Wax-treated Soils for Harvesting Water

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Highlight: *Shortage of water for livestock often limits the carrying capacity of rangeland. Water harvesting can provide extra water. Paraffin wax was applied as granules or flakes on the surface of two experimental watershed plots and allowed to melt and spread in the hot desert sun to form a hydrophobic soil surface, which then readily shed water. The wax-treated plots yielded an average of 90% precipitation runoff, compared to only 30% runoff from two untreated plots and to 100% runoff from a butyl-covered plot.*

The livestock-carrying capacity of many range areas is not limited so much by a shortage of grass as it is by a lack of drinking water. Reliable water sources often are too far apart, and available sources may be only seasonal. This is particularly true in areas where wells are infeasible because of unfavorable geology or excessive drilling costs.

Small earthen tanks are used in such areas to collect runoff from small local watersheds, but these offer only a partial solution. Many of these tanks routinely go dry for several months of the year—not because of lack of rain during these periods, but rather because of the low runoff characteristics of the contributing watershed. Water sometimes can be hauled into these areas, but considering the time, cost, and general nuisance involved, this can be regarded only as an emergency measure.

A cheaper water source is needed, and water harvesting offers promise of being that source. Water harvesting is the process of collecting water from areas that have been treated to increase runoff from rainfall or snowmelt. A number of techniques for treating watersheds have been tried, including: (a) altering the vegetation by clearing (Tadmor and Shanan, 1969) or replacing brush and trees with grass (Hibbert, 1971); (b) modifying the soil properties, such as by simple land

smoothing as practiced several centuries ago by certain agrarian people in Israel's Negev Desert (Evenari et al., 1961), or by dispersing clay with sodium salts to reduce infiltration rates (Cluff et al., 1971); (c) covering the soil with impermeable barriers such as galvanized steel sheeting (Kenyon, 1929), plastic films (Lauritzen, 1960), and asphalt-fiberglass (Frasier et al., 1970); and (d) making the soil water repellent by spraying it with certain organic chemicals (Hillel et al., 1966; Myers and Frasier, 1969). Certain of these water harvesting techniques are being used occasionally to supply water to livestock in remote areas. Universal acceptance, however, appears to depend on the development of a lower cost, easier, and more efficient method of water harvesting. The use of paraffin wax may be that method.

Research at this laboratory (Cooley and Myers, 1973) showed that paraffin wax can efficiently reduce evaporation from steel water storage tanks. The wax was simply floated onto the tanks as small chunks. Under the sun's heat, the wax slowly melted and spread until it formed a completely solid, floating cover. Evaporation from these wax-covered tanks was reduced to almost zero.

It was postulated that solid paraffin wax, similarly, might be spread on soil for water harvesting purposes. Energy from the sun should melt the wax, resulting in a water-repellent soil which should increase precipitation runoff. The objective of this study was to test the feasibility and practicality of using paraffin wax for water harvesting.

The experiment was conducted at the Laboratory's Granite Reef water harvesting test facility 15 miles northeast of Mesa, Arizona. The climate is hot desert with characteristic low humidity, low annual precipitation of about 7 inches per year, and average daily high temperatures greater than 100°F from early June to mid-September. The soil is decomposed granite and has a sandy loam texture.

Two plots for testing the wax were selected: (a) a 10-m² smoothed plot having a 5% south-facing slope and (b) a 200-m² ridge and furrow plot having a 3% longitudinal north-facing slope and 10% lateral slopes on the east- and west-facing side ridges.

The wax was the common paraffin type used commercially for making candles and for coating wax paper and milk cartons. The wax came as 11-lb slabs which had to be ground before spreading on the soil. Several methods were tried: grinding in a hand-cranked meat grinder, grinding in a large commercial electric meat grinder, and powdering by passing frozen slabs over a high-speed wood planer. All these methods reduced the wax to a usable form, but the hand crank is hard work and slow, the electric grinder is expensive, and the planer is a safety hazard. We are now testing a Sears Roebuck 6 h.p. Shredder-Bagger¹ for chipping the wax. This inexpensive machine normally is used for shredding lawn and garden trash but shows promise in its new role.

The ground wax was hand spread on the two plots (Fig. 1). The 10-m² plot was treated on June 29, 1972, at a rate of 1.35 lb/yd² and the 200-m² plot was treated on September 29, 1972, at a rate of 1.25 lb/yd². Preliminary laboratory studies had indicated that a rate of 1.0 to 1.5 lb/yd² of wax was necessary to insure complete surface coverage and to obtain a wax penetration of at least 2 to 3 mm into the soil.

Paraffin waxes with different melting-point temperatures are available, allowing selection for the prevailing soil temperatures. The 10-m² plot was treated with a 143–150°F melting-point wax and the 200-m² plot was treated with a 128–130°F melting-point wax. The wax on the first site melted within 2 days in the hot June sun; the wax on the 200-m² plot completely melted into the soil on the south- and west-facing slopes, but on the cooler north- and east-facing slopes, small isolated patches of fused wax remained atop the soil throughout the fall and winter

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¹ Trade names and company names, when included, are for the convenience of the reader and do not imply preferential endorsement by the U.S. Department of Agriculture of a particular product or company over others.

Fig. 1. Applying ground paraffin wax to water harvesting plots.

following treatment. These patches of wax, however, were impermeable to water and did not seem to reduce rainfall runoff.

The runoff was collected in tanks and measured at the end of each storm. Runoff data from the wax plots were compared with those from adjacent untreated plots and from a butyl-sheet-covered 10-m² plot.

Results

Total precipitation at the Granite Reef test facility for the initial 6-month test period was about 50% above normal. July, August, and September were very dry; each month had only one storm with measurable runoff (Table 1). October 1972, however, was the wettest October on record, producing 4.57 inches of rain from seven storms. Total precipitation on the 10-m² plots for the 6-month test period was 8.48 inches from 15 storms; total precipitation on the 200-m² plot for October through December was 7.73 inches from 12 storms.

Runoff from the wax plots averaged about 90% of the total precipitation (Table 1). Runoff variation from these two plots ranged from a low of 54% on the 200-m² plot for a 0.14-inch rain upwards to values approaching 100% for several of the larger storms. One wax plot was not consistently better than the other in producing runoff, and the overall runoff averages were nearly identical (92 vs 90%).

Runoff averaged only 28% from the 10-m² and 31% from the 200-m² untreated plots. The highest runoff per

storm, 41%, was recorded four times and was associated with large, high-intensity rains, or rains falling on soils still wet from a previous storm. Four rains ranging from 0.08 to 0.21 inch and totaling 0.53 inch produced no runoff at all from the untreated 10-m² plot, yet produced 0.44 inch or 82% runoff from the wax-treated 10-m² plot.

As expected, the butyl-covered plot yielded very high runoff; however, the 100% average runoff figure (based on total precipitation) is a bit fortuitous.

Variation ranged from 80% to 104% runoff. The low figure suggests that it takes a little rain to even wet the surface of a smooth cover, while the figures greater than 100% are probably associated with slight errors in reading the raingage or else variation in rainfall between the measuring station and the plot. Overall, Table 1 shows that the wax yielded 92% as well as the butyl.

Water penetration into the soil of the wax plots was minimal; the plots usually were dry shortly after a rain. The soil on the untreated plots, however, dried slowly after a rain and retained considerable soil moisture throughout the fall and winter commencing with the rains in early October. A considerable cover of grass and weeds developed on the untreated plots during this prolonged rainy spell, whereas the wax plots remained completely barren. Even a few plants which had established themselves on the wax plots prior to treatment eventually died.

Quality of the runoff water from the wax plots was very good. Salt content based on conductivity measurements (U. S. Salinity Laboratory, 1954) was less than 50 ppm. Percent light transmission of the runoff water averaged better than 90%, indicating a minimal sediment content. The wax thus served both to stabilize the soil as well as to make it water repellent. The organic matter content in the water, as measured with a Beckman Model 915 carbon analyzer¹ was below

Table 1. Precipitation runoff yields (%) of wax-treated, untreated, and butyl-covered soil.

Date (1972)	Precip. (inch)	Runoff (%)					
		10 sq. meter plots				200 sq. meter plots	
		Wax	Untreated	Butyl	Wax/Butyl	Wax ¹	Untreated ²
Jul 17	0.44	90	20	94	96		
Aug 12	0.21	98	0	100	98		
Sep 2	0.10	76	0	80	95		
Oct 4	1.00	89	31	101	88	84	32
Oct 5	0.30	99	33	89	111	78	41
Oct 5	0.14	71	0	86	82	54	0
Oct 6	1.30	97	41	104	93	93	41
Oct 18	1.44	94	35	98	96	89	35
Oct 19	0.31	90	27	98	92	91	22
Oct 25	0.08	69	0	89	78	87	0
Nov 11	0.81	94	31	104	91	91	41
Nov 17	0.54	92	32	99	93	98	33
Dec 8	0.35	82	8	99	82	95	20
Dec 28	1.30	95	21	100	95	96	21
Dec 28	0.16	85	32	100	85	80	19
Total yield							
Percent		92	28	100	92	90	31
Inches	8.48 ³	7.80	2.63	8.48			
Inches	7.73 ⁴					6.96	2.40

¹ Actual area 197.4 m².

² Actual area 194.5 m².

³ Accumulated rainfall on 10-m² plots.

⁴ Accumulated rainfall on 200-m² plots.

detectable limits. Since paraffin waxes already are approved for human consumption (candy bars, milk cartons, etc), one need not be concerned with dangerous contamination from micro-quantities of wax present in the water. With slight additional purification, the water from these paraffin plots will be completely safe for human consumption.

No discussion on water harvesting is complete without some cost analysis. The paraffin waxes may be purchased in quantity from the manufacturer for about 10¢/lb. For a wax application rate of 1 lb/yd², and a total rainfall of 20 inches, and assuming 100% runoff, the cost of water harvested amounts to 90¢/1,000 gal. If the wax must be purchased in smaller quantities at 15¢/lb, and is applied at 1.25 lb/yd², and the water yield is only 90%, then the cost of harvesting that 20 inches of precipitation doubles to \$1.80/1,000 gal. These initial material costs (10¢ to 15¢ per yd²) compare to asphalt-fiberglass costs of \$1.00 to \$2.00 per yd², and to butyl rubber costs of \$2.00-\$3.00 per yd². Of course, as Cooley et al. (1972) have

shown, actual costs per gallon of water harvested depend on a number of things: initial material costs, cost of application, durability and repair costs, rainfall and percent runoff, storage costs, and even land values.

The plots will continue to undergo testing to evaluate long-term durability. Also, additional plots are planned to check on minimal effective application rates of wax. A machine is being developed to spread the chipped wax. The technique seems especially well adapted for the rancher who needs additional water supplies in remote areas, and who does not wish to invest a large amount of money in supplies or equipment.

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