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Erosion Inhibitor Performance Evaluation Under Simulated Wind and Rain

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Final Report to CONWED Corporation

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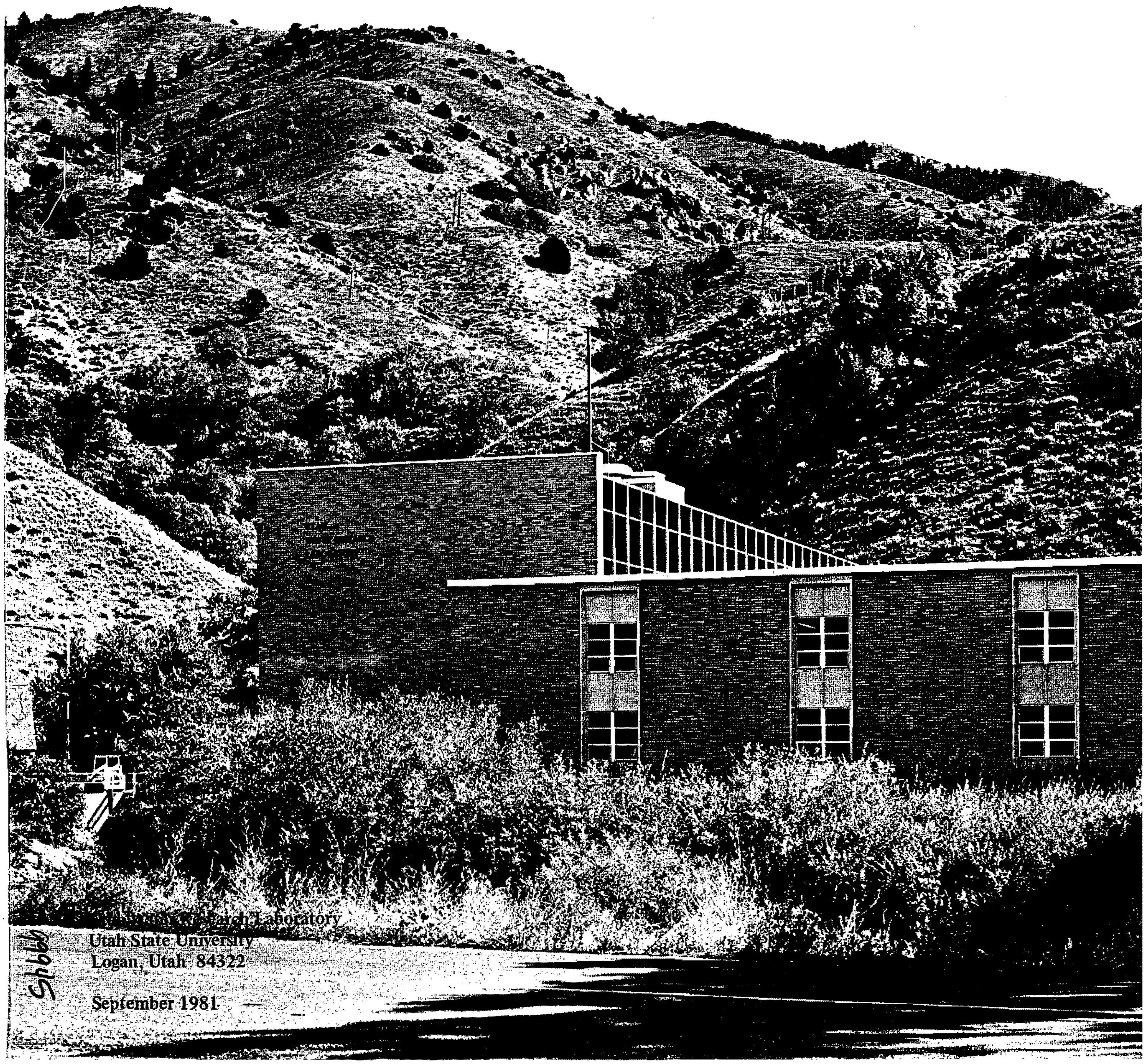

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September 1981

CONWED CORPORATION

Final Report

EROSION INHIBITOR PERFORMANCE EVALUATION UNDER SIMULATED WIND AND RAIN

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INTRODUCTION

Increasing public awareness of the desirability of protecting the environment from soil erosion caused by wind and water has centered attention on large construction projects such as highways and housing subdivisions, as well as on individual building sites and parking lots. If unattended, sediment produced from these areas pollutes surface water, restricts drainage, fills reservoirs, damages adjacent land, and upsets the natural ecology of lakes and streams.

The search continues for products and practices that will prevent or lessen the amount of sediment leaving construction sites. Products currently in use include chemical as well as organic materials, and they are applied with varying degrees of success. Many designed to stabilize the unprotected soil for a long enough period of time for vegetation to become established are in wide use and are quite effective (Clyde et al. 1978). Moreover, applying organic material to the soil surface around shallow-rooted crops has been a cultural practice for many years (Russell 1961). Janick (1963) summarized the effects of mulching as conservation of soil moisture, reduction of surface runoff and erosion, reduction of evaporation, and possible control of weeds. Others (Borst and Woodburn 1942; Duley 1939) have indicated the value of mulches in reducing runoff and erosion. Mulching has been reported as superior to other treatments for reducing soil and water losses and stabilizing bare slopes before grass is established (Swanson et al. 1965). Gilbert and Davis (1967) and Blaser (1962), in studies of highway slope stabilization, found mulches improved seed germination and seedling growth by conserving moisture and protecting highway slopes against erosion.

Many materials have been evaluated for use as a mulch, including bark, wood wastes, soybean residues, wheat straw, and seaweed (Bollen and Glennie 1961; Kidder et al. 1943; Latimer and Percival 1947). McKee et al. (1964) found wheat straw to be one of the best mulches, particularly when used to aid vegetation establishment on steep cut slopes of highways. Osborne and Gilbert (1978) also demonstrated that shredded hardwood bark mulch provided adequate erosion control on highway slopes.

The objective of the present study was to evaluate, using simulated rainfall and wind, the effectiveness of various mulches and tackifiers for controlling erosion. Results of these tests are comparable to those obtained by the Utah Water Research Laboratory for CONWED in 1979 in that they were generated in the same way and in the same test facility on similar soil, using identical conditions of slope and rainfall rate.

MATERIALS AND METHODS

Description of Testing Facility

Rainfall simulator. The rainfall simulator is a drip type device in which individual raindrops are formed by water emitting from the ends of small diameter brass tubes. The rate of flow is controlled by admitting water into a manifold chamber through fixed orifice plates under constant hydraulic pressure. Five separate inlet orifices are used in each chamber or simulator module. The ratios of the areas of the orifices are 1:2:4:8:16. By controlling the flow to the orifice with an electrically operated solenoid valve it is possible to vary flow in on-off increments with 31 steps. Outlet from the chambers or modules is through uniform equally spaced brass tubes. Each module is a 24 inch rectangular box about 1 inch deep and oriented so that the ends of the tubes or needles form a horizontal plane to let the water drip vertically toward the tilting flume. Each module has 672 needles spaced on a 1 inch triangular pattern.

The rainstorm simulator consists of 100 modules spaced and supported to make a continuous simulator 20 feet square. Each module has separate controls so that a spatially moving storm with time-changing intensities can be simulated. The 500 switches are manually operated, or can be controlled by a programmed computer if desired.

Raindrop sizes and velocities of impact have been designed to represent the energy of typical high intensity storms. The spatial distribution of the rain is essentially uniform and the control of application rates is within the accuracy requirement of most experiments. The simulator is shown in Figure 1 in position over the testing flume.

Tilting flume. The tilting flume is square and measures 20 feet on each side. The flume is designed so that a vacuum can be maintained beneath the soil to aid infiltration when this is necessary, and water sheet flow can be maintained over the top of the soil when desired. The rainfall simulator is supported over the flume so that rain falls directly onto the soil layer.

Approximately 1 foot depth of soil is supported in the tilting flume by a metal grating covered with filter cloth through which water can drain. The flume is divided into three test plots, each measuring approximately 4 feet by 19.5 feet. These plots are separated from

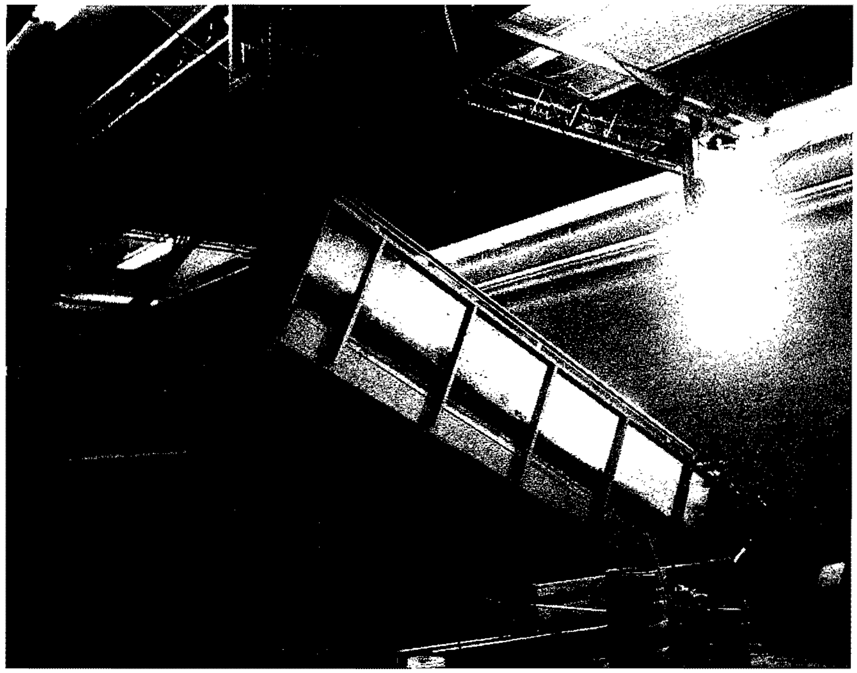


Figure 1. Erosion control testing facility.

each other and from the side walls of the flume by 2-foot wide buffer strips. Runoff from each test plot is collected in a large plastic tub then dried and weighed for determining the amount of mulch and soil leaving the plot.

Products Included in Tests

Several different products were included in the tests in various combinations, and are described below:

1. Straw--wheat straw was purchased in bales, processed through a commercial shredder and blower, then applied by hand to the plots.
2. CONWED Hydro Mulch Fiber.

3. CONWED Hydro Mulch 2000 Fiber.

4. CONWED Plastic Netting and 6"-long staples.

   Items 2, 3, and 4 were provided by CONWED Corporation, 322 Minn. Street, P.O. Box 43237, St. Paul, Minn. 55164.

5. Asphalt Emulsion SS1--purchased from a local contracting firm.

6. Terra Tack AR provided by Grass Growers, 424 Cottage Place, Plainfield, New Jersey 07061

Testing Procedure

Plot preparation. Each of the three test plots was filled with a loam soil having the following approximate composition: total sand = 28 percent; total silt = 49 percent; total clay = 23 percent; total organic matter = 2.7 percent. After every test run the top layer of soil and mulch was removed and discarded from each plot to the depth that erosion had occurred. New soil was added to replace that removed, then each plot was cultivated with a garden tiller to a depth of approximately 6 inches. It was then raked smooth and uniformly compacted with a lawn roller filled with water, and was ready for the next application of mulch.

After the plots were prepared and mulch was applied, the test flume was tilted to the desired slope in preparation for wind and rain applications. A slope of 2:1 (50 percent) was used for all of the tests described herein, except the final one where it was increased to 1 1/2:1 (67 percent).

Wind application. A 24-inch diameter squirrel-cage fan driven by a 15 HP, 440 VAC motor was mounted rigidly on a wall near the lower end of the testing flume. When the flume was positioned at a 2:1 slope, three 10 inch diameter metal ducts directed wind from the fan through the end of the flume onto the test plots (Figure 2). The wind, blowing up slope, impinged on the plots at approximately their mid points. Wind entered the flume at a velocity of approximately 60 miles per hour, dispersed to between 25 and 30 mph at the point of impingement, and was near 10 mph at the upper end of the plots. Window screen backed by wire netting was suspended from the perimeter of the rainfall simulator to keep the straw blown from the plots from scattering to other areas of the laboratory while the wind machine was running. This unidirectional constant velocity wind does not simulate all of the conditions found in the natural setting, but does enable the comparison of erosion control products under similar conditions. In each test involving wind, it was applied for a 15 minute time period.

Rainfall application. The test flume containing the mulch-covered plots was tilted to the desired slope and covered with a plastic sheet.

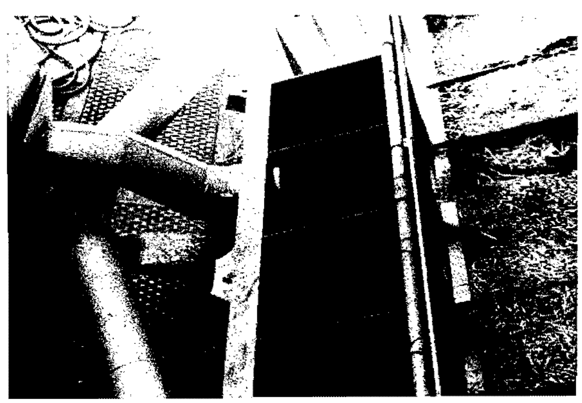


Figure 2. Wind machine in position at lower end of testing flume.

The rainfall simulator was turned on at full capacity to purge the air from the system. (During this purging the rain fell onto the plastic and ran into the drain without wetting the plots.) When the purging was complete the rainfall rate was adjusted to the desired rate and allowed to stabilize. Plastic covering the test flume was then quickly removed so the rain could fall directly onto the test plots, and the time clock was started. Total time was recorded from the instant that rain began falling onto the plots until failure of the mulch or the slopes occurred. As each plot failed, rainfall to that plot was stopped so that no additional soil or mulch would be lost.

Rainfall rate for all tests was 4 inches/hour except for the final one, which was increased to 12 inches per hour.

Runoff measurement. All of the sediment, water, and mulch leaving each plot during a test was collected in a large plastic tub. After the eroded materials had settled, water was decanted from the tub, and the materials were dried and weighed. Drying was accomplished by placing the tubs for a few days in the direct rays of the sun.

Test Descriptions, Results, and Discussions
(Refer to Tables 1, 2, and 3)

Test No. 1 (Figure 3) (Straw at 2 tons/acre, wind, and rain). Straw was applied to each of the three plots with a pitchfork, and was carefully spread so as to provide uniform coverage. Wind was applied for 15 minutes, then rain as described previously. Eroded sediment was collected and weighed.

Straw blew off immediately from almost the entire plots as soon as wind was applied. Sediment runoff began within 3 to 4 minutes after rain was initiated and continued at a constant rate throughout the run.

Table 1. Eroded material under 4 inches/hr rainfall and 2:1 slope.

Product		Replications					
		Wind			No Wind		
		North	Center	South	North	Center	South
Straw (2 tons/acre)	Elapsed time until erosion begins	4'-0"	3'-50"	3'-0"	16'-0"	19'-30"	21'-0"
	Elapsed time until failure occurs	No failure	No failure	No failure	30'-44"	20'-0"	21'-0"
	Total time of collecting runoff	34'-0"	22'-0"	22'-0"	30'-44"	*	*
	Amount of eroded material	37.0 lbs	22.1 lbs	27.8 lbs	0.5 lb	*	*
	Apparent rate of erosion	1.09 lbs/min	1.0 lbs/min	1.22 lbs/min	0.02 lb/min	*	*
	Average		1.10 lbs/min				
Straw (2 tons/acre) Covered with CONWED Mulch (750 lbs/acre)	Elapsed time until erosion begins	44'-0"	47'-0"	47'-0"	37'-56"	35'-55"	19'-13"
	Elapsed time until failure occurs	No failure	No failure	No failure	37'-56"	35'-55"	19'-13"
	Total time of collecting runoff	90'-0"	90'-0"	90'-0"	*	*	*
	Amount of eroded material	0.48 lb	0.29 lb	0.16 lb	*	*	*
	Apparent rate of erosion	0.005 lb/min	0.003 lb/min	0.002 lb/min	*	*	*
	Average		0.003 lb/min				
Straw (2 tons/acre) Covered with Asphalt Emulsion SS1 (250 gals/acre)	Elapsed time until erosion begins	4'-30"	3'-51"	5'-0"	16'-30"	14'-0"	15'-30"
	Elapsed time until failure occurs	45'-45"	No failure	53'-10"	No failure	No failure	43'-57"
	Total time of collecting runoff	*	60'-0"	*	37'-0"	37'-50"	37'-46" #
	Amount of eroded material	*	16.7 lbs	*	0.7 lb	1.1 lbs	0.3 lb
	Apparent rate of erosion	*	0.278 lb/min	*	0.019 lb/min	0.029 lb/min	0.008 lb/min
	Average					0.019 lb/min	
Straw (2 tons/acre) Covered with Terra Tack AR (120 lbs/acre)	Elapsed time until erosion begins	13'-40"	8'-0"	7'-30"	12'-0"	22'-0"	18'-0"
	Elapsed time until failure occurs	No failure	No failure	No failure	42'-20"	38'-54"	36'-17"
	Total time of collecting runoff	47'-0"	47'-0"	47'-0"	39'-50" #	*	*
	Amount of eroded material	2.3 lbs	6.77 lbs	3.26 lbs	0.3 lb	*	*
	Apparent rate of erosion	0.049 lb/min	0.144 lb/min	0.069 lb/min	0.008 lb/min	*	*
	Average		0.087 lb/min				
Product 80-10 (1600 lbs/acre)	Elapsed time until erosion begins	5'-0"	6'-0"	5'-0"	-	-	-
	Elapsed time until failure occurs	No failure	No failure	No failure	-	-	-
	Total time of collecting runoff	28'-10"	22'-40"	32'-40"	-	-	-
	Amount of eroded material	3.9 lbs	5.1 lbs	13.6 lbs	-	-	-
	Apparent rate of erosion	0.138 lb/min	0.225 lb/min	0.416 lb/min	-	-	-
	Average		0.260 lb/min				

*The amount of sediment collected before failure occurred was negligible.

#Catchment filled and was removed for weighing before failure occurred.

-No tests were run.

Table 2. Comparative testing of three mulches under 4 inches/hr rainfall and 2:1 slope.

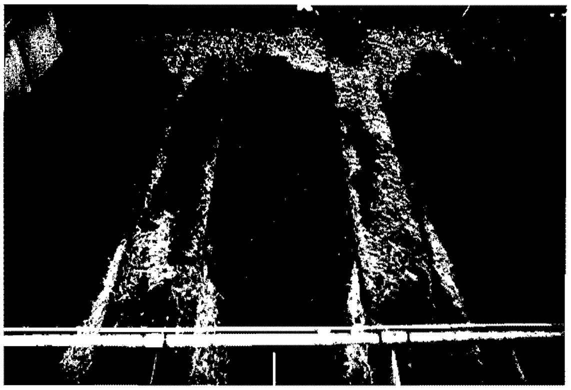
	North Straw (2 tons/acre)	Center CONWED 2000 (1600 lbs/acre)	South CONWED Mulch (2400 lbs/acre)
Elapsed time until erosion begins	6'-15"	9'-50"	3'-0"
Elapsed time until failure occurs	36'-25"	54'-43"	No Failure
Total time of collecting runoff	*	35'-35" #	20'-35"
Amount of eroded material	*	3.6 lbs	10.1 lbs
Apparent rate of erosion	*	0.10 lb/min	0.49 lb/min

*The amount of sediment collected before failure occurred was negligible.
#Catchment filled and was removed for weighing before failure occurred.

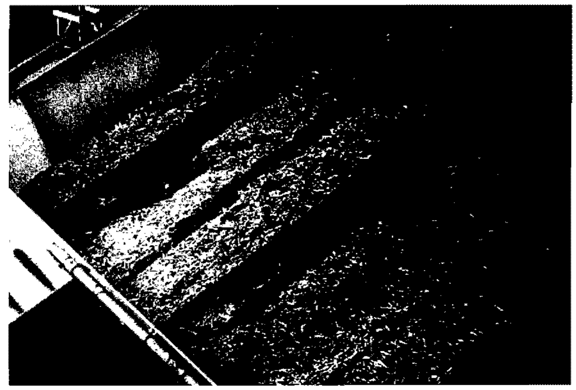
Table 3. Material eroded under 12 inches/hr rainfall and 1½:1 slope after 15 minutes of wind @ 30 mph.

		Replications		
		North	Center	South
Straw (3 tons/acre)	Elapsed time until erosion begins	2'-0"	2'-0"	2'-0"
Covered with	Elapsed time until failure occurs	24'-30"	No Failure	19'-40"
Stapled CONWED Netting	Total time of collecting runoff	15'-0" #	10'-0"	10'-0" #
(1 staple/yd^2)	Amount of eroded material	34.6 lbs	24.6 lbs	34.8 lbs
	Apparent rate of erosion	2.31 lbs/min	2.46 lbs/min	3.48 lbs/min
			Avg. = 2.75 lbs/min	

#Catchment filled and was removed for weighing before failure occurred.



Test No. 1. After wind but before rain.



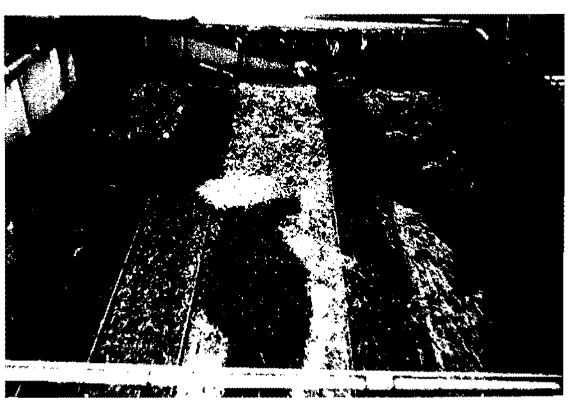
Test No. 2. After rain application on plots with no wind.

Figure 3. Straw @ 2 tons/acre.

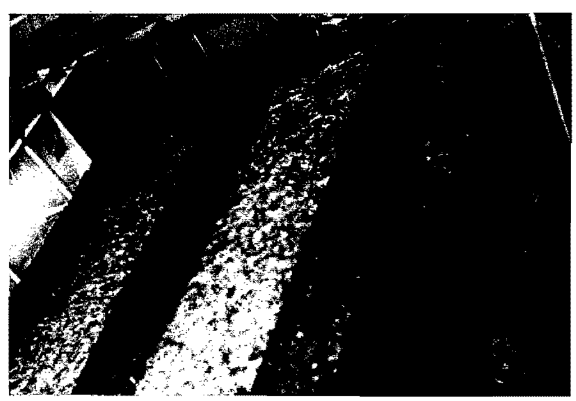
Test No. 3. After wind and rain.

Test No. 4. Plots before rain and without wind.

Figure 4. Straw @ 2 tons/acre covered with CONWED mulch @ 750 #/acre.



Test No. 5. After wind and rain.



Test No. 6. After wind application on plots with no wind.

Figure 5. Straw @ 2 tons/acre covered with asphalt emulsion SS1 @ 250 gal/acre.

Catchments were filled after 22 minutes of rain so the unit was shut down. Because of the bare soil surface, most of the rainfall ran overland and not enough infiltrated to cause the slopes to fail.

Test No. 2 (Figure 3) (Straw at 2 tons/acre, then rain). Straw was put on the three plots, rain was applied, and sediment was collected.

There was essentially no runoff from any of the plots until failure occurred (only 0.5 pound was collected from one plot during a 30 minute period). The straw absorbs all of the impact energy of the raindrops, then bleeds the water slowly into the soil until its moisture-holding capacity is reached, and the slope fails. This same phenomenon has been observed on several straw-covered slopes, and always occurs the same way. Erosion from the slope before failure occurs is always either a very low amount or zero. Because there is negligible runoff from the plots in these kinds of tests, and the soil and slopes remain unchanged, we are apparently measuring only the differences in initial conditions of the soil in the various plots as indicated by the differences in times from beginning of rainfall until slopes fail.

Test No. 3 (Figure 4) (Straw at 2 tons/acre covered with CONWED mulch at 750 #/acre, wind, and rain). Straw was applied to the plots, then oversprayed with CONWED mulch and allowed to dry for approximately 40 hours before wind was turned on. After 15 minutes of wind there was very little visible change in the position of the straw on the plots.

Rain was applied for 90 minutes and no failure occurred, either of the mulch cover or of the soil underneath. Equilibrium was soon reached where the amount of water infiltrating through the soil profile plus that running overland down the slope equaled the amount falling as rain, and failure of the slopes did not occur.

Apparent rate of erosion from the plots was very low throughout the time of the test.

Test No. 4 (Figure 4) (Straw at 2 tons/acre covered with CONWED mulch at 750 #/acre, then rain). Straw was applied to the plots and oversprayed with CONWED mulch, then allowed to dry for 40 hours before rain was applied. Rate of erosion for each of the plots was very low throughout the period of the test, until failure occurred. The north and center slopes failed after little more than 30 minutes of rain. The only plausible explanation for these slopes failing and the previous ones not is that the initial conditions such as moisture content and degree of porosity of the soil must have been different. Sedimentation runoff rate was not determined for the three plots because they failed suddenly and totally inundated the catchments before they could be removed for weighing. It is felt that the main value of the tackifier on the straw is for protection against wind.

Test No. 5 (Figure 5) (Straw at 2 tons/acre covered with asphalt emulsion SS1 at 250 gal./acre, wind, then rain). Straw was applied to the plots and oversprayed with asphalt emulsion, then allowed to dry overnight before wind was applied. (This shorter drying time was sufficient because no water was applied as in the previous two runs.) The wind very quickly blew the straw mat from the lower end of the center plot, rolling it upslope to about the mid point of the plot. When rain was applied, this bare plot quickly began to erode and continued to do so until the rain was turned off. The two outside plots failed when the soil beneath the straw became saturated, and no runoff measurements could be made. Failure of the north plot began about 1/3 of the distance down from the top, and the south one very near the top.

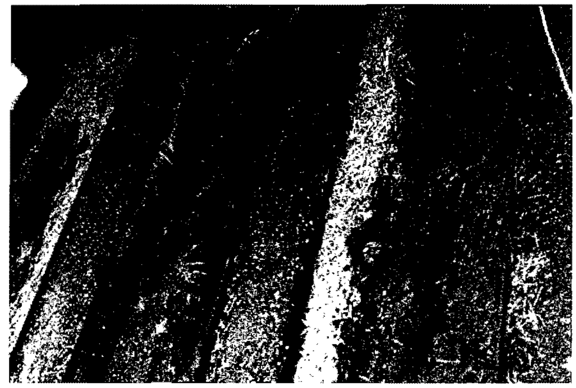
Test No. 6 (Figure 5) (Straw at 2 tons/acre covered with asphalt emulsion SS1 at 250 gals./acre, then rain). Straw was applied to the plots and oversprayed with asphalt emulsion, then allowed to dry overnight before rain was applied.

The south plot failed after about 44 minutes of rain, but the other two did not fail during a running time of 90 minutes. There was no failure of the mulch so the difference in performance of plots must be accounted for in the condition of the soil--perhaps more clods than usual which allowed water to infiltrate at a faster rate through the soil profile. Center and north plots appeared to be in equilibrium when the test was discontinued, i.e. the amount of water flowing overland plus that flowing through the soil layer, equaled the amount falling as rain.

Test No. 7 (Figure 6) (Straw at 2 tons/acre covered with Terra Tack AR at 120 #/acre, wind, then rain). Straw was applied to the plots, then it was covered with Terra Tack AR applied with a hydromulcher. The tacked mulch was then allowed to dry for 40 hours before wind was applied. During the first few minutes of wind, much of the straw was blown from the plots, particularly the lower halves of the slopes. When rain was applied, these bare areas quickly began to erode. Catchments filled within about 47 minutes and were removed to be dried and weighed. Rain was continued for a total of 90 minutes, but none of the slopes failed because of the large amount of water running overland.

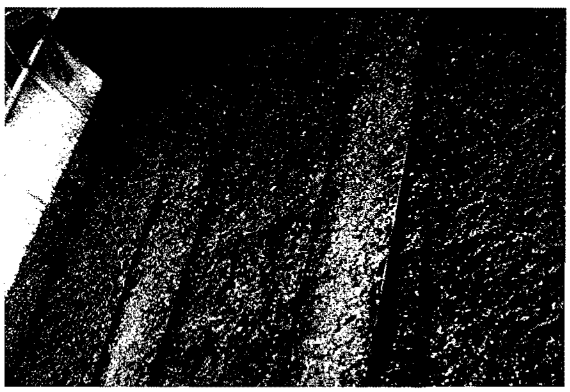
Test No. 8 (Figure 6) (Straw at 2 tons/acre, covered with Terra Tack AR at 120 #/acre, then rain). Straw was applied to the plots, then covered with Terra Tack AR by means of a hydromulcher. The tacked mulch

Test No. 7. After wind but before rain.



Test No. 8. After rain on plots with no wind.

Figure 6. Straw @ 2 tons/acre covered with Terra Tack AR @ 120 #/acre.



Test No. 9. After wind and rain.

Figure 7. Product 80-10 @ 1600 #/acre.

Test No. 10. After rain on plots with no wind.

Figure 8. Straw @ 2 tons/acre CONWED 2000 mulch @ 1600 #/acre CONWED regular mulch @ 2400 #/acre.

Test No. 11. After wind and rain.

Figure 9. Straw @ 3 tons/acre covered with CONWED netting.

was allowed to dry for 40 hours before rain was turned on. Visual appearance of the three plots was very similar throughout the period of the test. Almost no erosion occurred during the time of the test. Sediment leaving the north plot was caught and weighed, but the other two plots slid into the catchments and totally inundated them. However, up until this time, erosion rates appeared to be about the same on all three plots.

Test No. 9 (Figure 7) (Product 80-10 at 1600 #/acre, wind then rain). Product 80-10 was applied with a hydromulcher to bare soil on the three plots, then was allowed to dry overnight before wind was applied. Runoff began after about 5 minutes of rain and continued at a fairly uniform rate for 90 minutes, at which time the rain was turned off. Erosion began as "pock marks" on slope surfaces, which grew larger with time. After about an hour small rills began to form at lower ends of the slopes and grew in the uphill direction by "piping." The overall effect on the slope appeared as "sheet erosion." Visual appearance of the three plots was similar throughout the test. More water infiltrated on the north slope than on the other two, probably because of more hard clods in the soil profile.

Wind did not displace the mulch, so a separate run without wind was not made.

Test No. 10 (Figure 8) (Straw at 2 tons/acre, CONWED 2000 mulch at 1600 #/acre, CONWED regular mulch at 2400 #/acre). This unscheduled test was run for the purpose of comparing erosion rates of straw and commercial mulches. One plot was covered with straw, th second with CONWED 2000 and the third with CONWED regular, no replications were made. The covered plots were allowed to dry overnight before rain was applied.

The straw-covered plot produced no runoff until the time of failure, then the entire plot slid out as on previous tests with straw. The plot covered with CONWED 2000 retained water at a slower rate than the one with straw, but it eventually failed, too, by sliding. It eroded at a slow rate before failure occurred. The plot covered with CONWED regular mulch eroded at a greater rate throughout the period of the test, and the slope did not fail. It reached a point where the water flowing overland down the slope plus that infiltrating equaled the amount falling as rain, so just continued to erode as long as the rain was falling.

Test No. 11 (Figure 9) (Straw at 3 tons/acre, CONWED netting with one staple per square yard). Conditions for this test were different than all the rest in that the application rate of straw was increased to 3 tons/acre from 2 tons/acre, rainfall rate was increased to 12 inches/hour from 4 inches/hour, and slope was increased to 1 1/2:1 from 2:1.

Straw was applied to each plot, then covered with 3/4"-mesh plastic netting supplied by CONWED Corporation. Straw and netting were not placed on the walkways. The net was fastened in place with 6" long wire staples spaced 1 yard apart in both horizontal and upslope directions as shown in the following sketch.

Wind very quickly blew straw into piles beneath the netting, exposing patches of bare soil on lower portions of the slopes. Some of the straw escaped through the net, and some blew into bunches beneath it.

Erosion began almost immediately on exposed areas when rain was applied. Rainfall rate greatly exceeded infiltration rate of the soil, so there was a lot of overland flow down the slopes. The north and south plots both failed by sliding, the slides beginning in the upper parts of the slopes that were still covered with straw. Failures appeared to be

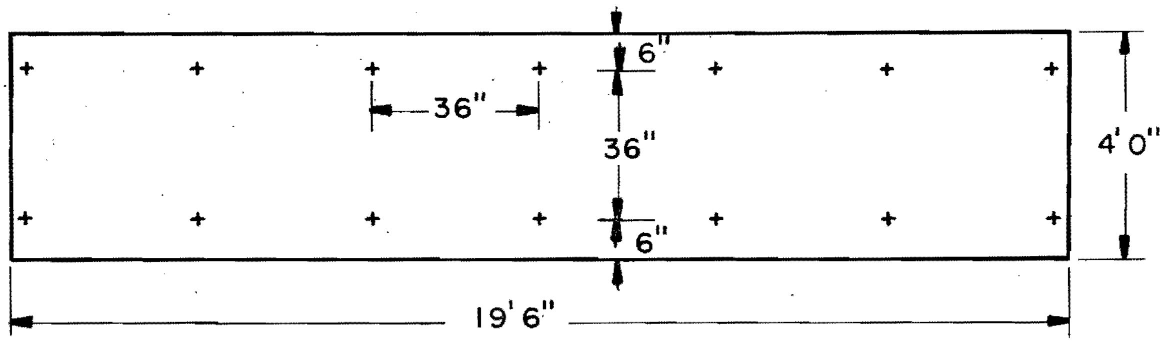


Figure 10. Sketch showing positions of staples holding the net on each test plot.

the same as those on previous straw-covered slopes, as soon as the soil profile became saturated the slope failed, carrying straw, netting and soil down the slope all rolled together.

SUMMARY AND CONCLUSIONS

Based on data collected in the foregoing tests, as well as on observations made and impressions received as a result of performing the tests, the following summary statements, suggestions, and conclusions are presented.

1. It should be remembered that the performance of erosion control products herein outlined was for a particular set of soil, slope, wind, and rainfall conditions and may be expected to be different if any or all of these conditions are changed.

2. Of the tackifiers tested under the conditions stated, CONWED Hydro Mulch Fiber appears to be the most effective, as well as the easiest to apply.

Terra Tack requires a much longer time of agitation in the hydro-mulcher to break up the lumps before it can be applied. At the application rate specified for these tests (97 gms per plot), Terra Tack doesn't supply nearly as much tacking of the straw as does the CONWED mulch (609 gms per plot). At a heavier rate it would probably perform more comparably.

Asphalt emulsion is messy to handle, and has a greater tendency to clog the applicating equipment. Because the hydro mulch is applied with ample water as a carrier, nearly every piece of straw is wetted which adds to the tacking effect of the mulch. At the application rate specified for the asphalt emulsion, the same is not true, and many of the straw pieces do not contact the asphalt at all, resulting in a greatly reduced tacking effect of the straw mat. Also, because the asphalt emulsion did not mat the straw to the soil surface as did the other tackifiers, the wind had more tendency to get underneath and roll it from the plots.

3. Straw appears to absorb all of the impact energy of the raindrops, and then allows the water to soak into the soil surface until the moisture-holding capacity of the soil is reached, at which time the slope fails by sliding. If the rain stops before this point is reached, or the soil is porous enough that the water can continue to drain through it rather than to saturate it, or if most of the water runs overland, the slope does not fail.

This implies that straw mulch on a well-drained sandy slope would provide maximum protection against erosion. Matting the straw against the sand surface, or better still, incorporating it into the surface with a disk or coulter will ensure that maximum infiltration occurs, rather than the water eroding the slope beneath the mulch. Excessive rainfall rates, beyond the amount that can flow through the soil profile, will fluidize the sand and cause slope failure as described above.

4. Of the mulches included in these tests that are applied directly to the soil surface, straw is the most effective in preventing surface erosion of a slope, up until the time the slope fails by sliding. CONWED Hydro Mulch 2000 Fiber is second most effective. It allows more water to flow overland, downslope, than does the straw, thus increasing the amount of surface erosion but also delaying the time of slope failure. CONWED Hydro Mulch Fiber is the least effective of the three. It allows erosion to progress at a constant rate throughout the period of rainfall, permitting enough rain to flow overland that the slope doesn't saturate and slide.

One could conclude from these test results that on a tight soil that saturates quickly (such as that used on these tests) that it might be better to use a mulch for controlling erosion rather than straw when a prolonged rainstorm is anticipated. This would allow some erosion to occur but would not result in a complete failure of the slope.

5. The primary value of tackifiers on straw mulch is to hold it in place against the wind (assuming that the straw mulch has been applied at a heavy enough rate to cover the soil surface, i.e. approximately 2 tons per acre or more). If the straw mulch does not cover the surface, and patches of bare soil are exposed, then a tackifier would be

applied directly to the soil as well and would offer some protection against water erosion as well as against that from wind.

6. The primary value of netting stapled in place over straw on a slope is to hold the straw in place against wind. When the soil beneath the straw becomes saturated either by rainfall or by water running down the slope, failure of the slope will occur. When a slide occurs, the netting, mulch and soil are all rolled together to the bottom of the slope.

7. Hard, compacted soil on a slope (such as existed on the walkways between the test plots) erodes at a rapid, constant rate if it is not protected from falling rain or from water flowing down the slope. If straw mulch were covered with plastic netting in a ditch on a slope, or in some other steep drainage where the soil is compacted, the netting would be expected to hold the mulch in place against the flowing water and against gravity pulling on the mulch. If the flows were of sustained duration or of excessive amount, either or both of two things would be apt to occur. First the weight of water and wet straw against the netting would pull some of the staples from the ground, the straw would slide downslope, and localized erosion would occur. Secondly, erosion would continue at a steady rate beneath the straw until some of the staples undermined. This would release the netting and straw in localized areas and excessive erosion or sliding would occur, rolling the soil, netting and mulch together to the bottom of the slope.

8. Plastic netting anchored over straw with one staple per square yard does not seem to be sufficient to hold the straw in place against 30 mile-per-hour winds. Some of the straw blows out through the net, and

some bunches up underneath, exposing patches of bare soil. Decreasing the staple spacing would improve the performance of the netting.

9. The greatest source of error in the tests was the inability to control the initial soil moisture of the plots and its effect on porosity of the soil profile. Varying amounts of water were applied for the several tests, and different quantities of dry soil were required after each run to replace soil that had eroded. These varying amounts of water resulted in the development of differing quantities of clods in the soil profile as the plots were cultivated and compacted before each test, and the clods affected the infiltration rates of rain applied to the plots. When plots were covered with straw and rain was applied, the differences in lengths of time until slope failure were largely measurements of differences in initial soil conditions of the plots.

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