ESTABLISHING WINDBREAKS IN SEMIARID AREAS BY ALTERING THE MICROCLIMATE OR SUPPLYING ADDITIONAL WATER 1/

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Abstract

Seven methods were used to supply additional water or alter the microclimate of redcedar (*Juniperus virginiana*) and Scotch pine (*Pinus sylvestris*) trees to induce faster growth and higher survival rates. For redcedars, 2 water-harvest treatments produced 32 and 31 percent more total growth than did a control, while drip irrigation and snowfence-protected treatments produced 25 and 24 percent more total growth, respectively. Shaded treatment did not increase redcedar growth but resulted in 100 percent survival as compared with 70 percent for the control.

Although Scotch pines had discouraging growth and survival rates, they tended to have better survival and total growth in a protected or shaded environment.

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Introduction

Trees planted in rows to protect fields, farmsteads, animals, and humans from winds are a valuable asset (2, 4, 7, 29, 31, 33, 36). Such tree barriers have been studied for their influence on wind erosion, microclimate, human and animal comfort, and other beneficial uses. Trees planted as barriers in areas of low annual rainfall and poor soil-physical characteristics generally grow slowly and erratically (9, 11, 27). Therefore, we initiated a study in an area of limited rainfall to find a simple, productive method of increasing tree growth and survival.

Numerous publications are available on rainfall multiplication techniques for obtaining water for agricultural production, livestock, and humans (8, 15, 22, 24, 25, 26, 28, 34); use of gravel mulches to reduce evaporation and enhance infiltration (1, 14); use of wind barriers to modify microclimate and trap snow for the benefit of vegetation and livestock (4, 5, 12, 13, 20, 29, 33, 35); solar stills for obtaining water in desert areas (16, 17, 21); profile modification to improve physical conditions of soils (10, 18, 19, 32); and effect of solar radiation and shading on evapotranspiration, crops, and animals (3, 6, 23, 30). We evaluated many techniques mentioned (water harvesting, mulches, etc.) to determine their application for increasing growth and survival of trees in arid and semiarid regions.

Design and Description of Experiment

At the Colby Agricultural Experiment Station, Colby, Kansas, we planted the first trees in April 1971. The soil at the site is a silty clay loam, 15 percent sand, 54 percent silt, and 31 percent clay. Mean annual rainfall for the area is 19 inches.

Seven treatments and a control were selected for the initial experimental design. Each treatment was replicated twice. The seven treatments were: (a) water-harvest area 50 by 100 feet, (b) water-harvest area 50 by 50 feet, (c) partial shading, (d) snowfence protection, (e) solar still, (f) profile modification, and (g) gravel mulch.

The trees were planted within a 3-acre plot in 50-foot rows with a 5-foot spacing between each tree. Half of each row was planted to redcedar (*Juniperus virginiana*); the other half to Scotch pine (*Pinus sylvestris*). The trees were measured at the beginning and end of the growing season, and the difference between the two measurements was the growth for that year; the sum of all the differences was total growth. Trees that did not survive were replanted at the beginning of each season.

The water-harvest areas were cleared, smoothed, and bermed around the edges to pond runoff on the tree row. Three methods, (a) 6 mil polyethylene, (b) asphalt emulsion, (c) silicone and latex-in-water, were used to cover the water-harvest areas--one for each successive year. We modified the soil profile by digging a trench 2 feet wide and 4 feet deep along the length of the row and then mixing the soil and refilling the trench. The solar stills--a trench 3 feet wide by 4 feet deep by 50 feet long covered with 1 mil Tedlar[3/]--were located adjacent to tree row; water collected in a partitioned trough was piped to each individual tree. A check valve was fabricated from a funnel, table-tennis ball, and wire mesh to allow rainwater to flow into the trench and not collect on the Tedlar cover. For partial shading, we covered the tree row with a 50-foot length of snowfence supported by steel posts. The barrier-protected areas were surrounded with 60-percent porous snowfencing, 48 inches tall, located 25 feet from the row laterally.

Tree heights were measured at the beginning and end of each season in 1971, 1972, and 1973. After thermographs, total wind anemometers, and a rain gage were installed June 8, 1973, one season's measurements were taken. Wind velocity and air temperatures were measured at a height of 2 feet.

3/ Trade names are used for clarity and do not constitute an endorsement by U. S. Department of Agriculture.

The solar still improved growth of redcedars 148 percent over the control and survival was the same, but because of problems with the Tedlar cover, after the first season we changed to a drip-irrigation treatment. For the drip-irrigation treatment, each tree was given 10 gallons of supplemental water per month. The system was arranged so that water was fed directly into the root zone, 12 inches below the soil surface.

Because of low survival rates, the gravel-mulch treatments were changed to straw-mulch treatments at the beginning of the third season because the gravel available at the site was a natural deposit containing some fine sand and soil particles that tended to form a crust on the surface and thus reduce water infiltration. No Scotch pines survived the first 2 years, whereas 50 and 30 percent of the redcedars survived in 1971 and 1972, respectively. Survival of controls for the same period was 50 and 10 percent for Scotch pine and 90 and 70 percent for redcedar. Straw then was spread at the rate of 4 tons per acre and anchored with a jute netting. The straw covered an area 25 feet wide by 60 feet long, centered on the tree row.

Experimental Data and Observations

The 6-mil polyethylene used on the water-harvest areas was torn and mutilated by the end of the first summer and totally blown away by the following spring. The second season an anionic asphalt emulsion was sprayed at a rate of 1,245 gallons per acre on the harvest areas. The emulsion deteriorated and was nonexistent by the end of the following winter. The third year a mixture of R-20 silicone [3/] (sodium methyl silionate in water) and Wicaloid 7035-AO[3/] was used to cover the harvest areas. This mixture--2.5 percent R-20 and 9.2 percent latex by volume in water applied at a rate of 5,600 gallons per acre--produced a hard, impervious surface which stood up very well throughout the summer. We do not yet know what the condition will be at the end of winter. Because of exposure, extreme temperature differential, and the expansive capabilities of the soil, it was difficult to find a simple, workable treatment for the water-harvest areas.

The average growth and survival for 1973 and total growth and survival for the original trees are presented in Table 1. Tables 2 and 3 summarize the climatic and moisture data taken during 1973. Rainfall for the recording period measured 11.92 inches, whereas the long-time average for the period was approximately 9.50 inches (Table 2).

Table 1.--Growth and survival, 1973. Total growth and survival of original trees.

Treatment	Redcedars				Scotch pines			
	1973		Original trees		1973		Original trees	
	Growth	Survival	Total growth 1/	Survival 1/	Growth	Survival	Total growth 1/	Survival 1/
	Inches	Percent	Inches	Percent	Inches	Percent	Inches	Percent
Water harvest 50 by 100 ft.	15.1	100	36.5	100	5.0	80	1.2	50
Water harvest 50 by 50 ft.	14.3	100	36.3	90	0.6	70	2.4	60
Drip irrigation	14.5	100	33.1 2/	90 2/	0.4	90	1.9 2/	90 2/
Snowfence protected	15.4	100	32.7	90	9.5	90	3.6	90
Control	11.1	90	24.9	70	0	10	0	0
Shade	9.9	100	23.0	100	0.3	100	2.3	90
Profile modification	8.6	90	20.6	70	0	20	0	20
Straw mulch	1.3	70	6.8 3/	20 3/	1.0	10	0 3/	0 3/

1/ Includes only those trees originally planted 3 years ago (1971), whereas 1973 includes replants 1 and 2 years old.

2/ Includes 1 year solar still and 2 years drip irrigation.

3/ Two years gravel mulch and 1 year straw mulch.

Table 2.--Climatic data, field site, Colby, Kansas.

Date	Rainfall	Mean temperature			Wind		
		Control	Snowfence	Shade	Control	Snowfence	Shade
1973	Inches	Degrees Farenheit			Miles per day		
June 8 July 7	0.71	77.4	77.9	79.5	149.05	106.35	145.25
July 8 August 6	4.55	74.5	75.3	75.9	134.40	97.90	140.90
August 7 September 10	0.75	78.2	78.9	79.9	168.68	114.12	162.20
September 11 October 17	5.91	57.4	58.1	59.1	168.55	110.89	166.11

Table 3.--Average available water[1/] during 1973 in the top 36 inches of the soil profile.

Date 1973	Water harvest 50 by 100	Water harvest 50 by 50	Drip irrigation	Snowfence protected	Control	Shade	Profile modification	Straw mulch
	Inches							
June 8 July 7	4.14	4.44	4.51	4.68	4.80	5.10	4.56	5.49
July 8 August 6	4.17	4.17	3.93	4.00	4.45	4.64	3.46	5.44
August 7 September 10	4.36	4.36	3.65	3.81	4.26	4.40	2.46	5.42
September 11 October 17	3.89	4.31	4.01	3.86	4.91	4.27	3.21	5.81
Average	4.25	4.50	4.22	4.24	4.61	4.70	3.73	5.69

1/ Available water in inches = $\frac{(BD)(\%H_2O)\text{ depth}}{(D_W)}$ where BD = soil bulk density, $\%H_2O$ = $\%H_2O$ as measured minus $\%H_2O$ at wilting point, depth = depth in inches that $\%H_2O$ represents, and D_W = density of water.

Temperature measurements indicate that average daytime temperature was lower for the control than for either the snowfence or shade treatments. That was expected for the snowfence, but it was not consistent with other shade data because of an oversight when temperature recording instruments were installed. The instrument for the shade treatment was placed 1-foot closer to the ground than were the two other instruments, which resulted in a higher daytime temperature and caused the mean temperature to be higher than it should have been. Nighttime temperatures were about as expected. The snowfence treatment had lower temperature than the control; whereas, the shade treatment had a higher temperature than either the snowfence or the control

The snowfenced area had an average wind reduction of approximately 50 miles per day; the control and shade treatments, 160 plus miles per day (Table 2).

Available soil water in the top 36 inches of the soil profile averaged approximately the same for all treatments, except for the profile modification and mulch, which averaged .69 inch less and 1.27 inches more, respectively, than the 6 other treatments (Table 3). At the time most samples were taken, the lower 2.5 feet of soil was near its field capacity, which would account for the small differences among treatments.

Interpretations and Discussion

In keeping with the primary function of this study--to find a simple, effective way to improve growth and survival of trees for wind barriers in arid and semiarid locations--the two water-harvest, drip-irrigation, and snowfence treatments improved total tree growth and survival, and shade improved survival only, compared with a control. Gravel mulch and profile modification improved neither growth nor survival (Table 1).

The two water-harvest treatments influenced total growth and survival of redcedar trees similarly. The 50- by 100-foot harvest area produced 32 percent more total growth than did the control; the 50- by 50-foot area, 31 percent more. Redcedar survival was 100 percent and 90 percent in the 50- by 100-foot and 50- by 50-foot harvest areas, respectively. Compared to the control, the drip-irrigation and snowfence-protected treatment produced 25 and 24 percent more total growth, respectively, and each had 90 percent survival. Data for the Scotch pines were erratic and inconclusive. Survival and growth tended to be greater in the snowfence-protected and shaded treatments, although 90 percent of the original trees planted survived under drip irrigation.

It is difficult to explain the low survival rates on the mulch treatments. One explanation is that the gravel contained such a high percentage of fines that it sealed over and suffocated the trees. Another possibility is that the gravel contained some foreign matter that produced a toxicity in the soil that remained when the gravel was removed and the straw mulch applied. The plots will be relocated within the study site next year (1974) in hope of obtaining better results.

Summary

Redcedar and Scotch pine trees were used to find a simple, workable method of supplying supplemental water or altering the microclimate to improve tree growth and survival rates in semiarid locations.

Out of seven methods used in this study, four improved growth and five improved survival of redcedars. In two different-sized waterharvest areas, redcedars produced 31 and 32 percent more growth, and also survived better than the control. Drip-irrigation and snowfence-protected treatments produced 25 and 24 percent more growth in redcedars, respectively, and survival rate was greater. A shaded treatment did not increase tree growth, but redcedars had a greater survival rate.

Data indicated that Scotch pines did better in snowfence-protected and shaded environments, but results were erratic. No treatment can yet be considered satisfactory for practical application.

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