water-dilution ratio	Average soil loss,* tons per acre
Control	—	10.95
Coherex	4:1	10.86
CMC-7HC	10 g/gal	9.43
Cationic asphalt emulsion	9:1	8.16
C.A.N.E. AR 105	9:1	6.15
Wicaloid Latex 7035(AO)	9:1	5.64
Cationic asphalt emultion	4:1	3.91

* Means do not differ at 5 percent level.

The field test in 1971 at site 2, established on fall-seeded alfalfa, involved the following:

Stabilizer	Water-dilution ratio	Total volume, gals per acre
Coherex	4:1	400
Petroset SB-1	25:1	300
Wicaloid Latex 7035(AO)	25:1	300

Strong winds blew for 5 days, beginning 6 days after we applied stabilizers. Windspeeds measured at 5 ft above the soil surface ranged from 20 to 29 mph. Petroset failed on the third day, Wicaloid Latex failed on the fourth day, and the Coherex plot was covered by creeping soil and abraded by saltation from upwind areas by the fifth day.

Soil losses from wind-tunnel tests (site 3 1972) were not statistically different among the stabilizer treatments and control (Table 5). However, average soil losses were lower for stabilizer-treated plots, and the effect of water dilution was indicated by lower average losses from 4:1 than from 9:1 dilutions of asphalt emulsion. All soil losses were too large to consider the treatments effective.

In spring 1973 tests at site 3, 30 days after application, winds gusting to 67 mph (from Weather Bureau reports) essentially stripped stabilizers and loose soil from the plot surfaces, and no valid wind-tunnel measurements were possible. We did learn that Ammonium Lignosulfonate was water-soluble after application and drying because the soil surface color, which darkened during application, disappeared after rainfall. Consequently, the type of Ammonium Lignosulfonate we used would not be effective for temporary wind-erosion control.

Another trial in summer 1973 at site 3 showed wind-tunnel soil losses were significantly reduced by soil stabilizers in 6 of 7 treatments (Table 6). Our attempt to increase the flexibility of asphalt emulsion (which ordinarily oxidizes, becoming hard and brittle as weathering proceeds) by adding small amounts of Wicaloid Latex or TRIDAR 33/1 did not reduce soil losses more than treatments in which those products were omitted.

A final trial in early fall 1973 at site 3 indicated soil losses from all stabilizer-treated plots were significantly lower than losses from control plots (Table 7). TRI-DAR 100 is a more concentrated form of TRI-DAR 33/1. The TRI-DAR 100 mixed with Coherex—an attempt to improve the effectiveness of Coherex (a less expensive product)—did not reduce the average soil loss significantly more than Coherex alone.

Practical Considerations

Quantitative interpretation of the data requires information on rates of soil movement considered damaging (for a particular situation) and on the degree of control to be attained. Hayes (1966) estimated that tolerances of vegetables to blowing soil ranged from 0 to 1 ton per acre per year (Table 8). Such levels of soil losses (especially zero tolerance) would be difficult to attain with spray-on stabilizers. From wind-tunnel tests with rainfall (Table 2), we know that all treatments noted in Tables 6 and 7 effectively prevent soil loss immediately after application. However, the degree of deterioration (presumably linear) at 6 or 7 wks after application is indicated by the soil losses given in Tables 6 and 7. Assuming that a treated soil surface stabilizes within the 4-min wind-tunnel test period (visual movement generally ceased after 1 or 2 min) and that crop protection is not needed after 6 or 7 wks, products that could be used with various vegetable crops are included in Table 8.

Economic considerations will largely determine the use of spray-on stabilizers for agricultural purposes. Stabilizer costs, excluding transportation (freight), are included in Tables 6, 7, and 8. Of the stabilizers effective for 6 to 7 wks, asphalt emulsion and Coherex were the most economical. However, costs given are bulk prices for both as supplied in trucks or railroad tank cars in minimum amounts of 800 gal. Prices for 55-gal drums are about twice the bulk prices. Neither product cost compares favorabily with use of vegetative strips, such as rye, oats, or barley (Drullinger and Schmidt 1968). The price of TRI-DAR 100 increased from $1.00 per gal in August 1973 to $3.75 per gal in November 1973, accounting for the high cost noted in Tables 7 and 8. Except for Ammonium Lignosulfonate (and perhaps CMC-7H and 7HC), any of the laboratory-tested products of Table 2—at water-dilution ratios of 1:1 and applied at minimum total vol-

TABLE 6. SUMMER WIND-TUNNEL SOIL LOSSES AT SITE 3, 1973. TEST PERIOD: 6 WEEKS WITH 4.30 IN. OF RAINFALL DURING PERIOD. TOTAL VOLUME: 400 GALS PER ACRE

Product	Water-dilution ratio	Average soil loss, tons per acre	Product cost, † dollars per acre
Control	—	6.44a*	
Wicaloid Latex 7035 (AO)	4:1	5.79a	92
Wicaloid Latex 7035 (AO)	2:1	2.55b	153
Cationic asphalt emulsion and Wicaloid Latex	2:1-25:1	2.03b	36
Cationic asphalt emulsion	2:1	1.40b	18
Cationic asphalt emulsion and TRI-DAR 33/1	2:1-25:1	1.27b	50
Cationic asphalt emulsion	1:1	0.60b	27
TRI-DAR 33/1	2:1	0.45b	266

* Means followed by same letter do not differ at the 5 percent level.

† November 1973 prices.

TABLE 7. FALL WIND-TUNNEL SOIL LOSSES AT SITE 3, 1973. TEST PERIOD: 7 WEEKS WITH 11.42 IN. OF RAINFALL DURING PERIOD. TOTAL VOLUME: 400 GALS PER ACRE

Product	Water-dilution ratio	Average soil loss, tons per acre	Product cost, † dollars per acre
Control	—	6.00a*	
Coherex and TRI-DAR 100	4:1-24:1	2.62b	80
Coherex	2:1	1.48c	33
Coherex and TRI-DAR 100	2:1-49:1	0.91cd	63
TRI-DAR 100	9:1	0.71cd	150
Coherex	1:1	0.44d	50
TRI-DAR 100	4:1	0.17d	300

* Means followed by same letter do not differ at the 5 percent level.

† November 1973 prices.

umes of 400 gal per acre—would effectively reduce soil losses by wind for 6 or 7 weeks. However, at such rates all products, except asphalt emulsion and Coherex, would cost more than $200 per acre—too expensive to apply even on high-value crops.

Other considerations in using stabilizers must include costs of storage and high-volume spraying equipment, costs of herbicides, extra labor for handling large volumes, and extra time required during seeding operations. Asphalt emulsions gum up gear and roller pumps and may gum up centrifugal pumps unless run continuously; thus, pressurized tanks are more reliable, but an air compressor is needed in lieu of a pump. Fortunately, large nozzles are required to apply the needed volumes, lessening nozzle plugging. However, we recommend straining of asphaltic products to remove bits of solids that could plug nozzles.

An important deterrent to use of spray-on stabilizers is lack of effective weed control with preemergence herbicides. Although some weed species are controlled, others may proliferate from reduced competition, as puncturevine did in our studies. Therefore, knowledge of weed species on particular fields and availability of herbicides for their control would be essential before attempting to use stabilizers in row crops for temporary wind-erosion control.

Laboratory screening tests help (a) identify handling problems, (b) provide information on solution stability, and (c) identify products that are obviously too expensive, but they do not help determine amounts that must be applied in the field where they must remain effective 6 to 7 wks. For example, 18 gal per acre of asphalt emulsion prevented erosion in laboratory tests with high-intensity rainfall (Table 2), but 200 gal per acre were required in field tests (Table 6).

All our tests involved sandy (coarse-textured) soils, the soils most susceptible to wind erosion. Chepil et al. (1963) did not recommend Coherex for very-fine-textured soils because it disintegrates rapidly, and they reported that asphalt emulsions disintegrate more rapidly on fine-textured than on coarse-textured soils. Both products probably would disintegrate rapidly on organic (muck) soils.

Unless more economical products are developed and weed-control problems solved, we think spray-on stabilizers will have limited use in controlling wind erosion on agricultural fields. For soil stabilization, they will likely remain special-use products, such as to establish turf on home lawns and golf courses, to establish vegetation along highways and around airfields, and to control dust of ash heaps, coal piles, and finely granulated products being transported in open-top conveyors.

TABLE 8. ESTIMATED TOLERANCES OF VEGETABLES TO BLOWING SOIL, AND STABILIZER AMOUNTS NEEDED TO PROTECT THEM ON SANDY SOILS

Estimated tolerances,* tons per acre per year	Crops	Stabilizer	Water-dilution ratio	Total volume, gallons per acre	Product cost, dollars per acre
0	Carrots, cucumbers, beets, onions, spinach, squash, lettuce	None†	—	—	—
0.5	Green peas, lima beans, snap beans, tomatoes	TRI-DAR 100	4:1	400	300
		Coherex	1:1	400	50
		TRI-DAR 33/1	2:1	400	266
1.0‡	Asparagus, broccoli, egg-plant, sweet peppers, cabbage	Asphalt emulsion	1:1	400	27
		TRI-DAR 100	9:1	400	150
		Coherex and TRI-DAR 100	2:1-49:1	400	63

* Data from Hayes (1966).

† No products in amounts and dilutions tested completely prevented soil movement at 6 or 7 weeks after application.

‡ Products effective at lower tolerances also would be effective here.

SUMMARY

We evaluated 13 commercial soil stabilizers in laboratory wind-tunnel and raintower tests for their effectiveness in preventing soil movement by wind. Those tests showed that higher total application volumes and/or lower water-dilution ratios were required if stabilizer-treated soils were subjected to rainfall before being exposed to wind.

In greenhouse tests, emergence of beans and alfalfa was not affected by stabilizers applied to soil surfaces after seeding.

Field trials were made at three sites in northeastern Kansas using selected stabilizers found effective in laboratory tests. In two field trials, water-dilution ratios were too large and/or total application volumes too low to protect soil effectively against wind 6 to 7 wks after application.

In two field trials, five stabilizers reduced soil losses (measured in wind-tunnel tests 6 or 7 wks after application) to less than 1 ton per acre. Those stabilizers, all applied at total volumes of 400 gal per acre, were cationic asphalt emulsion at 1:1 water dilution ratio; Coherex at 1:1 water-dilution ratio; a mixture of Coherex and TRI-DAR 100 at 2:1 and 49:1 water-dilution ratios, respectively; TRI-DAR 33/1 at 2:1 water-dilution ratio; and TRI-DAR 100 at 9:1 and 4:1 water-dilution ratios. Coherex is a petroleum resin-in-water emulsion, and the two TRI-DAR products are linseed oil-based emulsions.

Only asphalt emulsion and Coherex appear economically feasible for use in preventing wind erosion during emergence and early growth of high-value crops. Although effective in preventing wind erosion, those products will not aid growers unless preemergence herbicides are available to control all weed species on particular fields.

Laboratory-screening tests did not help determine amounts of stabilizers required in field applications where they must remain effective for 6 to 7 wks.

Results of our studies apply only to sandy (coarse-textured) soils.

References

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

2 Chepil, W. S., N. P. Woodruff, F. H. Siddoway, and D. V. Armbrust. 1963. Mulches for wind and water erosion control. USDA, ARS 41-84, July.

3 Drullinger, R. H., and B. L. Schmidt. 1968. Wind erosion problems and controls in the Great Lakes Region. Journ. Soil and Water Conserv. 23(2):58-59.

4 Hayes, William A. 1966. Guide for wind erosion control in the northeastern states. USDA, Soil Conserv. Ser., July.

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

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

7 Morrison, F. D., W. A. Geyer, J. K. Greig, L. D. Leuthold, C. E. Long, N. W. Miles, and E. B. Nilson. 1972. Chemical weed control in horticultural and forestry plants. Kans. Agr. Expt. Sta. Bull. 564, December.

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

9 Wittmeyer, E. C. 1974. Personal communication. Extension Horticulturist, Ohio State University.