A COMPARISON OF FIELD AND GROWTH CHAMBER PRODUCTIVITY OF THREE POPLAR CLONES

Thomas C. Hennessey and John C. Gordon
Department of Forestry, Iowa State University 1/

Abstract.--Three clones of *Populus* were grown at two field locations (Ames, Iowa, and Rhinelander, Wisconsin) and in the growth chamber under photoperiods of 13, 14, and 15 hours. Clones were ranked by size for seven growth variables, and correlations between field and growth chamber growth were calculated. Growth chamber and field rankings were similar for most variables and both locations, and correlation between field and growth chamber performance increased with increasing growth chamber photoperiod. Results indicate that growth chambers can be used for initial rapid selection of poplar clones for field trials.

If controlled environment growth studies could be used to predict field performance of clonal material, and thus to reduce the size of long-term trials, great savings would result. This is particularly true, we think, in the screening of the thousands of possible *Populus* clones that could be useful in short-rotation cultural systems. In these systems, the environment will be modified culturally toward the optimum for growth of the genotypes chosen. Because of this, the generally favorable growing conditions (adequate nutrients and water, suppression of pests) of controlled environments should have a better chance of producing growth responses similar to "field" response, than with field systems using longer rotations and lower cultural levels. Growth responses in most controlled environments, however, are known to differ in some qualitative ways from field growth. For example, most plant growth chambers are not equipped to produce light intensities similar to those encountered in the field, and only crude approximations of field temperature regimes can be realized with all but the most sophisticated controlled-environment equipment.

There is, however, still hope because it may be that, by choosing the proper variables and controlled environments, field growth potential can be predicted on the basis of controlled environmental studies without close simulation of field growth conditions. In this study, therefore, we attempted to define the relationship between growth room and field productivity for three hybrid Poplar clones, namely Tristis #1 (*Populus tristis* Fish. x *P. balsamifera* L.) (Cram 1960), Wisconsin #5 (*Populus* x *euramericana* (Dode Guinier) (Laundrie and Berbee 1972) and Crandon (*Populus alba* x *P. grandidentata* Michx.) (McComb and Hansen 1954) when only photoperiodic conditions in the field were roughly approximated in the growth chamber.

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The ultimate objective of this study is to develop a technique for rapid selection of those clones that might be expected to develop best in given field locations by means of a preliminary analysis of selected variables under growth room conditions.

METHODS

Field Study:

In this study, three *Populus* clones, adapted to Southern Canada (Tristis #1), Southern Wisconsin (Wisconsin #5), and Central Iowa (Crandon), were used. Cuttings were taken from stock plants growing in the greenhouse, were individually planted in commercially prepared Jiffy-7 pellets, and then placed under an alternating mist system on greenhouse benches. When the roots emerged from the pellets, 45 of the plants were planted in 5 Latin square designs at each of two locations: The State Nursery in Ames, Iowa (latitude 42° N) and the Hugo Sauer Nursery in Rhinelander, Wisconsin (latitude 45° N). Three degrees difference in latitude was enough to give markedly different environments, and hence different growth patterns were expected. High levels of nutrients and moisture were maintained in both locations. Measurements of stem height and leaf number were made every two weeks. In addition, at approximately 30-day intervals (July, August, and September), a destructive harvest was made of one Latin square (3 plants per clone, 3 clones), and stem height, stem diameter, stem dry weight, leaf number, leaf area, leaf dry weight, and total top dry weight were measured. This procedure was repeated for the years 1971, 1972, and 1973 at both locations. Plants that were not harvested in a particular year were left at the site to obtain information on second and third year growth.

Growth Room:

The three *Populus* clones were placed in Latin square designs in Percival growth chambers (3 plants per clone, 3 clones, 3 photoperiods) to examine the productivity of individuals as affected by genotype and photoperiod. Cuttings were taken from stock plants and rooted under mist and then were transferred into photoperiods of 13, 14, and 15 hours, with a day temperature of 25° C and a night temperature of 15° C. High nutrient and moisture levels were maintained throughout the experiment. Measurements of stem height and leaf number were taken approximately every four days until the end of the experiment, when all the plants were harvested and measured as in the field study. This portion of the study was replicated four times, with a total growing period being either six weeks (one time) or seven and one-half weeks (three times).

Correlation analysis was used to examine results, as well as simple ranking according to size.

RESULTS

Field, first-year growth:

Clones were ranked first, second, or third on the basis of their size at the end of each growing period for all three years. This was done for all seven variables measured at both locations.

Wisconsin #5 (W-5) ranked first or tied for first with Crandon (Cr) for all variables measured for all three growing seasons at both locations. In Ames, the ranking was W-5, Cr, Tristis #1 (Tr) for each variable measured for both 1971 and 1973; for 1972, the ranking was always W-5, Tr, Cr. Similarly, in Rhinelander, W-5 ranked first or tied for first with Crandon for all variables measured for years 1971 and 1973; for 1972, the ranking was always W-5, Tr, Cr. In general, growth trends were the same at both locations for the years 1971 and 1973; 1972 growth differed from those two years, but differed in the same fashion at both locations.

To supplement the harvest data, the seasonal growth patterns of the clones were examined. Tr consistently set bud by mid-July in Ames, whereas in Rhinelander it grew longer, but more slowly than during the first half of the growing season. In Ames, Tr showed approximately the same growth trends for all three years. At Rhinelander, however, Tr grew differently in different years. At the end of the 1972 growing season, for example, the total top dry weight of the Tr in Rhinelander was almost twice that in Ames, although in 1973 the total top dry weights were almost identical.

Cr grew throughout the growing season at both locations for all three years, although it did not grow well at either location in 1972. In 1972, Cr grew best in Ames with respect to stem height, stem diameter, and leaf number, while those at Rhinelander grew best with respect to leaf weight, total top dry weight, and leaf area; stem weights were nearly identical. In 1973, Crandon growth was clearly better in Rhinelander for stem height, stem diameter, and leaf area; other variables had similar values with stem weight and total top weight being only slightly larger in Ames.

By the end of each of the three growing seasons in Ames, W-5 far surpassed Cr and Tr for all variables measured. In Rhinelander, W-5 did rank ahead of the other two clones most of the time, but occasionally tied with Cr for first place. The magnitude of the difference between the first and second ranking clones, however, was not as consistently large as in Ames. In 1972, W-5 grew better with respect to six variables at the Rhinelander site, with the diameter of the Ames trees being only slightly larger. In 1973, W-5 grew better with respect to six variables at the Ames site, with only leaf area being slightly larger at Rhinelander.

Field, two- and three-year growth:

Trees that were not harvested by the end of the 1971 and 1972 growing seasons were left to grow until the end of the 1973 season. Rankings for material left two years in Ames (planted spring 1972, harvested fall 1973) were W-5, Cr, Tr for the variables stem height and stem diameter, and W-5, Tr, Cr for stem weight. Rankings for two-year-old material left at Rhinelander were W-5, Tr, Cr for all variables measured. All three clones, however, were larger in Rhinelander than in Ames after two years. For example Tristis stem weight at Rhinelander was approximately six times the weight in Ames, and W-5 stem weight was approximately twice the Ames weight. Rankings for material left three years (planted spring 1971, harvested fall 1973) at the Ames location were Cr, W-5, Tr for all variables measured. At Rhinelander, the rankings were W-5, Cr, Tr for all variables measured.

In general, after three years' growth in the field, Cr grew much better at the Ames location, W-5 grew somewhat better at Rhinelander and Tr grew only slightly better at Ames.

Growth Chamber:

Clones were ranked first, second, or third for each variable at the end of the growing period. The one growth period of six weeks was combined with the three growth periods of seven and one-half weeks, and the pooled means were used as a basis of comparison. Thus, each mean value represented twelve trees (3 trees per clone, 4 replications).

In the 13-hour photoperiod the ranking was W-5, Cr, Tr for the variables stem height, stem diameter, leaf weight, leaf number, and total top weight, whereas the leaf area ranking was Cr, W-5, Tr. In the 14-hour photoperiod the ranking was again W-5, Cr, Tr for the variables leaf number, leaf weight, leaf area, stem weight, and total top weight, but the stem diameter ranking was W-5, Tr, Cr. Stem height exhibited a third order: Cr, W-5, Tr. In the 15-hour photoperiod treatment, the ranking was W-5, Cr, Tr for leaf weight, leaf number, and leaf area. Ranking for stem height, stem weight, and stem diameter was W-5, Tr, Cr. Thus, W-5 ranked first in all variables except 13-hour leaf area and 14-hour stem height. Tr ranked last in 16 of the 21 measurements. Differences among clones were smallest in the 13-hour photoperiod, greater in the 14-hour photoperiod, and usually greatest in the 15-hour photoperiod.

To quantify the relationships for the measured variables between growth room and field growth, correlation matrices were calculated for three combinations of variables: (1) all variables in one location with all variables in the same location; (2) each variable in one photoperiod with each variable in the same photoperiod; and (3) each variable in each location with each variable in the different photoperiods. Thus, it was possible to get values of 'r', for example, between stem height in Ames with stem height in a certain photoperiod. These values are shown in Table 1.

Table 1.--Correlation coefficients between growth chamber and field growth, by growth chamber photoperiod and field location, with clones and years pooled

Field location	Growth chamber photoperiod	SH	SD	LW	TTW	LA	LN	SW	$\overline{XR}$
		Values of 'r'							
	13HR	.82	.44	.44	.57	.31	.60	.90	.58
Ames	14HR	.33	.91	.79	.83	.79	.81	.82	.75
	15HR	.80	.85	.86	.88	.78	.89	.90	.85
	13HR	.65	.34	.26	.34	.32	.47	.65	.43
Rhinelander	14HR	.30	.65	.70	.59	.69	.66	.53	.59
	15HR	.61	.61	.56	.59	.68	.73	.65	.63

SH = stem height, SD = stem diameter, LW = leaf weight, TTW = total top weight, LA = leaf area, LN = leaf number, SW = stem weight, $\overline{XR}$ = mean correlation coefficient for all variables.

DISCUSSION

By examining the values in Table 1, it can be seen that the 13-hour photoperiod yielded the poorest growth chamber and field correlations. This would indicate that there is not as much discrimination in ranking of clones in this photoperiodic treatment as compared with the longer photoperiods. The results, indeed, showed that the magnitude of the difference in performance between the three clones was least under the 13-hour treatment. Higher 'r' values were obtained between field and 14-hour growth chamber performance, with the highest values being obtained between field growth and 15-hour growth. Greatest differences in performance between clones were observed in the growth room at the longer photoperiods.

An average correlation value was calculated for each location and photoperiod; this value increased progressively by photoperiod for both locations. Thus, there seems to be consistency in ranking of clones between the growth room and the field for each variable measured, and variability in the field, when averaged over several trials is evidently not large enough to disrupt this ranking.

Values for the correlations between Ames and the three photoperiods are larger than those between Rhinelander and the three photoperiods. This may be because there was less difference between the first and second ranked clones at the Rhinelander location for many variables.

Ranking was consistent in the field at both locations for the years 1971 and 1973. Although W-5 did rank first in 1972 also, the fact that the rankings were inconsistent with the other two years with respect to Tristis and Crandon was due to the poor growth of Crandon in 1972. It is possible that differences in climatological factors caused this difference in growth patterns. First, the monthly averages in temperature for June, July, August, and September were all below the ten-year average for those months at the Ames location (National Oceanic and Atmospheric Administration 1972). Secondly, the monthly solar radiation totals for the months June, July, and August were less in 1972 than in 1971 at Ames. Third, the percentage of possible sunshine days (100% = full sun) was significantly lower than the average for the months July, August, and September in 1972 and was also less than the means for July and August in 1971 and 1973 (Waite and Shaw 1961). Temperature readings also were below normal for the months June, July, August, and September at the Rhinelander location in 1972.

By the end of the third year of growth in Ames, Crandon was firmly ranked in first place. Tristis continued to set bud early in the season at Ames, resulting in its being considerably behind the other two clones after three years.

This study showed that there was consistency in ranking of clones between the growth chamber and the field for many variables measured for one and two year growth. Although growth differences did occur between years, the variability, when averaged over several years, was not enough to disrupt these rankings.

Therefore, it seems that it may be possible to estimate initial field growth potential of clonal material by means of a preliminary analysis of selected variables when the material is grown under controlled environment conditions.

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