CLONAL SELECTION AND TESTING OF VIRGINIA PINE FOR CHRISTMAS TREE CHARACTERISTICS

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Abstract. --_Two and one-half year-old Virginia pine (Pinus virginiana Mill.) trees were selected for superior Christmas tree characteristics from a large Christmas tree grower's plantation. Three-inch-long stem cuttings were collected from the select trees and rooted using Hare's powder and a rooting bench. Rooted cuttings from 47 clones were field planted in spring 1987 near Hattiesburg, Mississippi and subsequently were cultured with standard Christmas tree practices, including shearing. The sole cultural treatment to be tested was the effect of staking versus not staking each clone.

Following four seasons of growth and culture, the trees were assessed for total height and overall quality rating. The unstaked ramets of each clone were as straight as the staked ramets. Highly significant clonal variance was apparent for total height with an average of 129.21 cm and a range of clone means of 102.44 to 160.00 cm. The top ten percent of the clones averaged 21.16 cm taller than the population average. Broad-sense heritability for height on a individual basis was .21. Based on a five-point scale, there were highly significant differences among clones in quality rating. The top ten percent had an average rating of 4.57 compared to the overall mean of 3.64. The broad sense heritability for the rating was .31.

Additional keywords: Pinus virginiana, vegetative propagation, rooting success, heritabilities, staking

INTRODUCTION

Selection and clonal propagation of superior trees are well established procedures in horticulture and in reforestation for a few tree species. The Christmas tree industry has made a few attempts to develop superior clones for their use (e.g., Proebsting 1981), but to date none of these efforts seems to have succeeded in an operational sense. Given that Christmas tree production and sales represent an important business in the U.S., development of large-scale clonal selection and propagation procedures will enhance the success of the industry.

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Little work has been done to improve most Christmas tree species genetically, with the most advanced program being with Virginia pine (*Pinus virginiana* Mill.). In this case, a **seed** orchard based tree improvement program is expected to produce genetically superior seedlings for the Christmas tree industry (Brown 1987). Development of cloning procedures applicable to large-scale use has been limited to a single published report by Snow and May (1962). Their best treatment for rooting of stem cuttings yielded an average of 72 percent rooting, hence the species appears to be at least moderately amenable to the rooted cutting process.

With the large potential impact of such a program on the Christmas tree industry and the paucity of clonal production information in mind, a pilot scale study was initiated with Virginia pine. The objectives were to: (1) assess the growth and form of Virginia pine rooted cuttings in an operational Christmas tree production system, (2) determine whether initial staking of the rooted cuttings influenced subsequent straightness of the resultant trees, and (3) measure the degree of genetic control of height growth and quality rating among Virginia pine clones.

MATERIALS AND METHODS

Phenotypically superior trees were selected from cultured plantations managed by Sunrise Tree Plantation Co. located near Hattiesburg, Mississippi. The trees were 2-1/2 or 3-1/2 years old from seed, and they were planted as 1-0 bareroot seedlings. The seed for the seedlings arose from bulk lots of seed from the Kimberly Clark Co. or the Bowaters Co. first generation seed orchards. The 47 select trees were chosen for superior height, straightness, a preponderance of four or more branches in each branch whorl, and good overall Christmas tree quality.

Stem cuttings were collected on July 8, 1986 for subsequent propagation. Following collection, the cuttings were placed in plastic bags, sealed, and put in an ice chest. The cuttings were set the next day for rooting at International Forest Seed Co., Odenville, Alabama. Their standard rooting procedures (Hughes 1987; Foster 1990) were used, and cutting length was standardized to three inches. The cuttings were established in 5.5 cu inch plastic Hiko containers in a greenhouse rooting area in a randomized complete block design with four replications of five cutting plots. The rooting process required about four months in the greenhouse, and an additional five months were needed to first harden-off the trees and then initiate additional new growth prior to outplanting.

The trees were planted on April 21, 1987 at Sunrise Tree Plantation. A completely randomized design was used with 3 to 5 rooted cuttings (mainly 4) for each of 47 clones. Single tree plots were used with a 6 x 6 ft spacing. Half of the ramets of each clone were staked to encourage erect growth. The experiment was located in the middle of an operational Christmas tree plantation. Test trees were cultured normally including shearing, grass and weed control, and insecticide application.

The test was measured in the fall, 1990 following four growing seasons, and the data were analyzed. A least squares analysis of variance was used (PROC GLM, type Ill sums of squares; SAS 1985), and the coefficients of variance components were adjusted for data imbalance (Hartley 1967; Goodnight and Speed 1978). The form of the analysis of variance is given in Table 1. Mean squares were equated with sums of squares, and variance components were derived (Kempthorne 1969). Variance components were also expressed as the percentage of the total variance accounted for by each source of variation. Staking treatments were fixed effects, and clones were random effects. Broad-sense heritabilities were calculated on an individual-ramet basis (H^2) and also on a clone-mean basis ($H^2_{\bar{x}}$).

$$H^2 = \frac{\sigma^2_c}{\sigma^2_c + \sigma^2_{sc} + \sigma^2_e} \qquad H^2_{\bar{x}} = \frac{\sigma^2_c}{\sigma_c + \frac{\sigma^2_{sc}}{s} + \frac{\sigma^2_e}{ns}}$$

where,

σ^2_c = variance among clones

σ^2_{sc} = variance due to interaction of staking and clones

σ^2_e = error variance

s = number of staking treatments

n = number of ramets per clone

The later heritability is appropriate in reference to selection based on clone-mean performance. It should be noted that the magnitude of the clonal variance component and also heritability are inflated by the size of the clone x location interaction since the test was located at a single site. Expected genetic gain can be predicted by multiplying broad-sense heritability based on clone means by the selection differential. Theoretically this value will apply only to the same site type as where this genetic test was growing.

RESULTS AND DISCUSSION

The ANOVA for both height and the quality rating is given in Table 2. The only significant source of variation was the effect of clones, which also accounted for a relatively high percent of the total variance. It is interesting to note that the effect of staking at time of planting was not significant for either of the measured characteristics nor did it account for much of the total variance.

Table 1. Form of the analysis of variance for four-year height and quality rating of Virginia pine clones.

Source of variation	Degrees of freedom	Expected mean squares
Stake Tmnt (s)	1	a2, + 1.634 02s, + 66.831-G25
Clones (c)	**46**	62e + 3.157 CY2c
S * C	42	o2, + 1.634 62sc
Error		02,
Total	157	

Table 2. Analysis of variance for height and quality rating of Virginia pine clones.

		Height			Quality Rating		
Source of variation	Degrees of fmaclan	Mean square	Variance component	% of total variance	Mean .square	Variance component	% of total variance
Stake Tmnt (s)	1	721.54NS	6.24	1.79	0.4184NS	.0005	0.08
Clones (c)	46	444.27**	71.73	20.55	0.9881**	.1845	31.24
S * C	42	304.79NS	53.23	15.25	0.3826NS	< 0	0.00
Error		217.81	217.81	62.41	0.4055	.4055	68.67
Total	157						

** Significant at $p<0.01$.
NS Non-significant at $p>0.05$.

After four years, 158 out of the original 184 rooted cuttings (85.9% survival) were still alive. Twenty-five of the clones had not lost any ramets, while 18 clones had lost 1 ramet and only 4 clones had lost 2 ramets. Even though there is insufficient data to test effectively, there do not appear to be any clonal effects on survival.

The mean height for all trees was 129.21 cm (Table 3) which is considerably less than previously reported heights for three-year-old trees (Brown 1987). The trees in this test had been sheared twice a year beginning in their third year, which would reduce their total height. Also, the rooted cuttings were planted fairly late (April) and the normal amount of growth usually observed on seedlings was not obtained during the first season. By the second year, the trees appeared to grow more normally. By the fourth year, the trees appeared to be very normal, except their height was comparable to sheared three-year-old trees.

Table 3. Clone means, ranges, heritabilities and select clone means.

	– – – – – – – – – – All 47 Clones – – – – – – – – –					Best 5
Variable	Mean	Max	Min	H2/x		Clones Means
Height (cm)	129.21	160.00	102.44	0.21	0.43	150.37
Quality rating (score)	3.64	4.67	2.33	0.31	0.59	4.57

Progeny tests previously evaluated by the author all had mean quality ratings between 3.0 and 3.4. The quality rating of 3.64 observed on this test indicates that the quality of the trees is at least as good as trees grown from seedlings, if not a little better. A higher quality rating should be expected because of the select nature of the clones. The overall improved quality was also commented on by the cooperator at Sunrise Tree Plantation who stated that the quality was better than normal, but that the growth was less by approximately one year. It appears that we can achieve quality Christmas trees from rooted cuttings, but that their initial growth may be delayed, especially if planted late.

It is not clear why the staking treatment had no effect on tree quality. Normally, a crooked stem is the single largest factor affecting quality. In this test, most of the trees appeared to be growing straight with very few leaning to one side. There is the possibility that because the first-year growth was less than normal, the root systems had more opportunity to develop prior to the top growth, creating more wind firm trees. Another possible explanation could be that all of the original select trees were picked because of their straightness. Both of these factors are confounded and may explain the lack of effect of staking.

Previously reported narrow-sense heritabilities for height based on half-sib progeny tests of Virginia pine were 0.19 for first generation tests (Brown 1987), 0.39 for unsheared second-generation trees and 0.20 for sheared second-generation trees (Brown 1990). It appears shearing lowers the heritability estimates by introducing a new source of environmental variance. The broad-sense heritability calculated on an individual-ramet basis (0.21) in this test agrees very closely with previous results. Broad-sense heritability is theoretically larger than narrow-sense heritability due to inclusion of non-additive genetic variance in the numerator. Although the narrow-sense heritability estimates arise from a different study (lessening their comparability), the closeness of size indicates a preponderance of additive genetic control of height growth. It appears that the heritability for height growth of sheared Virginia pine

Christmas trees will be approximately 0.20, which is sufficient to allow for selection and improvement in a breeding program.

The quality rating heritability of 0.31 calculated in this test is considerably higher than previous results of 0.16 for first-generation tests, 0.21 for unsheared second-generation trees and 0.13 for sheared second-generation trees (Brown 1990). The quality of the clones is more consistent within a clone than the quality within half-sib families. The clonal source of variation accounted for almost 50 percent of the total variance in quality rating, which is high. With similar rationale as above, quality rating may be under both additive and non-additive genetic control, resulting in higher broad-sense heritabilities. This may be an indication that the use of vegetatively propagated clones may result in higher gains in quality rating than the use of improved seed from a breeding program.

The analysis of both height and quality rating indicates that rooted cuttings can be used for the production of Christmas trees. The means of the best five clones (top ten percent) combining both quality and height (Table 3) indicate that the use of these clones would result in a quality improvement of 0.93 in rating and 21.16 cm in height compared to the overall means of the test. However, it should be noted that no seedling check nor other non-select clones were planted for comparison purposes, therefore, realized gains could not be calculated. Both of these gains are greater than those previously estimated from a breeding program (Brown 1987).

CONCLUSIONS

Virginia pine rooted cuttings appear to grow normally, especially when fairly juvenile ortets are used. The overall quality rating of the trees is as good and possibly better than that experienced from half-sib progeny tests. The overall height growth was less. The trees after four years in the field were very similar in height to three-year. old trees from seedlings. Additional studies will be needed to compare rooted cuttings and seedlings to assess the normalcy of height growth. There was no effect of staking observed in this test and it may not be of value as a general practice. This is not meant to imply that staking a leaning tree is of no value, but rather the random staking of newly planted rooted cuttings showed no effect.

Based on the relatively high estimates of heritabilities and their agreement with previous estimates, the height and quality of Virginia pine under similar cultural practices appear to be under moderate genetic control. The cultural practices required to produce quality Christmas trees are intensive and were thought by some to totally overwhelm the genetic component. Based on this research, the genetic component is still important, even when subjected to intensive cultural practices. Additionally, the practicality of clonal selection of Virginia pine for Christmas trees seems good.

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