

## EARLY FLOWERING AND SEED PRODUCTION IN PLANTATIONS OF SUGAR MAPLE

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While heavy flowering occurred early among grafts, the production of seed was relatively light. Trees of seedling origin still did not flower after 21 growing seasons.

Early flowering and seed production are important factors in tree-breeding experiments leading to the genetic upgrading of planting stock. Reforestation programs that make use of genetically improved stock require orchards that consistently produce heavy crops of flowers and seed. But very little information is available on the earliness of flowering and seed yield in sugar maple (*Acer saccharum* Marsh.). This is especially true among plantation-grown trees of both graft and seedling origins.

I have made observations on trees of one plantation of sugar maples of graft origin and two plantations of seedling origin, and found that grafted sugar maples, between the ages of 3 and 8 years, are capable of flowering heavily during a peak year. But trees of seedling origin, with one exception, have not flowered after 21 growing seasons.

### Literature Review

Periodicity of flower and seed crops in sugar maple appears to vary within the species' range. Heavy crops of flowers are produced annually by certain trees of relatively high sugar content in north central Ohio (4). Good seed crops were reported every 3 to 7 years in the Lake States (2). In central Pennsylvania, sugar maples are

reported to produce flowers at 3- to 4-year intervals (5), but no consistent pattern of periodicity was observed in the eastern part of that State (6).

In northern Vermont and Massachusetts, my observations have shown that the heaviest crops of flowers generally appear at intervals, or multiples, of 4 years. But a heavy crop does not necessarily occur every 4 years. An unusually heavy flowering year is generally followed by a year of light flowering. The environmental agents that trigger the physiological changes that cause bumper crops of flowers and seeds are so poorly understood that any effort to explain these phenomena would be purely speculative.

### Materials and Methods

The clonal orchard was established over an 8-year period, between 1968 and 1975, from grafted scions collected from 53 trees that were selected for superior sap sugar production. Selections were distributed over a six-State area in the Northeastern United States (3), and were all of flowering age, with the possible exception of two relatively young trees selected in New Hampshire.

Scions were side-grafted on seedling rootstocks grown from random seed collections made in the area of Burlington, Vt. Some of the trees were selected in closed forest stands where

they grew slowly and produced scions that were too short and too few in number. Satisfactory grafting material was finally obtained by fertilizing these trees. The delays in acquiring the necessary scion-wood are reflected in the uneven age of the clonal orchard. Although a representation of 10 ramets from each clone was sought, I ended up with an average of 9, and a total of 485 in the orchard.

The plantations of seedling origin were replicated at two locations: Underhill, Vt., and Williamstown, Mass. The plantings are separated in a north-south direction by about 130 air line miles. Seedlings were grown from open-pollinated seed collected in 1956, from 16 trees in two stands near Underhill, 15 trees in Williamstown, and one tree from Durham, N.H. Observations on flowering and seed production were made on 602 trees growing in the Vermont plantation, and 384 trees in the Massachusetts plantation.

### Results and Discussion

#### Clonal Orchard

In 1972, the peak of a 4-year interval in the periodicity of flowering in sugar maple, an examination of trees in Maine, New Hampshire, Vermont, Massachusetts, New York, and Pennsylvania indicated that the overall production of seed in these States was moderate in abundance.

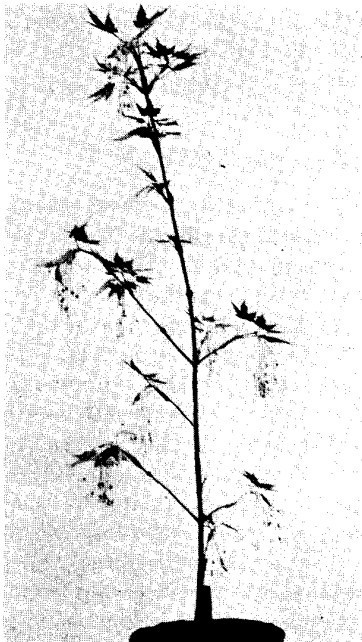
Nevertheless, nine potted grafts, representing five different clones, bloomed in the greenhouse at the beginning of their second growing season after grafting (fig. 1). The female flowers were artificially pollinated, and a small crop of seed was harvested.

A bumper crop of flowers was produced by trees in the North-eastern United States in 1976, another peak year in the periodicity of sugar maple. In the clonal orchard, 44 percent of all the ramets flowered, representing 87 percent of the clones present. Ramets ranged in age from 3 to 8 growing seasons, and varied in height from 1.5 to 12 feet (fig. 2).

According to earlier observations made in north central Ohio, grafts from flowering ortets first bloomed lightly 7 years after grafting; heavy blooming did not occur until 9 years after grafting (4). The differences observed in the time of initiation and early abundance in flower production between Vermont and north central Ohio cannot be satisfactorily explained at this time.

In a peak flowering year, age<sup>1</sup> and size of grafts seemed to have little effect on the beginning and relative abundance of flowering. Probably of greater importance was the influence of topophysis, a phenomenon in which age or

position effects from sexually mature mother trees are carried over to grafts. Thus, grafts react to flowering stimuli in much the same manner as mother trees. Topophytic effects are common in trees that arise from grafted scions or rooted cuttings. Wright (7) has listed a number of different examples of topophysis in his review of the subject and has discussed their importance in relation to forestry and horticulture.



**Figure 1.**—A ramet blooming at the beginning of its second growing season.



**Figure 2.**—A 5-year-old ramet with a good crop of flowers.

In the fall of 1976, an estimated 16,000 fruits were collected from the orchard. Of these, it was estimated that 7,900 contained seed. Filled fruits were separated from empties by a pentane flotation method (7). Of the 47 clones that flowered in the spring, 37 produced seed in the fall. Of the 214 ramets that flowered, 46 produced seed.

The failure of ramets to complete the reproduction cycle may be due to one or a combination of factors. The depletion of reserves during the heavy spring flowering might limit the development of seed, particularly among the many small trees in the orchard. Or the

<sup>1</sup> As measured in time from graft take.

reduced seed crop could be due, in part, to the incomplete pollination of female flowers. Pollen of sugar maple is sticky and it is carried from one flower to another by insects (entomophily). Unfavorable weather conditions that interfere with the normal activities of pollen vectors would result in a lower seed set.

The sex expression of flower-bearing grafts may be influenced in some cases by a position effect when flowers of different sexes are localized in the crown of the mother tree. Wright (6) reported that in sugar maples, female flowers appeared in some parts of the crown while male flowers appeared in other parts. I have observed certain protandrously-blooming trees in northern Massachusetts that produced only male flowers in the lower parts of their crowns, and a mixture of male and female flowers in the upper parts. Thus, it is possible that a low seed set, relative to the flowers produced, may be associated with the male flowering expression of grafts arising from scions collected from all-male branches of mother trees.

#### *Seedling Origin Plantations*

Flowering was first observed in the two plantations of seedling origin at the start of the 19th growing season. One tree, out of 986 under observation, flowered in 1975, and again in 1976.

Although bumper crops were produced in nearby natural stands of sexually mature trees, no other individuals flowered in either the Vermont or the Massachusetts plantations. Apparently, the sugar maples of seedling origin, even after having attained heights up to 47 feet and diameters of 9 inches<sup>2</sup> after 21 growing seasons, are still in their juvenile stage of development. I would consider the one tree that did produce flowers precocious in its blooming habit.

#### **Conclusions**

Grafts of sugar maple are capable of flowering as early as the beginning of their second growing season. The effect of topophysis, rather than size or age of graft, is probably a primary factor in the early flowering of grafts. Although grafts of small size flower profusely, they do not necessarily produce seed. Trees of seedling origin are not mature, with respect to flower and seed production, after 21 growing seasons.

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<sup>2</sup> Diameters measured about 1½ feet above root collar.