PLANTED HYBRID POPLAR CUTTINGS SHOW VARIABLE RESISTANCE TO DROUGHT

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The effects of an extremely dry summer and site conditions on the early development of nine hybrid poplar clones were recently investigated in central Pennsylvania. The results indicate the importance of genetic variation and drought resistance in the selection of hybrid poplar cuttings used for artificial regeneration on low-quality hardwood sites.

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Methods

In May 1965, nine randomly selected hybrid poplar clones, from known parent stock grown at the Clearfield Nursery (in Pennsylvania) were outplanted by hand. The experimental area, divided into three test units, is on the Stone Valley Experimental Forest near State College, Pa. On two of these units the overstory has been left intact, and on the third a clearcutting has been made. A 6- by 6-foot spacing on three adjacent 50-year-old oakhickory sites was used. In planting, a slit was opened with a planting bar, and each 10-inch cutting was inserted into the soil to two-thirds of its length. The soil type is an Ashby, shaly, silt loam supporting mostly white, scarlet, and red oaks with a diameter of 3 to 14 inches. Most of the trees are classified as pole size.

A direct comparison between the performance and early growth of planted cuttings on the clearcut and uncut areas was obtained by planting one-half of the total lot of clones on each area (fig. 1). On the clearcut area, all trees more than 3 inches in diameter were removed in April 1965. Each of the nine clones was represented by approximately 200 cuttings in blocks of one-tenth acre for all three units. The uncut units consisted of 20 blocks divided into two 10-block units. One uncut unit was prescribe burned lightly; the other was not. In each of these 10-block units, one block was planted with 10 randomized rows of each clonal variety. Individual clones were planted on the remaining blocks, on both the burned and unburned areas. Therefore, each clone was replicated in the burned and unburned units. In addition, each clone was represented in a separate block of the clearcut site.

At the end of the study, the ramets in the randomized blocks were lifted to assess differences in their morphological and phenological development. Several living ramets were also lifted intact from blocks on the clearcut site to compare root and stem development with ramet growth on the uncut units.

Figure 1.--Nine hybrid poplar cuttings survived and grew well on a clearcut site (lower). The same clones planted on uncut plots showed 98-percent mortality after an extreme drought period (top).

Soil Moisture

Trends and fluctuations in the soil moisture of the clearcut and uncut test units were recorded during the 1965 growing season (fig. 2). To assess these changes, gypsum soil-moisture blocks were embedded at 3- and 12-inch depths at randomly located stations on each area. Precipitation on the units during the summer was also recorded. By plotting the moisture data obtained for each unit at its corresponding soil depth and the amount of rainfall, differences in available soil moisture associated with the various clones were determined. The foliage and stem development for each clone was periodically observed and recorded according to its leaf wilt. These data, in turn, were then related to the level of soil moisture at the time of observation. Soil

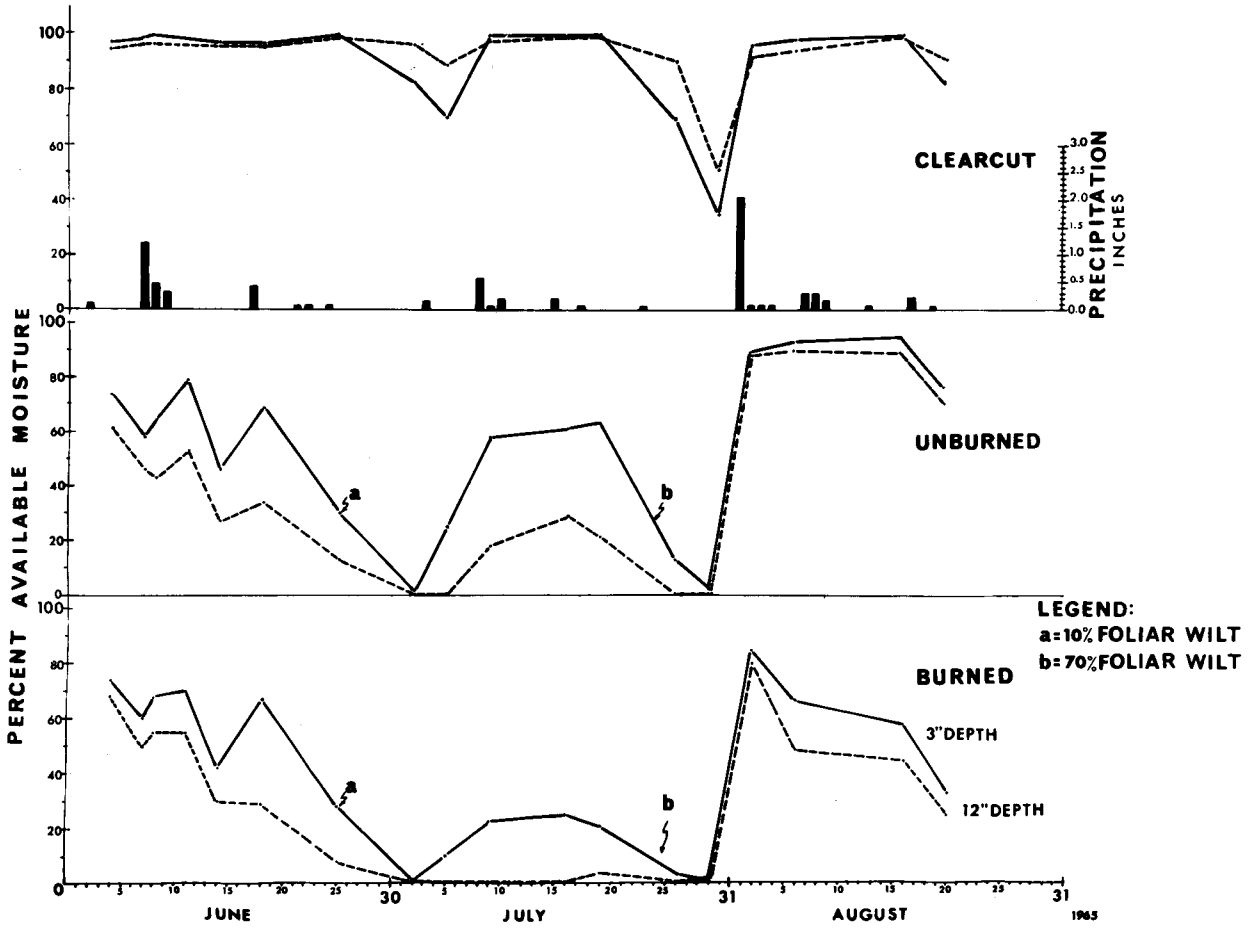

Figure 2.--Soil moisture and rainfall patterns on the clearcut and uncut test sites are given.

moisture levels on the clearcut treatment remained consistently above those on the uncut units throughout the drought season. Although 2.1 inches of rain fell on August 1, it was insufficient to revitalize the ramets on the uncut areas which had already reached a 70percent wilting level. None of the clonal varieties planted on the clearcut unit showed signs of wilting throughout the June-August test period. Most soil moisture on the uncut units remained at the 3-inch depth. Conversely, on the clearcut treatment the removal of the overstory resulted in a periodic reversal of the maximum level of soil moisture recorded at the 3- and 12-inch soil depths.

Clone Survival

Approximately 3 weeks after planting, most of the clones on both clearcut and uncut experimental units had begun to develop aerial stems, roots, and leaves from adventitious buds (fig. 3). Several clonal varieties developed more rapidly than others. A survival count taken in May showed that 83.1 and 85.3 percent of the clones on the uncut and clearcut areas, respectively, were growing vigorously. This level of survival and growth was maintained on the clearcut site throughout the growing season. Conversely, foliage wilting began on ramets on the uncut units about 54 days after

Figure 3.--A vigorously growing hybrid poplar cutting prior to extreme drought conditions on the uncut area.

planting, and by the end of the 1965 growing season, approximately 98 percent of all clones was dead. Thus, the interaction of drought and soil moisture depletion and the physical characteristics of the various clones could be evaluated (fig. 4).

Ranking the Clones

From the uncut area, 20 planted ramets of each of the 9 clonal varieties were lifted and analyzed according to specific morphological characteristics. Each ramet was examined and assessed as to its total length, length below ground, stem diameter, number of buds above and below ground, number of stems produced, length of longest stem, number of nodes producing stems, and the weight of roots and stems produced after ovendrying. The resulting data were subjected to a chi-square analysis for nonparametric statistics and ranked by clonal characteristics. To determine the significance of the relation among all clones and their corresponding morphological features, the following formula for ranked sums was employed.[2]

$$X_r^2 = \frac{12}{mp\,(p+1)} \sum T_r^2 - 3m\,(p+1)$$

where m = number of characteristics,
p = number of clonal varieties, and
T_r = sum of ranked clones.

The ranked sums were assumed to be the differences in value between any two clones as positively or not positively better than median or not positively better than median, with a probability of 0.5. A separate analysis of clones on the burned and unburned units showed no significant differences for unit treatment; therefore, these two categories were combined, giving a total of 180 analyzed clones. The insertion of appropriate values in the above equation and its solution showed significance at the 10-percent level of probability. Clones are ranked in descending order of their ability to develop morphologically under drought conditions prior to eventual mortality on the uncut units (table 1). Had the drought been alleviated, these variable droughtresistant characteristics might have been expressed more vividly by differential clonal development at the end of the growing season. An additional statistical comparison of clone NE-49 between clearcut and uncut units clearly indicated the superiority of this clone and its development on the clearcut area. These data for the clearcut unit are not shown in table 1. The data available did not provide for valid morphological comparisons of all clones common to both clearcut and uncut units.

[2] Walker, H. M., and Lev, Joseph. Statistical inference, pp. 438-458. 1953.

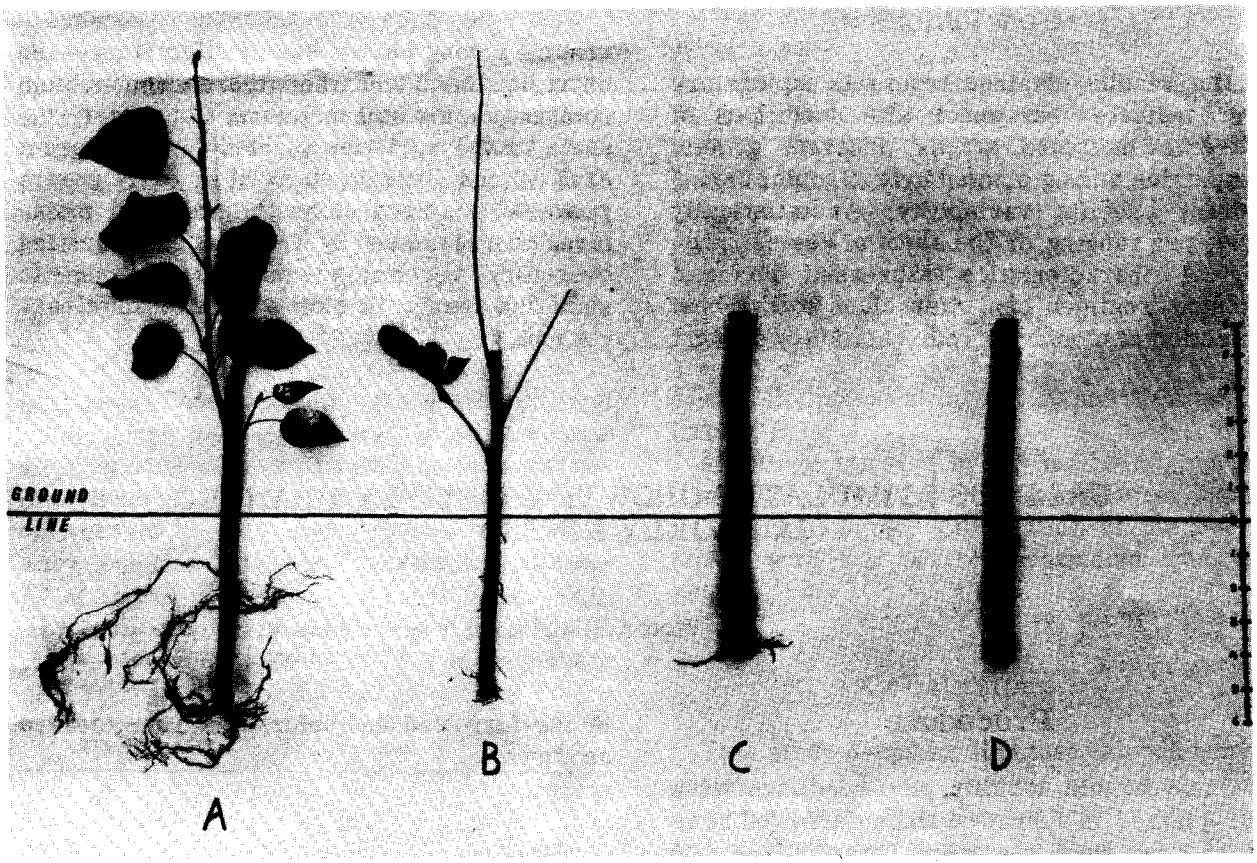

Figure 4.--Variation in clonal growth following extreme drought on clearcut and uncut sites. A, Clearcut; B, uncut (roots and stems); C, uncut (roots only); D, uncut (no development).

TABLE 1.--Clones ranked in descending order of their morphological performance prior to drought-incurred mortality on the uncut units

Clone No.	Parentage	Total length (inches)	Length below ground (inches)	Stem diameter (inches)	Buds below ground (number)	Buds above ground (number)	Aerial stems produced (number)	Length of longest stem (inches)	Nodes where roots produced (number)	Ovendry weight roots (grams)	Ovendry weight stems (grams)		Significantly more resistant than clone number
NE-252	Populus cv. angulata X trichocarpa	*Rank* 3	*Rank* 10	*Rank* 15.5	*Rank* 2	*Rank* 8	*Rank* 9.5	*Rank* 3	*Rank* 4	*Rank* 8.5	*Rank* 5	*Total Rank*[1] 68.5	NE-48, 49, 388, 52
NE-207	P. deltoides X trichocarpa	7	11	8	14	6.5	8	7	5	6	11	83.5	NE-48, 49, 52
NE-350	P. deltoides X trichocarpa	12	11	9.5	8	11	5.5	3	7	15	4	86.0	NE-302, 49
NE-216	P. deltoides X trichocarpa	12.5	16	2	12.5	7	4.5	9	11	10.5	6.5	91.5	NE-48, 49, 52
NE-388	P. maximowiczii X trichocarpa	11	6	16	5	10	10	10.5	10	6.5	12	97.0	NE-49, 52
NE-302	P. cv. betulifolia X trichocarpa	13	15	16	10.5	6	4.5	9.5	7	10.5	7	99.0	NE-52
NE-48	P. maximowiczii X cv. berolinensis	8	6	8.5	9.5	7.5	17.5	18	18	11	18	122.0	None
NE-52	P. maximowiczii X cv. plantierensis	10	4	4	16	18	16.5	16	16	10.5	14	125.0	Do.
NE-49	P. maximowiczii X cv. berolinensis	13.5	11	10.5	12.5	16	14	14	12	11.5	12.5	127.5	Do.

[1] Combined burned and unburned plots. Significant at 10 percent level of probability (P = .10)

Conclusions

The results obtained from this exploratory test indicate that under site conditions of extreme moisture stress, inherent genetic properties among planted hybrid poplar clones exhibit specific variability. A statistically analyzed ranking of the sums of key morphological characteristics expressed during a drought regimen can offer clues to the best selection of clones for reforestation on drought sites.

This study shows that inherent resistance to drought among clones was most striking on the uncut hardwood unit where there was maximum competition for soil moisture. Conversely, the same clonal varieties planted on the clearcut area varied little in survival or early growth between or among clones. Better soil moisture conditions by removal of competing overstory vegetation equalized the genetic variation among the clones tested on the clear-cut unit.