ROOTING OF MATURE AMERICAN SYCAMORE CUTTINGS

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Abstract.--Trees located on the western Highland Rim of Tennessee and varying in age from 13 to 31 years produced significantly different numbers of rooted stem cuttings. The percentage of rooted cuttings ranged from 83 to 8 percent, but was not related to age of ortet. Trees which produced greater numbers of rooted cuttings also had a significantly higher number of main roots and significantly longer main roots per cutting. In another experiment, using four mature sycamores growing in Knoxville, Tennessee, five different hormones were applied to girdled branch tips; only two (1 percent IAA and 0.8 percent IBA) surpassed the control in number of rooted cuttings.

Additional keywords: Platanus occidentalis L., cuttings, rooting, rooting hormones, variation in rooting.

American sycamore (Platanus occidentalis L.) has gained much attention by foresters in the United States due to its fast growth, favorable wood qualities for pulp and paper production, and large natural range. An ability to clonally propagate juvenile sycamore stem cuttings has been demonstrated by several authors (Briscoe, 1963; Hare, 1975; McAlpine, 1966; Nelson, 1957; Nelson and Martindale, 1957; Steinbeck and McAlpine, 1973).

Vegetative propagation of mature trees is important in tree improvement because superior selections are generally physiologically mature trees. Until recently, no method had been found to root mature material; however, Hare (1975) developed a technique for rooting sycamore cuttings which produced equal rooting success with stem cuttings from 6 and 13 year old ortets.

Knowledge of among-tree variation in rooting ability is needed in developing vegetative propagation procedures for clonal breeding work in sycamore. The inherent difference in rooting ability among sycamore trees has been alluded to by Hare (1975) but has not been directly tested.

One objective of this study was to evaluate natural variation in rooting ability of stem cuttings from mature sycamore trees using Hare's (1975) technique. The second objective was to compare six different rooting treatments.

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EXPERIMENT 1

Materials and Methods

Twelve trees ranging in age (at breast height) from 13 to 31 years (Table 1) were selected on upland sites on the western Highland Rim of middle Tennessee. The trees were selected in natural stands at a sufficient distance from each other to assure reproductive isolation, from 5 kilometers apart to approximately 80 kilometers apart.

Table 1.--Age, number of rooted cuttings per tree, average number of main roots per cutting, and average length of the longest main root per cutting obtained from the 12 selected upland sycamore trees.

Tree number	Age at breast ht. (years)	Number of rooted cuttings (24 attempted)	Average number of main roots per cutting	Average length of longest main root per cutting (cm)
1-18	17	20	21.7	5.2
1-23	17	14	18.2	5.1
1-5	16	14	11.5	3.8
1-3	20	13	15.3	3.4
I-1	31	12	16.1	4.9
1-2	13	12	7.3	2.5
1-9	13	11	17.0	5.7
1-21	14	8	3.3	2.3
1-7	20	5	3.6	1.7
1-22	27	3	8.2	1.6
I-10	13	2	5.0	0.6
1-13	21	2	1.5	0.3

On May 6-8, 1976, branch tips on each of the 12 trees were girdled, and girdles were covered with Hare's (1975) paste (1 percent indolebutyric acid; 1 percent 3-methyl-l-phenyl-5-pyrazolone; 20 percent sucrose; 5 percent Captan; 73 percent talc). Each branch tip (terminals and laterals were used) was girdled approximately 20 cm from the apical meristem using current year's shoots. The girdle was approximately 2 cm wide and did not completely circle the twig; a 1-2 mm bridge of bark, phloem, and cambium was left intact to help the twig survive until collection. A paste consisting of Hare's powder in distilled water was applied over the cut surface; the girdle was then wrapped with plastic wrap and aluminum foil tied in place by a copper wire. On each of the 12 trees, 30 twigs were girdled and treated although only 24 cuttings were needed for the experiment. The 6 extra cuttings allowed for some expected mortality. On June 1-2, 1976, the cuttings were taken from the trees and transported to Knoxville in buckets of ice water.

Greenhouse procedure.--The medium consisted of one part peat moss and one part perlite; heating cables provided bottom heat of 18-24°C. An inter-

mittent mist, of three seconds every three minutes, was applied from 8:00 a.m. to 6:00 p.m. A plastic tent was constructed around the mist benches to keep humidity high around the cuttings. Prior to placing the cuttings in the mist bench, the leaves were cut in half to reduce transpiration. Each cutting was dipped in Benomyl fungicide to prevent fungal growth and then in a powder containing 20 percent sucrose, 5 percent Captan, and 75 percent talc. The cuttings were spaced at 15.24 cm x 15.24 cm in the mist benches, and they were placed in a replicated design.

Cuttings remained in the mist benches for approximately one month. On June 28, 1976, the cuttings from the 12 selected upland trees were lifted and evaluated. Each cutting *was* evaluated for number of main roots per cutting, length of the longest main root, and whether callus was present.

Statistical analysis.--Because of the high number of non-rooted cuttings and therefore zero values, the frequency distributions were highly skewed to the low end of the scale; and consequently non-parametric tests were used for analysis. A Chi-square test was conducted for the relationship of number of rooted cuttings with ortets. This test was used because of the need to compare the distribution of rooted cuttings for a population of ortets with the expected frequency of equal rooting among cuttings from all ortets.

Kruskal-Wallis One-Way Analysis of Variance tests (Siegel, 1956) were used to analyze number of main roots per cutting and length of the longest main root per cutting. This test was used to analyze these two variables because each cutting which rooted has a value for both variables; and since there were unequal numbers of rooted cuttings among the ortets, the means would have to be used in a Chi-square test resulting in wasted information. The Kruskal-Wallis One-Way Analysis of Variance (Siegel, 1956) can be used when there are unequal numbers within each class and is a powerful non-parametric test.

Correlation coefficients were calculated for combinations of average number of main roots per cutting for each tree, length of longest main root per cutting for each tree, and percentage of rooted cuttings per clone.

Results and Discussion

The number of rooted cuttings was significantly different among ortets at the 1 percent probability level for the population of 12 upland trees. The observed values were the number of rooted cuttings per ortet; and since each ortet had an equal chance of rooting success, the population mean was the expected value. With 11 degrees of freedom, the Chi-square value was 36.58**. The range in rooting response among the 12 trees was quite large with the poorest tree producing 8 percent rooted cuttings and the best tree producing 83 percent rooted cuttings (Table 1).

Results of these tests indicate that phenotypes of sycamores differ in rooting ability and that some mature sycamore trees produce stem cuttings which have a high rooting percentage. That this strong among-tree variation

is not due to the age of the ortet is demonstrated for the upland trees by a non-significant correlation coefficient, r = -0.14.

To obtain an estimate of the quality of the root mass produced, the number of main roots and the length of the longest main root were recorded for each rooted cutting (mean values are in Table 1). The results of the Kruskal-Wallis One-Way Analysis of Variance tests (Siegel, 1956) revealed that the 12 upland clones are significantly different (1 percent probability level) in their number of main roots per rooted cutting and in the length of the longest main root per rooted cutting.

Correlation coefficients were calculated for the following combinations of three variables: average number of main roots per cutting for each tree x average length of longest main root per cutting for each tree, percentage of rooted cuttings per tree x average number of main roots per cutting for each tree, and percentage of rooted cuttings per tree x average length of the longest main root per cutting for each tree. The correlation coefficients were 0.92, 0.84, and 0.85, respectively, all significant at the 1 percent probability level. Although a cause and effect relationship cannot be drawn from correlation coefficients, it can be said that all three of these variables increase positively together. Apparently, cuttings from trees which have a better rooting ability also have more main roots and longer roots.

EXPERIMENT 2

Materials and Methods

On May 20-27, 1976, current year's shoots were girdled on four 27 year old trees selected on the Institute of Agriculture campus in Knoxville, Tennessee. Each branch tip (terminals and laterals were used) was girdled and the paste was applied as in Experiment 1. Ninety twigs were treated on each tree although only 72 cuttings were needed for the experiment. The 18 extra cuttings per tree were to compensate for any mortality taking place before harvesting of the twigs. Six treatments, consisting of a control and five growth regulators applied as a paste using distilled water, were used:

1. Hare's powder.
2. 0.8 percent IBA in 99.2 percent talc.
3. Control -- girdle only.
4. 1 percent IAA in 99 percent talc.
5. Hare's powder plus 10 ppm ethrel.
6. 0.8 percent IBA plus 10 ppm ethrel.

On June 30, 1976, the cuttings were taken and brought to the greenhouse.

Greenhouse procedure.--The greenhouse procedure in Experiment 2 was the same as in Experiment 1 except for using six hormone treatments instead of one. The cuttings were also placed in a replicated design as were the cuttings in Experiment 1.

The cuttings remained in the mist benches for approximately one month. On August 3, 1976, the cuttings from the four trees in the second experiment were lifted and evaluated. Again, each cutting was evaluated for number of main roots per cutting, length of the longest main root, and whether callus was present.

Statistical analysis.--Non-parametric tests were again used due to the desirability of not having to make the assumptions necessary for parametric tests. Chi-square tests were used to test the relationship between number of rooted cuttings and ortets and also between hormone treatment and number of rooted cuttings.

Friedman Two-Way Analysis of Variance tests (Siegel, 1956) were used to analyze the number of main roots per cutting and the length of the longest main root per cutting. Data were organized by clone and hormone treatment; clone-hormone treatment interactions cannot be determined with this test. This test was used because the data could be ordered in a two way table - by ramets and hormone treatments. In this case, the means were used because of the unbalanced nature of the data.

Results and Discussion

To date, only one technique has been presented in the literature (Hare, 1975) for rooting mature stem cuttings of sycamore. The experiment which compared Hare's technique with a check and four other chemical treatments revealed that while the reported technique gave some rooted cuttings, the check as well as the other four treatments produced a larger percentage of rooted cuttings. A Chi-square test revealed a significant relationship (at the 5 percent probability level) between hormone treatment and number of rooted cuttings (Table 2). The four ortet totals were pooled within each hormone treatment. The total number of rooted cuttings per treatment was the observed value, and the population mean was the expected value.

Table 2.--Effect of hormone treatments on rooting of cuttings from four sycamore trees and Chi-square test.

Hormone treatment	Number of rooted cuttings (48 attempted)	Percent of cuttings which rooted
1 percent IAA	30	63
0.8 percent IBA	21	44
Check	20	42
Hare's treatment + 10 ppm ethrel	16	33
0.8 percent IBA + 10 ppm ethrel	13	27
Hare's treatment	10	21

NOTE: DF = 5. $X^2 = 13.62^*$.

*Significant at 5 percent probability level.

All the branch tips had calloused next to the girdled area and some had root primordia present. Only two of the hormone treatments exceeded the check treatment in the number of rooted cuttings produced. These two treatments utilized 1 percent IAA and 0.8 percent IBA and produced 63 percent and 44 percent rooted cuttings, respectively.

The number of rooted cuttings was related (significant at the 1 percent probability level) to ortets as shown by a Chi-square value of 22.16**. The six treatment totals were pooled within each ortet. The total number of rooted cuttings per ortet was the observed value, and the population mean was the expected value. Rooting ranged from 17 to 63 percent for the four clones.

As a further attempt to check the quality of the rooted cuttings, a Friedman Two-Way Analysis of Variance test (Siegel, 1956) was conducted on both the number of main roots per cutting and the length of the longest main root per cutting. No evidence was found that the hormone treatments differentially affected the two characteristics.

One major problem encountered with all clones and all treatments was leaf drop during the period cuttings were in the mist bench. Cuttings from some ortets tended to drop more of their leaves, but all the ortets had some leaf drop on their cuttings. In several instances, a cutting would root while the leaves were still alive; but when the leaves dropped, the cutting died within one or two months.

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