EARLY FLOWERING IN CHERRY: EFFECTS OF GENOTYPE, ENVIRONMENT AND CHEMICAL GROWTH RETARDANTS

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Abstract. --In a series of tests with juvenile Prunus serotina, growth retarding chemicals (Alar, CCC, Ethrel), long-day greenhouse conditions and drought did not stimulate flowering. All seedlings from a low elevation source flowered in pots within two years from seed, regardless of chemical or environmental treatment; no high elevation seedlings flowered under similar conditions. Flowering observations in a three-year-old planting of black cherry confirmed this relationship between early flowering and altitudinal provenance. In a comparison test Prunus besseyi seedlings flowered prolifically after their first season's growth and P. virginiana after two seasons.

INTRODUCTION

The normally long juvenile period exhibited by most forest tree species has generated a search for practical ways of shortening the breeding cycle. Research on this problem was most recently reviewed by Zimmerman (1972), who surveyed results from a number of experimental approaches. Investigation of environmentally induced flowering has generally supported the notion that sexual maturity is dependent upon attaining a certain size and morphological complexity (e.g., Longman and Wareing, 1959; Zimmerman, 1971). There is also increasing evidence that duration of the juvenile period is genetically controlled (e.g., Greene, 1967; Johnsson, 1949; Visser, 1965). The success of floral induction in some ornamental shrubs with growth retarding chemicals (Stuart, 1961; Marth, 1963) has led to trials with juvenile trees which have so far produced generally unpromising results (Zimmerman, 1972).

We report here a series of tests aimed at evaluating the influence of growth retardants, several environmental conditions, and genetic composition of material on early flowering of black cherry (Prunus serotina Ehrh.) and two shrub cherries (sand cherry P. besseyi (Bailey) GI. and choke cherry P. virginiana L.).

TEST I

A test including 12 six-tree replications of nine treatments (Table 1) was established in the spring of 1968 with three-year-old black cherry seedlings (western North Carolina seed origin), to study effects of Alar (N-dimethylamino suc cinamic acid) and CCC (2-chlorethyl trimethyl ammonium chloride) foliar sprays on growth and flowering. Freshly prepared aqueous solutions were applied in early morning. The seedlings were growing vigorously on an alluvial site in Anderson County, Tennessee, which received 1000 pounds per acre of 15:15:15 fertilizer in both 1966 and 1967.

No treatment significantly reduced growth relative to controls (Table 1), although trees treated with 4000 ppm. Alar grew less than those treated with CCC. Some rosetting was noted on lateral branches, but height growth was vigorous during the spring. Although some trees stopped growing briefly in July, late July rains caused resumption of apical growth until late August. In the spring of 1969 a single tree in Treatment 2 flowered; in the spring of

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1970 two trees flowered. The planting has been maintained without further treatment and less than 5 percent of the trees flowered in 1973, when they were 5 to 10 meters in height.

Table 1. Height increment (in 1968) of black cherry seedlings as influenced by spray treatment with growth retardants

Treatment	Height Growth (Centimeters)
(1) Control	52
(2) Alar, 4000 ppm. One application immediately after leaf expansion and two additional applications at two-week intervals.	34
(3) Alar, 1000 ppm. Applied as in Treatment No. 2.	52
(4) Alar, 4000 ppm. One application at one month after leaf expansion and three additional applications at one-week intervals.	37
(5) Alar, 1000 ppm. Applied as in Treatment No. 4.	46
(6) CCC, 4000 ppm. One application immediately after leaf expansion and two additional applications at two-week intervals.	67
(7) CCC, 1000 ppm. Applied or in Treatment No. 6.	55
(8) CCC, 4000 ppm. One application at one month after leaf expansion and three additional applications at one-week intervals.	64
(9) CCC, 1000 ppm. Applied as in Treatment No. 8.	85

TEST II

Objectives of this test were to (1) induce early flowering in cherry by growing seedlings rapidly in a greenhouse environment, and (2) evaluate the effect of Alar on growth and flowering under two environmental conditions.

In April 1968, 60 one-year-old seedlings each of black cherry (eastern Tennessee source, altitude unknown), choke cherry (Pennsylvania source), and sand cherry (North Dakota source) were planted in 10-gallon plastic pots filled with a loam soil. Stems were pruned to a height of eight cm. Choke cherry and sand cherry were used because they flower early in ontogeny under natural conditions and were considered potentially good experimental material. Seedlings were divided into four groups of 15 each and assigned to the following treatments:

1. Seedlings grown under long-day (18 hours) greenhouse conditions.
2. Same as 1, treated periodically with a soil drench of 4000 ppm Alar.
3. Seedlings grown outdoors under normal day-length conditions.
4. Same as 3, treated periodically with a soil drench of 4000 ppm. Alar.

During the summer of 1968, Alar treatments were applied on July 4, 8, 19, and August 4. Height was measured biweekly throughout the growing season. By early September apical growth of all plants had stopped. In mid-October, after trees in outdoor treatments were naturally defoliated, all plants were placed in an unheated basement for overwintering.

Treatments 1 and 2 were returned to the greenhouse on March 10, 1969, and observations of foliation date and flowering were recorded. By May 8, it was necessary to move all plants out of doors because of the height attained by some of them.

In April 1969, foliation and flowering observations were recorded for plants in Treatments 3 and 4, which were moved out of doors from the chilling room in mid-March. During the 1969 growing season Alar treatments began in mid-May and were applied at weekly intervals until late June. By this time all plants had stopped apical growth after shoot increments of 50 to 60 cm. Plants overwintered out of doors, and flowering observations were recorded in the spring of 1970.

The 1968 growth pattern for black cherry is presented in Figure 1; patterns for the other species were similar. Many Alar-treated plants exhibited the rosette apex typical of growth retardant effects. Typical plants of all three species are shown in Figure 2.

Sand cherry foliated first in the spring of 1969 and all plants flowered profusely regardless of treatment. Alar-treated plants of both black and choke cherry began growth earlier than control plants. Twenty percent of the choke cherry plants treated with alar flowered regardless of environment; seven percent of controls grown out of doors flowered, but none grown in the greenhouse flowered. No black cherry trees flowered in 1969.

All choke cherry trees grown out of doors during the entire test flowered prolifically (50 or more racemes per tree). Plants initially grown in the greenhouse and moved outside later flowered less abundantly, with slightly more Alar-treated plants flowering than controls (53 vs 33 percent). A few black cherry trees (13 percent) grown out of doors flowered while none initially grown in the greenhouse did so.

TEST III

Effects of Alar and Ethrel (2-chloroethyl phosphonic acid), moisture stress, and source of stock were studied in a factorial test. Forty black cherry seedlings from a high elevation (1,100 to 1,370 meters) source and the same number from a law elevation (275 to 365 meters) source in Madison County, Tennessee, were established in 15 cm. pots during March 1970. Eight plants from each of five open-pollinated families from each source were included. Seedlings were grown in a greenhouse until May when they were transplanted to 33 and 43 centimeter metal pots containing loam soil and grown out of doors for the remainder of the season. After winter chilling out of doors, some low elevation trees flowered in the spring of 1971 (Farmer and Barnett, 1972).

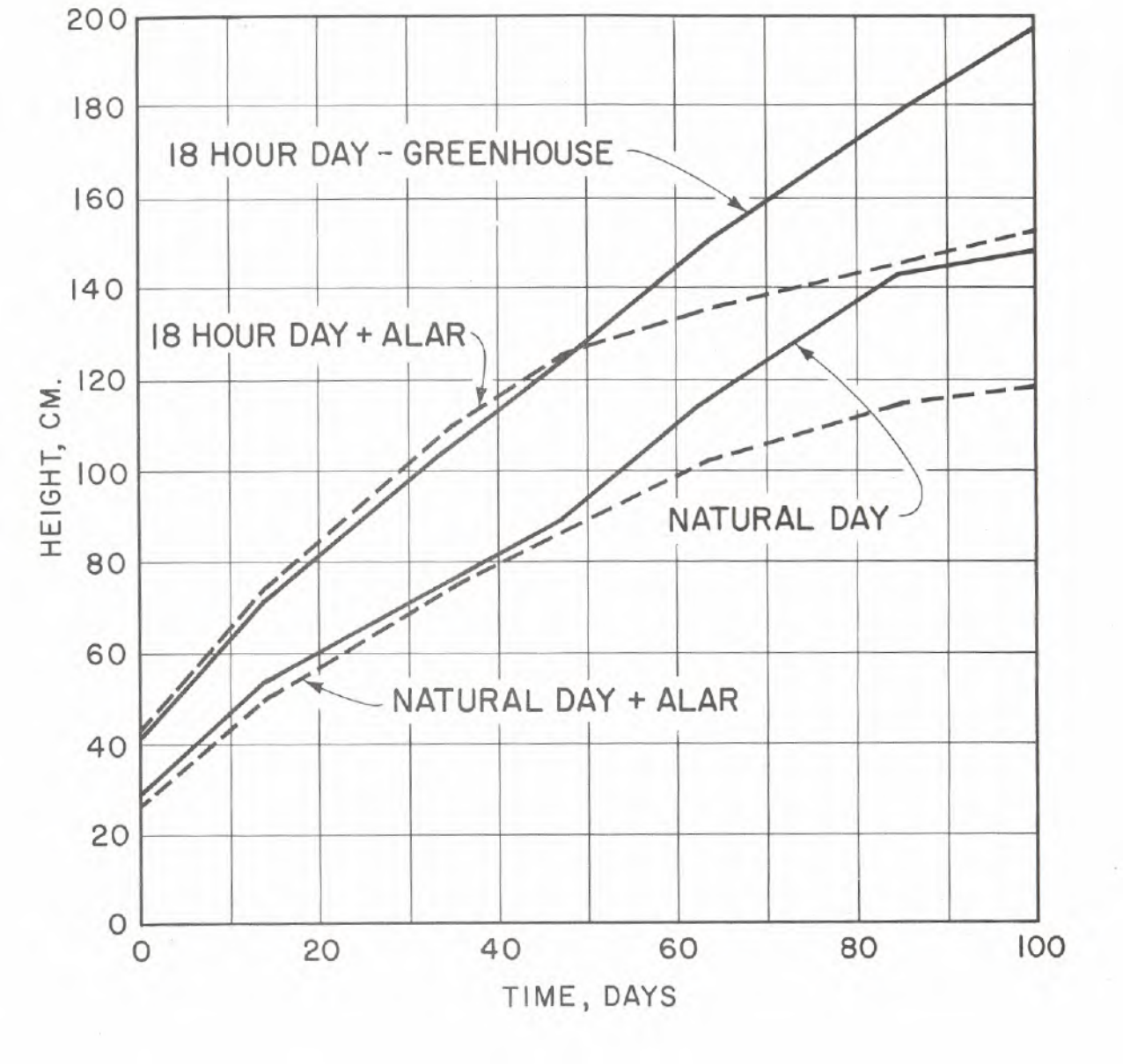

Figure 1.--Cumulative height growth of Prunus serotina as influenced by test treatments.

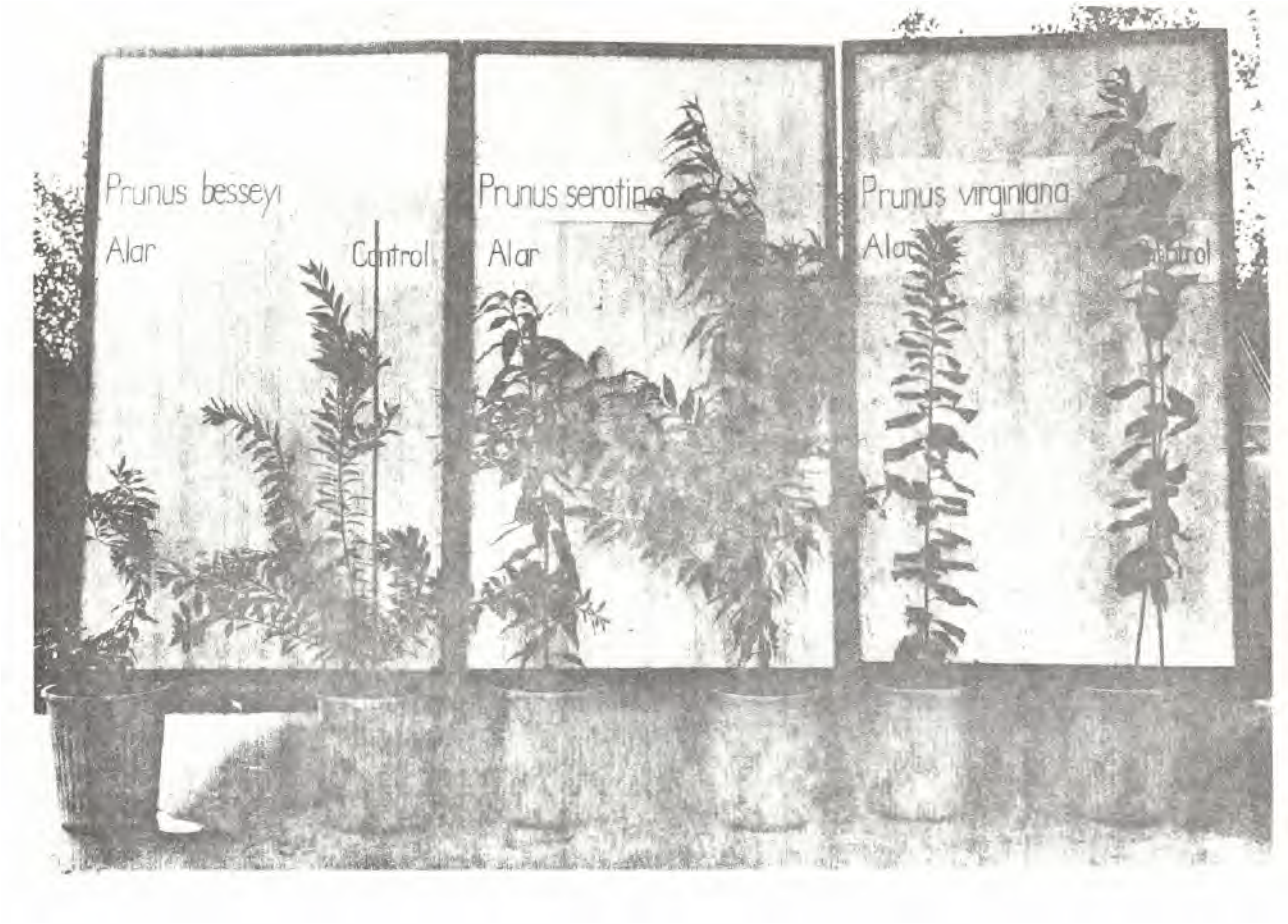

Figure 2.--Typical plants of three cherry species treated with a soil drench of Alarm

In April 1971, four pots from each family were fitted with covers of hardware cloth and builders felt to exclude rainfall. These trees were observed daily throughout the growing season and watered only when severely wilted in the afternoon; the remaining plants were watered daily.. Average plant height at the beginning of the growing season was 100 centimeters for low elevation trees and 82 centimeters for high. One of the following four spray treatments was assigned to each plant in family groups growing under the two moisture regimes: control, 2,000 ppm Alar, 250 ppm Ethrel, and 500 ppm Ethrel. Treatments were begun on May 24 when leaves of most families had attained full expansion and continued at weekly intervals until late June.

Main shoot lengths were measured on April 26, May 25, June 1, and June 18, at which time shoot elongation had stopped. Growth from April 26 through May 25 was 30 to 40 cm and was not influenced by either drought treatment or altitudinal source. Shoot increment (cm) after May 25 for all material is summarized by treatment below:

Soil Moisture	Spray Treatment			
	Control	Alas 2000 ppm	Ethrel 250 ppm	Ethrel 500 ppm
Control	4.6	3.5	1.5	1.3
Drought	5.0	2.5	1.0	0.6

An analysis of variance indicated that growth reductions due to spray treatments were significant (.05 level) and that drought further reduced shoot elongation when coupled with sprays. The lack of drought effect in the control treatment was unexpected, especially in view of the moisture influence in other treatments. In addition to reducing shoot elongation, Ethrel at 500 ppm caused some defoliation on 65 percent of plants by June 8; 15 percent of those sprayed with 250 ppm Ethrel exhibited defoliation. Ethrel-treated plants also exuded a clear gum-like material from the lenticels of shoots. Apical shoots on some of these plants abscised, resulting in lateral shoot development.

In the spring of 1972, all law elevation trees flowered abundantly; no high elevation plants flowered. Flower racemes per tree ranged from 140 to 250, depending upon family. Since size and degree of branching influenced the number of flowers per tree, the number of racemes per shoot terminal was used to evaluate treatment effects. Neither spray treatments nor drought significantly influeced the degree of flowering, which averaged 3.5 racemes/ terminal. The control treatment, with an average of 4.4 racemes/terminal, flowered most prolifically. Family means for number of racemes/terminal ranged from 2.3 to 5.0.

Observations in a three-year-old provenance test have confirmed the relationship of altitudinal source to flowering observed in this study. No trees from sources above 640 meters in east Tennessee have flowered at a law elevation site. Thirty-five percent of the trees from sources below 640 meters have flowered at three years, and 30 out of 38 open-pollinated families in this sample contain some flowering trees. It is also notable that while all five low elevation families used in the spray test exhibited some flowering in the field test, in no case did 100 percent of the trees in these five families flower.

DISCUSSION

Evidence to date indicates that the major factor influencing early flowering in southern Appalachian black cherry is genetic variation associated with altitudinal source. Hence, genetic manipulation may be a fruitful approach to development of early flowering in desirable breeding material. Published information for some other deciduous tree species supports this conclusion (Zimmerman, 1972). Because of the generally poor growth and form of low elevation black cherry, caution should be exercised until the breeding value for characteristics other than flowering is evaluated for such cherry. However, populations of early flowering low elevation cherry can provide experimental material for fundamental genetic studies since two or three year generations are possible.

Promotion of early flowering in high altitude selections remains a major problem in improvement efforts. Our data suggest that neither short-term environmental manipulations nor growth retarding chemicals offer immediate promise as practical solutions to this problem. Perhaps the most useful approach to the breeder will be to grow material as rapidly as possible under ideal field conditions. In this regard, fertilization and irrigation may be useful experimental tools.

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