DURABILITY OF ASPHALTIC SOIL SEALANTS IN NORTHEASTERN COLORADO AND SOUTH-CENTRAL NORTH DAKOTA

November 1970 ARS **41-169**
Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

ACKNOWLEDGMENT

The authors are indebted to the following who aided in the planning of these studies and in the installation of these experiments:

R. J. Hanks, formerly Research Investigations Leader, Northern Plains Branch, Soil and Water Conservation Research Division, Agricultural Research Service, USDA, Fort Collins, Colorado, now Professor of Soil Physics, Utah State University, Logan, Utah.

H. R. Gardner, Soil Scientist, USDA, Fort Collins, Colo.

R. L. Florian, Agricultural Research Technician, USDA, Akron, Colo.

W. Graves, Agricultural Research Technician, USDA, Akron, Colo.

J. J. Bond, Director, Soil Scientist, USDA, Mandan, N. Dak.

R. T. Vredenburg, Agricultural Research Technician, USDA, Mandan, N. Dak.

John R. Griggs, Physical Science Technician, U.S. Water Conservation Laboratory, USDA, Phoenix, Ariz.

DURABILITY OF ASPHALTIC SOIL SEALANTS IN NORTHEASTERN COLORADO AND SOUTH-CENTRAL NORTH DAKOTA [1]

By Frank Rauzi, Merle L. Fairbourn, Howard J. Haas, and Rome H. Mickelson[2]

Water harvesting has been defined as the collection of water from an area specifically set aside and treated to increase precipitation runoff.[3] Numerous methods for increasing yields of harvested water have been investigated, including spraying the soil surface with asphalt emulsions, and ground covers with foil, building paper, plastics with and without asphalt, sheet metal, and butyl rubber sheeting.

Lauritzen and Thayer[4] developed a rain trap consisting of a butyl rubber sheet and collecting bag. Lauritzen investigated sheet metal rain traps and storage structures.[5]

Myers, Fraiser, and Griggs[6] tested several asphaltic formulations and concluded that the penetration and bonding of the asphaltic materials into and with the soil particles are functions of the chemical composition of the soil, the asphaltic materials used, soil structure, and soil water content. Plastic films bonded to asphalt-treated soil generally have not proved satisfactory for harvesting water.[7] Matlock and Shaw[8] used 8 mil black polyvinyl plastic sheet for a ground cover to harvest water for domestic use near Tucson, Ariz.

The present study was initiated in the summer of 1965 to evaluate the stability of asphaltic emulsions with and without plastic film on the surface under adverse climatic and soil conditions.

EXPERIMENTAL AREAS AND PROCEDURE

Table 1 describes the experimental sites in northeastern Colorado and two in south-central North Dakota which were selected for their diversity in climate and soils.

The experimental sites, except at the Central Plains Experimental Range, were cleared of native vegetation, smoothed with a scraper or grader, and packed with a roller. A scraper was used to remove the native vegetation at the Central Plains Experimental Range site, and the plots were raked smooth, but not rolled or packed.

The roots and organic matter present on the plot surfaces were burned with a weed burner at the Central Great Plains Field Station and at the Northern Great Plains Research Center. No attempt was made to burn the protruding roots to ground level at the other two Colorado sites. Polyborochlorate (granular), a soil sterilant, was applied on all Colorado plots, and monuron (CMU) was applied to the North Dakota plots to prevent vegetative growth. All plots were sprayed with water before the weedicide or asphaltic treatments were applied at all sites except at the Central Plains Experimental Range.

Six treatments other than the checks were replicated three times at the Colorado locations and twice at the North Dakota locations. Plots were 10 x 20 feet in size.

---

[1] Contribution from Northern Plains Branch, Soil and Water Conservation Research Division, Agricultural Research Service, USDA.

[2] Soil Scientists, ARS, USDA, stationed at Laramie, Wyo., Fort Collins, Colo., and Mandan, N. Dak.; and Agricultural Engineer, ARS, USDA, stationed at Akron, Colo.

[3] Myers, L. E. Water harvesting. Presented at the 17th Annual Nevada Water Conference. Carson City, Nev. Sept. 28, 1962.

[4] Lauritzen, C. W., and Thayer, A. Raintraps for intercepting and storing water for livestock. U.S. Dept. Agr. Info. Bul. No. 307, 10 pp. 1966.

[5] Lauritzen, C. W. Raintraps of steel. Utah Science 28: 1-3. 1967.

[6] Myers, L. E., Fraiser, Gary W., and Griggs, J. R. Sprayed asphalt pavement for water harvesting. J. Irrig. and Drain Div., Amer. Soc. Civil Eng. Proc. 93: IR3. pp. 79-97. 1967.

[7] Myers, L. E. Water harvesting with plastic film. Presented at the Sixth National Agricultural Plastics Conference. Phoenix, Ariz. 1965.

[8] Matlock, W. G., and Shaw, R. J. Rainfall collection for domestic water supplies. Prog. Agr. in Arizona 18(4): 10-11. 1966.

TABLE 1.—Description of experimental sites

Location	Elevation	Average annual precipitation	Frost-free period	Mean annual temperature	Slope exposure	Slope of the site	Soil type
	Feet	*Inches*	*Days*	*°F.*		*Percent*	
Central Plains Experimental Range, near Nunn, Colo.	5,400	12.0	135	45.8	North	5.5	Terry fine sandy loam.
Central Great Plains Field Station, near Akron, Colo.	4,500	16.7	143	48.4	do	1 to 2	Platner loam.
Eastern Colorado Range Station, 17 miles north of Akron, Colo.	4,200	17.0	145	48.0	East	2	Dune sand.
Northern Great Plains Research Center, near Mandan, N. Dak.	1,750	16.0	135	41.0	South	7	Flasher loamy fine sand.
Northern Great Plains Research Center, near Mandan, N. Dak.	1,750	16.0	135	41.0	South	5	Bainville silty clay loam.

Two plots were used for checks at each of the Colorado locations. Treatments were as follows:

1. Check - only at the Colorado locations
2. 0.5 gal./yd.^{2} peneprime plus SS-1 seal coat at 0.33 gal./yd.^{2}
3. 1.0 gal./yd.^{2} peneprime plus SS-1 seal coat at 0.33 gal./yd.^{2}
4. 1.5 gal./yd.^{2} peneprime plus SS-1 seal coat at 0.33 gal./yd.^{2}
5. 1.5 gal./yd.^{2} peneprime plus SS-1 seal coat at 0.33 gal./yd.^{2}
6. 0.75 gal./yd.^{2} MC-250 cutback asphalt plus SS-1 seal coat at 0.33 gal./yd.^{2}
7. 0.75 gal/yd.^{2} MC-250 cutback asphalt plus SS-1 seal coat at 0.33 gal./yd.^{2} and 1.5 mil black polyethylene film bonded to surface.

MC-250 is a medium cure cutback made from soft asphalt containing 5.6 pounds of asphalt per gallon. SS-1 seal coat is a slow setting anionic emulsion with additives to improve adhesion to aggregates and contains 5 pounds of asphalt per gallon. Peneprime is a product of Empire Petroleum Company of Denver, Colo. The peneprime and MC-250 cutback asphalt were applied at temperatures of 150° to 200° F., and the seal coat (SS-1) was heated to 130° to 160° before application.

Treatments were observed and rated at all locations in mid-April 1966, 1967, and 1968 to evaluate the stability, durability, and water harvesting qualities of the soil sealants. At the Northern Great Plains Research Center, plots were also evaluated in 1969. The treatments were rated as follows: 3 - Excellent, 2 - Good, 1 - Fair, and 0 - Poor.

RESULTS AND DISCUSSION

In the early fall of 1965, the polyethylene film was smooth and in firm contact with the asphalt surface on plots with smooth surfaces at the time of installation at the Colorado locations. The polyethylene film tended to wrinkle with lower temperatures and following a rise in temperatures remained in that condition. At the North Dakota locations, the polyethylene film was wrinkled because of difficulties experienced in applying the film to the asphalt surface. On plots where roots were not burned or where the surface was not entirely smooth at the time of installation, the polyethylene film did not uniformly adhere to the asphalt surface. The roots pierced the polyethylene film, leaving small holes which later cracked and enlarged as the air temperature dropped. Wherever the polyethylene film cracked, the wind peeled it away from the asphalt surface.

Soil surface fracturing was observed in 1965 on the loam and fine sandy loam soils with the MC-250 cutback and all peneprime treatments. No fracturing was noted on the dune sand soils. Surface fracturing was more prevalent on the plots treated with the lower rates of peneprime.

The rapidity of deterioration for all treatments is shown in tables 2 and 3 which summarize annual conditions of all treatments. Generally, deterioration was faster on the loam, sandy loam, and clay loam soils and on treatments without a polyethylene film. The treatments with and without the polyethylene film on the dune sand and the loamy fine sand were rated nearly the same for their water harvesting qualities in 1968.

TABLE 2.—Physical condition of soil surfaces treated with various sealants at three locations in northeastern Colorado

Treatment	Ratings[1]								
	Platner loam			Dune sand			Terry Fine Sandy Loam		
	1966	1967	1968	1966	1967	1968	1966	1967	1968
Check	0	0	0	0	0	0	0	0	0
0.5 gal./yd.^{2} peneprime plus seal coat	0	0	0	2	2	1	0	0	0
1.0 gal./yd.^{2} peneprime plus seal coat	1	1	0	3	2	1	1	1	0
1.5 gal./yd.^{2} peneprime plus seal coat	2	1	0	3	3	2	3	1	0
1.5 gal./yd.^{2} peneprime plus seal coat and 1.5 mil black polyethylene film	3	1	0	3	2	2	1	1	0
0.75 gal./yd.^{2} MC-250 cutback plus SS-1 seal coat	1	1	0	3	3	2	3	1	0
0.75 gal./yd.^{2} MC-250 cutback plus seal coat and 1.5 mil black polyethylene film	3	1	0	3	2	2	2	1	1

[1] 3 - excellent; 2 - good; 1 - fair; 0 - poor.

TABLE 3.—Physical condition of soil surfaces treated with various sealants at Northern Great Plains Research Center, Mandan, N. Dak.

Treatment	Ratings[1]							
	Flasher loamy find sand				Bainville silty clay loam			
	1966	1967	1968	1969	1966	1967	1968	1969
No check	-	-	-	-	-	-	-	-
0.5 gal./yd.^{2} peneprime plus seal coat	3	2	1	1	2	1	1	0
1.0 gal./yd.^{2} peneprime plus seal coat	3	2	1	1	2	1	1	0
1.5 gal./yd.^{2} peneprime plus seal coat	2	1	1	1	2	1	1	0
1.5 gal./yd.^{2} peneprime plus seal coat and 1.5 mil black polyethylene film	3	2	2	2	3	2	1	1
0.75 gal./yd.^{2} MC-250 cutback plus seal coat	3	1	1	1	2	1	1	0
0.75 gal./yd.^{2} MC-250 cutback plus seal coat and 1.5 mil black polyethylene film	3	2	2	2	3	2	1	1

[1] 3 - excellent; 2 - good; 1 - fair; 0 - poor.

PLATNER LOAM

By the third year, all treated plots on the Platner loam soil were fractured. Of the coating, 20 to 50 percent was eroded from the plots not covered with the polyethylene film. The plots covered with the polyethylene film had from 30 to 50 percent of the film peeled away from the surface (fig. 1). Weeds and grasses were growing in some of the fractures in the plots. The check plots had a block-type fracturing pattern, which is characteristic of the loam soil.

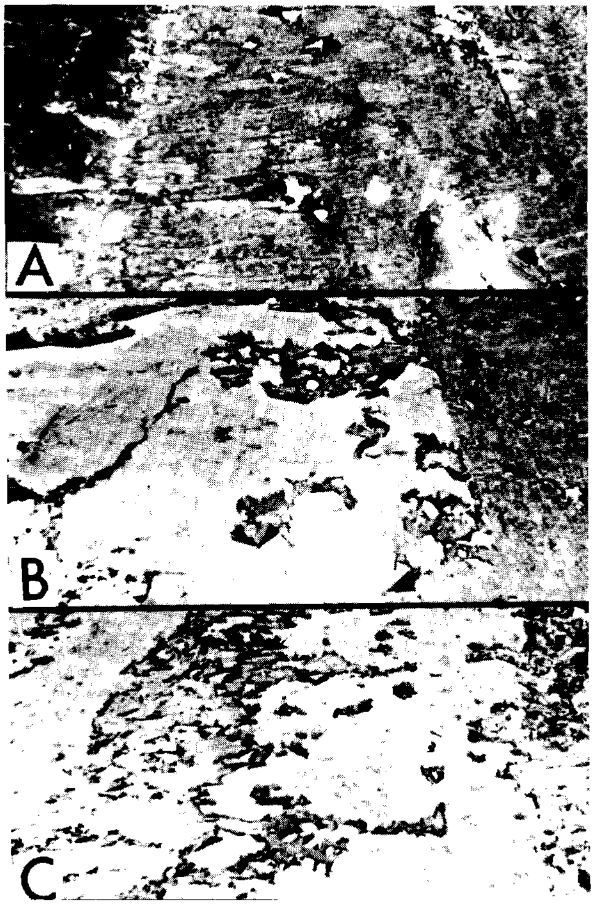

Figure 1.--Plots treated with peneprime 1.5 gal./yd.^{2} plus a seal coat and 1.5 mil black polyethylene in 1965: *A*, Dune sand; *B*, Platner loam; and *C*, Terry fine sandy loam.

TERRY FINE SANDY LOAM

The degree of weathering of the treated surfaces on the Terry fine sandy loam varied with the treatment. Up to 100 percent of the surface area cracked, peeled, and eroded on some treatments. Almost 90 percent of the polyethylene film had been peeled from both the MC-250 cutback asphalt and the 1.5 gal./yd.^{2} peneprime treated plots (fig. 2). By the end of the third year, the value of all surfaces for water harvesting was nil. Wind and water erosion was evident on the check plots.

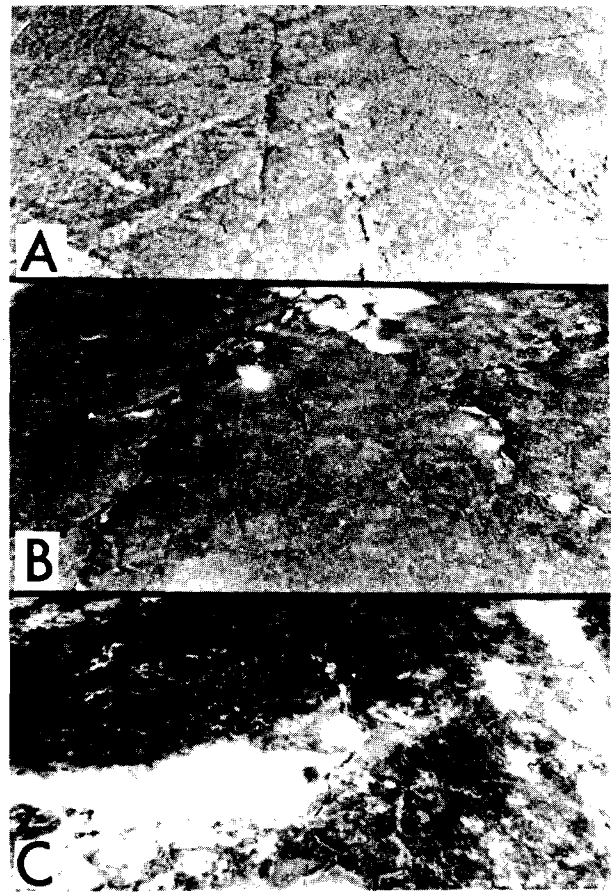

Figure 2.--Plots treated with MC-250 cutback 0.75 gal./yd.^{2} plus a seal coat in 1965: *A*, Dune sand; *B*, Platner loam; and *C*, Terry fine sandy loam.

DUNE SAND

Overall, the treatments did not deteriorate as rapidly on the Dune sand as on the loam and fine sandy loam soils. Rodent damage to the plots on sand was more severe than the normal weathering. The polyethylene film covered 75 to 95 percent of both the MC-250 and peneprime treated plots surface after 3 years. The condition of the remaining treated plots varied from fair to good after 3 years (fig. 3).

Treatments with 1.5 gal./yd.^{2} of peneprime and MC-250 asphalt cutback both rated good on the sand after 3 years. However, when the treated surfaces cracked, peneprime tended to curl while the MC-250 remained flat. Therefore, MC-250 asphalt cutback would be preferable on the sand.

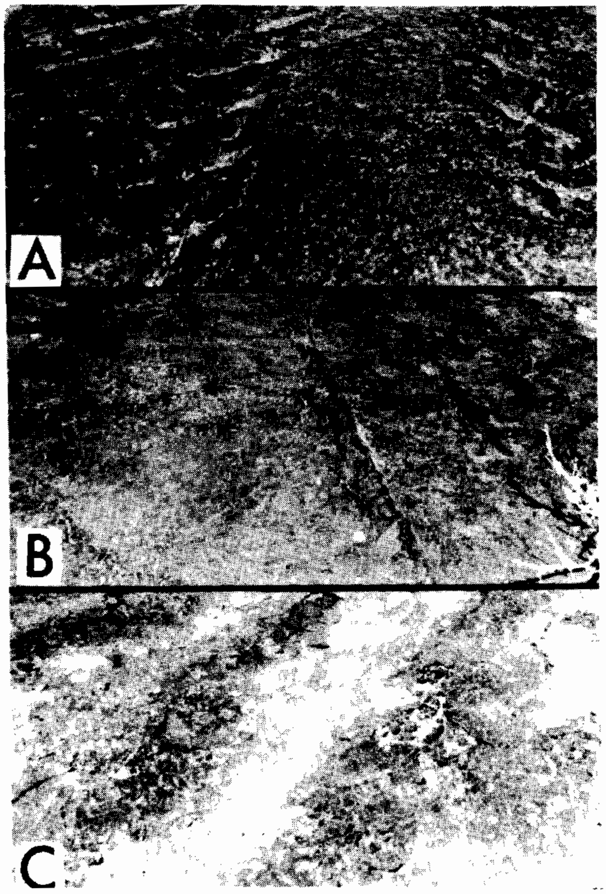

Figure 3.--Plots treated with peneprime 1.5 gal./yd.^{2} plus a seal coat in 1965: *A*, Dune sand; *B*, Platner loam; and *C*, Terry fine sandy loam.

FLASHER LOAMY FINE SAND

The deterioration of the treated surfaces on the Flasher loamy fine sand was not so rapid or severe as on the silty clay loam. Soil cracking was evident on all plots, and the polyethylene film began to peel away wherever soil cracking occurred. Condition of the plots was the same in 1969 as in 1968, indicating that the surfaces had not materially deteriorated during the fourth year.

BAINVILLE SILTY CLAY LOAM

By the end of the third year, the treated surfaces on the Bainville silty clay loam soil were rated as being of no value for water harvesting. The treated plots were badly cracked and the polyethylene film was largely peeled away from the asphalt surface. Weeds were growing in many of the plots as the effectiveness of the weedicide was reduced. The 1969 ratings for the treated surfaces on the silty clay loam soil were lower than those in 1968, except those for the plots covered with the polyethylene film remained the same.

The treated surfaces covered with the 1.5 mil black polyethylene film remained in a better condition longer than the plots not covered.[9] Once the plastic film cracked from root puncture or shrinkage, the wind removed parts of the film. The plastic film also deteriorated and with time became more brittle and easier for the wind to remove.

The various rates of peneprime and MC-250 cutback asphalt treatments were more durable on the Dune sand and on the Flasher loamy fine sand than on the other soils. The peneprime and MC-250 cutback asphalt penetrated deeper into the soil surface on the coarser textured soils than on the finer textured soils. The expansion and contraction properties of the finer textured soils cause fracturing of the immediate soil surface. This permits water to enter into the soil surface, and the wetting and drying, along with shrinking and swelling processes, break down the surface sealant. The sand had a relatively small amount of silt and clay present and had the most durable surface. The sand grains were easily cemented together and expansion and contraction were apparently minor.

SUMMARY

A study to evaluate asphaltic soil sealants for possible use in water harvesting was initiated during the summer of 1965. The studies were made at three locations in northeastern Colorado and two, in south-central North Dakota.

The asphaltic emulsions used were peneprime and MC-250 cutback asphalt. One peneprime and one MC-250 cutback asphalt treatment were covered with 1.5 mil black polyethylene film.

The evaluations were conducted on a Platner loam, Terry fine sandy loam, Dune sand, Flasher loamy fine sand, and a Bainville silty clay loam. The slope of the sites ranged from 1 to 7 percent.

After 3 years, all treated surfaces on the loam, fine sandy loam, and the silty clay loam had deteriorated to a

[9]Observations at the Newell Irrigation and Dryland Field Station were similar for the short period before plots were affected by water seepage from a reservoir.

point where they were of no value for harvesting water. The treated surfaces on the sand and loamy fine sands without a polyethylene film cover were rated in fair to good condition for water harvesting after 3 years of exposure. The plots covered with a 1.5 mil polyethylene film were usually in a better condition than the plots not covered even after most of the film had been removed from the surface.

Soil preparation before application of the asphaltic emulsion is important in determining the longevity of the treatment. Climatic conditions and the type of asphaltic emulsion used are important factors to be considered. The soil type best suited to the asphaltic emulsion used appears to be one low in silt and clay contents.