GENETIC VARIATION FOR ROOTING, GROWTH, FROST HARDINESS, AND WOOD, FIBER, AND PULPING PROPERTIES IN FLORIDA-GROWN EUCALYPTUS AMPLIFOLIA

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Abstract. Variability in clonal rooting, clonal and seedling growth and frost-tolerance, and wood properties was noted in a 1st-generation E. *amplifolia* genetic base population in Florida. Rooting success averaged only 40% but varied considerably among 84 cloning candidates. Their growth in clonal tests also varied, while many new introductions grew as well as the best of previous accessions in addition to providing comparable or better frost tolerance. Variability among and within families was significant for frost tolerance. Artificial freeze testing procedures hold promise for screening accessions and identifying frost-tolerant individuals. Wood specific gravity (SG) and moisture content (MC), pulp yield and viscosity, and other important fiber and paper characteristics varied among- and within-provenances. Compared to sweetgum, E. *amplifolia* was lower in SG, pulp yield, and sheet strength but less consumptive of energy and chemicals for bleaching to similar brightness; and higher in smoothness and opacity for writing grade papers.

Keywords: Provenances, progenies, clones, Australia, pulp and paper.

INTRODUCTION

Eucalyptus amplifolia Naud. has grown well on good sites in peninsular Florida (Rockwood et al. 1991) but needs further evaluation. Provenance, progeny, and tree variability was significant for growth and frost-tolerance, and E. *amplifolia* progenies were more frost-resilient than four other *Eucalyptus* species. The rooting abilities of cloning candidates varied. Relatively little is known about its wood properties in Australia (Dadswell 1972) or elsewhere. This paper reports recent results on the following aspects critical to its use: 1) clonal rooting and testing, 2) growth in an expanded 1st-generation genetic base population, 3) artificial freeze screening, and 4) basic wood, fiber, and pulping properties.

MATERIALS AND METHODS

Rooting Study. Over 5,700 coppice stem cuttings of 84 selections from a previous base population (Rockwood et al. 1991) were rooted in May 1992 using a commercial rooting hormone, after soaking the cuttings in a fungicide. After 40 days in mist, rooting percentages were determined. Ramets were outplanted in studies SRWC-47, -48, and -50 (Table 1) and seed orchard CT74 near LaBelle in August.

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Table 1. Means and ranges for height (in m) of 31 E. amplifolia progenies and up to 63 clones in three field studies established in 1992.

Entry		SRWC-47			SRWC-48			SRWC-50		
		No.	Mean	Range	No.	Mean	Range	No.	Mean	Range
			11-mo Height			13-mo Height			6-mo Height	
Progenies:	Tested	9	0.9	0.6-1.3*	9	3.0	1.5-4.0	9	0.7	0 .4- 1 .0*'
	New	22	0.9	0.7-1.3*	22	3.0	2.0-4.0	22	0.7	0.5-1.0*'
			6-mo Height			9-mo Height			2-mo Height	
Clones:	Set 1	2	0.3	0.2-0.5	21	1.0	0.5-1.7	21	0.4	0.2-0.5
	Set 2				21	0.9	0.3-1.7	24	0.3	0.2-0.5
	Set 3				14	1.3	0.8-2.0	18	0.3	0.1-0.6*'

* and ** - Progeny/Clone variability significant at the 5% and 1% levels, respectively

Growth Studies. In April 1992, three studies of 31 progenies, 22 new introductions from frost-frequent regions of northern New South Wales (NSW), Australia, plus the nine best progenies in previous studies (Rockwood et al. 1991), were established in Florida (Table 1). Study SRWC-47 was planted near Zephyrhills at 2.4 x 1.5 m spacing in a randomized complete block design with three replications of 5-, 6-, and 7-tree row plots, respectively, due to space/slope constraints. Study SRWC-48 at Gainesville used a 2 x 1 m spacing with 8-tree row plots within three replications of a randomized complete block design. Study SRWC-50 was installed near Flemington at 3 x 2 m spacing with three replications of 6-tree row plots. Survival, height, and DBH were measured periodically through May 1993.

Freeze Studies. In Freeze Study 1, five seedlot groups (Table 2) were screened by the CSIRO Division of Forestry. Groups 1 and 2 were five frost "resistant" and five frost "sensitive" seedlots, respectively (based on field tests in Florida), from a broad region in northern NSW. Group 3 was five untested seedlots originating east of Guyra, NSW. The E. grandis Hill ex Maid. and E. regnans F. Muell. groups provided baselines for assessing relative species tolerance: Group 4 - two frost resilient E. grandis seedlots from a 4th-generation seed orchard in Florida (Rockwood et al. 1989), Group 5 - included one standard E. regnans seedlot widely used in previous tests (Raymond et al. 1992a). Hardening of some 128 trees was accomplished by 38 days under shadecloth at night temperatures of 6°C or less followed by 21 days of 3°C or less night temperatures without cover. For hardened trees, liquid cold bath temperatures were -5.5, -7.0, and -8.5°C and for unhardened seedlings -1.0, -2.3, and -3.6°C. Frost tolerance was determined using the relative conductivity (RC) technique of Raymond et al. (1986, 1992a).

In Freeze Study 2, four E. amplifolia families, including three in Freeze Study 1 (Table 2), were used to assess a cold bath testing procedure developed for citrus in Florida. Eleven vigorous 2-month-old seedlings of each progeny were subjected to 15 hour nights at 4°C for hardening. After one month, progeny comparisons were conducted using 6mm disks from two leaves, i. e., one detached leaf from each of the first two fully expanded leaf pairs of each seedling. To assess variability between leaf pairs, a second leaf was taken from each leaf pair in family 4809. A second leaf in each pair for another two families was used to a) compare 6mm with 8mm disks in the case of family 4873, and b) contrast RC with visual whole leaf damage in family 5010. After exposing each leaf or disk to -5.5°C, RC was determined by procedures similar to those of Freeze Study 1.

Freeze Study 3 applied a modification of the Freeze Study 2 procedure to progenies and clones in SRWC-48. Two vigorous young leaves were collected from up to five unhardened ramets of each of 55 clones and up to 24 unhardened seedlings of each of 15 progenies (Table 2). Similar leaves were also collected from four to six hardened (21 days of 15-hour nights at 4°C) ramets of five of the 55 clones.

Table 2. Relative conductivity (RC) of various Eucalyptus groups in three artificial freeze studies.

Group-Family	Florida Freeze Rating (% Undamaged)	Study[1] Unhardened No.	Study[1] Unhardened RC	Study[1] Hardened No.	Study[1] Hardened RC	Study 2 Hardened No.	Study 2 Hardened RC	Study 3 Unhardened No.	Study 3 Unhardened RC
1-"Resistant" E. amplifolia			.826		.857				
4809	60.0	15	.841	10	.871	11	.556	23	.735
4822	80.0	15	.746	7	.835				
4842	55.0	13	.830	5	.825	11	.459	12	.757
4859	52.3	15	.865	7	.882				
4861	64.3	12	.853	5	.856				
2-"Sensitive" E. amplifolia			.746		.793				
4812	11,1	15	.614	10	.726				
4825	28.6	12	.800	5	.850				
4830	10.0	15	.884	9	.865				
4831	10.5	13	.787	4	.759				
4844	10.5	15	.662	10	.782				
3-Untested E. amplifolia			.815		.792			187	.699
4869								11	.752
4870								13	.713
4871								14	.689
4872								14	.708
4873						11	.419	24	.711
4875								14	.682
5010		15	.812	7	.850	11	.486	20	.693
5011		14	.838	10	.717			12	.711
5012		15	.858	5	.771			11	.678
5017		11	.764	8	.847			14	.667
5018		10	.777	0				10	.661
5020								15	.671
5022								16	.739
4-E. grandis			.791		.651				
2814		10	.804	4	.641				
2817		12	.780	8	.656				
5-E. regnans			.615		.722				
MG98		14	.752	10	.747				
108		14	.478	4	.661				
E. amplifolia Cloning Candidates								157	.721

[1] Results for temperatures of -2.3 and -5.5°C for unhardened and hardened trees, respectively

A 6 mm disk removed from each leaf by a paper punch was placed in a test tube containing frozen deionized distilled water. Unhardened trees were then exposed to -2.3°C; hardened trees were screened at -5.5°C. RC was determined as in the previous studies.

Wood, Fiber, and Pulping Studies. Four studies (basic wood properties, preliminary pulping assessment, comparative pulping, and comparative bleaching) were conducted using trees established at Belle Glade (Rockwood et al. 1987). Three 53-month-old trees between 8 and 14 cm in DBH per three provenances were felled in December 1989. Each tree was measured for DBH and total height before being bucked and measured for diameter at 1.5 m intervals. At each interval, a disk was removed, stored in a refrigerator, and processed for SG and MC determinations within a month. Stem sections were shipped to IPST where they were frozen until processed. Stem material between 0.5 and 2.5m above ground was manually debarked, chipped, and sized. In the preliminary Kraft process pulping assessment, the effects of amount of alkali and total H-factor on pulp yield, intrinsic viscosity, and Kappa number were assessed. The "cooks" for the comparative pulping study used a derived H-factor of 700 and an alkali charge of 13% to assess pulping yield, viscosity, Kappa number, fiber length, etc. For comparison of pulping properties, a 38-year-old sweetgum, Liquidambar styraciflua, from northwestern Georgia was also processed. In the bleaching study, samples of provenances 2-3 and 2-7, which had distinctly different characteristics in the comparative pulping study, and sweetgum were compared for brightness, viscosity, and strength. Bleaching was done in three stages: chlorine dioxide delignification, caustic extraction, and chlorine dioxide brightening. From each fully bleached sample, 30g subsamples were removed, refined in a PFI mill, formed into handsheets and brightness pads, and subjected to physical testing.

RESULTS AND DISCUSSION

Rooting Study. Rooted cutting survival in 1992 was very similar to results in previous years with different clones. The 84 cloning candidates had an average rooting of 40%, with individual clones rooting from 0 to 97%. Only seven clones, about 8% of all clones, equalled or exceeded the 80% rooting typically achieved for E. grandis in Florida (Meskimen et al. 1987). In two previous years, 10 clones rooted at 41 %, and eight clones averaged 39%, with respective variation among clones ranging from 2 to 71 % and 0 to 84% (Rockwood et al. 1991).

The notable similarity in rooting average and variability across years raises several concerns. A rooting rate averaging only 40% makes commercial rooting of superior E. amplifolia clones more expensive and thus less feasible, although a few clones could apparently be readily propagated by rooting. The time needed for cuttings to develop good root systems also varied greatly. Many clones, though, rooted very poorly, e. g., 32% of the 84 clones had rooting less than 20% and eight clones, including some very superior phenotypes, failed to root. Micropropagation does not appear to be a viable alternative method of vegetative propagation for E. amplifolia (Rockwood et al. 1991).

Some 32 of these 84 clones from the first E. amplifolia genetic base population (Rockwood et al. 1991) were interplanted in seed orchard CT74 in southern Florida, which typically has milder winters than northern Florida. A seedling seed orchard for E. amplifolia in northern Florida, patterned after a successful program conducted for E. *grandis* in southern Florida (Reddy et al. 1986), would involve much risk to developing flower crops. In CT74, these clones may by natural crossing accomplish two objectives: 1) produce E. amplifolia seedlings adapted to Florida by matings among themselves and 2) generate useful hybrids by crossing with other redgums to combine desirable aspects such as the superior frost-tolerance of E. amplifolia and the high rooting ability and site adaptability of Florida-adapted E. camaldulensis and E. tereticornis Sm.

Growth Studies. Early height growth in three field studies varied considerably among progenies, but the previously tested progenies did not grow more than the new accessions (Table 1). In each of the three studies, the average height of nine "tested" progenies was virtually the same as the average of the 22 accessions from more frost frequent areas. For both tested and new progenies, the tallest progenies were nearly twice the size of the shortest progenies. At this early stage, the broadening of the genetic base