PERFORMANCE OF HYBRID POPLAR CLONES ON AN ALKALINE SOIL

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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 nonstructural timber products. Plantings of hybrid poplar for sawlogs have increased in the Treasure Valley.

Many hybrid poplar clones are susceptible to nutrient deficiencies in alkaline soils, leading to chlorosis, poor growth, and eventual death of trees. Poor growth on alkaline soil can be partly a result of iron deficiency caused by the low solubility of iron compounds in alkaline soil. A symptom of iron deficiency is yellow leaves or "chlorosis". Chlorosis can also be caused by other nutrient problems.

Previous clone trials planted in 1995 in Malheur County demonstrated that clone OP-367 (hybrid of *Populus deltoides* x *P. nigra*) was the only clone performing well on alkaline soils at that time. Growers in Malheur County have made experimental plantings of hybrid poplars and found that other clones have higher productivity on soils with nearly neutral pH. New poplar clones are continually being developed. The current trial seeks to provide poplar growers with updated information on the relative vigor and adaptability of a larger number of clones on alkaline soils.

Materials and Methods

2003 Procedures

The trial was conducted on Nyssa silt loam with 1.3 percent organic matter and a pH ranging from 7.7 at the field top to 8.4 at the field bottom. The field had been planted to wheat in the fall of 2002. On March 28, 2003, the wheat was sprayed with Roundup® (Glyphosate) at 1.5 lb ai/acre. Based on a soil analysis, on April 9, 2003, 20 lb magnesium (Mg), 40 lb potassium (K), 1 lb boron (B), and 1 lb copper (Cu) per acre were broadcast. The field was again sprayed with Roundup at 1.5 lb ai/acre on April 9. On April 10, 9-inch poplar sticks of 24 clones (Table 1) were planted in a randomized complete block design with 5 replicates. Three of the clones were designated Malheur 1, 2, and 3 corresponding to three selections of eastern cottonwood (*Populus deltoides*) found growing in Malheur County. Tree rows were spaced 5 ft apart and trees were spaced 5 ft apart within the rows. Each plot consisted of four trees two rows wide and two trees long. Goal® herbicide (Oxyfluorfen) at 2 lb ai/acre was applied on April 11. The field was irrigated with 0.6 inch of water on April 11.

Drip tubing (Netafim Irrigation, Inc., Fresno, CA) was laid along the tree rows prior to planting. The drip tubing had two emitters (Netafim On-line button dripper) spaced 12 inches apart for each tree. Each emitter had a flow rate of 0.5 gal/hour. The field was irrigated when the soil water potential at 8-inch depth reached -25 kPa. Each irrigation applied 0.6 inch of water based on an 8-ft^2 area for each tree. This irrigation strategy was able to maintain the soil water potential above -25 kPa until around mid-July. Starting around mid-July the irrigation rate was increased to 1 inch per irrigation. This increased irrigation rate did not maintain the soil water potential above -25 kPa due to inadequate irrigation frequency, so starting in mid-August the field was irrigated 5-7 times per week until the last irrigation on September 30. Soil water potential was measured with six Watermark soil moisture sensors (model 200SS, Irrometer Inc., Riverside, CA) installed at 8-inch depth. The soil moisture sensors are read every 8 hours by a Hansen Unit datalogger (Mike Hansen Co., Wenatchee, WA).

Analysis of leaf samples (first fully expanded leaf from clone OP-367) taken on July 11 showed unexpected needs for boron and sulfur fertilization (Table 1). On July 28, sulfur at 10 lb/acre as ammonium sulfate and B at 0.2 lb/acre as boric acid were injected through the drip system.

2004 Procedures

On March 25, 2004, Casoron 4G® at 4 lb ai/acre was broadcast for weed control. Based on a soil analysis, nitrogen (N) at 80 lb/acre, Cu at 1 lb/acre, and B at 1 lb/acre were injected through the drip tape on May 10. Analysis of leaf samples (first fully expanded leaf from clone OP-367) on July 8 showed the need for B (Table 1). On July 19, B at 0.2 lb/acre was injected through the drip system. On August 20, a soil sample consisting of 20 cores was taken from each replicate and analyzed for pH.

On August 10, leaf chlorophyll content was measured on two leaves per tree using a Minolta SPAD 502 DL meter (Konica Minolta Photo Imaging U.S.A., Inc., Mahwah, NJ). On August 20, trees in all plots were evaluated subjectively for visual symptoms of leaf chlorosis. On September 10 the trees in all plots were evaluated subjectively for stem defects. The heights and diameter at breast height (DBH, 4.5 ft from ground) of all trees in each plot were measured in October 2003 and 2004. Stem volumes (cubic feet, excluding bark and including stump and top) were calculated for each tree using an equation (stem volume = $10^{(-2.945047+1.803973*LOG10(DBH)+1.238853*LOG10(Height))}$) developed for poplars that uses tree height and DBH (Browne 1962). Clonal differences in height, DBH, and wood volume were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05). The LSD (0.05) values at the bottom of Table 2 should be considered when comparisons are made between clones for significant differences in performance characteristics. Differences between clones equal to or greater than the LSD (0.05) value for a characteristic should exist before any clone is considered different from any other clone in that characteristic. To evaluate the sensitivity of the clones to soil pH, a regression analysis of leaf chlorophyll content against soil pH was run for each clone separately. If the regression analysis had a probability level of 5 percent or less, the clone was considered to be sensitive to soil pH.

Results and Discussion

Starting around mid-July 2003 and 2004, the soil water potential failed to remain above the target of -25 kPa (Fig. 1). A total of 22 and 44 inches of water plus precipitation were applied during the season to the whole field in 2003 and 2004, respectively (Fig. 2). Based on our previous work (Shock et al. 2002), greater tree growth and wood volume would have been expected if the intended soil water potential could have been maintained, which would have required a greater amount of water to be applied. However, water infiltration in this field was restricted; we observed runoff out of the bottom of the field.

Chlorotic leaves were observed on trees in replicates 2, 3, and 4 of the trial. The soil pH was 7.7, 8.2, 8.4, and 8.4 for replicates 1 to 4, respectively. Relative leaf chlorophyll content rankings ranged among clones from 25.8 to 49.3 percent (Table 2). The regression analysis of soil pH and leaf chlorophyll content showed some clones to be insensitive to soil pH in terms of leaf chlorophyll content (Table 2). The leaf chlorophyll content of the sensitive clones decreased with increasing soil pH. The leaf chlorophyll content of the clones insensitive to soil pH (12 clones) averaged 42.4 percent. The leaf chlorophyll content of the clones sensitive to soil pH (12 clones) averaged 31.8 percent. There was a linear relationship ($R^2 = 0.62$, $P = 0.001$) between leaf chlorophyll content and the visual rating of leaf chlorosis (Fig. 3). The trees insensitive to soil pH averaged a subjective visual rating of leaf chlorosis of 0.52 (0 = no visual symptoms of chlorosis, 5 = very chlorotic). The trees sensitive to soil pH averaged a visual rating of leaf chlorosis of 2.15. The three *P. deltoides* selections from Malheur County had among the darkest green leaves, and leaf sizes were smaller. For the clones sensitive to soil pH, tree growth decreased with increasing severity of leaf chlorosis and with decreasing leaf chlorophyll content (Figs. 4 and 5). For the clones insensitive to soil pH, tree growth was not related to leaf chlorosis or leaf chlorophyll content.

Subjective rating of stem defects (0 = no defects, 2 = more than half of the trees have either split or crooked tops) ranged from 0 defects for clone 57-276 to 1.75 for clone 49-177 (Table 1).

Tree height in October 2004 ranged from 13 ft for 50-184 to 22.6 ft for 59-289 (Table 2). Diameter at breast height ranged from 1.45 inches for 311-93 to 2.41 inches for 184-401. Stem volume ranged from 119.3 inch^3 for 50-184 to 437 inch^3 for 59-289. Clones 59-289, Malheur 3, 184-401, and 50-197 were among those with the greatest stem volume. Stem volume growth in 2004 ranged from 113.3 inch^3 for 50-184 to 414.2 inch^3 for 59-289. Clones 59-289, Malheur 3, 184-401, and 50-197 were among those with the greatest stem volume growth in 2004.

Considering all measured characteristics, clones 59-289 and Malheur 3 had among the best performance over the 2 years of the trial. These two clones had high growth, high leaf chlorophyll content, insensitivity to soil pH, and low incidence of stem defects. Clone 59-289 was taller than OP-367. Compared to OP-367, clones 59-289 and Malheur 3 had greater stem volume, but were similar in leaf chlorophyll content, insensitivity to soil pH, and incidence of stem defects. The choice of clones for commercial production needs to be made on the basis of wood productivity through an entire growth cycle and ultimately on wood quality, parameters that are currently unavailable for 59-289 and Malheur 3.

References

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.

Shock, C.C., E.B.G. Feibert, M. Seddigh, and L.D. Saunders. 2002. Water requirements and growth of irrigated hybrid poplar in a semi-arid environment in eastern Oregon. Western J. of Applied Forestry 17:46-53.

Table 1. Analysis of hybrid poplar leaf samples (first fully expanded leaf from clone OP-367), Malheur Experiment Station, Oregon State University, Ontario, OR.

Nutrient	Sufficiency range*	July 11, 2003 analysis	July 8, 2004 analysis
N (%)	3 - 3.5	4.02	3.73
P (%)	0.3 - 0.4	0.45	0.41
K (%)	1.7 - 2.1	5.88	2.52
S (%)	0.3 - 0.4	0.22, deficient	0.64
Ca (%)	0.8 - 1.2	0.9	1.55
Mg (%)	0.15 - 0.25	0.29	0.57
Zn (ppm)	15 - 25	36	29
Mn (ppm)	70 - 110	81	115
Cu (ppm)	3 - 5	12	16
Fe (ppm)	65 - 95	256	205
B (ppm)	35 - 45	17, deficient	25, deficient

* analyses by Western Labs, Parma, ID.

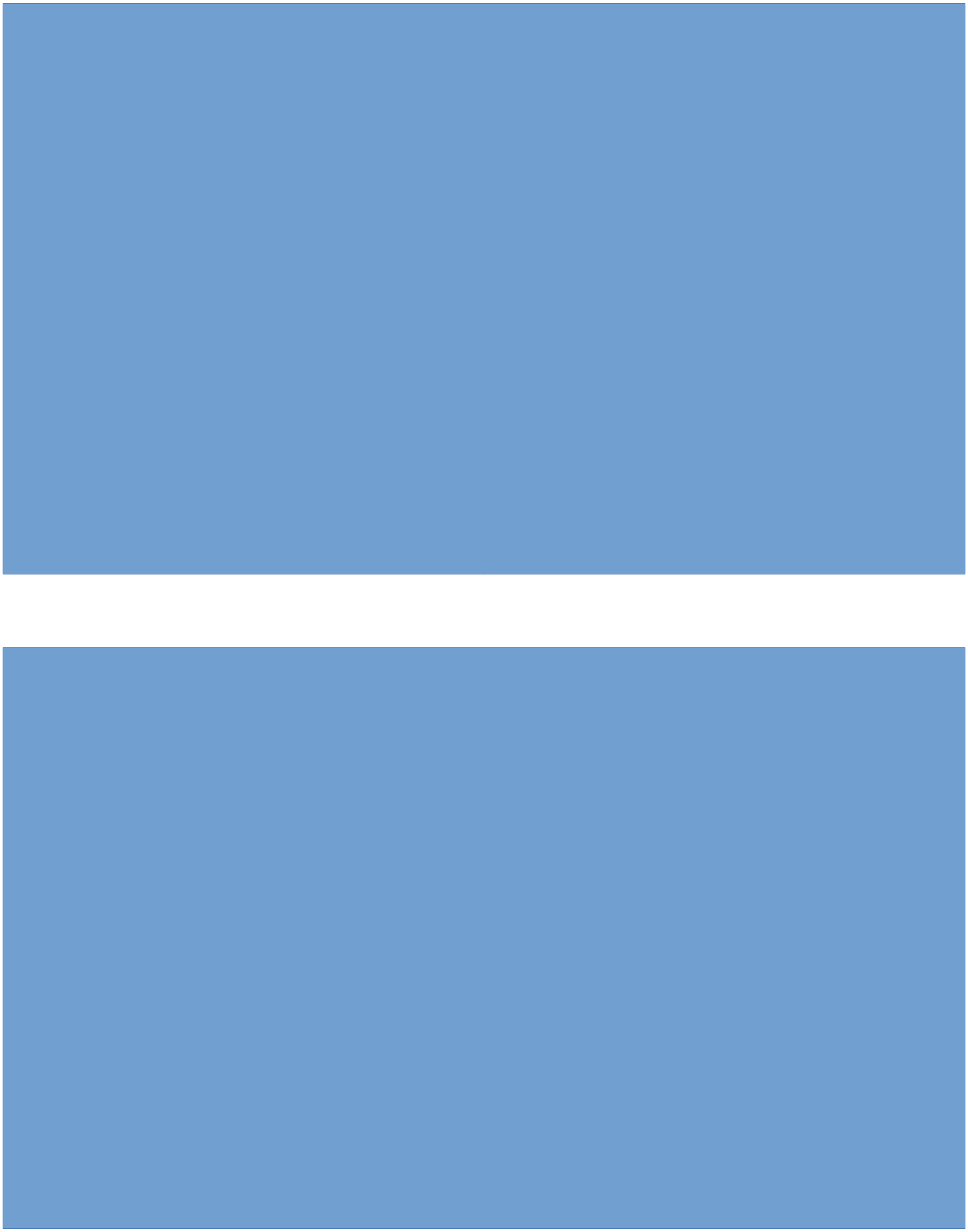

Figure 1. Average soil water potential at 8-inch depth during 2003 and 2004 for poplar clones irrigated with a drip-irrigation system with two emitters per tree, Malheur

Experiment Station, Oregon State University, Ontario, OR.

Figure 2. Cumulative water applied to poplar clones in 2003 and 2004. Trees were irrigated with a drip-irrigation system with two emitters per tree, Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 3. Relationship between relative leaf chlorophyll content measured with a Minolta SPAD meter and subjective rating of leaf chlorosis (0 = no chlorosis symptoms, 5 = severe chlorosis symptoms), Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 2. Performance of hybrid poplar clones planted on April 10, 2003 at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			November 2004 measurem.			2004 growth increment			Leaf chlorophyll content	Leaf chlorosis symptom
No.	Clone	Cross	Height	DBH	Wood volume	Height	DBH	Wood volume		
			feet	inch	$inch^3$/tree	feet	inch	$inch^3$/tree	0 - 100	0 - 5*
1	15-29	*P. trichocarpa X P. deltoides*	18.89	1.95	283.6	7.98	1.23	253.0	35.70	1.50
2	50-184	*P. trichocarpa X P. deltoides*	13.02	1.63	119.3	5.66	1.19	113.3	31.10	2.50
3	50-197	*P. trichocarpa X P. deltoides*	20.20	2.19	348.5	10.07	1.45	333.2	30.30	3.00
4	52-225	*P. trichocarpa X P. deltoides*	18.77	1.93	252.1	9.90	1.35	240.5	26.60	3.00
5	55-260	*P. trichocarpa X P. deltoides*	16.62	1.80	203.6	7.24	1.25	191.7	25.80	2.75
6	56-273	*P. trichocarpa X P. deltoides*	19.81	2.11	318.6	10.10	1.48	303.1	40.80	1.00
7	57-276	*P. trichocarpa X P. deltoides*	16.85	1.90	214.3	6.66	1.22	195.4	36.30	1.75
8	58-280	*P. trichocarpa X P. deltoides*	17.76	2.00	252.5	9.01	1.40	240.2	44.40	0.75

9	59-289	*P. trichocarpa X P. deltoides*	22.56	2.30	437.0	10.07	1.35	414.2	42.00	0.50
10	184-401	*P. trichocarpa X P. deltoides*	20.39	2.41	407.1	7.24	1.26	385.5	34.00	0.50
11	184-411	*P. trichocarpa X P. deltoides*	19.61	2.05	312.5	10.02	1.38	300.4	32.40	1.50
12	195-529	*P. trichocarpa X P. deltoides*	17.68	1.96	246.3	7.25	1.29	227.3	32.20	1.50
13	309-74	*P. trichocarpa X P. nigra*	19.89	2.02	302.6	8.78	1.28	282.4	26.30	2.75
14	311-93	*P. trichocarpa X P. nigra*	16.40	1.45	141.9	7.66	1.00	133.9	30.20	3.25
15	NM-6	*P. trichocarpa X P. maximowiczii*	18.60	1.78	214.0	8.24	1.14	196.5	43.50	1.50
16	DTAC-7	*P. trichocarpa X P. deltoides*	15.18	1.66	171.0	7.25	1.20	162.5	34.00	2.00
17	OP-367	*P. deltoides X P. nigra*	18.10	2.10	284.9	8.14	1.46	269.1	40.60	0.00
18	PC1	*P. deltoides X P. nigra*	20.17	2.09	310.3	10.99	1.56	300.0	45.80	0.00
19	PC2	*P. trichocarpa X P. deltoides*	18.68	1.82	221.0	9.47	1.23	208.7	45.30	0.25
20	49-177	*P. trichocarpa X P. deltoides*	18.75	1.82	237.9	9.46	1.24	228.7	33.50	1.50
21	Malheur 1	*P. deltoides,* Malheur County, OR	19.79	1.53	186.4	10.16	1.01	176.7	49.30	0.00
22	Malheur 2	*P. deltoides*, Malheur County, OR	18.18	1.59	177.8	8.14	0.94	167.7	46.70	0.00
23	Malheur 3	*P. deltoides*, Malheur County, OR	19.92	2.37	407.9	9.64	1.59	396.1	42.20	0.00
24	DN-34	*P. deltoides X P. nigra*	20.25	1.87	259.3	12.24	1.36	250.2	43.80	0.50
LSD (0.05)			2.17	0.32	102.9	1.98	0.24	98.2	8.80	1.61

*Subjective evaluation of leaf chlorosis on a scale of 0-5: 0 = no symptoms, 5 = very chlorotic.

†Subjective evaluation of trunk defects on a scale of 0-2: 0 = all trees have straight stems and single tops, 1 = less than half of trees have either split or crooked stems, 2 = more than half of the trees have either split or crooked stems.

Figure 4. Relationship between leaf chlorosis symptoms (0 = no symptoms, 5 = severe chlorosis symptoms) and stem volume in September 2004 for hybrid poplar clones sensitive to soil pH, Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 5. Relationship between relative leaf chlorophyll content and stem volume in September 2004 for hybrid poplar clones sensitive to soil pH, Malheur Experiment Station, Oregon State University, Ontario, OR.