SUCCESSFUL ROOTING OF EASTERN WHITE PINE CUTTINGS FROM A 17-YEAR-OLD PROVENANCE PLANTING

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ABSTRACT

The rooting response of cuttings from forty eastern white pines representing seven geographic sources was studied. Timing the collection of cuttings was the most important factor in rooting success. Cuttings collected in early May with suitable treatments rooted as much as 88.3% in 160 days. Cuttings can be collected as early as mid-January with moderate success but late April to early June should be considered the most favorable time for collecting cuttings in the Northeastern Region of the United States. Rootability of cuttings among individual trees within sources was significantly different but differences among sources were not significant. The results of this investigation should be of interest to workers in tree improvement programs where multiplication of superior genotypes is a primary concern.

INTRODUCTION

Eastern white pine (*Pinus strobus* L.) is one of the most valuable softwood species in the northeastern United States and southeastern Canada. However, damage caused by the white pine weevil (*Pissodes strobi* Peck.) is so serious in the region that the value of this species for quality products has been greatly reduced (Marty and Mott 1964). It will be necessary to solve the weevil problem before we can realize the full potential of the species for reforestation programs. Chemical control of this pest appears to be feasible but economically impractical and biological controls are not available.

Studying weeviling in a planting containing 27 provenances of eastern white pine, Garrett (1972) reported that differences in weevil injury among provenances were not significant. He suggested that the individual tree selection rather than the provenance is a more realistic approach to solving the weevil problem (Garrett 1972, 1973). Multiplication of genotypes resistant to weeviling would be most useful if the material could be collected from trees that are old enough to be evaluated for weevil injury.

Numerous studies have been conducted of rooting eastern white pine cuttings; results tend to be variable although all report that season of collection and age of the tree are important factors. Deuber (1940, 1942)

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reported that cuttings taken in November root better than cuttings taken later in the year and his best success was slightly higher than 47 percent. Thomas and Riker (1950) had better rooting with cuttings taken during mid July-mid September than spring. Doran (1953) reported that the period December-March was better than October-November and noted that lateral branch cuttings rooted easier than terminal cuttings. Many investigations have reported that cuttings from young trees (2 to 3 years old) root easily, but it is difficult to root cuttings from trees more than four years old (Deuber 1942, Thimann and Delisle 1939, Patton and Riker 1958a). Patton and Riker (1958b) reported that four- to six-year-old white pine could be rooted easily (90-100%) but 15- to 60-year-old trees were harder to root (20-35%) and results tended to be more variable. Doran (1953) found that some clones rooted better than others and Patton and Riker (1958a, 1958b) found "good" and "poor" rooting years. Enright (1959) reported that cuttings rooted better and faster if fertilizer had been applied to the stock plants for a period before cuttings were taken.

The application of plant growth hormones generally improves the rootability of cuttings in many species, Eastern white pine responds to auxin positively in rooting and IBA (indolebutyric acid) proved to be superior to IAA (indoleacetic acid) and NAA (naphthaleneacetic acid) (Hitchcock and Zimmerman 1939, Snow 1940, Thimann and Delisle 1942, Thomas and Riker 1950, Patton and Riker 1958a). Recently some fungicides such as Benlate, Captan, and Phygon XL were used alone or in mixture with IBA in rooting cuttings. IBA and fungicide treatment improved rooting (Stack 1970, Thielges and Hoitink 1972).

One of the problems of rooted cuttings is that the root system and growth are not comparable to those of seedlings. Thomas and Riker (1950) reported that the rooted cuttings usually developed horizontal and unilateral root systems that were difficult to lift and transplant. However, planting cuttings in tubes greatly improves the root system and makes transplanting easy (Zufa 1972, Kiang et al. 1974). Schreiner (1953) found that rooted cuttings planted near Beltsville, Maryland 12 years earlier grew as fast as seedlings. Patton and Riker (1958b) and Doran (1953) found similar results and reported that while the root systems tended to be atypical in the cutting beds they were indistinguishable from seedling systems soon after outplanting.

This paper reports the results of a two-year study of rooting eastern white pine cuttings collected from forty 16- to 17-year-old trees composed of seven geographic sources in a planting.

<u>Materials and Methods.--A</u> provenance planting of eastern white pine containing 27 sources was used for cuttings. The planting is located on the Massabesic Experimental Forest in southern Maine (70°40' W, 40°30' N) (Garrett et al. 1973). Forty trees including seven geographic seed sources were selected as donors (see Table 4). Because the rooted cuttings will be used in weevil resistance studies, trees were selected on the basis of previous history of weevil attack and damage. They consisted of five categories with regard to weeviling injury: (1) no evidence of weevil feeding, 4 trees; (2) weevil feeding leader not killed, 5 trees; (3) weevil killed leader one year, 11 trees; (4) weevil killed leader two years, 10 trees; (5) weevil killed leader three years, 10 trees.

The planting was 16 years old from seed when the first collections were made in 1972, The cuttings were taken on May 1, June 2, July 7, September 12 of that year and January 11, May 1, June 11 of 1973. The May and June collections were included in this study because eastern white pine cuttings collected during that period were found to root best (see Kiang et al. 1974), July and September cuttings were used because Thielges and Hoitink (1972) obtained the best results with cuttings of current year softwood. The January collection was for the purpose of testing rootability of winter cuttings.

The lower branches of the trees had been pruned to a height of 1.5 meters, and the lateral branches and terminal shoots within reach from the ground were taken. Six cuttings were collected from each of 40 ortets each time, The cuttings were kept under cool condition (5-8°C) before they were planted in the rooting medium. They were washed with 5 percent chlorox solution (0.3 percent sodium hypochlorite). The 1972 cuttings were trimmed to a length of 16-18 cm except June cuttings which were about 12 cm of one-year-old wood with soft candles on them. One half of the cuttings were treated with a quick basal dip in a 95 percent ethanol solution containing 0.4 percent IBA and 1 percent Benlate.[3] Then the bases of cuttings were dusted with Hormodin #3 powder. The other half collection was treated exactly the same except the IBA concentration was increased to 0.6 percent.

The 1973 cuttings were shorter (about 12 cm) and the Benlate concentration was increased to 5 percent. One half of January cuttings were dipped in 0.4 percent IBA-5 percent Benlate in 95 percent ethanol and the other half in 0.6 percent IBA-5 percent Benlate in 95 percent ethanol then dusted with Hormodin #3 powder. May and June cuttings were also divided into two treatments, with one half of them receiving 0.1 percent IBA-5 percent Benlate in 95 percent ethanol, and the other half 0.4 percent IBA-5 percent Benlate in 95 percent ethanol plus dusted with Hormodin #3 powder.

After treatment cuttings were immediately planted in round, open-ended metal tubes 7 cm in diameter and 21 cm in height (Hill and Libby 1969). The bottom 1/3 of the tube was filled with a mixture of equal volumes of Jiffy mix and light loam from a white pine forest. The upper 2/3 of the tube was filled with a mixture of equal parts of peat moss, white pine litter, old sawdust and finely shredded tree bark.

The cuttings were kept under an intermittent mist system in a fiberglass house on the Massabesic Experimental Forest. They were examined after three, four, and five months. The cuttings were recorded in three groups at the end of experiments: living cutting rooted, living cutting unrooted, and dead cutting. At the end of five months unrooted cuttings were discarded, except the cuttings of January 1973, which were kept for 8 months. The rooted cuttings were retained for field planting.

[3] Benlate contains 50 percent of the active ingredient benomyl.

Results and Discussion.--The results indicate that time of collection is one of the critical factors in rooting response (Table 1). Cuttings collected in May consistently rooted best, and those taken in June ranked second best. The cuttings taken in July and September showed poorest rooting response and January collections were intermediate (Table 1). July cuttings had the highest mortality. They came from current season growth and needles were not fully developed when the cuttings were taken. Needle elongation discontinued on many of these cuttings in the mist bench and the foliage became chlorotic and shriveled in appearance. The softwood cuttings of white pine appear to be unsuitable for rooting.

The various concentrations of IBA used (0.1, 0.4, and 0.6 percent) did not appear to influence rooting significantly for any period of 1972 or 1973 (Table 1). The largest difference was in May 1973 when 0.4 percent IBA treatment was 9 percent better than 0.1 percent, but in June 0.1 percent IBA was 9 percent better than 0.4 percent IBA treatment. Neither of these differences was statistically significant although May cuttings treated with 0.4 percent IBA and Hormodin #3 rooted significantly better than those treated with 0.1 percent IBA during the first 87 days (Fig. 1). Significantly higher mortality was observed in cuttings treated with 0.4 percent IBA and Hormodin #3 than in those with 0.1 percent IBA in June 1973 (Table 1). That June cuttings with lower IBA concentration treatment resulted in a higher rooting response and lower mortality appears to support the suggestion that June cuttings may not need as high concentration of IBA treatment as cuttings taken in other months for good rooting (Kiang et al. 1974).

The differences of rooting percentage and mortality between two years of the same month (May and June) were statistically significant. There is some indication that Benlate has some effect on rooting eastern white pine cuttings (Thielges and Hoitink 1972). Deuber (1940) reported that short cuttings of eastern white pine rooted better than longer ones. Therefore, increasing the Benlate concentration and reducing the length of cuttings in 1973 may have accounted for increase in rooting and reduction in mortality from 1972 to 1973. However, when rooting and mortality of May cuttings treated with 0.4% IBA with differing concentration of Benlate were compared, the differences were not statistically significant between 1972 and 1973. (Rooting $.05<P<.10$; mortality $.10<P<.20$ Table 1). Any significance of increasing the Benlate concentration could be obscured by the physiological condition of the plant tissue, and the rootability difference between 1972 and 1973 may well be the result of yearly fluctuation (Patton and Riker 1958a).

The highly significant differences in rootability and mortality of June cuttings between 1972 and 1973 can probably be explained partly by the different number of soft candles on cuttings. The 1972 cuttings had more cuttings with high number of candles than 1973 cuttings (Table 2). The average number of candles per cutting for 1972 was 3.5 versus 2.7 for 1973. Although no special attention was paid in taking cuttings with regard to the lateral branch versus terminal shoot, it is probable that a greater number of lateral branch cuttings were included in the 1973 collection than in the 1972, since the lateral branch normally has fewer number of candles than the terminal shoot. In looking at Table 2, it is apparent that rooting decreased and mortality increased with increasing number of candles per cutting. However, the homogeneity of rootability test with respect to the number of candles per cutting showed deviation to be nonsignificant, In a study of relationships between rooting response and number of soft candles on June cuttings, Kiang et al. (1974) divided the cuttings into six groups based on the number of candles on each cutting (0, 1, 2, 3, 4, 5, and 5+ candles). They deliberately removed some of the extra candles and found that rooting response was significantly reduced with increasing number of candles and that mortality was positively correlated with the number of candles. With this additional information we suggest that June cuttings with a medium number of candles should be used and excess candles removed for the best rooting result.

The faster rooting response of cuttings collected in May and June may result from the interaction of internal conditions of the cuttings and the favorable external factors, such as day length, light intensity and temperature, There seems to be a distinct optimal period for rooting eastern white pine cuttings. During such period the cuttings may develop a physiological condition ready for rooting. Thus, cuttings taken in such period may root fast and well, while those collected before or after such period may root slowly and poorly. Our observations seem to support this hypothesis. The cuttings taken in early May and early June rooted rapidly with a high proportion of cuttings rooted, whereas cuttings taken in July rooted poorly with high mortality. Shoots in May and June are in active growth and cuttings collected in early May and June tended to maintain active growth in the mist bench. The buds of May cuttings continued to develop and grow new shoots. The soft candles of June cuttings also continued to grow but rather slowly. However, the needles of July cuttings, which were not fully developed, stopped growing in the mist bench. The September cuttings rooted very poorly and the January cuttings did not root until May. In fact, 94 percent of the total January rooted cuttings were obtained during May, June, and July (Fig. 1). The observations indicate that the eastern white pine cuttings in Northeastern regions root rapidly at the beginning of the active growing season, late spring and early summer, but do not root or root slowly in the dormant season. Therefore, it is advantageous to collect cuttings of eastern white pine during late April, May, and early June in order to obtain the fastest and best rooting.

The rootability of the cuttings was compared to susceptibility of donor trees to weeviling. There was no significant difference in rootability among different susceptibility groups but differences within groups were significant (Table 3). The rooting response of the cuttings from seven geographic seed sources is shown in Table 4. The seed sources used in this study represent the geographic distribution of eastern white pine in U.S.A. No significant difference in rooting among sources was found, however, differences within seed sources were statistically significant (Table 5). The lack of differences among geographic sources in rootability of eastern white pine suggests that cuttings collected in late April through early June, with the best combination of treatment and rooting medium, may be successfully rooted regardless of the source. Our findings make tree improvement and reforestation programs of this species much more bright than before.

SUMMARY

1, Successful rooting of eastern white pine cuttings can be expected from trees as old as 17 years.

2, Time of collection is the most important factor for successful rooting. Cuttings shculd be secured at the beginning of the growing season.

3. Seed source of donor trees is not an important factor in rooting success.

4. Rooting success is related to genotypes of individual trees.

5. No correlation between rootability and weevil susceptibility was found.

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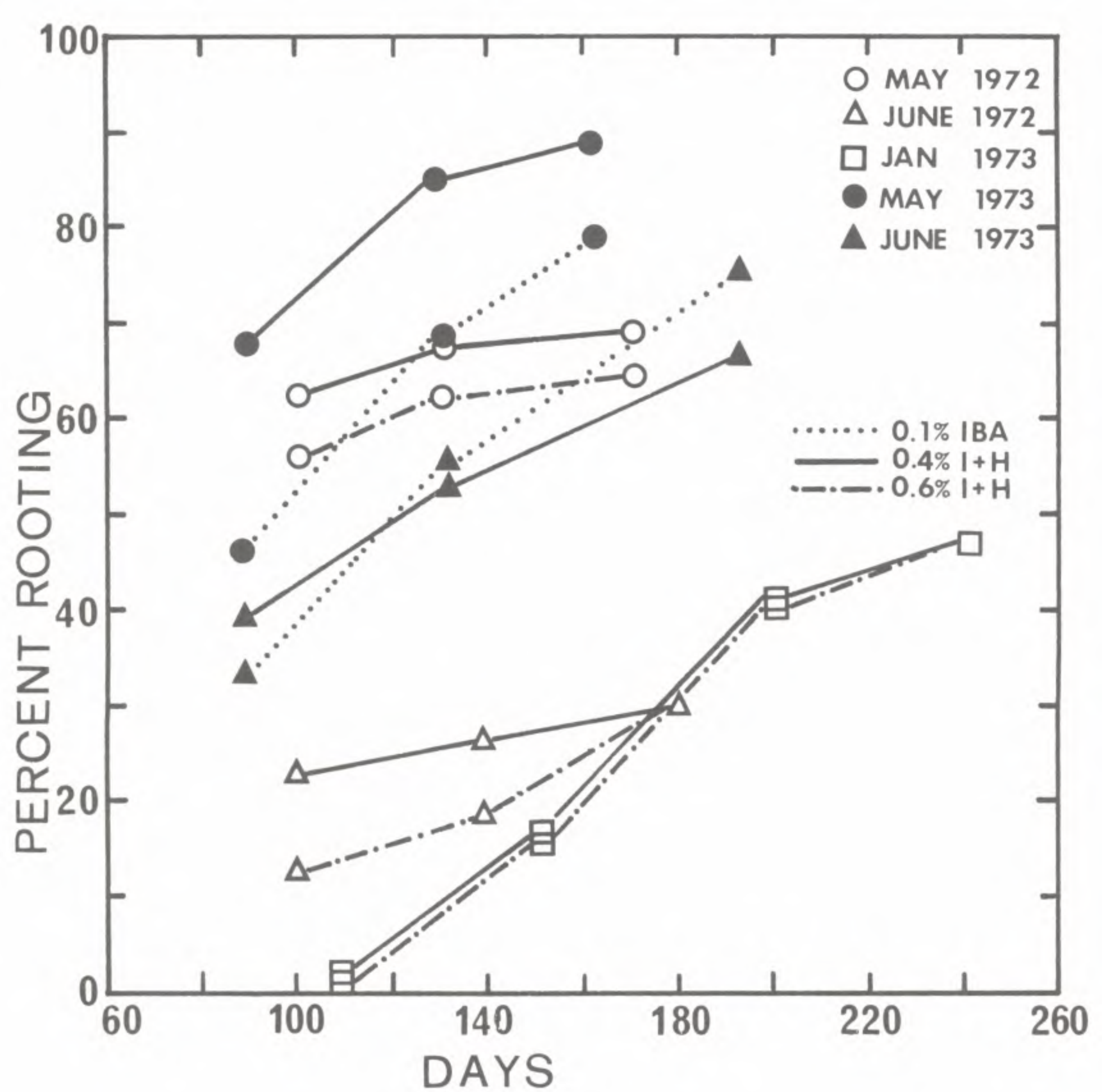

Figure 1.--Cumulative rooting percentage of eastern white pine cutting by date of collection and IBA treatment (I+H - IBA + Hormodine #3 powder).

Table 1.--Rooting response of eastern white pine cuttings.[a]

Collection Date	Treatment IBA	Treatment Benlate (%)	Percent rooted	Percent living unrooted	Percent dead	No. of roots/ rooted cutting
May 1, 1972	.4% + H-3[b]	1	68.3	26.7	5.0	2.8
	.6% + H-3	1	64.2	26.6	9.2	2.7
May 1, 1973	.1%	5	79.2	20.8	0.0	---[c]
	.4% + H-3	5	88.3	10.1	0.8	---
June 2, 1972	.4% + H-3	1	29.2	21.6	49.2	4.0
	.6% + H-3	1	29.2	15.0	55.8	3.2
June 11, 1973	.1%	5	75.8	20.9	3.3[d]	2.6
	.4% + H-3	5	66.7	17.5	15.8[d]	3.0
July 7, 1972	.4% + H-3	1	8.3	26.7	65.0	2.2
	.6% + H-3	1	7.5	22.5	70.0	1.7
Sept. 12, 1972	.4% + H-3	1	7.5	73.3	19.2	2.9
	.6% + H-3	1	2.5	80.8	16.7	1.3
Jan. 11, 1973	.4% + H-3	5	46.7	15.8	37.5	2.2
	.6% + H-3	5	46.7	14.1	39.2	2.2

[a] 120 cuttings collected from 40 ortets were used in each treatment.

[b] Hormodine #3 powder.

[c] Number of roots was not recorded.

[d] Difference significant at the 1% level.

Table 2.--Rooting response of eastern white pine cuttings in relation to the number of candles on each cutting.

Number of candles	June 2, 1972 collection: Number cuttings planted	Percent rooted	No. of roots/rooted cutting	Percent dead	June 11, 1973 collection: Number cuttings planted	Percent rooted	No. of roots/rooted cutting	Percent dead
1	14	50.0	3.0	21.4	31	87.1	2.7	3.2
2	28	39.2	3.7	46.4	64	75.0	2.6	6.3
3	72	31.9	3.2	51.4	101	71.3	2.9	10.9
4	96	24.0	3.6	56.3	28	60.7	2.9	14.3
5 and 6	30	20.0	6.8	63.3	16	43.8	3.0	18.8
Homogeneity test for rooting		X^2=4.93	df 4	.2<P<.3		X^2=3.33	df 4	.3<P<.4

Table 3.--Rootability of cuttings in relation to weevil susceptibility of the ortets.[a]

Source of variation	df	SS	MS	F
Between group	4	23.45	5.86	1.00
Within group	35	205.70	5.88	1.66*
Error	160	568.00	3.55	

[a] Cuttings collected in May, June, 1972, and 1973, and January 1973, were included in the analysis.

* Significant at the 5% level.

Table 4.--Rooting response of eastern white pine cuttings from seven geographic seed sources.[a]

Source of Population	Number of ortets	Number of cuttings planted	Percent rooted	Percent dead
Georgia	8	240	57.5	13.3
North Carolina	5	150	77.3	11.3
Massachusetts	8	240	60.0	20.8
Maine	8	240	50.8	26.7
Iowa	2	60	55.0	36.7
Wisconsin	8	240	58.3	24.2
New York	1	30	66.7	26.7

[a] Including cuttings collected in May, June, 1972, and 1973, and January 1973.

Table 5.--Analysis of variance of the rootability of eastern white pine cuttings collected from six geographic sources in a provenance planting.[a]

Source of variation	df	SS	MS	F
Between population	5	40.9	8.18	1.44
Within population	33	187.3	5.68	1.60*
Error	156	552.0	3.54	

[a] Cuttings taken in May, June 1972 and 1973, and January 1973 were included in the analysis. New York source was excluded for the reason of a single ortet used.

* Significant at the 5% level.