Genetic Improvement of Virginia Pine for Christmas Tree Production

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Virginia pine is grown as a Christmas tree species throughout the Coastal Plain and Piedmont of the South. A combination of attributes make it a worthy Christmas tree species. Virginia pine grows rapidly, so that 6-7 ft. Christmas trees may be harvested 3 to 6 years after planting. For a pine species, its needles are comparatively short (1.5 – 3.0 in.) reducing interference with hanging ornaments. Its branches are relatively fine, but strong enough to hold ornaments. It also responds readily to shearing producing a full dense crown and has a pleasant pine scent. Virginia pine grows well on a variety of sites and, at least for Christmas tree rotations, can be readily grown in the Coastal Plain of the South, outside of its natural range.

Several negative characteristics offset Virginia pine's beneficial ones. Naturally, Virginia pine stems are extremely crooked and the crown form is unkempt and scrubby. The species requires frequent shearings (usually 2 or 3 times per growing season) and is highly susceptible to Nantucket pine tip moth infestations. Controlling this pest is quite intensive and is best accomplished by trapping adult moths and tracking degree-days in order to time the required two to four pesticide applications each growing season While Virginia pine naturally has a dark green color, this color turns yellowish during the winter so that most growers apply colorant on their marketable trees. Due to the cumulative effects of these defects and the large amount of natural variation in the species, growers often only sell half or less of their Virginia pine trees.

To increase the profitability for Virginia pine Christmas tree growers through the use of seedlings and rooted cuttings with superior growth and quality, the North Carolina State University Christmas Tree Genetics Program began an aggressive genetic improvement effort with this species in 1997.

Genetic Testing

Origin of Test Material The improvement effort began by establishing tests to evaluate Christmas tree value of open-pollinated families (i.e., trees grown from seeds of the same mother tree). A total of 120 seedlots of Virginia pine were obtained from seed orchards or clone banks of six organizations (Bowater, Inc., Cokesbury Seed Orchard, Kimberly-Clark, N.C. Division of Forest Resources (NC DFR), Texas Forest Service, and MeadWestvaco Corp.). Most seedlots were open-pollinated families collected from either first (n=56) or second (n=60) generation select trees. These selections had been made in forestry tree improvement programs where rapid stem growth and stem straightness were favored. Two checklots were bulked seed orchard collections from the NC DFR and had also been selected for growth and straightness. Five seedlots obtained from the Texas Forest Service were top families in a tree improvement program based upon Christmas tree quality. Two checklots were bulked from sets of five open-pollinated families from the privately owned Cokesbury Seed Orchard and had been selected for Christmas tree quality.

Test Establishment & Management Seedlings were grown in a campus greenhouse in Raleigh and during the 1997-1998 winter, were hand planted at two Coastal Plain (Clinton and Rocky Mount) and two Piedmont (Reidsville and Salisbury) field stations in North Carolina. Three sites, which were formerly farm fields, were tilled

before planting while the fourth site (Salisbury) was largely pasture and was ripped prior to planting. Spacing was 6 x 10 ft. All sites received pre-plant fertilization according to results from soil nutrient analyses. Subsequent fertilization at each site was based on nutrient analysis of foliar and soil samples and varied across sites and years. Methods and effectiveness of Nantucket pine tip moth control and weed management also varied across sites and years. A single contracted crew sheared the studies in June during the third growing season, and in June and September during the fourth growing season.

The studies were established according to a pre-determined experimental design to optimize the statistical and genetic information gained from the analysis. A total of 16,440 seedlings were planted across all four sites. However, due to mortality and other causes, 14,883 seedlings were used in the final year's analyses with the number of seedlings/seedlot at each site ranging from 7 to 69 (31 average).

Measurements Total height was measured on the greenhouse tubelings prior to planting and at the end of each growing season in the field. Additional field traits measured included number of growth cycles, tip moth infestation, straightness, color, and Christmas tree quality. Retail value after the fourth growing season was determined as follows. First, three Christmas tree growers independently surveyed each test site and assigned a retail value to each tree. Unmarketable and dead trees were given a value of $0.00. Then, the average of three retail values was taken as the tree's retail value.

Results Site had a large influence on Virginia pine height and retail values. Due to its clayey soil and more northerly latitude, four-year-old trees at the Reidsville site were considerably shorter (4.9 ft.) compared to trees at the other sites (6.0-6.3 ft.). Similarly, the average retail value was lower at Reidsville ($5.62) compared to the other three sites

($10.62-$16.60). These average values included short trees, cull tree ($0), and dead trees ($0), and so are less than the average price that growers realize per tree sold.

The retail value of Virginia pine Christmas trees is strongly controlled by genetics. There was a three-fold increase from the least valuable ($5.14) to the most valuable ($16.10) open-pollinated family. Seedlots from trees previously selected for Christmas tree quality ranked high demonstrating the success of the selection process. For example, the most valuable family (TX 1-4) was from the Texas Forest Service while the fourth and sixth ranked seedlots (out of a total of 120) came from the Cokesbury Seed Orchard. The average retail value of the best five open-pollinated families averaged $2.40/tree more than the checklots and $3.90/tree more than the overall average retail value of all material tested (Table 1). Growers using these family would realize an additional revenue of about $2,900/acre compared to the checklots and over $4,700/acre compared to the overall average value assuming a 6 x 6 ft. spacing (1,210 trees/acre).

Selections In 2002, based on analysis of the retail value data and field inspections, 62 of the best trees from the best families were selected and multiple scions (cuttings) from each selection were grafted onto loblolly pine rootstock an NCSU campus greenhouse. Over 100 grafts were made of the overall best selection, Cokesbury-02-026.

Planting Stock Production

Using the superior selections from the genetic test series, two routes are being pursued to provide growers with genetically improved planting stock for establishing Christmas tree plantations: 1) a traditional seed orchard approach, and 2) clonal multiplication of superior selections using rooted cuttings.

Seed Orchard Approach In 2003, grafts of the best 12 clones were planted to establish a clonal seed orchard at the NC DFR Rockpile Farm in Morganton. Planting stock produced from the seed orchard is expected to survive better, grow faster, and produce better quality trees with fewer culls than the planting stock currently available to growers. Depending on orchard development, the first significant seed harvest from the orchard is expected in 2007 or 2008 so that genetically improved seedlings will be available to growers in 2008 or 2009.

Cloning Approach The 100^{+} grafts of Cokesbury-02-026 and grafts of other select clones are being managed in the a greenhouse in Raleigh as stock plants for rooted cutting propagation. Applying research results, these grafts were severely hedged back in 2003 and the resulting juvenile shoots were rooted. Subsequently, additional cycles of hedging and rooting are being carried out to further multiple these selected clones.

Vegetative multiplication of the clones is proceeding nicely and some rooted cuttings have been used to establish a clonal field trial at the Horticultural Crops Field Station near Clinton. Over 2,600 additional rooted cuttings representing 44 of the selected clones have been produced so far. The number of cuttings produced varies widely by clone. However, there are over 900 rooted cuttings of the best clone, Cokesbury-02-26, since special attention has been directed toward its multiplication. Many rooted cuttings have been transplanted into larger containers and are being hedged and managed as stock plants to accelerate multiplication. Once sufficient numbers of productive stock plants have been developed, commercial production of genetically superior rooted cutting clones for Christmas tree growers will commence.

Further Improvement

Grafts of all 62 selected Virginia pine clones were planted in a clone bank at an NC DFR site near Morganton. In the near future, this clone bank will be used to perform control-pollinations among the best selections. The control-pollinated seeds then will be used to grow seedlings to establish another series of genetic tests and thus, begin the next cycle of the genetic improvement process.

Additional Technical Reading

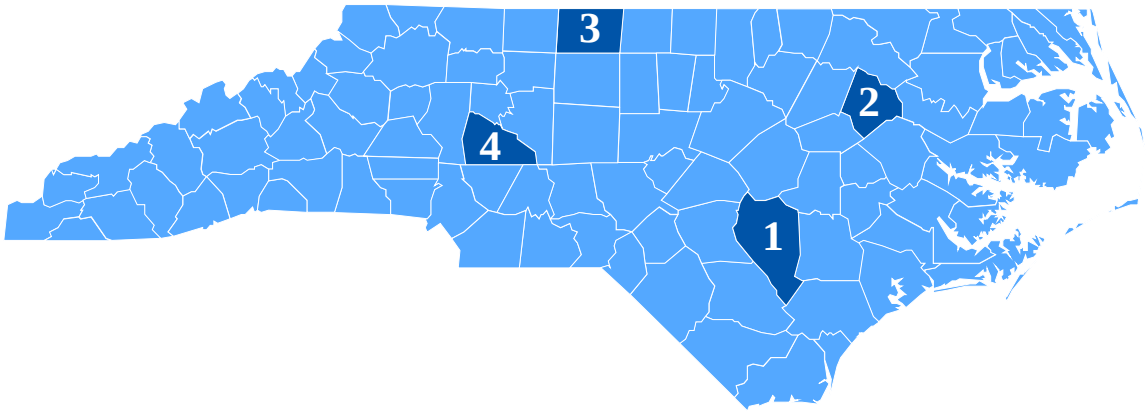
Frampton, J, and F. Isik. 2004. Genetic improvement of *Pinus virginiana* for Christmas tree production. *Forest Genetics.* 11(2):137-147.

Rosier, C.L., J. Frampton, B. Goldfarb, F.C. Wise, and F.A. Blazich. 2004. Growth stage, auxin type, and concentration influence rooting of Virginia pine stem cuttings. *HortScience* 39(6):1392-1396.

Rosier, C., J. Frampton, B. Goldfarb, F. Blazich and F. Wise. 2005. Improving the rooting capacity of stem cuttings of Virginia pine by severe stumping of parent trees. *Southern Journal of Applied Forestry*. (in review)

Table 1. Genetic gain estimates for retail value ($) of Virginia pine Christmas trees resulting from various selection schemes. Trees grafted into the Cokesbury Seed Orchard had been specifically selected for Christmas tree quality.

Seedlots	Average	Genetic Gain			
		Versus Checklots		Versus Overall Average	
	Value ($)	%	Value ($)	%	Value ($)
Best 5 Families	15.3	18.7	2.4	34.8	3.9
Best 10 Families	14.8	15.2	2.0	30.8	3.5
Best 15 Families	14.5	12.6	1.6	27.8	3.2
Cokesbury Seed Orchard	14.7	13.9	1.8	29.4	3.3
Checklots	*12.9*	-	-	*13.5*	*1.5*
Overall Average	***11.3***	***-11.9***	***-1.5***	**-**	**-**



Site Number	Physiographic Region	Field Station	Town	County
1	Coastal Plain	Horticultural Crops Research Station	Clinton	Sampson County
2	Coastal Plain	Upper Coastal Plain Research Station	Rocky Mount	Edgecombe County
3	Piedmont	Upper Piedmont Research Station	Reidsville	Rockingham County
4	Piedmont	Piedmont Research Station	Salisbury	Rowan County

Location of the Virginia Pine Progeny Test Series established by the N.C. State University Christmas Tree Genetics Program.

Four-year-old Virginia pine genetic test in the Piedmont (Salisbury) of North Carolina.

Superior Virginia pine trees like this 4-year-old selection from a genetic test are cloned by 1) grafting branches, 2) severely cutting back the graft to produce vigorous juvenile shoots, and 3) rooting cuttings from these shoots in a propagation greenhouse.