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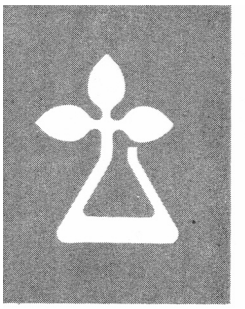

U.S. FOREST SERVICE
RESEARCH NOTE

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ANGELIQUE [1]

Dicorynia guianensis Amsh.

By

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Introduction

Angelique has for many years been incorrectly identified with the botanical name Dicorynia paraensis Benth. It differs from this species and from other described species of Dicorynia in the structure of the flowers and its restricted range of growth. Presently known as Dicorynia guianensis, angelique occurs only in French Guiana and Surinam. Dicorynia paraensis occurs along the Rio Negro and its tributaries in Brazil's Amazonas Territory. Aside from angelique, or basra locus as it is also known, the characteristics and properties of the various Dicorynia species are practically unknown at this time.

Angelique is well known in the producing areas for its strength and inherent natural durability, but its highly desirable characteristics have only recently come to the attention of the United States trade. Small quantities are currently entering the United States, but it is expected that imports will gradually increase as the wood becomes better known.

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[1] This Research Note was previously issued as Forest Products Lab. Rpt. No. 1787, under the same title, originally dated 1951 and revised in 1958.

Distribution and Habitat

Commercial stands of angelique occur in Surinam and French Guiana. In Surinam the main stands are found between the Coppename and Marewijne Rivers on higher ground not subjected to flooding. In French Guiana it is most common in the western part of the country in the valleys of the Sinnamary, Mana, and Maroni Rivers.

The Tree

The average height of the trees from the buttress to the first branches is about 95 feet, and the average diameter is about 24 inches. It is considered a large tree and attains a maximum height of 150 feet and a diameter of 5 feet measured above the low buttresses.

The Wood

Because of the variability in color between different trees, three forms or types are recognized by the producers. Heartwood that is russet colored when freshly cut and becomes superficially dull brown on drying, commonly with a purplish cast, is referred to as angelique gris. Heartwood that has a more distinctly reddish cast and frequently shows wide bands of purplish color is called angelique rouge. And grayish-white colored wood, which apparently comes from trees that are late in forming typical heartwood, is call angelique blanc. The wood of angelique blanc contains abundant starch deposits, and in this respect possesses the characteristics associated with sapwood.

Only the gris and rouge types are imported into the United States and generally no differentiation is made between them. They are delivered without any limitation as to maximum allowable percentage of one or the other.

Gross Features

The grain is generally straight or slightly interlocked. The texture (size of pores) is about equal to that of African limba (Terminalia superba Engl. & Diels) and somewhat coarser than that of American black walnut (Juglans nigra L.). Flat-sawn surfaces usually show a pattern produced by the wood parenchyma

bands, which appear violet colored against the background color of the wood. Storied elements of the wood produce a ripple mark pattern on the side-grain surfaces, but this is very small. Quartered material shows a more or less distinctive stripe associated with interlocked grain, The wood surfaces may appear rather dull, but a definite golden subluster is one of the distinctive features of this species.

Mechanical Properties

The mechanical properties of angelique are given in table 1 as compared with those of teak (Tectona grandis L. f.) and white oak (Quercus alba L.). The values for angelique are based on tests made at Yale University on two trees from Surinam and three trees from French Guiana (1,5).[2] The comparative teak values are from Tropical Woods (5) and the white oak values from the Wood Handbook (4).

Angelique is superior to teak and white oak, when either green or air dry, in all properties except tension perpendicular to the grain, in which it is surpassed by both.

Mechanical tests made on three forms of angelique show no significant differences.

Machining Properties

Sawing and other machining properties vary among the different forms of angelique and are reportedly due to differences in density, moisture content, and silica content. Angelique rouge is reported to be the easiest to saw and the blanc form the most difficult; the latter also tends to produce lumber with fuzzy surfaces. Sawing is least difficult when the wood is in the green condition, although considerable dulling of the saw does occur. After the wood is thoroughly air dried or kiln dried, it can be worked effectively only with carbide-tipped tools. A planer cutting angle of 15° is said to be suitable for working this species.

The wood finishes smoothly and is moderately easy to glue.

Seasoning

Duke University found that 4/4, 6/4, and 8/4 stock air seasoned well during the period of 2 months in which the average temperature was 61° F. and the average relative humidity was 58 percent. During this period green boards of

[2] Underlined numbers in parentheses refer to Literature Cited at the end of this report,

the above thicknesses, which varied between 67 and 92 percent moisture content, were dried to a 13 to 23 percent range with only mild end checking and with slight cup in the unrestrained boards on the top of the pile. Air-dried 4/4 stock was kiln dried to 8 percent without degrade on a normal hardwood schedule. However, it was found necessary to use a very mild schedule for kiln drying green stock to avoid collapse.

One of the producers of angelique has reported successful use of a kiln schedule given in table 3 for green 4/4 flooring stock The drying time is 21 to 24 days. The temperature during the initial steaming is high enough to cause collapse in collapse-prone materials, so caution should be used if this procedure is followed. The producer reported that the cooling-off period was necessary to avoid bowing and crooking when the material was manufactured into flooring. Perhaps a good conditioning treatment, such as is given in Agriculture Handbook No. 188 (3), would achieve the same result.

Shrinkage

Shrinkage values for angelique are given in table 2.

Decay Resistance

Soil-block tests performed at Yale University (1,5) indicate that angelique is somewhat superior to teak and considerably superior to white oak in resisting white rot fungi. In resistance to brown rot it was inferior to teak but better than white oak. These comparisons pertain only to heartwood; sapwood is not decay resistant.

In tests made at the U.S. Forest Products Laboratory, the angelique samples sustained such small amounts of decay by even the most active fungus that it can be unqualifiedly classified for general consideration as very resistant. It would be expected to have superior resistance to fungus damage both in ground contact and in above-ground service. The test data reveal it to be comparable to black locust (Robinia pseudoacacia L.) in this respect.

With respect to commercial heating, the studies indicate that steaming of boat frames may Power the decay resistance of some woods moderately. Angelique was by far the least subject to heating effects of the nine durable woods tested at the U.S. Forest Products Laboratory.

Marine Borer Resistance

Angelique has a favorable reputation as resistant to marine borers in the Guianas, Panama Canal Zone, France, and the Netherlands. Wood after 15 years' exposure in borer-infested waters at Balboa, Canal Zone, showed little pholad attack and no significant damage by teredos (2).

Tests conducted at Harbor Island, N.C., and in Hawaiian waters generally confirm the favorable reputation of angelique in this regard. After 10 months' exposure at Harbor Island, small specimens showed no evidence of marine borer activity and after 15 months only moderate attack by teredo and pholads. This performance surpassed that of teak, and under the same conditions white oak specimens were heavily attacked within 6 months (6). Edmondson reports angelique as showing no infestation by teredo and limnoria after an exposure of 3 years in Hawaiian waters (2).

Termite Resistance

Experimental data on the termite resistance of angelique are rather meager. Wolcott's data (7) rate angelique as 44, which is comparable to walnut and white oak, with teak rated at 80 in its resistance to the West Indies termite. Local reputation indicates that the wood has considerable resistance to termite attack and that the rouge form is superior to the others.

Abrasion Resistance

Tests indicate that angelique is superior to teak and white oak in resisting abrasion. Service trials on the landing decks of aircraft carriers show that angelique wears at least as well as teak under these rigorous conditions.

Weathering Ability

When exposed to weathering without a protective coating, angelique develops characteristic hairline checks that cover practically all of the surface. This checking does not appear to become more extensive with time and is not disqualifying for most structural uses. The heartwood is quite resistant to moisture absorption and in this respect is comparable to white oak.

Fastening Strength

The Material Laboratory, New York Naval Shipyard, found that angelique holds wood screws at withdrawal loads about one-third greater than those of

teak and white oak. A similar relationship could be expected to apply for drift bolts, lag screws, and other types of fastenings, depending on frictional resistance.

Silica Content

The high degree of resistance of angelique to marine borer attack has been generally attributed to the relatively high silica content of the wood, This is one of the very few American legumes that accumulate silica, and in Dicorynia it occurs in the vertical parenchyma cells and in the marginal cells of the wood rays. The individual particles are generally about 0.001 inch in diameter. It has been reported that the rouge form lacks silica; however, every authentic specimen of all forms of angelique examined at the U.S. Forest Products Laboratory was found to contain silica. Judging from the reports of a number of investigators, the silica content is extremely variable and may account for the variation in machinability and borer resistance. Tests on individual specimens show a range of variation from 0.20 to 2.92 percent of the weight of the dry wood in the three forms of angelique.

Silica determinations made on the three forms of angelique at the U.S. Forest Products Laboratory are given in table 4.

Availability

Angelique is available in thicknesses from 4/4 to 16/4 and in average widths of about 8 inches; infrequently, boards are cut to a width of 18 inches. Poles and piling are readily available in 40- to 60-foot lengths. Timbers may be obtained in sizes up to 16 by 16 inches; however, the average for timbers is more commonly about 10 by 10 inches in lengths up to 33 feet.

Quartered lumber for ship and boat decking may be obtained in lengths of 14 feet and more, averaging 16 feet, and in widths up to 6 inches. Small quantities of wider material can be obtained on special order.

Lumber suitable for hull planking, sheathing, and inner planking is available in widths up to 10 inches, since flat-sawn material is permitted in these categories. Stress-rated grades may be obtained in lengths up to 18 feet and widths up to 10 inches and in thicknesses of 2, 3, and 4 inches. Larger sizes can usually be provided on special order.

Uses

Its strength and durability combined make angelique especially suitable for heavy construction, harbor installations, bridges, heavy planking for pier and platform decking, and railroad bridge ties. The heartwood is particularly suitable for ship decking, planking, boat frames, and underwater members. At the present time, small quantities of flooring are entering the United States market, and the wood is undoubtedly suitable for many other building uses.

Identifying Features

The characteristic color of angelique and the presence of ripple marks will generally separate this wood from those commonly used for heavy construction and ship building. The ripple marks are best seen on flat-sawn surfaces, and may be easily seen with the unaided eye. The ripples occur at the rate of 50 to 60 per inch along the grain, One Amazonian species (Androcalymma glabrifolium Dwyer) resembles angelique very closely. It, however, lacks the ripple marks and silica that are characteristic of angelique. The presence of silica in the vertical parenchyma and the marginal cells of the wood rays further insures the separation of angelique from other leguminous woods.

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Table 1.--Mechanical properties of angelique and some comparable hardwoods, teak and white oak

Property	Species		
	Angelique (*Dicorynia guianensis*)	Teak (*Tectona grandis*)	White oak (*Quercus alba*)
Moisture content			
Green.....percent	81	52	68
Air dry.....percent	12	12	12
Specific gravity -- Based on volume when green and weight when ovendry	0.62	0.58	0.60
Static bending			
Fiber stress at proportional limit			
Green.....p.s.i.	8,560	7,250	4,700
Air dry.....p.s.i.	12,980	8,160	8,200
Modulus of rupture			
Green.....p.s.i.	12,320	11,380	8,300
Air dry.....p.s.i.	18,590	13,770	15,200
Modulus of elasticity			
Green.....1,000 p.s.i.	1,920	1,580	1,250
Air dry.....1,000 p.s.i.	2,240	1,670	1,780
Work to proportional limit			
Green.....in.-lb. per cu. in.	2.06	1.89	1.08
Air dry.....in.-lb. per cu. in.	3.96	2.51	2.27
Work to maximum load			
Green.....in.-lb. per cu. in.	13.8	10.0	11.6
Air dry.....in.-lb. per cu. in.	14.2	±9.3	14.8
Compression parallel to grain			
Fiber stress at proportional limit			
Green.....p.s.i.	5,060	4,120	3,090
Air dry.....p.s.i.	7,160	5,180	4,760
Maximum crushing strength			
Green.....p.s.i.	5,750	5,490	3,560
Air dry.....p.s.i.	9,020	7,520	7,440
Hardness			
End			
Green.....lb.	1,300	900	1,120
Air dry.....lb.	2,010	1,010	1,520
Side			
Green.....lb.	1,290	980	1,060
Air dry.....lb.	1,510	1,100	1,360

Table 1.--Mechanical properties of angelique and some comparable hardwoods, teak and white oak (continued)

Property	Species		
	Angelique (*Dicorynia guianensis*)	Teak (*Tectona grandis*)	White oak (*Quercus alba*)
Compression perpendicular to grain			
Stress at proportional limit			
Green.....p.s.i.	1,110	1,040	830
Air dry.....p.s.i.	1,420	1,190	1,320
Tension perpendicular to grain			
Green.....p.s.i.	680	960	770
Air dry.....p.s.i.	540	980	800
Shear			
Green.....p.s.i.	1,390	1,300	1,250
Air dry.....p.s.i.	1,780	1,360	2,000
Toughness.....in.-lb.	151.2	84.4	144.9

[1] At moisture content of 11.2 percent.

Table 2.--Shrinkage values for angelique, teak, and white oak

Species and source	Shrinkage[1]		
	Radial	Tangential	Volumetric
	Percent	Percent	Percent
Angelique (*Dicorynia guianensis*) Surinam	4.6	8.2	14.0
Teak (*Tectona grandis*) Burma	2.3	4.2	6.8
White oak (*Quercus alba*) United States	5.3	9.0	15.8

[1] Shrinkage values represent shrinkage from the green to the ovendry condition expressed as a percentage of the green dimension.

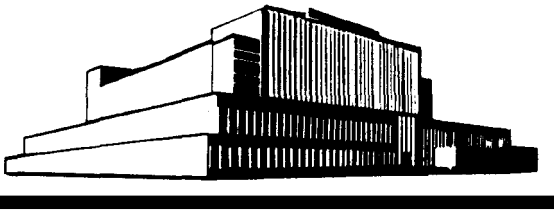
Table 3.--Kiln schedule for drying 4/4 angelique for flooring

Time	Moisture content	Temperature		Remarks
		Dry-bulb	Wet-bulb	
Days	Percent	°F.	°F.	
3		153	153	Initial steaming
	Above 30	129	120	
	30-25	134	123	
	25-20	140	123	
	20-15	145	123	
	15-10	149	120	
5				Cooling

Table 4.--Silica and ash content of angelique[1]

Form	Silica		Ash		Percent silica in ash
	Range	Average	Range	Average	
	Percent	Percent	Percent	Percent	
Blanc	0.22-0.80	0.52	0.59-0.89	0.77	67
gris	0.20-1.70	1.09	0.64-1.81	1.31	83
rouge	0.30-0.72	.51	0.43-0.77	.61	87

[1]Values based on ovendry weight of unextracted wood.



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