IRRIGATION MANAGEMENT FOR HYBRID POPLAR PRODUCTION

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Summary

Hybrid poplar (cultivar OP-367) was planted in April 1997 at the Malheur Experiment Station and submitted to six irrigation regimes. Irrigation regimes consisted of a combination of soil water potentials as thresholds for initiating irrigations and water application rates. The irrigation system consisted of microsprinklers installed along the tree row. Wood volume at the end of September 1997 was highest with the wettest treatment (keeping soil water potential at 8-inch depth wetter than -25 kPa and a total water application of 24 acre-inches). Trees in the wettest treatment averaged 9 feet, 11 inches in height and produced 2.8 ft^3/ac of wood volume by the end of September, 1997.

Introduction

With timber supplies from Pacific Northwest public lands becoming less available, sawmills and timber products companies are searching for alternatives. Hybrid poplar wood has proven to have desirable characteristics for many timber products. Growers in Malheur County have shown interest in growing hybrid poplars for saw logs. Clone trials in Malheur County have determined that the clone OP-367 (hybrid of *Populus deltoides* X *Populus nigra*) performs well on alkaline soils for at least two years of growth.

Hybrid poplars are known to have growth rates (Larcher, 1969) and transpiration rates (Zelawski, 1973) that are among the highest of temperate deciduous trees, suggesting that irrigation management is a critical cultural practice. Little research on irrigation management of poplars for saw logs has been done. The objective of this study was to test the effect of different irrigation rates and frequencies on poplar growth to determine optimum irrigation management practices.

Materials And Methods

The trial was conducted on a Nyssa-Malheur silt loam (bench soil) with 6% slope at the Malheur Experiment Station. The soil has a pH of 8.2 and 0.8% organic matter. The field was planted to wheat for the previous two years and before that to alfalfa. Treflan at 1lb ai/ac was broadcast and incorporated on April 22. The field was marked using a tractor and a solid set sprinkler system was installed prior to planting. Hybrid poplar sticks, cultivar OP-367, were planted on April 25, 1997 on a 14 foot by 14 foot spacing. The sprinkler system applied 1.4 inches on the first irrigation immediately after planting.

Thereafter the field was irrigated twice weekly at 0.6 inch per irrigation until May 26. A total of 6.3 inches of water in 9 applications was applied from April 25 to May 26.

On May 27 the solid set sprinkler system was removed and the field divided into 24 plots consisting of 5 trees surrounded by a single row of buffer trees (total plot area: three rows wide and 7 trees long). A microsprinkler system (R-5, Nelson Irrigation, Walla Walla, WA) was installed with the risers placed between trees along the tree row at 14 foot spacing. The sprinklers had a water application rate of 0.12 inches per hour at 25 PSI and a radius of 14 feet. Each plot had a pressure regulator (25 PSI) and ball valve allowing independent irrigation. Water application amounts were monitored daily by water meters in each plot.

Soil water potential (SWP) was measured in each plot by two granular matrix sensors (GMS; Watermark Soil Moisture Sensors model 200SS; Irrometer Co., Riverside, CA) at 8-inch depth, two GMS at 20-inch depth, and two at 32-inch depth. The GMS were installed along the middle row in each plot and between the riser and the third tree. The GMS were read at 8:00 A.M. daily starting on June 13, becoming the starting date for the irrigation treatments. The daily GMS readings were averaged for each plot and over all plots in a treatment for each depth separately.

The 6 irrigation treatments were replicated 4 times and consisted of 3 SWP thresholds (treatments 1,3, and 4) and 3 irrigation rates (treatments 2,5, and 6; Table 1). All plots in a treatment were irrigated when the treatment average SWP at 8-inch depth reached the threshold. Plots were irrigated separately as needed to maintain the plot average SWP at 8-inch depth below the threshold. Irrigation treatments were terminated on September 29.

Soil water content in the wettest and the two driest treatments (treatments 1, 5, and 6, respectively) was measured with a neutron probe. Two access tubes were installed in each plot along the middle tree row on each side of the fourth tree between the sprinklers and the tree. Soil water content readings were made twice weekly at the same depths as the GMS. The neutron probe was calibrated by taking soil samples and probe readings at 8-inch, 20-inch, and 32-inch depth during installation of the access tubes. The soil water content was determined gravimetrically from the soil samples and regressed against the neutron probe readings, separately for each soil depth. The regression equation was then used to transform the neutron probe readings during the season into inches of water per foot of soil. Coefficients of determination (R^2) for the regression equations were 0.89, 0.88, and 0.81 at $P= 0.001$ for the 8-inch, 20-inch, and 32-inch depths, respectively.

The field was kept weed free by rototilling between the tree rows and by hand weeding along the tree rows. The field was rototilled twice and hand weeded five times during the season.

The trees were fertilized with 100 lb N/ac, 44 lb P/ac (100 lb P_2O_5/ac), and 10 lb Zn/ac as a mixture of urea, monoammonium phosphate, and zinc sulfate on June 27. The fertilizer was applied on the soil surface as a ring around each tree and 2.5 feet away from the trunk. Leaf tissue analyses during the season, consisting of a composite sample of the first fully developed leaf from each of the 5 middle trees in the middle row of all plots in the wettest treatment were used to monitor and correct nutrient deficiencies. Trees in the wettest treatment might have the most vigorous growth and the greatest nutrient leaching so they would be expected to have the highest nutrient demand.

The heights and diameters at 8 inch height of the central 5 trees in the middle row in each plot were measured at the end of June, August and September. Diameter at breast height (4.5 ft from ground) was also measured at the end of August and September. Wood volumes were calculated for each of the central 5 trees in the middle row in each plot using an equation developed for poplars that uses tree height and diameter at breast height (Browne, 1962).

Results And Discussion

The highest wood volume at the end of August was obtained by the wettest treatment (Table 1). By the end of September, the tallest trees and the highest wood volume were obtained by the two wettest treatments (Treatments 1 and 2).

Since the plots in each treatment were irrigated individually as necessary, the total water applied to each plot within a treatment was slightly different. Regression analysis gives a perspective of the response of wood volume to water applied. Wood volume both at the end of August and at the end of September showed a strong linear response to applied water (Figure 1). The highest wood volume was obtained by 23 acre-inches of water applied through the end of August and by 26 acre-inches of water applied through the end of September.

The regression analysis suggests that at least 24 acre-inches of water are needed the first year for optimum poplar growth. Reducing the irrigation threshold from -25 kPa to -50 kPa reduced the number of irrigations from 21 to 11. Reducing the number of irrigations would result in a higher water application per irrigation. The feasibility of reducing irrigation frequencies and increasing application amounts will depend on the soil type and irrigation system.

On average, 91% of tree height growth occurred by August 31. However, only 69% of the growth in diameter at breast height and only 46% of the growth in wood volume occurred by August 31, suggesting the importance of irrigation during the month of September for year of establishment trees. Terminal budset occurred in approximately mid September. Leaf abscission started by mid to late October with trees becoming completely leafless in mid November.

The SWP at 8-inch depth remained wetter than the threshold for the treatment irrigated at -25 kPa and for the treatments irrigated at -50 kPa with 1.2 and 1.56 inches applied per irrigation (Fig. 2). In the treatments irrigated at -75 kPa or at -50 kPa with less than 1.2 inches applied per irrigation, the SWP at 8-inch depth became progressively drier during the season. Soil water potential at 20-inch depth generally tracked the SWP at 8-inch depth for the treatments irrigated at -25 kPa, for the treatments irrigated at -50 kPa with 1.2 and 1.56 inches applied per irrigation, and for the treatment irrigated at -75 kPa. In the treatments irrigated at -50 kPa with less than 1.2 inches applied per irrigation, the SWP at 20-inch depth became progressively drier during the season. The SWP at 32-inch depth was little influenced by irrigation management and remained relatively constant during the season, with little difference between treatments.

In early June the leaves showed general chlorosis symptoms typical of nitrogen deficiency, indicating the need for fertilization. A nitrogen deficiency would be expected since the field previously had two years of unfertilized wheat. The soil sample taken on April 11 showed only 45 lb/ac of available N in the top foot of soil.

After the June 27 fertilization, the leaf N content was in the excessive range on July 24 and September 2, and within the sufficiency range on August 12 (Table 2). Phosphorus and zinc were in the excessive range on all sampling dates. Potassium was deficient on July 24 and then became excessive and sufficient on August 12 and September 2, respectively, suggesting the effectiveness of the July 30 foliar application of potassium carbonate (Double OK, Na-Churs Plant Food Co., Marion, OH). Iron was deficient on July 24, and August 12, but sufficient on September 2, suggesting that the July 30 foliar application of iron chelate (Sprint 330, Ciba-Geigy, Greensboro, NC) did not completely correct the deficiency and that the August 14 foliar application of iron sulfate was effective in raising leaf iron levels. Magnesium levels fell below the sufficient range on August 12, and did not respond to the August 14 foliar application of magnesium sulfate. Leaf analysis in the spring of 1998 will determine if the September 15 ground application of magnesium sulfate was effective. Boron was deficient on all sampling dates, suggesting that the August 14 foliar application of boric acid (Borosol 10, Platte Chem. Co., Fremont, NE) did not completely correct the deficiency. Leaf analysis in the spring of 1998 will determine if the September 15 ground application of boric acid was effective.

Literature cited

Browne, J.E. 1962. Standard cubic-foot volume tables for the commercial tree species of British Columbia. British Columbia Forest Service, Forest Surveys and Inventory Division, Victoria, B.C. 9p.

Larcher, W. 1969. The effect of environmental and physiological variables on the carbon dioxide exchange of trees. Photosynthetica 3: 167-198.

Zelawski, W. 1973. Gas exchange and water relations. pp. 149-165 in S. Bialobok, ed. The poplars-*Populus* L. Vol. 12. Nat. Techn. Info. Serv., U.S. Dept. of Comm., Springfield, Va.

Table 1. Average tree height and wood volume for first year hybrid poplars submitted to six irrigation treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 1997.

Treatment	Irrigated when soil water potential[a] reaches	Water application		Total number of irrigations[c]	Tree height		Wood volume	
		per irrigation	total[b]		August 31	Sept. 30	August 31	Sept. 30
		---- inches ----			---- feet ----		---- ft^3 /ac ----	
1	25 kPa	0.80	23.9	30	8.85	9.94	1.31	2.82
2	when trt 3 is irrigated	1.56	19.8	20	8.66	9.7	0.95	2.50
3	50 kPa	1.20	15.3	18	8.26	9.11	0.80	1.77
4	75 kPa	1.50	14.4	15	7.33	8.14	0.44	1.07
5	when trt 3 is irrigated	0.90	12.9	17	7.71	8.47	0.62	1.15
6	when trt 3 is irrigated	0.60	11.0	17	7.37	7.8	0.43	0.82
	LSD (0.05)		2.7	3	0.47	0.62	0.35	0.70

[a]at 0.2 m depth

[b]from June 20 to Sept. 22 (includes 6.3 inches applied in 9 irrigations during tree establishment).

[c]average of 4 replications. Includes 9 irrigations applied during tree establishment).

Table 2. Hybrid poplar leaf tissue analyses and nutrients applied. Leaf tissue was a composite of the first fully developed leaf from each of 5 middle trees from all plots in the wettest treatment. Malheur Experiment Station, Oregon State University, Ontario, OR, 1997.

	Sufficiency range	Leaf nutrient concentrations			Nutrients applied*			
					Soil		Foliar	
		July 24	August 12	Sept. 2	June 27[a]	Sept. 15[d]	July 30[b]	Aug. 14[c]
Nutrient	---------- % ----------				---------- lb/ac ----------			
N-nitrogen	2.0-3.2	5.72	2.25	3.39	100			
P-phosphorus	0.22-0.45	0.61	0.67	0.55	44			
K-potassium	1.7-3.0	1.46	4.05	2.76			2	
S-sulfur	0.22-0.40	0.22	0.4	0.72				
Ca-calcium	0.60-2.40	0.92	0.92	0.97				
Mg-magnesium	0.40-0.80	0.45	0.39	0.34		10		2
Na-sodium	0.01-0.02	0.02	0.02	0.02				
	---------- ppm ----------							
Zn-zinc	25-55	69	109	81	10			
Mn-manganese	60-175	106	76	137				
Cu-copper	6-30	5	13	9				
Fe-iron	125-350	93	116	284			0.2	0.2
B-boron	30-65	27	23	19		0.2		0.1

[a]June 27: urea, $NH_4H_2PO_4$, and $ZnSO_4$ applied to ground around tree, 2.5 ft from trunk.

[b]July 30: K_2CO_3, and Fe chelate* foliar sprayed at 30 gal/ac.

[c]August 14: $MgSO_4$, $FeSO_4$, and boric acid* foliar sprayed at 30 gal/ac.

[d]Sept. 15: $MgSO_4$ applied to ground around tree, 2.5 ft from trunk. Boric acid injected in sprinkler syst.

*see text for trade names

Figure 1. First year poplar wood volume response to total water applied. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1997. Each data point is the average of 5 trees.

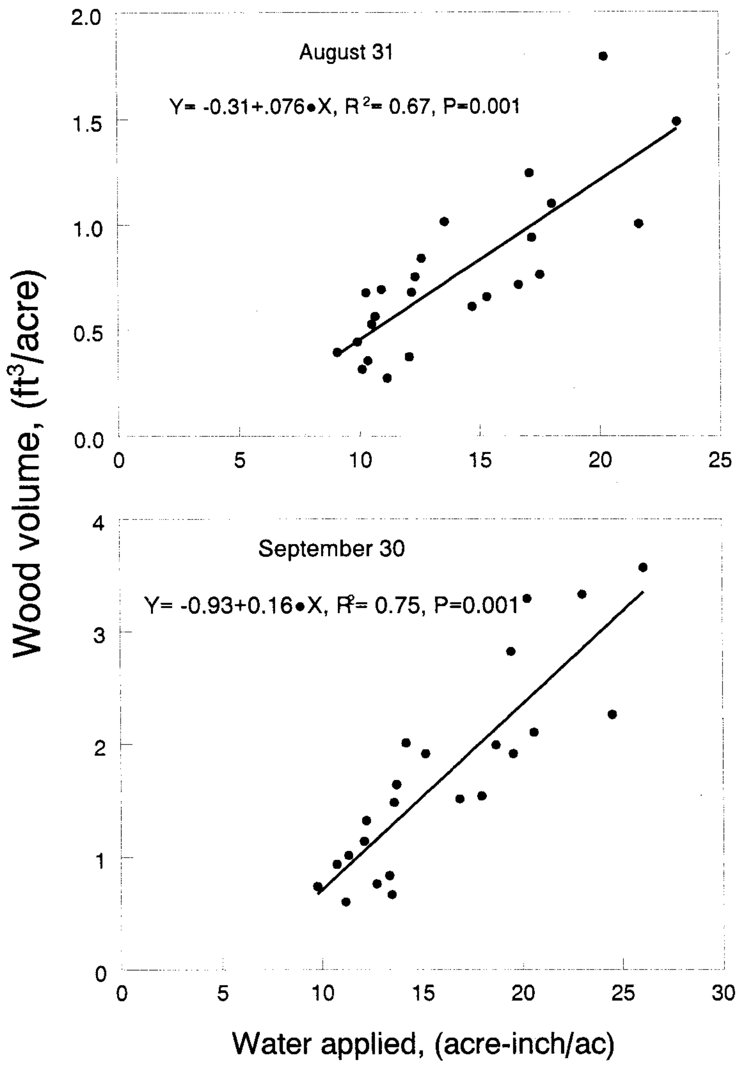

Figure 2. Soil water potential at 3 depths in a poplar stand submitted to 6 irrigation treatments. Malheur Experiment Station, Oregon State University, Ontario, OR, 1997.