CHILLING AND PHOTOPERIOD AFFECT DORMANCY OF COTTONWOOD CUTTINGS

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Abstract.--Unrooted cuttings of 23 cottonwood clones were chilled at 1.6°C for periods of 0 to 90 days and planted in a greenhouse under normal and extended (16 hr.) photoperiods. The clones varied in flushing response to chilling treatment. Some required only 40 to 60 days of exposure to cold temperature to reach a point where additional chilling had no significant effect on reducing flushing time, while others continued to respond at 90 days. There were no distinct geographic trends associated with this variation. The extended photoperiod was effective in breaking bud dormancy only when the buds were not adequately chilled. Even short exposure to cold temperature (50 days) was sufficient to overcome any significant photoperiod's effect. These results suggest the possibility of using fast-growing northern selections of cottonwood with low "chilling requirements" for planting in the South.

Additional keywords: Populus deltoides, clones, flushing, selection.

A significant amount of genetic gain may be realized by introducing exotic species or geographic races of a native species under the assumption that the introduced plants will outperform the native stock. The success of these projects depends, of course, on knowledge of the interaction of the introduced genotypes with their new environment. One of the most critical factors is the adaptability of the introduced plant to the local climate.

The literature is filled with reports of unsuccessful projects, most commonly involving the testing or introduction of fast-growing southern selections of a species into a more northerly climate. The reason for these failures is usually obvious -- the trees fail to become dormant and are killed (or severely retarded) by cold temperatures.

The opposite situation, movement of plants in a southerly direction, should avoid many problems related to harsh environment. If soil and moisture conditions are adequate and susceptibility to disease and insects is low, selections which grow well in a native locale with a growing season of 150 days should grow even better when moved southward into a 300-day growing season. Unfortunately, these introductions are not always successful either, and there is a pronounced absence of many northern species in southern arboreta. Also, exotic ornamental and Christmas tree species which have been commercially successful in the North, such as Norway maple (Acer platanoides L.) and Scots pine (Pinus sylvestris L.), will not grow in many areas of the South. As in the movement of plants from southern latitudes to northern latitudes, one of the major problems concerns climate and dormancy. However, the properly timed induction of dormancy to escape freezing temperatures in the fall is not important here, but rather the failure of climatic conditions in the South to provide the stimulus to break dormancy in the spring.

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In a comprehensive review of the subject of dormancy in woody plants, Worrall and Mergen (1967) described winter bud dormancy as possessing two distinct phases: rest, an internal condition of the bud tissues which cannot be broken by exposing the plant to favorable environmental conditions, followed by a transition to quiescence, which may be broken by a return of favorable environmental conditions. The relative success of northern genotypes in southern climates depends upon the transition from the state of rest to quiescence.

Many greenhouse and laboratory investigations confirm that chilling and photoperiod are definitely factors affecting the breaking of rest in *Populus* species, but there has been some controversy over the relative importance of each factor (Pauley and Perry 1954, Wareing 1956, Van der Veen 1951). Studies of other hardwood species have shown that chilling time required for flushing varies from species to species and between geographic sources, but long photoperiods often prove to be suitable aids in restoring tree growth, especially when chilling is inadequate (Farmer 1968, Perry and Wang 1960).

To provide further information on the genetic variability in eastern cottonwood, a study was initiated to evaluate the effects of photoperiod and chilling on flushing and stimulating the rooting of stem cuttings of the species under greenhouse forcing conditions.

METHODS

One hundred cuttings were collected from each of 23 cottonwood clones of northern origins (Fig. 1) from the NC-51 Regional Cooperative provenance and progeny test growing at Wooster, Ohio. Ten chilling treatments, ranging from 0 to 90 days at 1.6°C, were applied to the cuttings. The initial "unchilled" treatment was established by planting 10 cuttings per clone, five in a normal photoperiod (9.5 to 10.5 hours) and five in a 16-hour photoperiod. Additional chilling treatments of 10 to 90 days were effected by removing 10 cuttings per clone from cold storage at (approximately) 10-day intervals and planting five each under each photoperiod.

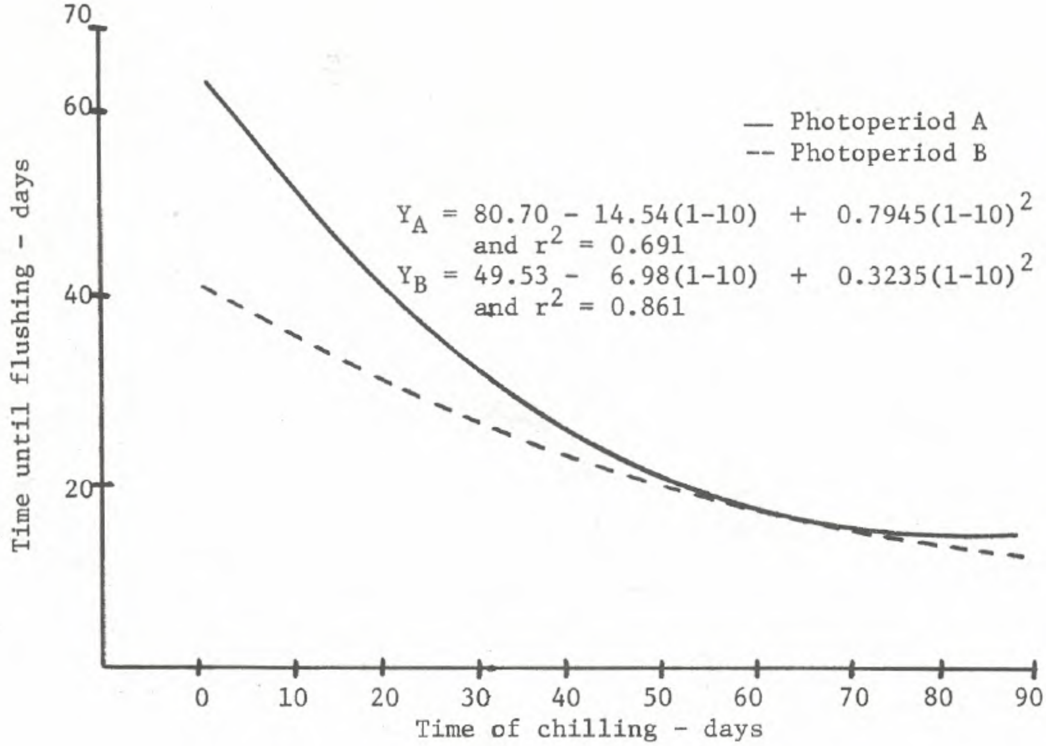
Cuttings were checked for flushing and rooting three times per week and the dates of observed flushing and rooting were recorded for each cutting.

RESULTS

The analysis of variance for the flushing study revealed highly significant ($P < .01$) effects of clone, photoperiod, and chilling time, and the interactions of clone x chilling time and photoperiod x chilling time. The clone x photoperiod interaction was significant ($P<05$) while the clone x photoperiod x chilling time interaction was highly significant. These significant responses and interactions were further evident after determination of the best-fitting empirical function (linear, quadratic, and/or cubic) for the flushing responses of each of the 23 clones as illustrated in Figure 2.

In general, regression analyses determined that all of these northern cottonwood clones required some degree of chilling to overcome rest. Increase in chilling time significantly reduced time until flushing for all clones up to a point at which further chilling had little or no effect. Additionally, as chilling time increased, the range of flushing time among ramets of a single clone decreased greatly.

Figure 1, Location of sources of eastern cottonwood clones used in the study.



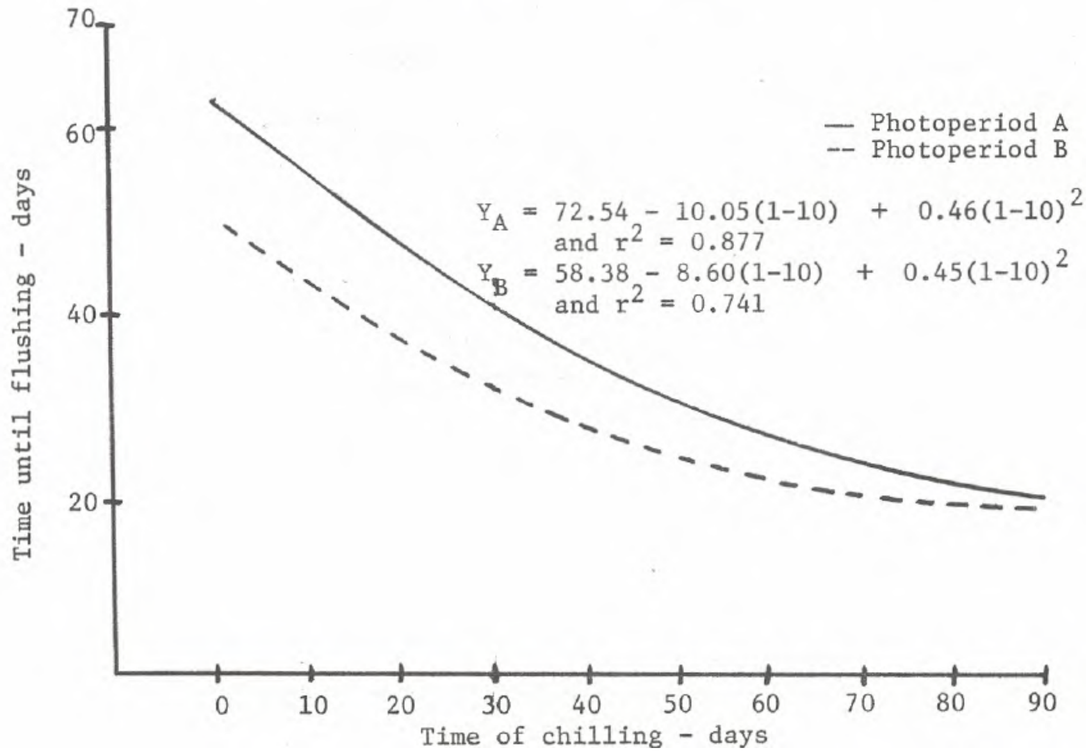


Figure 2. Comparison of the flushing responses of clones 218-2 (top) and 232-2 (bottom) as they were exposed to each photoperiod at various chilling times.

Although the flushing responses to chilling time varied among clones and there were also variations in the shape of the response curves between photoperiod treatments for certain clones, an important aspect of this study was the marked reduction in the effect of photoperiod on flushing time as chilling time increased. There was a significant positive response to the extended photoperiod in unchilled and inadequately chilled cuttings, but differences in flushing time became less pronounced as the chilling requirements of each clone were satisfied. These observations corroborate the findings of Worrall and Mergen (1967) who obtained similar results with Norway spruce (*Picea abies* L.) clones.

There was no evidence of a regular or clinal relationship between latitude of the seed source and response to chilling treatment in this study. Two factors may serve to explain this: (1) the clones utilized in this study are all of northern origin and the latitudinal range represented by the seed sources is rather narrow and (2) the parent trees for the NC-51 study were selected along the banks of major rivers to test the hypothesis of gene exchange by immigration from upstream populations. Significant downstream migration would certainly tend to mask any distinct geographical trends in a comparison of river-bottom populations.

The analysis of variance for rooting response revealed highly significant effects on time of rooting for clone, photoperiod, and chilling. All interactions were highly significant with the exception of the clone x photoperiod interaction which was non-significant. All of the clones showed a trend toward a decrease in time until rooting with increased chilling period, but this relationship was not as pronounced as that for flushing.

The 16-hour photoperiod was effective in reducing time until rooting in unchilled and inadequately chilled cuttings and, in many instances, the relationship was similar to that for flushing, i.e., a decrease in the effect of the extended photoperiod with increased chilling.

CONCLUSIONS

The following conclusions may be drawn from the results of this study:

1. A period of exposure to cold temperature is required to relieve the condition of rest in dormant buds of cottonwood from the northern portion of the range of the species. The longer this chilling period, the fewer days required for the buds to flush after exposure to warm temperatures.

2. There is genetic variation in flushing response to chilling. Some clones require only 40 to 60 days of exposure to cold temperature to reach a point where additional chilling has no significant effect on reducing the time until flushing, while others continue to respond at 90 days. No distinct geographic trends were associated with this variation. Apparently, northern stands of cottonwood are heterogeneous mixtures of heterozygous individuals with regard to chilling requirement.

3. An extended photoperiod is effective in breaking bud dormancy or rest only when the buds have not been adequately chilled. Even short exposures to cold temperatures (50 to 60 days in this experiment) are sufficient to overcome any significant effect of photoperiod. The results of this study confirm those of Worrall and Mergen (1967) with Norway spruce and Lavender et al. (1970) with Douglas-fir (*Pseudotsuga menziesii* Mirb. Franco) and

provide additional evidence that, in nature, completely chilled plants in northern latitudes initiate growth in the spring in response to warming temperature and not in response to photoperiod.

Based upon the results of this study, one of the most obvious applications is the use of some of these fast-growing northern clones in reforestation programs in the South. Many of the clones used in this experiment required only 50 to 60 days of chilling to begin growth in the spring and this requirement would be satisfied during a normal winter in many areas of the Lower Mississippi Valley. A test of these northern clones established in the L.S.U. Forestry nursery in the spring of 1972 has shown that all 23 clones flushed normally after exposure to a mild winter and that significant growth occurred. Field outplantings will be established as the nursery clones develop.

LITERATURE CITED

Farmer, R. E., Jr. 1968. Sweetgum dormancy release: effects of chilling, photoperiod, and genotype. Physiol. Plant. 21:1241-1248.

Lavender, D. P., R. K. Hermann, and J. B. Zaerr. 1970. Growth potential of Douglas-fir seedlings during dormancy, p. 209-222. In L. C. Luckwill and C. V. Cutting, Ed., Physiology of tree crops. Proc. 2nd Long Ashton Symp., 1969. Academic Press, New York.

Pauley, S. S., and T. 0. Perry. 1954. Ecotypic variation of the photoperiodic response in Populus. J. Arnold Arboretum Harvard Univ. 35:167-188.

Perry, T. 0., and C. W. Wang. 1960. Genetic variation in the winter chilling requirement for date of dormancy break for Acer rubrum. Ecology 41:790-793.

Van der Veen, R. 1951. Influence of daylength on the dormancy of some species of the genus Populus. Physiol. Plant. 4:35-40.

Wareing, P. F. 1956. Photoperiodism in woody plants. Annual Rev. Plant Physiol. 7:191-214.

Worrall, J. G., and F. Mergen. 1967. Environmental and genetic control of dormancy in Picea abies. Physiol. Plant. 20:733-745.