U. S. FOREST SERVICE RESEARCH NOTE NE-17

1964

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FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 102 MOTORS AVENUE, UPPER DARBY, PA.

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VARIATION IN SUGAR CONTENT IN A BUDDED SUGAR MAPLE CLONE

The production of maple sugar and maple syrup from the sap of the sugar maple tree (*Acer saccharum* Marsh.) is an important industry in the Northeast, particularly in Vermont and New York. Although it has been recognized for a long time that some trees are sweeter than others — have a higher sugar content in their sap — systematic study of ways to improve sugar production by this species was begun only rather recently.

The need for a practicable way to mass-produce selected sweet or otherwise superior trees by vegetative means became apparent very soon. Vegetative propagation ordinarily is done either by rooting cuttings or by bud- or stem-grafting onto seedling rootstocks, and some studies in rooting sugar maple cuttings have been made.[1] Although vegetative propagation theoretically results in plants that are genetically identical with the parent, the rootstock of grafted plants may induce some deviation from the parent type. Of particular interest in grafting sugar maples is the question: Does the rootstock influence the sugar content of the tree sap?

A study was made to compare the variation in sugar content among young budded trees of a single sugar maple clone with the variation among young seedling trees. Although the clone used in this study was only an average producer, the results may be applicable for any maples budded or grafted on rootstocks of unknown characteristics.

Materials and Methods

All the trees used in this study were located in closely spaced nursery rows at the Adams Nursery in Westfield, Mass. The parent tree (ortet) of the clone, a pyramidal type propagated for ornamental use, was a

[1]Gabriel, William J., Marvin, James W., and Taylor, Fred H. Rooting of greenwood cuttings of sugar maple: effect of clone and medium. Northeast. Forest Expt. Sta., Sta. Paper 144, 14 pp., 1961.

planted specimen in Denton Circle, Springfield, Mass. The rootstocks used in the nursery were wild seedlings of sugar maple that had been lifted bare-rooted and transplanted to the nursery site for budding with the select type. All of the trees were being propagated for eventual sale by the nursery and were used with the owner's permission.

In the spring of 1954, the nursery contained 246 trees that had been budded in August 1950, and several hundred unworked seedlings. The ramets (budded trees) ranged from 3 to 7 feet high in 1954; no height measurements were made on the seedlings. The ramets occupied two rows about 130 feet apart and each of these rows was adjacent to 2 rows of seedlings. These two areas were designated arbitrarily as Section I and Section II.

All 246 ramets were tested for sap sugar; and 87 seedling trees — every tenth tree in the seedling rows — were used for comparison.

Sugar percent was determined with a Zeiss Saccharimeter on drops of sap exuded from holes made with an ice pick. Readings were made to the nearest 0.2 percent. Tests were performed on the budded trees on March 2, March 19, and April 2, 1954. The seedlings and the mother-tree were tested only on the two latter dates. The budded trees were removed from the nursery in 1954, thus eliminating the possibility of future tests.

Results and Discussion

Forty-eight ramets and 34 seedlings were completely dry on all sampling dates. March 19 proved to be a particularly poor day for testing: 71 percent of the ramets and 38 percent of the seedlings that yielded sap at one time or another were dry on that date.

Table 1. — Sugar percent of young clonal and seedling sugar maples

Item	Section I				Section II	
	Seedling (19)[1]		Clonal (39)		Seedling (29)	Clonal (83)
	3/19/54	4/2/54	3/19/54	4/2/54	4/2/54	4/2/54
Range	2.4-5.0	2.2-4.6	2.4-5.2	1.6-3.8	1.6-3.8	1.4-6.8
Average	3.17	2.87	3.74	2.79	2.46	2.90
C[2]	18.5	19.2	20.8	18.5	24.3	29.1

[1]Figures in parentheses are the numbers of trees that gave readings on the dates indicated. No comparison was possible in Section II on March 19 because none of the sample seedlings gave readings.

[2]Coefficient of variation, expressed as a percentage. Coefficients of variation are measures of variation relative to the mean, and are not affected by sample size.

The average sugar percent in the ramets proved to be very close to that of the mother tree. Comparative data for the mother tree and all the ramets that gave readings on the two dates when the mother tree was tested (a total of 52) are tabulated below:

Date	*Mother tree (percent)*	*Ramets (mean percent)*
March 19	3.60	3.49
April 2	3.00	2.72
Average	3.30	3.10

However, more meaningful data are given in table 1, where the range and variability of clonal and seedling tests are listed. It can be seen here that the average sugar percents of seedling and clonal stock are similar. None of the differences between seedling and clonal means for single dates or combined dates, within sections or for both sections combined, was statistically significant by "t" test. Moreover, the coefficients of variation were similar except between sections where somewhat larger coefficients in Section II probably denote more environmental variation than in Section I.

Thus the data show that, for this particular clone budded on seedling stock of unknown parentage, the variation in sugar content among ramets was as great as the variation among seedlings of similarly unknown parentage.

Since identical genotypes may reasonably be expected to show closer similarities to each other than to unrelated genotypes, the failure of ramets of the same clone in our study to conform to this expectation led to speculation as to the cause. One possibility — a remote one in our opinion — is that the rather wide variation among the ramets was associated with their youthfulness, and the variation would have decreased as the trees became older. There was no significant correlation between percent sugar and tree height. Site effects can be discounted in view of the proximity of the trees to each other in each section, and the large differences that often occurred between adjacent trees.

Thus, by a process of elimination, rootstock influence remains as the most likely cause of the variation among the clonal members. The effect of the rootstock in modifying growth and flowering has long been known and utilized in fruit tree production, as with the Malling rootstocks for apples. It does not seem illogical to assume that the rootstock may also influence the amount of sugar in the sap of a sugar maple tree.

Many chemical products of woody plants, such as rubber, quinine, and resin, are end products of metabolism that are rarely, if ever, reused by the plant. However, the sucrose of the sugar maple is both a metabolic product and a food substance; and any influence of the rootstock on the production and utilization of sucrose by the plant is likely to modify the sugar content of the sap. Phenomena such as the appearance of nicotine in the leaves of tomato grafted on tobacco[2] and the production of oleoresin constituents of the scion in the stock of pine grafts[3] may be partially explained by the translocation of enzymes or precursors of products across the graft union. The influence of the rootstock on sugar content in the scion in sugar maple may depend on a simpler quantitative relationship between sucrose production and utilization.

Since variability is inherent in the reproduction of any species from seed, vegetative propagation is a much more reliable way to perpetuate and propagate superior genotypes. However, with sugar maple, vegetative propagation presents problems. In grafted trees, according to the results of our study, the rootstocks may induce an undesirable degree of variability in sugar production. The study was too small for the results to be considered conclusive. But if the present indications as to rootstock influence are confirmed in future tests, grafted stock will be little or no better than seedling stock for reproducing superior trees.

Propagation by cuttings, on the other hand, precludes variation from internal factors. But mass-production techniques have not been perfected. Successful rooting has been accomplished only in mist chambers or by air-layering, and no way has been found for preventing excessive mortality of rooted cuttings during their first winter. These problems with cuttings are under study and are expected to be solved.

If mass-production techniques can be developed, propagation of select trees by cuttings undoubtedly will be the best means for providing uniformly high-yielding trees to the maple sugar industry. Moreover, for certain research purposes, propagation by cuttings will offer definite advantages because the uniformity of genotype thus achieved will permit more accurate appraisal of the effects of environment on sugar production than can be obtained with any other propagation method.

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[2]Dawson, Ray F. Accumulation of nicotine in reciprocal grafts of tomato and tobacco. Amer. Jour. Bot. 29: 66-71, 1942.

[3]Mirov, N. T. Effect of the crown on the composition of oleoresin in pines. Jour. Forestry 43: 345-348, 1945.

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