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EXOTICS FOR HARDWOOD TIMBER
PRODUCTION IN THE SOUTHEASTERN UNITED STATES

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Abstract.-- Several species of eucalypts as well as European black alder show promise as exotic hardwood pulpwood species. Each meets the following important requirements: (1) has fast growth rate on typical all-weather logging sites of moderate to poor quality, (2) produces genetically improved seed with management (3) does not produce potentially noxious seedling populations in the wild, and (4) yields good quality pulp by conventional processes.

Additional keywords: Eucalyptus grandis, E. camaldulensis, E. macarthurii, E. nova-anglica, E. robusta, E. tereticornis, E. viminalis, Alnus glutinosa, provenance testing, site selection, fertilization.

INTRODUCTION

Manufacturing of kraft pulp from native hardwood (broad-leaved) species in the Southeast has developed rapidly in the last two decades. Three reasons were compelling: (1) it was plentiful, (2) it was available at a very favorable price compared to pine, (3) it averaged about 5% higher pulp yields than pine. With certain modifications in processing, hardwood became first a usable, and in a short time, a necessary source of fiber for certain products. Now much of the easily obtained hardwood for pulp has been or soon will be harvested. Much of what remains in some areas of high utilization is periodically inaccessible due to weather or terrain, or completely unavailable due to restraints favoring other forest values.

Under these circumstances, plantations have become a viable option for supplying a portion of the needed hardwood. Plantation culture also offers management opportunities that are elusive or non-existent under natural conditions, but the management opportunities have a high price tag. Intensive site preparation, large seedlings, weed control and fertilization are all necessary for success in most situations. Efforts to find species, native or exotic, with the highest production per unit cost under these circumstances are well justified.

A large number of species and provenances are presently being tested, and a few are being planted on a pilot or commercial scale. The most promising

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exotics include several species of eucalypts (*Eucalyptus grandis* Hill ex Maiden, *E. camaldulensis* Dehnh., *E. macarthurii* Deane & Maiden, *E. nova-anglica* Deane & Maiden, *E. robusta* Sm., *E. tereticornis* Sm., *E. viminalis* Labill.) and European black alder (*Alnus glutinosa* [L.] Gaertn.)

BASIC REQUIREMENTS

Fast Growth on Available Sites

The exotic hardwood must have fast growth and high production on sites suitable for logging during almost any season. There is no justification for growing exotics which produce pulpwood at rates equal to or lower than native species at comparable costs. High-priced plantation hardwood must be available when other supplies are not. Typically, all-weather logging sites are the higher dryer sites of inherently moderate or low quality, i. e., uplands and sandhills rather than fertile bottomlands. Moreover, nontarget species in plantations on the best sites either require prohibitively expensive competition control measures or create an unmanageable plantation environment. So the successful exotic hardwood must do more with less than native species in plantations or managed natural stands.

Seed Production of Improved Genetic Quality

Almost all exotic hardwoods introduced into the southeastern United States are not sufficiently adapted in the first generation to form commercial stands. Genetic adaptation to the new environment must be accomplished through selection and breeding. Therefore, the successful exotic species or provenance must be amenable to genetic improvement and must produce commercial quantities of improved seed with conventional seed orchard management.

Not a Potentially Noxious Weed

Man has often imported exotic plants and animals into his home environment. Most such introductions have been inconsequential failures, but many have been outright disasters -- imported organisms have filled a vacant niche or driven native organisms out and occupied the new environment in unwanted numbers. Therefore, it is extremely important that exotic hardwoods not reseed naturally in more than intended quantities or on nontargeted sites.

Produce Good Quality Pulp by Conventional Processes

As a supplemental pulpwood supply, exotic hardwoods must be utilizable by the same pulping and papermaking processes as native hardwoods. In most cases, the exotic pulps will be used in mixtures with native hardwood or pine pulps in the papermaking process. Therefore, typical exotic plantation hardwoods must be carefully tested at expected rotation ages to be sure that the raw material is suitable for the intended product (Einspahr, 1976).

It is clear that exotic hardwood plantations are an opportunity over a rather restricted range of sites and supply situations. The marginal market for exotic plantation hardwood can be reasonably well predicted. If new markets develop for wood as chemical and energy sources, production opportunities could increase considerably in the near future. With this background in mind we can review some of the most promising species and provenances now being tested and planted.

EUCALYPTS

Adaptability, Growth, and Seed Production

Eucalypts were widely planted in south and central Florida before the turn of this century. Zon and Brisco (1911) describe requisite conditions in Florida for some 28 species which were considered for commercial planting. It was about 60 years later that collaboration between private, state and federal agencies made eucalypt planting a commercial possibility. Current research leading to genetic advances in cold hardiness and growth rate may extend plantation culture into many of the Southern Atlantic and Gulf Coast states.

In southern Florida, Eucalyptus grandis and E. robusta are the primary species under development. First generation genetically improved stock of both species produces pulpwood of acceptable dimensions for roundwood harvest on an 8-year rotation at rates of from 2 to 3 cords per acre per year. Soils are of poor fertility, deep and sandy; they support palmetto, wire grass and occasional slow-growing slash pine (Pinus elliotii var densa Little & Dorman). These sites are generally termed "palmetto prairies" and have been proven to be best for E. grandis in southern Florida (Meskimen and Franklin, In press). Intensive site preparation, including chopping, burning and bedding, is best. Ground rock phosphate at the rate of $\frac{1}{2}$ ton per acre is applied. Recommended stocking at establishment is 600 trees per acre on beds 12 feet center to center. No cultivation or other treatments are recommended prior to harvest. Fertilization with nitrogen and potash are under investigation.

Genetically improved seeds of both species are produced in seedling seed orchards containing trees chosen by between- and within-family selection plus progeny testing (Franklin and Meskimen 1973, 1975a). Within 2 years, second and third generation improved seed may boost yields to 3 to 4 cords per acre per year.

Seedlings are produced in a 12-week nursery season in containers from hand-sown pelletized seed (Meskimen 1974). Total nursery production in 1977 of E. grandis is expected to reach 1,300,000. E. robusta is not being planted in large numbers.

The greatest promise for future development is E. grandis X E. robusta F_1 hybrids which outproduce either species by at least 50 percent.

Great promise for growth on exceptionally well-drained, sandy longleaf pine (P. palustris Mill.) ridges has been shown by an E. camaldulensis strain from Spain. The strain also has more cold hardiness than either E. grandis or E. robusta. Unfortunately, three seed orchards in southern Florida have never produced enough seed annually for more than 100 acres of plantation. Immature capsules are abundant in early fall, but fail to yield mature seed the following June. Until this problem is solved, no commercial use of this strain can be made.

A naturalized strain of E. tereticornis has potential commercial value. It is called the St. Leo strain because the seed orchard currently in production is on a farm owned by St. Leo Abbey, St. Leo, Florida. In tests, these trees start slowly but grow well after age 3 years to reach pulpwood size in a 10-year rotation. It is the most coldhardy of the 4 species considered and may be used in central and northern Florida when genetic gains in cold hardiness are obtained.

All 4 species at age 6 months suffered severe defoliation or death during the exceptionally cold winter of 1976-77 when planted near Orlando, Florida (about 28° N latitude). In the same test planting, E. viminalis from several provenances showed wide variation in cold hardiness, thus offering an excellent opportunity to make selections.

E. viminalis is being widely tested in the South Atlantic and Gulf Coast Regions and may offer the best opportunity of moving eucalypt plantation culture into those areas. Growth on an array of upland sites has generally exceeded that of native plantation-grown hardwoods. These sites are thoroughly prepared before planting and cultivated to control weeds; and fertilizer is applied to enhance growth.

Efforts are underway to produce commercial quantities of seed both in seedling and grafted clonal orchards. In seedling seed orchards it is difficult to obtain provenances which when exposed to severe cold have enough trees left to select and leave for seed production. Techniques for grafting E. viminalis must be perfected before grafted clonal orchards can be developed. Increased research and development over the next few years should lead to efficient production of genetically adapted strains of this species in commercial quantities. Second only to E. viminalis is E. macarthurii, which is more coldhardy but has somewhat poorer growth rate and form than E. viminalis. A large number of other species and provenances of eucalypts are being tested, but results to date are inconclusive regarding adaptability and growth rate.

Noxious Weed Potential

Most eucalypt species and provenances introduced into the Southeastern United States produce moderate to large quantities of seed, but reproduction under natural conditions has been limited to areas of a few acres in central and southern Florida. The species most frequently found is E. robusta, but E. camaldulensis and closely associated species as well as hybrids are also found. The

ecological limitations that constrained natural reproduction are not known. The limited reproduction is consistently associated with abandoned shade and ornamental plantings rather than with modern plantation culture.

Pulp and Paper Properties

The pulping properties of eucalypts vary considerably among species. Juvenile density is relatively high, ranging from 0.44 to 0.55 g/cc depending on species (Franklin and Meskimen 1975b). Fiber length is shorter than that of many native hardwoods, ranging from 0.75 to 0.95 mm. Debarking presents no problem, while pulping without debarking increases chemical consumption about 25%. The longer fibers in the bark tend to increase tear strength slightly.

Screened kraft pulp yields from wood of E. grandis, E. robusta and Spanish E. camaldulensis for bleached and dissolving grades were generally equal to or slightly less than those for native hardwoods with no process modifications. Kraft pulping of St. Leo E. tereticornis resulted in inferior yields. Neutral sulfite semi-chemical (NSSC) process on E. tereticornis, E. robusta and E. camaldulensis gave yields (dry weight basis) averaging 7 points higher than native hardwoods. Paper properties are slightly to substantially inferior to checks, reflecting the shorter fiber lengths. Bleaching costs were lower and brightness was superior to checks (Franklin 1977). Mixing eucalypt pulps with longer-fibered hardwood pulps has increased strength. Thus, these 4 species were generally satisfactory for pulping and papermaking without major process modification.

Results on wood quality of 3-year-old E. viminalis and E. nova-anglica were reported by the School of Forest Resources, N. C. State University.^{2/} Wood density of both species was 0.45 g/cc; bark density was only slightly lower at 0.38 g/cc, while moisture content of wood was 58% of green weight. Green density (about 1.03 g/cc in this case) often exceeds 1 in juvenile wood. Fiber length of E. viminalis, 0.86 mm, was consistently greater than that for E. nova-anglica, 0.76 mm, in the basal 2-foot bolt. Preliminary pulping results by Erling Riis Research Laboratory, International Paper Company, Mobile, AL, indicated stronger paper from pulp of bark-free E. viminalis than from E. nova-anglica but both pulps were acceptable considering the juvenility of the wood.

EUROPEAN BLACK ALDER

Adaptability, Growth and Seed Production

Since alder ranges over most of Europe and into parts of North Africa and Asia Minor, local strains have undoubtedly adapted to a wide range of climatic conditions. This adaptation presents both a challenge and an opportunity for intensive provenance testing in the Southeast to quickly reap the benefits of extensive natural variation.

Some recent interest in black alder for reforesting coal spoils (Lowry et al. 1962) portended increasing interest by the pulp and paper industry to try it for

^{2/} 20th Annual Report. Cooperative Tree Improvement and Hardwood Research Programs. 1976. 97p.

hardwood pulping. The silvical characteristics of the species are well known (Funk, 1965), and of particular interest is its nitrogen-fixing capability.

Cold hardiness combined with good growth was demonstrated in test plantings of unknown provenance in the upper Piedmont and mountains of North Carolina (Boyette and Brennehan 1976). Heights averaged 30 feet, diameters 4.3 inches in 5 years over three sites, a growth rate equal to the best native hardwoods on the best sites. On wet or infertile sites, black alder is expected to grow substantially better than native hardwoods. Although black alder is widely planted on spoil areas (Funk and Dale 1961), black locusts (Robinia pseudoacacia L.) outgrew it on sand, gravel and solite spoils in North Carolina (Boyette per. comm.). Fast early growth of black alder on most sites minimized need for weed control. Additional studies of site adaptability and growth rate have been installed in the lower Piedmont and Coastal Plain of North Carolina, South Carolina, Virginia and West Virginia, and others are planned for Georgia and Florida.

Black alder has been established to evaluate performance over a range of sites by Champion International as a part of the N. C. State Hardwood Cooperative Species Site Studies (White, per comm.1/). Upland sites in northern Alabama and southern Tennessee were planted with sycamore (Platanus occidentalis L.) black alder, and loblolly pine (Pinus taeda L.). Height growth of black alder was best on all sites at age 4, although sycamore was a close second on the Red River Terrace site as was loblolly pine on the Plateau (Table 1). Black alder did not compare as favorably in another test of site treatments on an upland site of index 75 for loblolly (Table 2). Provenance of the planting stock in both studies is unknown, but it is tempting to speculate that a provenance difference is one reason for the relatively better growth of the material tested in North Carolina.

Seed production began on many black alders in North Carolina, Alabama and Tennessee during the second growing season. Seed production is generally abundant by the fourth year but may be somewhat periodic, with good crops at least every 4 years (Schopmeyer, 1974). A half-diallel of 17 selections has already been completed by Gordon White, Champion Timberlands, and open-pollinated progeny testing of 50 additional trees is underway. Ninety percent of the attempted crossings produced seed (White, per. comm.). These results indicate that production of genetically improved seed can be accomplished readily.

The importance of provenance testing has already been emphasized. In 1976 several cooperators in the N. C. State Hardwood Research Program planted 9 lots of black alder from Denmark (2), Romania (3) and Sweden (4) and 1 lot of European speckled alder (Alnus incana L. Moench) from Denmark. Survival was excellent in the plantation established by Westvaco Corporation in the lower Coastal Plain of South Carolina. No measurements have been made, but substantial variation among sources is already apparent. Champion Timberlands is now obtaining seed for provenance trials of black alder, Italian alder (A. cordata Dess) and oriental alder (A. orientalis Dene).

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Table 1. --Heights of sycamore, black alder and loblolly pine on 6 sites in northern Alabama and southern Tennessee at age 4. (Source: G. White, Champion Timberlands, Courtland, AL)

Species	Iron Spoil	Red River Terrace	Cove Upland	Upland Not Bedded	Upland Bedded	Plateau
	-----feet-----					
Sycamore	5.3	14.8	7.4	7.4	7.7	8.9
Alder	10.8	15.6	8.2	12.1	13.6	12.9
Loblolly	3.1	7.0	7.7	7.2	8.6	10.6

Table 2. --Heights of sweetgum, sycamore, loblolly pine and black alder with 4 intensities of site preparation on an upland loblolly site (index 75) at age 4 in northern Alabama. (Source: G. White, Champion Timberlands, Courtland, AL)

Species	Site Prep Treatments			
	Clear	Clear & Disc	Clear Disc & Bed	Clear & Bed
	-----feet-----			
Sweetgum	5.5	5.5	6.8	6.1
Sycamore	3.9	5.3	6.2	6.2
Loblolly	8.8	9.3	9.0	9.1
Alder	5.2	5.1	6.1	7.1

Noxious Weed Potential

In its native habitat, black alder is an aggressive pioneering species (McVean 1956) with moderately good shade tolerance (Leibundgut 1963). However, as an exotic in the Southeastern United States there has been no indication of unwanted natural regeneration, even though it is a precocious, prolific seed producer (Boyette and Brenneman 1976).

Pulp and Paper Properties

Bleached grade kraft pulp yield and properties as well as hand sheet properties of black alder were recently compared with those of a native hardwood mixture by Champion International (White per. comm.). Included in the comparisons were:

1. Chips without bark of 3-year-old alder,
2. Compositeds chips of wood, bark, twigs and leaves of 3-year-old black alder,
3. Compositeds chips of wood and bark of 9-year-old black alder,
4. Compositeds chips of wood and bark of native mixed hardwood long logs.

Samples 1, 2 and 4 were from northern Alabama; sample 3 was from southern Illinois. When compared to sample 4 (unbarked native hardwood) black alder in sample 1 (young debarked stems) had lower density, shorter fiber length, equal chemical requirements and pulp yield, slower drainage, higher burst, lower tear, much higher fold and equal opacity. It could be considered a usable but somewhat inferior pulp, but the utility of debarking such small stems is questionable.

The black alder whole-tree composite (sample 2) wood (62%), twigs (19%), bark (8%) and leaves (11%) was unsatisfactory in pulp yield and paper quality. Density, pulp yield, fiber length, tear and drainage rate were exceptionally low.

The 9-year-old black alder with bark (sample 3) was the best tested. Compared to the check (sample 4), it gave equal or better yield of pulp with slightly shorter fiber length, lower freeness and tear, higher burst and fold, and equal opacity.

These results indicate that 3-year-old black alder wood is too immature for bleached kraft pulp but might be suitable for hardboard or chemical groundwood. The 9-year-old wood is much superior in yield and properties, approaching comparability with the native mature hardwood.

CONCLUSIONS

Recent research has clearly demonstrated excellent biological potential for producing pulpwood in the Southeastern United States with certain exotic hardwood species. A relatively small-scale but vigorous research effort is necessary to rapidly develop this potential. Concurrently, pilot and commercial-scale plantations must be established to produce wood for economic analysis of silvicultural and manufacturing facets of management and utilization systems. We are off to a good start which promises a new technology by the middle 1980's.

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