Extract of publication no. 62 of the I.A.S.H.
Committee for Evaporation, pp. 7-12

EVAPORATIVE LOSS FROM SOIL, NATIVE VEGETATION, AND SNOW AS AFFECTED BY HEXADECANOL

Henry W. ANDERSON, Allan J. WEST,
Robert R. ZIEMER and Franklin R. ADAMS

ABSTRACT

Only in a bulldozed brush field and with heavy applications of hexadecanol under snow did significant reductions in evapotranspiration occur with application of hexadecanol to natural stands. Marked reductions in evaporation from snow occurred when hexadecanol emulsion was applied to the snow surface.

More than two-thirds of the precipitation in the United States is used by forest, browse, and non-economic vegetation areas (Wolman 1963). If transpiration or evaporation in these areas could be suppressed, important savings of water for other uses might be effected. One way of suppressing this water use might be by applying a chemical suppressant such as hexadecanol (Olsen et al. 1961, Roberts 1961, Woolley 1962).

This paper reports results of a study of the effects of hexadecanol on summer soil moisture losses and winter snow surface evaporation loss at high elevation sites in the central Sierra Nevada.

SUPPRESSION OF SUMMER SOIL MOISTURE LOSS

Methods

In the 1961 tests, we applied hexadecanol in mid-summer as a water emulsion to the soil surface at bare soil sites, to the forest floor at red-fir forest sites, and to the vegetation and soil at brush and herbaceous sites. One inch of water was then sprayed on the site to flush the hexadecanol into the soil.

In the 1962 tests, hexadecanol was applied to the snow late in the melt season, or where snow was absent, it was applied to the wet soil, and nearby snow was shoveled on to the site to a depth of about 6 inches.

In all, 14 natural sites ranging in size from 1/30 to 1/15-acre were treated at the rate of 35, 130, or 680 pounds per acre. Similar sites in all cases were untreated. Experimental controls consisted of "test" and "control" sites measured for 3 years before treatment and during the years after application of hexadecanol.

Results

Reduction in evapotranspiration for each summer period was taken as the difference in soil moisture storage at maximum depletion between the test and a control site, adjusted for differences between the two sites in the years before treatment. Reductions in evapotranspiration differed between the natural site type, between the first and second year after treatment, and between methods of applying the hexade canol (Table 1).

Red-fir forests, with one exception, showed essentially no difference between treated and untreated sites the first year after treatment - both when hexadecanol was applied to the soil and flushed in with water and when applied to a deep snowpack

([1]) Snow Research Leader, Research Foresters, and Forest Technician, respectively, Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Berkeley, California.

and allowed to percolate with the melting snow water (Table 1). The second year after application on soil, we found a consistent decrease in the soil moisture storage at maximum depletion, ranging from 0.2 to 0.6 inches less water than in the control sites.

The exception to the general lack of effects on red-fir sites was found at site No. 92. A heavy treatment, (680 pounds per acre) was applied, with an average saving of 1.5 inches. Part of the site was bare of snow, so that hexadecanol was applied to the soil and 6 inches of snow shoveled on top. At these places, a large reduction in loss occurred – 3 1/2 inches for the 3-foot soil depth in the summer of 1962. At other points where hexadecanol was applied to deep snow, at the same site, the saving was only 0.7 inches. Lesser rates of application of hexadecanol under similar circumstances failed to show appreciable effects.

Brushland sites which had been bulldozed in 1957 behaved differently than natural brush sites when treated with hexadecanol. The bulldozed brush sites, which had been planted to small pine trees and brush was becoming re-established, showed a large difference in water loss the first year after treatment - 2.0 inches associated with an application of 135 pounds per acre of hexadecanol in mid-summer. The second year after this application, a reduction in evapotranspiration of only 0.5 inches was indi cated. In a natural brush site, very little effect was observed from an application of 35 pounds per acre of hexadecanol. With the 135 pound per acre application on natural brush, a small increase in loss the first year was indicated and a small decrease the second year occurred. Deeper soils showed a similar deficit in soil moisture in the first year, but a larger reduction in loss the second year : 1.8 inches instead of 0.5 inch.

Bare soil and herbaceous Wyethia sites showed essentially negligible reductions in evapotranspiration associated with hexadecanol applications. Reductions the first year ranged from -0.1 to 0.3 inches. The second year results indicate small but consistent negative effects, ranging from -0.1 to -0.3 inches. These values are, however, approaching our accuracy of measurement of total summer water loss.

Suppression of evaporation from snow

Methods

To test the effects of hexadecanol on the evaporation from snow, hexadecanol was applied either as an emulsion or as flakes on snow surfaces in small plastic pans. Pans with and without hexadecanol were set in the natural snow surface, and evaporation was determined by repeated weighings. New sets of snow-filled pans, with new applications of hexadecanol, were put out each day, and total evaporation for 4- to 12-day periods were compared between three forest sites and three open areas. In preliminary tests, reductions of evaporation with 10 to 15 pounds per acre of hexadecanol were as great as with larger amounts, but greater than when smaller amounts were applied; therefore about 12 pounds per acre were used in subsequent tests. Hexadecanol applied as flakes caused rapid melting of the snow. Further tests were made only with the hexadecanol applied as an emulsion because this melting is considered undesirable.

Results

Reductions in snow evaporation as a result of the application of hexadecanol were sizable, ranging from 13 to 90 percent in daily evaporation (Tables 2 and 3). Reductions were greatest where the evaporation potential was greatest - in open areas. Under the forest, both the amount of evaporation and the reductions with the applications of hexadecanol were smaller.

The effects of hexadecanol on daytime versus nighttime evaporation were measured. Nighttime reductions in evaporation or gains in condensation were nearly identical at all sites, totaling from 0.007 to 0.011 inches in the 12-day study period (Table 2). Obviously, the differences in the effects of hexadecanol among the sites, occurred largely during daytime. Under conditions of condensation, which more typically prevail in the late spring and early summer at these sites, the data indicate that we can expect hexadecanol to cause small gains.

Applications

Tree Planting at Adverse Sites

Survival of planted seedlings or planting stock at sites with sprouting brush might be increased by using hexadecanol to reduce competition. Reductions in the evapotranspiration might be sufficient to allow the tree to extend their roots to available soil moisture, thereby increasing survival. Similarly, such other vegetation as grass or desirable browse plants might be successfully established.

General Water Loss Suppression

With the technique we have used, general water loss suppression from soils does not seem feasible by applying hexadecanol. On the other hand, loss suppression from snow may be possible if the effects of hexadecanol, which we have measured, persist for long periods in treated snow. Tests of the duration of hexadecanol affects on snow are now underway

Summary

First and second year effects of hexadecanol applies to soil, forest floor, and brush foliage indicate *(a)* significant reduction in evapotranspiration from bulldozed brush field the first year and smaller reductions the second year; (b) small increases in water use by brush the first year and small reductions the second year; (c) and generally no reductions of summer evapotranspiration of forest stands or from bare soil either the first or second year after application of hexadecanol at rates of 35 to 135 pounds per acre. In a special case, a marked reduction occurred when 680 pounds per acre was applied to the soil of a forest stand and snow was added.

Marked reductions in daily evaporation from snow were brought about by applications of 12 pounds per acre of hexadecanol to snow surfaces. Reductions ranged from as little as 13 percent in a dense forest stand to as much as 70 percent in open areas.

LITERATURE CITED

Olsen, S. R., Watanabe, F. S., Kemper, W. D., and Clark, F. E. 1961. Effect of hexadecanol and octadecanol on efficiency of water use and growth of corn, U. S. Dept Agric., Agric. Res. Serv. Ft. Collins, Colo. Sci. Jour. Series. 731, 7 pp.

Roberts, W. J. 1961. Reduction of transpiration. *Jour. Geophys. Res.* **66** (10) : 3309-3312.

Wolman, Abel. 1963. Water resources. National Acad. Sci., Publ. 1000-B, 20 pp.

Woolley, Joseph T. 1962. Soil-applied hexadecanol as an evapotranspiration suppressant. *Jour. Soil and Water Conserv.*, **17** (3) : 130 p.

TABLE 1

Soil moisture storage at maximum depletion for test and control periods at sites with and without hexadecanol, central Sierra Nevada, California, 1961 and 1962

Site ([1])	Hexadecanol amount and Method ([2])	Soil depth	Test Period		Control Period		Reduction in Evapotranspiration ([3])
			Control Site	Test Site	Control Site	Test Site	
	Lbs/Acre		Inches				
Red Fir Forest:							
# 62 1961	35-S	48	7.59	8.68	7.78	8.58	+0.3
# 62 1962	-	48	8.53	8.76	7.78	8.58	-0.6
# 71 1961	35-S	48	7.49	8.22	7.34	7.78	+0.3
# 71 1962	-	48	8.71	8.70	7.34	7.78	-0.4
# 91 1962	35-Sn	48	8.97	8.53	7.56	7.13	0
# 87 1961	135-S	48	7.58	7.74	8.10	8.35	-0.1
# 87 1962	-	48	8.53	8.46	8.10	8.35	-0.3
# 90 1962	135-Sn	48	7.20	10.10	6.60	9.46	0
# 89 1961	680-S	48	7.58	7.23	7.54	7.53	-0.3
# 89 1962	-	48	8.64	8.70	7.96	8.20	-0.2
# 92 1962	680-Sn	36	5.51	7.54	5.32	5.83	+1.5
Bulldozed Brush							
F 1961	135-S	48	10.46	12.73	14.85	15.09	+2.0
F 1962	-	48	10.84 [1]	11.60	11.60	15.09	+0.5
Natural Brush							
H 1961	35-S	36	7.92	7.72	7.78	7.70	-0.1
H 1962	-	36	7.92	7.96	7.78	7.70	+0.1
G 1961	135-S	48	11.62	11.81	11.34	12.01	-0.5
G 1962	-	48	11.69	12.86	11.34	12.01	+0.5
Wyethia							
# 6 1962	135-Sn	36	5.37	4.41	5.46	4.50	0
# 88 1962	135-Sn	48	8.12	7.51	8.06	7.58	-0.1
Bare Soil							
# 80 1961	35-S	36	9.54	8.46	9.46	8.12	+0.3
# 80 1962	-	36	10.20	8.52	9.46	8.12	-0.3
# 80 1961	680-S	36	9.54	8.74	9.46	8.78	-0.1
# 80 1962	-	36	10.20	9.46	9.46	8.78	-0.1

([1]) Vegetation type, site number and year.

([2]) Hexadecanol in 1961 applied in mid-summer on soil (S); 1962 application on snow (Sn) near end of melt season.

([3]) Difference in soil moisture between Test and Control in Test Period, adjusted for difference in Control Period.

TABLE 2

Twelve-day total evaporation from snow surface with and without hexadecanol (HD) ([1]), *central Sierra Nevada, California, 1962*

Site and Treatment	Evaporation			Reduction by Hexadecanol
	8 a.m.-5 p.m.	5 p.m.-8 a.m.	Both periods	
	Inches			Percent
Center of large open meadow				
Without HD	0.210	0.005	0.215	-
With HD	0.074	-0.006([2])	0.068	-
Reduction	0.136	0.011	0.147	68
Center of opening in forest, 2 tree heights across				
Without HD	0.206	-0.034	0.172	-
With HD	0.091	-0.044	0.047	-
Reduction	0.115	0.010	0.125	73
Red fir forest, 35 percent density				
Without HD	0.100	0.041	0.141	-
With HD	0.059	0.030	0.089	-
Reduction	0.041	0.011	0.052	37
Red fir forest, 80 percent density, exposed to wind				
Without HD	0.034	0.045	0.079	-
With HD	0.033	0.036	0.069	-
Reduction	0.001	0.009	0.010	13
Lodgepole pinered fir forest, 70 percent density				
Without HD	0.030	0.018	0.048	-
With HD	0.020	0.011	0.031	-
Reduction	0.010	0.007	0.017	35

([1]) Hexadecanol applied as 2-1/2 percent emulsion at a rate of 12 pounds per acre sprayed on the snow surface; snow was changed daily at 5 p.m. Test dates April 12-19, May 29, 31 and June 2-3, 1962.

([2]) Minus sign indicates condensation.

TABLE 3

Four-day total evaporation from snow surface (ridge site compared io urge open meadow) as affected by hexadecanol, central Sierra Nevada, California, 1962 ([1])

Site and Treatment	Evaporation			Reduction by Hexadecanol
	8 a.m.-5 p.m.	5 p.m.-8 a.m.	Both periods	
	Inches			Percent
Exposed ridge site				
Without HD	0.079	0	0.079	-
With HD	0.020	-0.012([2])	0.008	-
Reduction	0.059	0.012	0.071	90
Center of large open meadow				
Without HD	0.089	-0.018	0.071	-
With HD	0.020	-0.011	0.009	-
Reduction	0.069	-0.007	0.062	87

([1]) Hexadecanol applied as 2-1/2 percent emulsion at a rate of 12 pounds per acre sprayed on the snow surface; snow was changed daily at 5 p.m. Test dates May 29, 30, 31-June 3, 1962.

([2]) Minus sign indicates condensation.