Hybrid Poplar Research at the Klamath Experiment Station

Poplar Clone Trial: First Season (1996) Results

Introduction

Poplar is a generic term used to refer to trees in the genus Populus. Aspen, lombardy Poplar, black cottonwood, and eastern cottonwood are all members of this genus. Hybrids are produced by cross-fertilizing plants of different species, such as eastern cottonwood and black cottonwood. Hybrids can be produced to increase growth and to improve tolerance to environmental extremes. In the Pacific Northwest, hybrid poplar have grown 60 to 70 feet in height and 10 to 15 inches in diameter in just 7 years.

The ability of hybrid poplars to achieve very rapid growth and the decline in availability of federal timber in the Northwest have stimulated great interest in hybrid poplar production. Within the last several years, four Oregon pulp and paper companies have established hybrid poplar plantations to help supply their paper mills. There is also interest in the wood products industry (e.g., sawmills, plywood mills, door and window manufacturers, etc.) to assess the suitability of poplar wood for wood products.

Growers and the wood products industry in the Klamath Basin have expressed interest in determining if hybrid poplar can be grown economically in the basin, and if so, which of the many hybrid clones available are best suited to local climatic conditions.

Procedures

Mt. Jefferson Farms of Salem, Oregon provided 560 poplar cuttings ("sticks") representing eight different clones (70 trees of each clone). Seven clones (49-177, 52-225, 1529, 50-194, 50-197, 288-64, and 184-411) were derived from parent stock involving crossing of *Populus trichocarpa* (black cottonwood) and *Populus deltoides* (eastern cottonwood). The other clone (OP-367) was from a cross of *Populus deltoides* (eastern cottonwood) and *Populus nigra* (European black poplar).

A field at the Klamath Experiment Station (KES) with Fordney fine sandy loam soil was selected as the research site. Previous crop history included spring barley or oats in the past four years preceded by grass and legume forage crops. One potato crop and one sugarbeet crop was grown at the site in the past 10 years. Soil samples were collected and analyzed in the spring of 1996. An area of approximately 200 feet square (200 feet per side or 40,000 square feet) was prepared for planting on June 11 and 12.

The field was ripped, with shanks spaced 18 inches apart, to a depth of 18 inches. A broadcast application of 500 lb/acre of 16-20-0-13S was incorporated by rototilling to a depth of 10 inches, followed by moderate compaction with a Brillion roller. A preplanting irrigation provided slightly less than field capacity in the top foot of soil. Poplar sticks were planted at 7-foot spacing in 10-foot rows on June 13. Individual plots (16 trees) consisted of 4 trees in 4 rows and were arranged in a randomized complete block design with three replications.

The plot area was surrounded by two border rows of trees on all sides. Border trees were the same hybrid clones as in adjacent plots. Irrigation was provided with solid-set sprinklers arranged on a 40- by 40-foot spacing equipped to apply 0.25 inches/hour. The total irrigation for the 1996 season was approximately 30 inches.

Excellent weed control was achieved by cultivating between rows in both directions with a small harrow pulled with a four-wheel drive ATV. The field was cultivated at about two week intervals. Nutrient deficiency symptoms evident during early foliage development prompted applications of elemental sulfur at 1,000 lb/acre on August 13, and four applications of a fertilizer blend containing 6 percent nitrogen, 5 percent sulfur, 6 percent iron, 2 percent manganese, and 1 percent zinc. The first application was made with a conventional ground sprayer at 5 gallons/acre in 30 gallons/acre of solution on July 23. Applications were made by drenching each tree individually with the concentrated solution applied with a backpack sprayer on August 10, August 16, and August 24. A total of 2 gallons of product was applied in the three applications. Height growth was measured on all trees on September 16. Height data was subjected to analysis of variance.

Results and Discussion

Soil analyses indicated a potential for nutritional deficiencies and a need for soil amendments. Soil pH ranged from 7.9 to 8.8 with the gradient in the direction of replications such that replication 1 was positioned at the highest pH, and replication 3 at the lowest pH. Soil test results are presented in Table 1. Major elements and micronutrients were generally low. Exchangeable sodium was quite high, particularly in the area with high pH. Due to limited experience with poplar production, and little information on how trees might respond to the soil conditions, use of soil amendments was delayed to observe crop response to the site.

Buds broke dormancy within about five days of planting and leaf development was evident within two weeks. As soon as expanded leaves were present the effects of high pH, high sodium content, and other nutritional stresses became evident. The trees in the area of highest pH and highest salt content exhibited severe bronzing to nearly purple color in leaves. At the lowest pH area, leaves appeared normal in color and growth was more rapid. The first application of the micronutrient mix did not result in noticeable improvement in leaf color or growth of the foliage. Some improvement in color and growth was observed after the application of elemental sulfur. The hand applications of nutrient during August also appeared to be beneficial. However, trees in the highest pH area continued to appear stressed throughout the season.

Some mortality was experienced in most clones in the first season. All trees survived in the OP-367 and 50-197 clones. Clones 49-177 and 52-225 each had one mortality out of 64 trees. Losses of 2, 3, 4, and 4 trees were experienced by clones 50-194, 1529, 184-411, and 288-64, respectively.

Tree height measurements indicated significant differences between clones and a clear correlation between pH and tree growth (Figures 1 and 2). The OP-367 clone, which was the only clone derived from an eastern cottonwood - European black poplar cross, had an average height of 48 inches. This was significantly taller than the group including 50-197, 50-194, 15-29, and 49-177, which ranged in height from 37 to 34 inches. Clones 288-64 and 184-411 produced significantly shorter trees than all other clones, at about 26 inches.

The effects of high pH, high sodium levels, and related nutrient problems were also documented to some degree by the tree height measurements. Averaged over all clones, the heights ranged from 40 inches in the replication with lower pH to 33 inches in the middle replication and 30 inches in the highest pH replication. The superior performance of the OP-367 clone seemed to be partially a tolerance to high pH and related soil conditions. It was more vigorous than other clones in each replication.

The limitations of this site for hybrid poplar production were recognized prior to planting the experiment. However, alternative sites were not offered within a limited time frame. It was also expected that the site could provide some insight into the opportunity to correct soil limitations. Further efforts in correcting soil limitations will be explored in 1997.

In the Columbia Basin and other long season areas, reports of tree heights of 7 to 10 feet in the first season are common. Much earlier planting is a major factor in this greater growth potential.

A small planting of the OP-367 clone was made at the Klamath County Extension Office site on May 31. Leaf growth was starting within 5 days after planting. A frost was experienced at the site on June 10 although the minimum temperature recorded at KES was 34 degrees F. A lower temperature occurred on June 18 when the minimum recorded at KES was 30 degrees F. These frosts resulted in 25 percent mortality in the trees planted at the Extension office site, with no recovery. This is not an unusual event in the Klamath Basin, and suggests that early planting of hybrid poplars in the Klamath Basin would be very risky. The fact that the clone which performed best at KES was the one used at the Extension office site may also be significant. Survival of other clones might have been even less.

One of the major problems experienced in poplar production has been controlling weed competition. The use of an ATV with a small cultivator was very satisfactory and cost effective. The ATV could drive over three-inch irrigation laterals with no damage and no need to disassemble the irrigation system. It is anticipated that this equipment will be able to maneuver through the plantation in the second year. By the third year, shading should provide adequate competition for weed control.

Overhead sprinkler irrigation is not widely used in hybrid poplar production. The system was very satisfactory in the first year, with no evidence of damage to leaves. In the first year, sprinkler heads were mounted on 36-inch risers. Taller risers may be required in the second year if leaf damage is observed. When trees reach fuller canopy conditions, other irrigation options may be required. The use of drip irrigation is probably not feasible in land irrigated with Klamath Project water due to algae growth, which would present filtering problems. Gated pipe and furrow irrigation will probably be the most practical approach in commercial scale situations.

The planting was made on the standard population of 70 square feet/tree used for pulp production. Slower growth rates in shortseason climatic zones may require lower tree density to achieve adequate size in 10 years. Use of hybrid poplar for wood products will require larger diameter trees than necessary for pulp production. The preliminary plan for this study was to thin the stand after several years to provide more space and greater growth potential. In view of the poor growth due to adverse soil conditions, this site will not provide a good estimation of the potential for hybrid poplar to produce pulp or wood products. However, the experience gained has provided valuable information on adaptability of clones, effects of early season frost risk, irrigation and weed management options for first year establishment, and may, in the second year, demonstrate the ability to correct soil limitations.

Table 1. Soil test data for the hybrid poplar research site at the Klamath Experiment Station, Klamath Falls, OR, 1996.

		Quadrant			
Parameter		NE	NW	SE	SW
pH	(%)	8.3	8.0	8.8	7.9
Organic matter	ppm	1.0	0.7	0.9	0.8
Phosphorus	ppm	6.0	6.4	5.6	7.0
Sulfur	ppm	4.5	3.0	2.5	8.5
Potassium	ppm	463	187	422	228
Calcium	ppm	3890	2700	4050	2950
Magnesium	ppm	492	298	673	271
Sodium	ppm	163	85	432	91

Cation exchange	mEQ	14.9	11.4	15.4	11.0
Base saturation	%	171	147	187	163
Zinc	ppm	1.1	0.9	0.9	0.9
Iron	ppm	2.1	3.7	1.0	4.0
Manganese	ppm	7	5	5	7
Copper	ppm	0.4	0.2	0.7	0.2
Soluble salts	EC	0.35	0.48	0.40	0.46

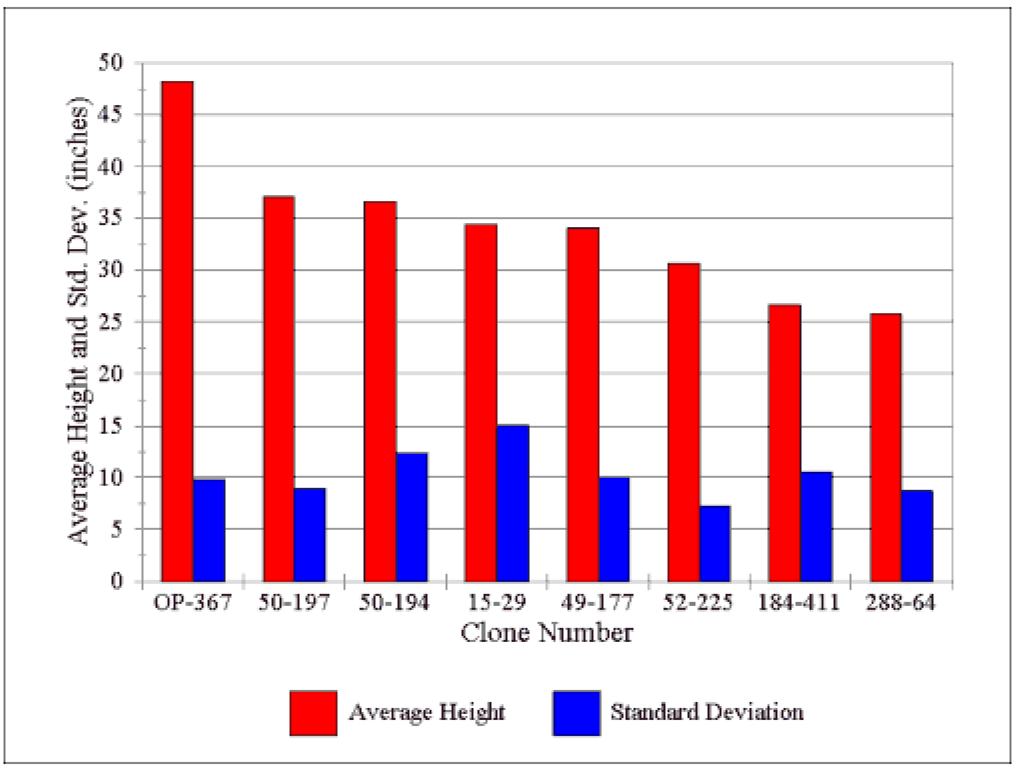

Figure 1. Average first-season height for the 8 hybrid poplar clones grown at the Klamath Experiment Station in 1996.

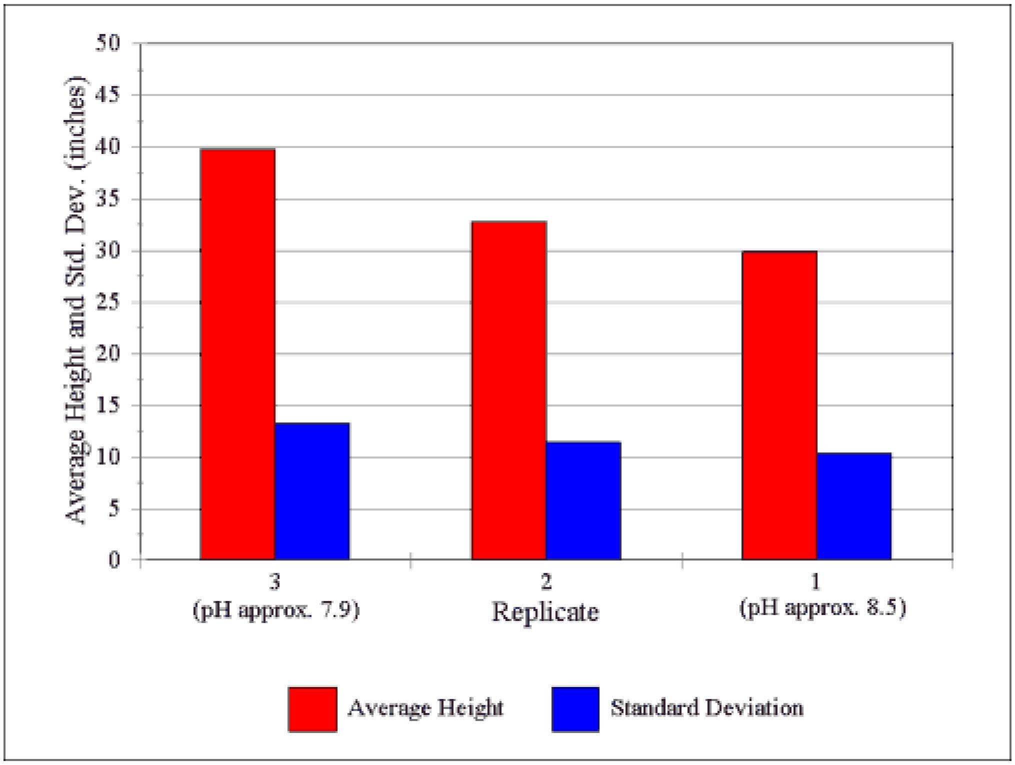

Figure 2. Average first-season height (across all clones) for the 3 replicates grown at the Klamath Experiment Station in 1996.

Poplar Clone Trial: Mortality after first winter

By Spring of 1997 (after the trees' first Winter), things looked pretty grim for the poplars at the Klamath Experiment Station. Not a single tree had a live top and many of the trees appeared to be dead. On May 20th the trees were measured and 113 of 560 trees were dead above ground (upon removal, many of these trees were alive and growing 3-4 inches below ground). Another 102 trees were killed above ground but had broken bud below ground and had live green foliage above ground by May 20th. Data analysis revealed that even the "best" clone had lost an average of 80% of its height growth from last year. The research plot at the Experiment Station was laid to rest on May 27th, 1997.

Does this indicate that we cannot and should not try to establish hybrid poplar fiber plantations in Klamath County? Maybe. However, nursery producers and Dr. Dave Hibbs, OSU's hybrid poplar expert, feel that the poor results at the Klamath Experiment Station are likely due to a combination of factors. High soil pH stressed the trees and therefore the trees went into dormancy under less than ideal conditions. Also, irrigating the trees into October likely delayed dormancy such that the buds were too soft and green when the first few hard frosts hit. Nursery producers advise stopping irrigation in the Klamath Basin no later than the first week of September.

1999 Update

On June 15th of this year, 500 hybrid poplar trees were planted at the Klamath Experiment Station. All trees were of the same clone, OP-367, the clone that performed the best in the previous experiment (1996). Approximately 60 percent of the trees were planted on the same site (hereafter referred to as the "south plot") as the previous experiment. The remainder were planted on a site ("north plot") expected to provide better results due to lower soil pH.

Prior to planting, soil pH data were collected for the south plot. Soil pH averaged approximately 7.7, 8.4, and 8.5 for the west, center, and east portions, respectively.

All trees on the north plot appeared healthy throughout the growing season. Trees in the center and eastern (higher pH) portions of the south plot began to show stress within 4 weeks of planting. Foliar analysis was conducted in early August to attempt to determine the specific causes of plant stress. Leaves from trees that appeared in good health (those that were growing well and had green leaves) had similar levels of nitrogen as leaves from trees that were stunted in growth and had yellow/ brown leaves. Levels of phosphorus, potassium, sulfur, calcium, sodium, zinc, manganese, copper, and iron were all higher for the stressed trees than for the healthy trees. Magnesium was the exception; stressed trees had much lower levels of magnesium than healthy trees.

On September 8th, height growth data were collected for all the trees and statistical analysis was performed on the data. Height growth varied significantly between the trees in the north plot and all 3 portions of the south plot. Average height was approximately 49 inches for trees in the north plot. In the south plot, average height was approximately 58, 33, and 22 inches for trees in the west, center, and east portions. The data are shown in Figure 3.

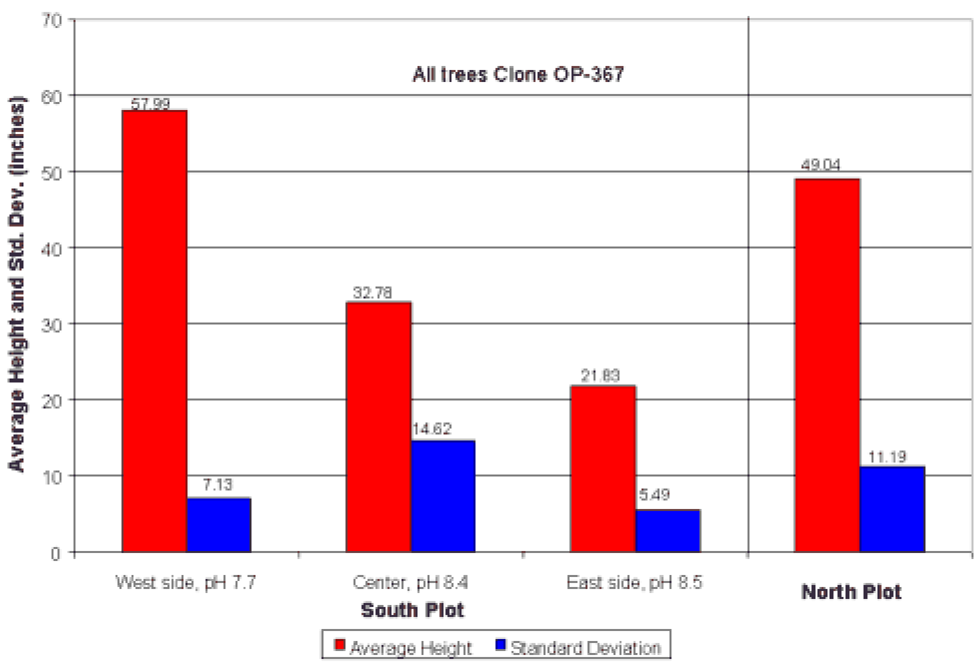

Figure 3. Average first-season height for clone OP-367 grown at the Klamath Experiment Station in 1999.

Average height growth for this clone is similar to slightly higher this time around than it was for the 1996 project.

Our greatest challenge in the 1996 study was winter mortality. We will report winter mortality in the Spring of 2000.

2000 Update

Of 500 trees planted in June of 1999, 306 survived the winter, though mortality was far from uniform across the plots. Specifically, in the eastern and center portions (pH approx. 8.5 and 8.4, respectively) of the south plot, winter mortality was 100% and 59.4%, respectively. Mortality was only 1.8% for trees on the western portion (pH approx. 7.7) of the south plot and 7.1% for the north plot. Thus it appears for optimum growth in the Klamath Basin, soil with a pH around 7.5 works well.

Following the practices being used by other poplar growers, we opted not to mechanically cultivate during this growing season. Some researchers have reported that mechanical cultivation may stunt growth by damaging the shallow roots of the trees. Herbicides are therefore the preferred method of weed control. Unfortunately, however, I was a "day late and a dollar short" this spring when I thought about applying herbicide; the risk of herbicide damage to the trees was too high. As an alternative, we manually removed the larger weeds and planted a winter wheat cover crop. Research conducted at the Malheur Experiment Station indicates that cover crops reduce tree growth. Therefore, we accepted the likelihood for less-than-optimal growth this year and will plan to spray early enough next year to maintain a "bare ground" plantation.

In October, the heights of all the trees were measured. For those trees that survived last winter, average height is now nearly 12 feet for the north plot, and for the west side of the south plot. Figure 4 shows the average height and standard deviation for the trees at the end of the second growing season ('99) and at the end of this growing season.

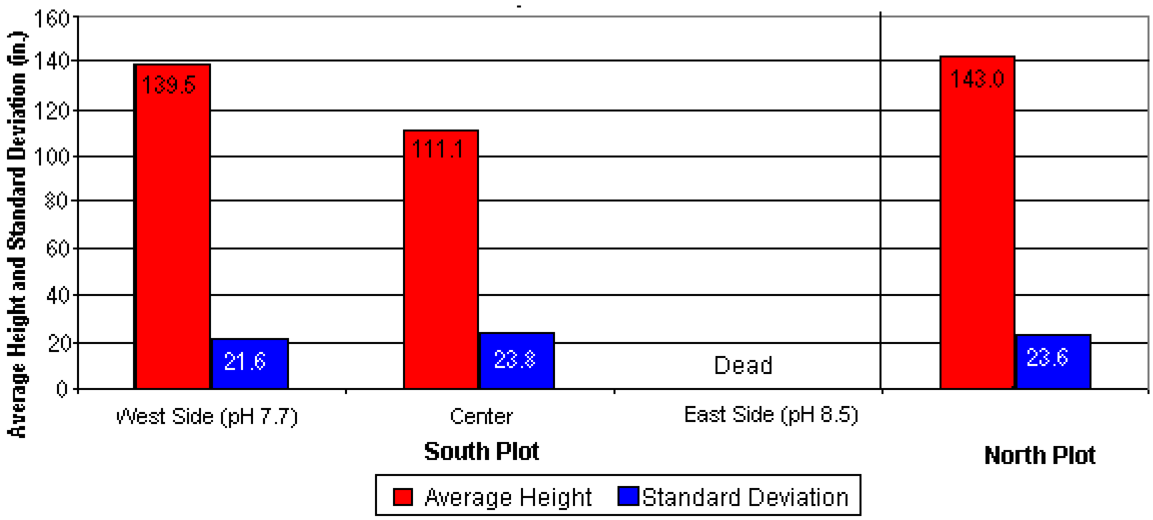

Figure 4. Average second-season height for clone OP-367 at the Klamath Experiment Station. October 2000.

At the end of the first growing season, the trees in the western edge of the south plot averaged nearly a foot taller than those in the north plot. During this growing season, the trees in the north plot caught up and passed even the tallest trees in the south plot.

2001 Update

January 2001, we removed the basal sprouts (i.e., pruned all trees to one primary leader) and pruned the limbs up to about 18 inches, and thinned the stand back to a 14 ft. x 14 ft. spacing, as opposed to the planting spacing of 7 ft. x 14 ft.

At the end of this season, we will measure diameter as well as height so that we can begin to estimate volume production per acre.