This document has been digitised by the Bodleian Libraries, University of Oxford as part of the Oxford Digital Library for Forestry (ODLF) project.

Digitisation of this document has been made possible through the support of the Andrew W. Mellon Foundation.

The original contents of this document remain the copyright of the University of Oxford (http://www.ox.ac.uk/).

For enquiries please contact: enquiries.rsl@bodleian.ox.ac.uk

C.F.I. OCCASIONAL PAPERS

CFI Occasional Papers
No. 9

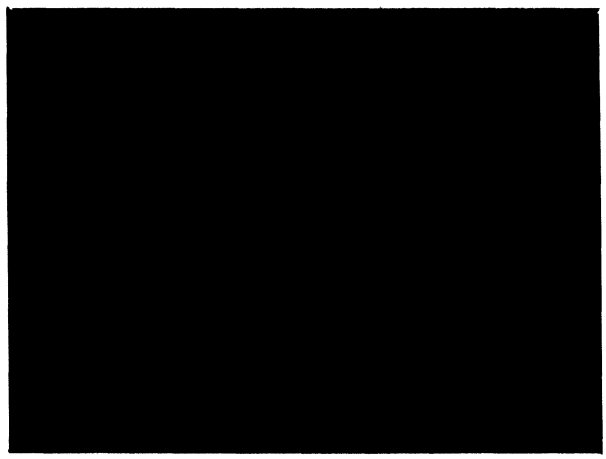
PERICOPSIS ELATA
(Afrormosia)

by

Peter Howland[1]

1979

DEPARTMENT OF FORESTRY
COMMONWEALTH FORESTRY INSTITUTE
UNIVERSITY OF OXFORD



CFI Occasional Papers
No. 9

PERICOPSIS ELATA
(Afrormosia)

by

Peter Howland[1]

1979

[1] Current address:- Research Officer,
British Technical Cooperation,
C/o Department of Forestry,
Babar Mahal,
Kathmandu,
NEPAL.

ISSN 0141-8181

This report was produced by Mr. Peter Howland during an attachment to the CFI from May to August 1979. During this time Mr. Howland was supported by the Ministry of Overseas Development to whom grateful acknowledgement is made.

It is hoped that this introductory paper to the species and its properties will provide useful background information for its further development. Ultimately, it is hoped that the monograph might be published in a more permanent form.

The species selection form shown on page 13 is taken from a forthcoming paper on the identification of species for plantations.

P.J. Wood.
July, 1979

Contents

	Page
Introduction	1
Background	1
Botanical description	2
The timber	3
The wood	3
Distribution	6
Silvics	8
Recommendations for future work	11
Conclusions	12
Figure 1. Sketch map of Central and West Africa showing the distribution of *Pericopsis elata*	13
Literature cited	16

Pericopsis (Afrormosia) elata (Harms) van Meeuwen

Introduction

Pericopsis elata is a gregarious tree of limited distribution in the moist, semi-deciduous forest of West and Central Africa. It is a valuable species; the wood being recognised as an excellent substitute for Teak (Tectona grandis L.f.) for ship and boat building and other purposes requiring high strength properties, stability and durability combined with an attractive appearance. It is also in demand for use in high class joinery, furniture, flooring and as a decorative veneer. Increasing demand for the timber has led to its rapid exploitation in all but the most inaccessible parts of the species limited distribution.

Since the early 1950s foresters in West and Central Africa - principally those serving in Zaire and in Ghana - have shown interest in the regeneration of the species, either by the encouragement of natural regeneration, by enrichment plantings, or through the establishment of plantations. However, few long term results have been published. The purpose of this note is to bring together all available published information, and to assess the potential for artificial regeneration in this species.

Background

A broad knowledge of the tree, including its taxonomy, anatomy, geographic distribution, timber properties and commercial importance is a useful background when formulating programmes of research and development. The following summary of readily available information provides a description of the tree, its timber and its distribution.

Nomenclature

Botanical name: Pericopsis elata (Harms) van Meeuwen Papilionaceae

Synonyms: Afrormosia elata Harms

Name change: Knaap van Meeuwen (1962) reduced Afrormosia to Pericopsis which now comprises five species, four of which occur in Africa:-

1a. P. angolensis (Baker) van Meeuwen, comb. nov. var. angolensis

1b. P. angolensis (Baker) van Meeuwen, var. subtomentosa (De Wild.) van Meeuwen comb. nov.

2. P. elata (Harms) van Meeuwen comb. nov.

3. P. laxiflora (Benth.) van Meeuwen comb. nov.

4. P. schliiebenii (Harms) van Meeuwen comb. nov.

Standard names: Afrormosia United Kingdom

Oleo pardo France

Other names:		
	Kokrodua	Ghana (Ashanti)
	Asamela	Ivory Coast
	Bohalala	Zaire (Bongoyie)
	Ole	Zaire (Turumbu)
	Obang	Cameroun
	Ayin	Nigeria (Yoruboa)
	Aneran	Nigeria (Benin)
	Elo Uta	Nigeria (Ibo)

Botanical description

First described by Harms in 1913, based on specimens collected in Cameroun, the morphology of the species has subsequently been described in a number of publications (Aubréville, 1936; Louis and Fouarge, 1943; Institut National pour l'Etude Agronomique du Congo, 1953; Hutchinson and Dalziel, 1958; Irvine, 1961 and Keay et al., 1964). The more recent distribution from Keay et al. is given below:-

"Tree to 120 ft (36.6 m) high and 10 ft (3 m) girth, sometimes larger, with massive spreading branches and a rather flat-topped crown. Bole often clean and straight for 60-80 ft (18-24 m) but sometimes twisted, with low blunt buttresses and often rather fluted above. Bark fairly smooth greyish or creamy, flaking off in large irregular patches and bright reddish-brown beneath; slash bright green at the surface, yellowish beneath turning reddish-brown. Branchlets drooping.

Leaves with the common stalk slightly grooved along the upper surface, 3-6 in (76-152 mm) long and with a very short swollen base; usually about 9 leaflets progressively enlarging upwards, the terminal one 2.5-3.5 in (63-89 mm) long by 1-1.5 in (25-38 mm) broad; leaflets elliptic, to ovate-elliptic, shortly and gradually acuminate, rounded or slightly cuneate at the base; thin, glabrous, with 5-10 pairs of very thin upcurving lateral nerves, vaguely looped well away from the margin, and a very close network of inconspicuous veins, leaflet-stalks stout, up to 0.25 in (6 mm) long, with a threadlike stipel at the base (2 beneath the terminal leaflet) sometimes nearly as long as the stalk and often persisting after the leaflet has fallen.

Flowers (Apr.) white to cream or greenish, appearing with the new leaves in slender panicles drooping at the ends of the shoots; individual flowers with slender stalks about 0.25 in (6 mm) long, calyx 0.25-0.3 in (6-7.5 mm) long, finely hairy, standard-petal almost circular.

Fruits (Dec.) very persistent, elongated, pointed at each end, 3-6 in (76-152 mm) long, 1-1.5 in (25-32 mm) broad, (occasionally larger), flat, brown, smooth, with a conspicuous network of veins between the thickened nerves running parallel to the margin; the wing along each margin about 0.1 in (2.5 mm) broad; pods not splitting open, sometimes slightly constricted between the 1-3 flat seeds."

Taylor (1960) reports that there is sometimes confusion between P. elata and Distemonanthus benthamianus Baill. arising because of the similarity in the colour (red) of the bole. He lists the following discriminatory characters:-

	P. elata	D. benthamianus
Bole:	Light colour, peeling off to leave rusty blotches.	Red, especially towards the top. Peels off on the lower part to leave light coloured marks.
Leaflets:	Stipellae present	Stipellae absent
Flowers:	S5 P5 A10 G1	S5 P5 A3+2 G1
Pod:	Marginal ridges present	Ridges absent
Seed:	Notched margin	Margin entire

The timber

General description. Rendle (1969) described the timber in general terms as a "high quality timber with an attractive appearance resembling a fine grained teak (Tectona grandis) L.f. but without the latter's oily nature. The heartwood is yellowish-brown, somewhat variable in shade as between one log and another, creating difficulties in matching. Unlike teak it does not bleach on exposure to the weather, but tends to darken with time."

This account does not differ greatly from numerous other independent descriptions (Institut National pour l'Etude Agronomique du Congo, 1966; Jay, 1968; Farmer, 1972).

The wood

Anatomy. Similarly its anatomy has been described by Desch (1951) and Nairn (ed.)(1957) although both report some past confusion with other species shipped under the trade name Afrormosia.

The description that follows is taken from Nairn (1957):-

"Growth rings: present

Vessels: diffuse, porous. Pores small to moderately small, barely visible to the naked eye; numerous, solitary and in radial groups; tending to be arranged in oblique undulating lines; simple perforations; deposits present.

Rays: fine, bare y visible to the naked eye, 1-4 (mainly 2-3) cells wide, up to about 20 cells high.

Parenchyma: paratracheal, confluent and some aliform. Crystals abundant.

Fibres: non-septate; thick-walled. Ripple marks present, all elements storied.

Physical and mechanical properties: Farmer (1972) describes the various properties of P. elata as follows:-

Colour: yellowish-brown, somewhat resembling teak but on exposure to light progressively darkening to dark brown.

Sapwood: clearly distinguishable from heartwood; light-coloured, rarely more than 25 mm (1 in) wide.

Grain: varies from straight to interlocked. Texture moderately fine.

Weight: from 620-780 kg/m^3 (39-49 lb/ft^3) averaging about 690 kg/m^3 (43 lb/ft^3) at 12% moisture content.

Chemical staining: dark stains liable to appear on the wood if it comes into contact with iron or iron compounds under damp conditions.

Strength: slightly higher than European beech. Jay (1968) reports it as appreciably stronger and harder than Teak.

Moisture content	Bending strength		Modulus of elasticity		Compression parallel to grain	
	N/mm^2	lbf/in^2	N/mm^2	1000 lbf/in^2	N/mm^2	lbf/in^2
Green	108	15600	11400	1650	53.8	7800
12 percent	134	19400	12500	1810	71.5	10350

Movement: small.

Moisture content in 90% relative humidity: 15%

Moisture content in 60% relative humidity: 11%

Corres onding tangential movement: 1.3% (5/32 in/ft)

Corresponding radial movement: 0.7% (5/64 in/ft)

Processing

Drying: Dries rather slowly but very well with little degrade apart from slight distortion

Kiln Schedule J.

Shrinkage: Green to 12% moisture content:
Tangential about 2.5% (5/16 in/ft)
Radial about 1.5% (3/16 in/ft)

Working properties: Interlocked grain affects many machining operations

Blunting: moderate

Sawing: rip-sawing - Saw type HR 54. Tungsten carbide tipping an advantage for long runs.
Cross-cutting - satisfactory apart from burning with saw type 3

Narrow bandsawing - satisfactory
Wide bandsawing - saw type B

Machining: Satisfactory provided cutting edges are kept sharp and timber is well supported during drilling and mortising. A cutting angle of 20° required to minimise tearing of interlocked grain in planing.

Nailing: Not satisfactory unless pre-bored.

Gluing: good

Wood bending: Inclined to distort during steaming and radii quoted cannot be achieved if small knots are present.
Classification: moderate
Radio radius/thickness for solid bends (steamed):
Supported: 14 Unsupported: 29
Limited radius for 3.2 mm (1/8 in) laminae (unsteamed): 165 mm (6½ in).

Plywood manufacture: Employed for plywood and usually available in the United Kingdom.
Movement: 4.5 mm plywood from 30% to 90% relative humidity: 0.14%
Surface splitting on exposure to weather - Grade II
Staining and polishing: satisfactory.

Durability and preservation: Insect attack: reported highly resistant to termites in West Africa.
Durability of heartwood: very durable.
Preservative treatment: extremely resistant.

Uses: Outstanding for small dimensional movement, high durability rating and good appearance combined with good strength properties and satisfactory working and drying properties. Suitable for a wide range of exterior and interior work such as boat building, joinery, furniture and flooring. Widely used as decorative veneer as well as in solid timber form."

The following publications provide additional information:-

Utilisation: Plywood: U.K., Forest Products Research Laboratory, 1952; woodwool: Ashiabor, 1973; particle board: Vital et al., 1974; flooring: U.K. Timber Research and Development Association, 1959; resistance to wear: Armstrong, 1951; gluing: Chugg et al., 1965.

Strength: Fouarge et al., 1953; Sallenave, 1964; Addo Ashong et al., 1975.

Seasoning: Lele, 1967.

Durability: Extractives: U.K., Forest Products Research Laboratory, 1963; Foxall and Morgan, 1963; Morgan, 1964; U.K., Forest Products Research Laboratory, 1965; resistance to attack: Eekhout, 1952; Bavendamm and Roch, 1970; Barnacle and Bentum, 1972; Oliver, 1974.

Testing, general: Centre Technique Forestier Tropical, 1974.

Distribution

General

P. elata is restricted to the drier parts of the moist, semi-deciduous forests of Central and West Africa. It is a semi-gregarious species with a limited and discontinuous distribution; sometimes locally abundant. It has a longitudinal range from about 3° 30'W to approximately 25° 00'E, i.e. 3,200 km and a latitudinal spread from nearly 8° 00'N in Ghana and Ivory Coast, to just north of the equator in Zaire, i.e. about 850 km. Within these limits P. elata is found in four major zones (see map). The most westerly occurance is in an area spaning the Ivory Coast/Ghana border at about 7°N where it is locally abundant in the Antiaris - Chlorophora forest type association (Aubréville, 1959; Taylor, 1960). Taylor also records its presence in two outliers in the Worobong Forest Reserve in the eastern part of Ghana. In Nigeria it is less common and has a more scattered distribution. According to Keay et al. (1964) it occurs in western Nigeria at Ilaro; in the mid-western parts at Asaba, on the Niger river; and in the eastern areas at Abakaliki, Obubra, Ukpon Bende, Iyamoyong, Ogoja, Yache and Gabu. Unwin (1920) also records it growing in the Benin, Ondo, Oweri and Calabar provenances. It Cameroun it is said to occur in the southeast in the upper Nyong and Boumba-Ngoko catchment area (Centre Technique Forestier Tropical, 1956; Reidar, 1975). It has also been located in the nearby forests of the Moloundou and Quesso districts in Northern Congo (Reidar, 1975). Finally, its most eastern occurence is in Zaire, in the forests of the Yangambi-Banalia-Kiangani area (Louis and Fouarge, 1943).

The species is most abundant in the Ivory Coast/Ghana and Zaire zones.

Ecology

The species would appear to lie entirely within the Guinean equatorial ecological zone at elevations of 150-300 m at its western extremity (Ivory Coast and Ghana) to 500-1000 m in Cameroun, Congo and Zaire. In Nigeria, it is said to occur below 100 m altitude (Keay et al., 1964). It is found in the 1,000-1,500 mm rainfall zone throughout much of its range; the average annual amount tending to increase from west to east. This trend is related to differences in the rainfall, distribution pattern, which is characteristically of the 'two peak' type in Ivory Coast, Ghana and Nigeria; changing progressively to a single, extended rainfall season, in Cameroun, Congo and Zaire. Temperatures are generally equable, the mean maximum being about 30°C and the mean minimum around 20°C.

Thus the distribution pattern comprises a series of apparently genetically isolated sub-populations growing in two, or more, distinct ecological sub-zones. It is not known if their isolation is comparatively recent in evolutionary terms, but variation could be expected, and this should be tested at an early opportunity.

Likely major provenances would appear to be:-

1) Ivory Coast/Ghana zone
2) western Nigeria

3) eastern Nigeria
4) eastern Cameroun/Congo
and 5) Zaire: the two most important being provenances 11) and 5).

Within these major groups, variation might still be expected to be random but normal provenance trial procedures would quickly detect if there was any useful local variation within these groups (Burley and Wood, 1976).

Position in the timber trade

The wood was little known to the trade before World War II and Jay (1968) reports that the earliest shipments from Ghana were made in 1948. Since that time exploitation has been rapid (Table 1); the bulk (90%) of exports coming from Ghana and the Ivory Coast (Table 2).

Table 1. Export trends for round and sawn wood (1,000 m^3) of Pericopsis elata

Data taken from statistics published by the Organisation for Economic Cooperation and Development (1955-68) and Erfurth and Rusche (1976).

Year	55	56	57	58	59	60	61	62	63	64	65	66	67	70	73
Round wood	4	5	6	9	27	54	55	40	91	91	64	78	66	62	23
Sawn wood	-	-	-	-	-	-	39	-	39	49	37	36	29	38	29

Table 2. Export of round and sawnwood (1,000 m^3) by countries for selected years

Data taken from Erfurth and Rusche (1976): Data in ( ) authors unpublished results.

		Ivory Coast	Ghana	Nigeria	Cameroun	Congo	Zaire	Total
Round wood	1961	4	49	-	-	1	-	54
	1970	37	21	(0.07)	-	4	-	62
	1973	8	12	-	0.7	2	3	26
TOTAL		49	82	(0.07)	0.7	7	3	142
Sawn wood	1961	-	37	-	-	2	-	39
	1970	16	21	(0.07)	-	1	-	38
	1973	11	15	-	0.4	2.4	1.8	30
TOTAL		27	73	(0.07)	0.4	5.4	1.8	107

However, these data take no account of timber utilised in the local markets which has increased sharply in recent years.

Estimates of the extent of future supplies of P. elata are difficult to come by but Reidar (1976) quotes several F.A.O. or country sponsored forest inventories which indicate that the supply of accessible trees is likely to be limited. Moreover, the surveys reveal a shortage of individuals in the smaller size classes. These data would appear to confirm the views held by Aubréville (1938) and Taylor (1960), that natural regeneration in this species

is unreliable, and recruitment to the exploitable intermediate and larger size classes often inadequate. It was this last feature which stimulated research into the silviculture of the species.

SILVICS

Phenology

The flowering and fruiting patterns are the same throughout the species range (Gilbert and Wagemans, 1944; Taylor, 1960). Flowering occurs in April-May at the beginning of the main rainy period and pods start to form in May but do not ripen until August-November towards the end of the rainy season. However, flowering and fruiting intensity has been shown to be irregular (Gilbert and Wagemans, 1944). In their 7 year study of fruit production on three geographically separate trees, no fruit was produced in 2 years and individual tree yields were variable in other years. During the period of their study, the three trees produced a total of 12,000, 22,000 and 12,500 fruits respectively.

Natural regeneration

Seeding levels, although erratic, would appear to be adequate for natural regeneration purposes. A number of authors report years of abundant germination in this species: in the Congo (Louis and Fouarge, 1943; Pieters, 1958 and Donis, 1958) and in Ghana (Ghana Forest Products Research Institute, 1968) although, as previously noted, Taylor and Aubréville state that natural seedlings are "remarkably rare", despite apparently adequate seed production. In this context, Gilbert (1948) reports that a good seed year occurred in the Congo in 1938, but with only rare subsequent germination.

Thus it would appear that there are three types of seeding year: 1) no seed produced, 2) adequate seed production but poor and limited germination and 3) adequate seed production and subsequent germination.

It was clear that in the long term, the supply of viable seed was not a factor limiting natural regeneration and this promited a number of workers to examine the light requirements for successful germination and subsequent development of natural seedlings.

Light requirements

Pieters (1948) studied the germination and subsequent development of P. elata seed sown in artificial conditions under five different lighting intensities (9, 20, 40, 50 and 100% of full light). Germination was excellent (64-71%) under all but the full light exposure where no germination occurred. Germination was rapid (11-13 days) tending to be faster under the more shady conditions. The best subsequent growth occurred where seedlings were raised under light intensities of 40 and 50% of full light. Height growth under these conditions ranging from 1) undisturbed full canopy, through 2), 3) and 4) increasing canopy opening, to 5) no overhead canopy, gave similar results. Germination of surface sown pods ranged from 29 to 22% under all but full light conditions where only 4% of fruits produced seedlings. Here also germination was noted to be more rapid under the more shady conditions. Subsequent mortality was assessed after 38 weeks and at that time the highest losses (64%) were recorded under full shade and least under conditions of partial shade. The best results for survival and growth occurred in the

canopy treatment where all the non-commercial trees had been killed and under these conditions 18% of the surviving seedlings attained a height of 0.75 m in the first year; weeding, however, was necessary.

Later, Ampofo and Lawson (1972) studied the effect of light on the growth and morphology of 3-4 week old P. elata seedlings planted under three different light intensities (7, 18 and 100% of full light). Adequate water and freedom from competition were ensured in all treatments. Under conditions of full shade they discovered that the general growth of seedlings, in a 6 month period, was significantly reduced: stem diameter increase was markedly less (60%), the number and area of leaves significantly reduced, root development was poorer and root nodulation low. Growth was best under a relative light intensity of 18% and they conclude that, since average forest floor light intensities are of the order of 2% or less, the silvicultural system of post exploitation canopy reduction would appear to be beneficial to the natural regeneration of P. elata.

Thus it appears that P. elata germinates best under shady conditions, but thereafter is increasingly light demanding. Canopy opening and release from competition are essential treatments for optimum growth.

Enrichment plantings

Maudoux (1958) describes field trials (10 ha) where seedlings of P. elata raised in flying nurseries were group planted at 20 m espacement; groups being 49 plants at 0.5 m espacement. Initial establishment was excellent (90-100%) but plants needed to be released from competition during the first 7 months. In 3½ years the mean height of the tallest seedlings was over 2 m. Donis (1958) also reports the successful outcome of some enrichment trials and records the mean height growth of P. elata as up to 9.5 m ($\bar{h}$ 4.5 m) and diameters up to 119 mm ($\bar{d}$ 51 mm) in 13 years.

Some enrichment plantings were undertaken in Ghana (82 acres) in 1956 and 1957 which included P. elata (Ghana, Forestry Department, 1957) and general establishment levels of 80% were obtained. In a later report (Ghana Forestry Department, 1959) reference was made again to P. elata in line plantings and growth was said to be vigorous, but at 3.7 m, the trees still had a bush-like form.

Plantation trials

Records of plantation establishment are rare. Donis (1958) records the growth of P. elata in the Yangambi Arboretum at 16 years as 26.5 m max. height ($\bar{h}$ 14.5 m) and 970 mm max. diameter ($\bar{d}$ 130 mm).

The Ghana Forestry Department considered P. elata to be a most promising plantation species reporting that it is easy to handle in the nursery, plants out well and that given ample light early growth is vigorous. Although the form is initially bush-like a main stem does eventually develop. Unfortunately, supplies of viable seed are said to be difficult to obtain (Ghana Forestry Department, 1960).

P. elata has also been included in the species trial programmes run by the Forest Products Research Institute of Ghana and the species has been included in trials planted at sites representing different ecological zones at Pra-Anum, Subri and Afram Headwaters. (Ghana Forest Products Research

Institute, 1965, 1968, 1971, 1973.) At Pra-Anum 7 year old plantation grown P. elata were reported to have a mean height of 8 m and a diameter of 92 mm and at Afram Headwaters 4 year old trees were 1.7 m tall and 43 mm diameter.

In these, and in other reports, frequent reference has been made to the poor-bushy form of most young trees. A study made of the developmental anatomy and morphology of such young plants demonstrated that the initial 'sprawling' nature of P. elata was not due to environmental factors and therefore the bushy pattern of growth is a characteristic of the species. Furthermore, studies of the cell wall arrangement showed nothing that would account for the 'drooping' habit, although the presence of much reaction wood was established.

It would appear from these preliminary results that the species can be directly established into the forest using standard enrichment, direct sowing or planting, techniques (see Parry, 1956 for description of techniques) optimum survival and subsequent growth, however, depends on providing the young plants with ample light and freedom from competition. The establishment of plantations using nursery raised seedlings would also appear feasible.

Pests and diseases

Little appears to be known about the possible problems that might arise if larger scale introductions of P. elata are made, especially at plantation densities. Kudler (1967) describes two insect pests which attack P. elata. The first is a shoot borer Doliopygus sp., but attacks were of short duration being for feeding purposes only, the infestation stops as soon as the larval stage is passed. Such attacks could contribute to the bushy nature of young trees but this, as previously mentioned, is not considered to be the main causal factor. The second insect, Lamprosema lateritalis Hamps. is a more serious pest and Kudler describes a severe defoliation of both nursery seedlings and 5 year old plantation trees that occurred in 1965. Successive defoliations were recorded and Kudler is of the opinion that the insect could become a serious menace to P. elata plantations.

Tree improvement

P. elata has been included in the tree improvement programme for Ghana. It was selected on the basis of its relative commercial importance; its potential as a possible plantation species, and on the desire to improve on the poor stem form frequently found in mature natural trees. (Jones, 1966, 1969). A number of candidate plus trees have been selected (Britwum, 1970) but attempts to centralise this material by grafting had not been successful. However, stem cuttings taken from a 4 year old tree were successfully rooted and developed into normal plants. This was an extremely promising development which could be of value in studying the cause of poor form in the early growth stages (Jones, 1966). The potential for using rooted cuttings as an alternative means of raising planting stock should be investigated further, particularly in view of the difficulties reported in obtaining a regular supply of viable seed.

Potential for growing P. elata

Increasing demands for wood and wood based products have led to over exploitation of the so-called "economic species" (P. elata included) in much of the tropical high forests of West and Central Africa, where harvests now often exceed the increment of the growing stock (Baidoe, 1976). Systems of

forest management which depend upon natural regeneration to maintain and enhance the growing stock have proved difficult and expensive to operate; it is only where the established stocking of "economic species" is adequate (50-100/ha), that a selection system of silvicultural management has proved satisfactory (Wyatt-Smith, 1968; Lowe, 1975; Britwum, 1976). Consequently there has been a shift from natural to artificial regeneration methods, using mostly the fast growing, and more light demanding, of the economic species. Natural regeneration systems of management are not therefore recommended for P. elata. But, because it is a high value, light demanding, species, capable of rapid growth (classed with Lovoa trichilioides and Triplochiton scleroxylon by Jacks, 1958 in Baidoe 1976) it is possibly a suitable candidate for artificial regeneration purposes.

P. elata has been successfully established on a small scale, in both enrichment plantings (line and group methods) in Zaire and Ghana and in taungya and direct plantations in Ghana. The early form was characteristically poor, but growth was healthy and vigorous. The initial promise shown by this species should now be more fully tested.

Recommendations for future work

Background knowledge:

1) Provenance research. In view of the discontinuities in the species distribution patterns, provenance testing could be highly rewarding, and an early start to this work is recommended. The international nature of such work is already apparent and properly designed trials will require the cooperation of the Forest Departments of six west and central African countries: Ivory Coast, Ghana, Nigeria, Cameroun, Congo and Zaire.

2) Field trials. It is further recommended that large scale field trials be undertaken wherein the comparative success and costs of the different methods of establishment may be determined. The trials should include enrichment planting, by line and group planting methods, directly compared with plantations, raised under taungya and direct methods of establishment. The trials should be sufficiently large to provide reliable estimates of seed collection, nursery, and field establishment costs. Ideally trials should be replicated locally and at different parts of the species east/west range. It would be valuable to include some Teak plantings in the trial for comparative purposes.

Special studies

3) Seed supplies. One of the essential requirements for a plantation species is that viable seed should be plentiful. At present little is known about the phenology of P. elata but the results from the few studies made would indicate that flowering and fruiting may be irregular and unreliable. Moreover the viability of seed crops is often suspect.

A simple, in depth, study designed to establish the characteristic flowering and fruiting patterns and seed viability in P. elata should have a high priority. The possibilities for long term storage of seed should also receive early attention.

4) Vegetative propagation. The potential for using vegetative propagation for the production of planting stock should be fully explored.

The international aspects of these proposals make this programme of research a suitable scheme for international technical cooperation and aid.

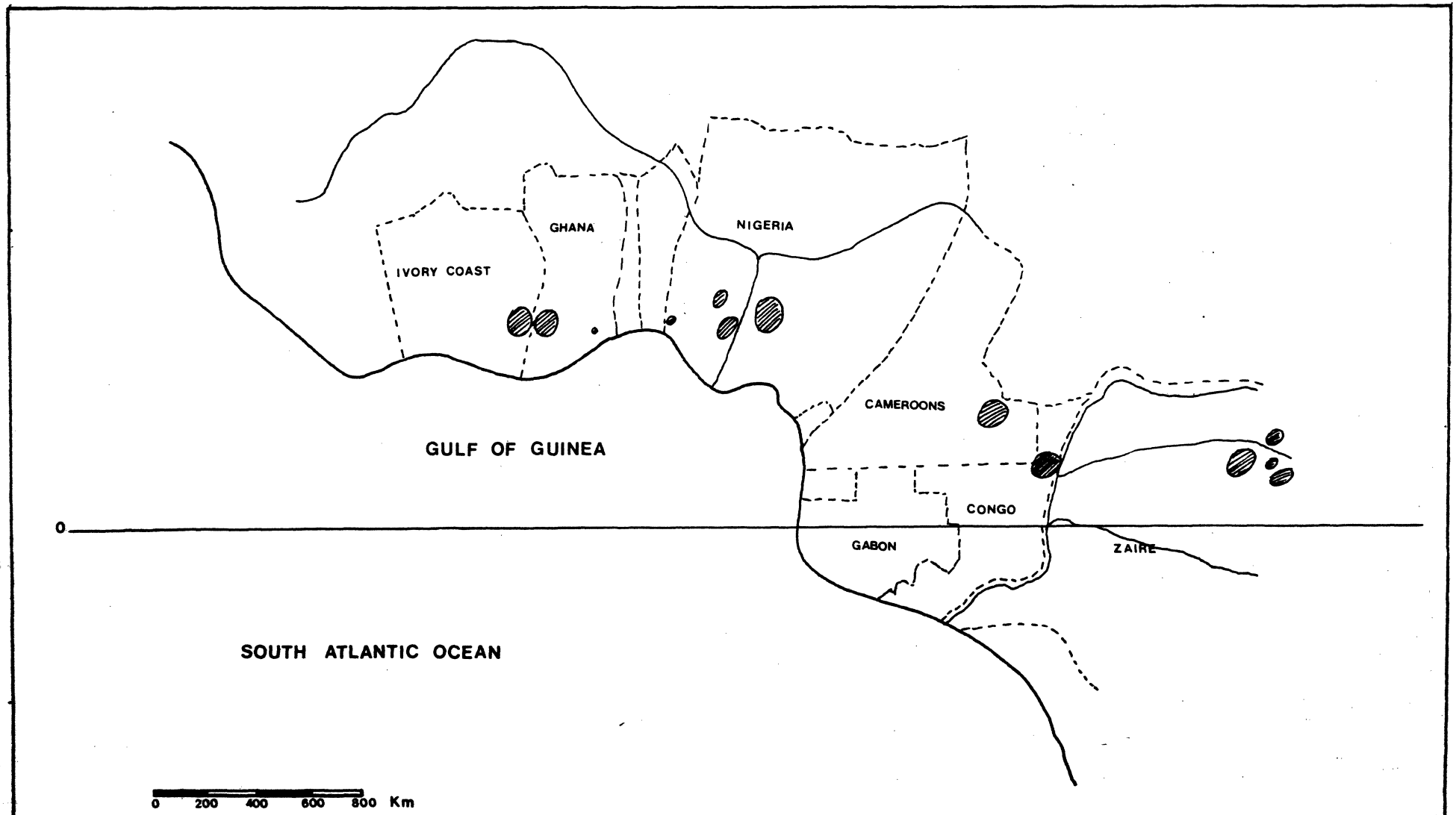
Conclusions

Demands for high quality timber will continue and can be met for some time from the natural forest although the productivity of such forest is now known to be inadequate. Steps need to be taken now to ensure future supplies, through the establishment of timber crop plantations on high quality sites. P. elata has been suggested as a promising species for this purpose and present evidence would appear to justify further large scale field trials. Moreover international cooperation among producer countries in the planning and execution of uniform trials would maximise the benefits accruing from such work. For example the performance of different geographically widely separate provenances could be scrutinized simultaneously in several West and Central African countries, thus providing a sounder basis for interpreting the performances of the different silvicultural systems under test.

These and other considerations make the proposed programme of research a suitable area for international aid and cooperation.

FIG.1 SKETCH MAP OF CENTRAL AND WEST AFRICA

SHOWING THE DISTRIBUTION OF PERICOPSIS ELATA.



species: PERICOPSIS ELATA	prov. or var:
synonyms: AFRORMOSIA ELATA	local names: Afrormosia, Kokrodua, Asamela

1. CLIMATE

Latitude:

1.	tropical	√
2.	subtropical	

Altitude:

3.	0-500 m	√
4.	500-1500 m	
5.	1500-2500 m	
6.	2500 m	

Annual rainfall:

7.	250-400 mm	
8.	400-650 mm	
9.	650-1000 mm	
10.	1000-1600 mm	√
11.	1600 mm	

Rainfall regime:

12.	Winter	
13.	Summer	√
14.	Uniform	

Dry season:

15.	2 months	
16.	2-4 months	√
17.	4-6 months	
18.	6 months	

Temp. mean max.

19.	20°C	
20.	20-25°C	
21.	25-30°C	√
22.	30°C	√

Temp. mean min.:

23.	0°C	
24.	0-10°C	
25.	10-20°C	√
26.	20°C	√

2.3. SOIL/SILVICULTURE

Texture:

1.	heavy (clay	
2.	medium (loam)	
3.	light (sandy)	√

Soil reaction:

4.	acid pH 6	
5.	neutral ph 6-7.5	√?
6.	alkaline pH 7.5	

Other soil characters:

7.	Seasonal w/log	
8.	Salinity	

Volume, m^3/ha/an

1.	I = 5	N/A
2.	I = 5-10	
3.	I = 10-20	
4.	I = 20	

Diameter increment:

5.	1 cm/an (sapling)	√
6.	1 cm/an	

Size:

7.	Large tree 30 m	√
8.	Tree 10-30 m	
9.	Shrub 10 m	

Form:

10.	Exceptional	
11.	Acceptable	√

Other silv. char.:

12.	Coppices	
13.	Fire resistant	
14.	Resist. to termites	
15.	Underplanting	
16.	Amenity value	

4. TIMBER & UTILISATION

Relative density at 12% mc

1.	0.45	
2.	0.45-0.75	√
3.	0.75	

Natural durability:

4.	Very durable	√
5.	Mod. durable	
6.	Non durable	

Other timber charact.:

7.	treatability	
8.	seasons easily	√
9.	saws easily	√
10.	machines easily	√
11.	nails/screws easily	
12.	interlocked grain	√
13.	fissile	
14.	tough	

Utilization:

15.	construction	√
16.	veneer	√
17.	marine use	√
18.	transm. poles	
19.	building poles	
20.	light construct.	
21.	boxes/shuttering	
22.	decorative	√
23.	pulp	
24.	posts	
25.	fuel/charcoal	
26.	fodder	
27.	resins, etc.	

Details of tree: (Growth characteristics, evergreen/deciduous, light requirements, etc.)

A large, dominant deciduous tree of the semi-deciduous forest of west and central Africa 36 m high; 3 m girth, massive spreading branches; clean straight bole. Initially shade bearing but rapidly becoming light demanding. Prostrate form when young but eventually produces a main stem.
Flowers: April-May Fruit:- August-November

Seed and nursery technique: (Seed sources, weight, viability and storage, nursery requirements, planting stock)

Seeds: 128/oz 4.5/gm
Germination: 8 days
Handling: raised successfully in Ghana and Zaire nurseries without problems.

Other characteristics: (Silviculturally similar or related species, special site requirements

Diseases and Pests:

Shoot borer: Doliopygus sp. (feeding attacks only)
Defoliation: Lamprosema pateritalis (serious)

Experience as an exotic:

NIL

Principal references:

Literature cited

Addo-Ashong, F.W., Bentum, A.L.K. and Ashiabor, W.K. (1975): Construction and decorative timbers of Ghana. Bull. 3, For. Prod. Res. Inst., Ghana.

Armstrong, F.H. 91951): Abrasion tests on some recently introduced hardwoods. Wood, 1951, 16 (11) 418-9).

Ashiobor, W.K. (1973): Suitability of some Ghanaian wood species for the manufacture of cement bound wood wool building slabs. Tech. Note No. 17, For. Prod. Res. Inst., Ghana.

Aubréville, A. (1936): La flore forestière de la Côte d'Ivoire. Larose Editeurs, Paris 2, France

Aubréville, A. (1938): La Forêt coloniale. Les Forêts de l'Afrique-Occidentale francaise. Ann. Acad. Sci. Vol. 10.

Aubreville, A. (1950): Flore forestière, soudano-Guméumne. Soc. d'Editios Geographique, Paris.

Aubreville, A. (1959): La flore forestière de la Côte d'Ivoire Publ. Cent. Tech. For. Trop. No. 15 (2nd ed. rev.)

Baidoe, J.F. (1976): Yield regulation in the high forest of Ghana. Ghana For. J. (1976) 2 (22-27)

Barendamm, W. and F. Roch (1970): /Investigations on the natural resistance of tropical woods to marine borers/ Holz Roh-u Werkstoff 1970 28 (3) (105-7).

Barnacle, J.E. and Bentum, A.L.K. (1972): Performance of wood and preservatives in marine environment. Marine exposure test of timber species grown in Ghana - a summary and interpretation of test data from various countries. Prog. Rep., For. Prod. Res. Inst., Ghana.

Britwum, S.P.K. (1970): Preliminary selection of provision plus trees in the tropical high forest. Tech. News Lett., For. Prod. Res. Inst., Ghana. 4 (2) (5-7).

Britwum, S.P.K. (1976): Natural and artifical regeneration practices in the high forest of Ghana. Ghana For. J. (1976) 2 (45-49).

Burley, J. and Wood, P.J. (Comp.) (1976): A manual on species and provenance research with particular reference to the tropics. Trop. For. Pap., Dept. of For., Oxford Univ. 1976. No. 10.^

Centre Technique Forestier Tropical (1956): Asamela. Bois Forêts Tropiques, No. 50, 1956. Paris.

Centre Technique Forestier Tropical (1974): Investigations and tests carried out on tropical timber by several Research Laboratories. Cent. Tech. For. Trop., Paris.

Chugg, W.A., Wood. T. and James, P.E. (1965): The gluability of hardwoods for structural purposes. Res. Rep. Timb. Res. Dev. Ass. London. E/RR/22.

Desch, H.E. (1949): Teak alternative. Timb. Plywood 1949, 97 (2505) (62-64).

Desch, H.E. (1951): Manual of Commercial Timbers, Vol. 1. Crockham Hill, Ken (Private publ.).

Denis, C. (1958): La forêt dense Congolaise et l'etat actual de sa sylviculture. Trop. Silv. III, F.A.O., Rome.

Eeckhout, L.E. (1952): /Durability tests of Congolese woods/ Meded. Lab. Houttechnol., Gent, No. 9. 1952.

Erfurth, T. and Rusche, H. (1976): The marketing of tropical wood: Wood species from African tropical moist forests. For. Dept. F.A.O., Rome.

Farmer, B.A. (1972): Handbook of hardwoods. H.M.S.O., London.

Fouarge, J. et al. (1953): Bois du Congo. Inst. Natn. Etude Agrom. Congo. Brux. Belg.

Foxall, C.D. and Morgan, J.W.W. (1963): Extractives of Afrormosia elata (Pericopsis elata). J. Chem. Soc. 1963 (Nov.) 5573-5).

Ghana. Forest Department. (1957): Annual report of the forestry dept., 1957. Government Printers, Accra.

Ghana. Forest Department. (1959): Annual report of the forestry dept., 1959. Government Printers, Accra.

Ghana. Forest Department. (1960): Annual report of the forestry dept., 1960. Government Printers, Accra.

Ghana. Forest Products Research Institute. (1965): Annual report of the For. Prod. Res. Inst., 1965. Ghana Academy of Sciences, Accra.

Ghana. Forest Products Research Institute. (1968): Annual report of the For. Prod. Res. Inst., 1968. Ghana Academy of Sciences, Accra.

Ghana. Forest Products Research Institute. (1971): Annual report of the For. Prod. Res. Inst., 1970-71. Ghana Academy of Sciences, Accra.

Ghana. Forest Products Research Institute. (1973): Annual report of the For. Prod. Res. Inst., 1972-73. Ghana Academy of Sciences, Accra.

Gilbert, G. and Wagemans. (1944): Observation sur la biologie des essences forestières. Rapp. Inst. nat . l'Etude Agron. Congo. Congo Belge.

Gilbert, G. (1948): Observation sur la biologie des essences forestière. Rapp. Inst. nat . l'Etude Agron. Congo. Congo Belge.

Harms, H. (1913): Leguminosae africanae. VI. in Engler Botanische Jahrubucher XLIX (1913) (430).

Hutchinson, J. and Dalziel, J.M. (1958): Flora of West Tropical Africa. Crown Agents, London.

Institut National pour l'Etude Agronomique du Congo. (1953): Flore du Congo Belge et du Ruanda-Urundi: Vol. IV. Spermatophytes. Inst. natu. l'Etude Agron. Congo. Brux. (42-5).

Institut National pour l'Etude Agronomique du Congo. (1966): Bois du Congo. Inst. natu. l'Etude Agron. Congo.

Irvine, F.R. (1961): Woody plants of Ghana. Oxford Univ. Press, London.

Jay, B.A. (1968): Timbers of West Africa. T.R.A.D.A., High Wycombe, England. (Revised.)

Jones, N. (1966): Tree selection and seed improvement in Ghana. Tech. Note No. 1, For. Prod. Res. Inst., Ghana.

Jones, N. (1969): The relationship between the form and value of some tree species in West Africa. Tech. Note No. 9, For. Prod. Res. Inst., Ghana.

Keay, R.W.J., Onochie, C.F.A. and Stanfield, D.P. (1964): Nigerian trees. Fed. Gov. Print., Lagos.

Kinloch, D. and Miller, W.A. (1949): Gold Coast Timbers. For. Dept. Ghana, Takoradi, Ghana.

Knaap van Meeuwen, M.S. (1962): Reduction of Afrormosia to Pericopsis (Papilionaceae). Bull. Jard. Bot. Brux. 1962 32(2) (213-9).

Kudler, J. (1967): Problems of forest insect defoliators in Ghana. Proc. 14th Congr. IUFRO, Munich 1967, Pt. V, Sect. 4 (618-28).

Lamb, G.N. (1950): Foreign woods - origin, use, properties and nomenclature. Wood Prod. 1950 55(7) (26-7).

Lele, D. (1967): Working out a seasoning schedule for Afrormosia and Finnish Birch. Faip. Kutatas, Budapest, 1967 (1/2) (87-99)

Louis, J. and Fouarge, J. (1943): Essences forestières et bois du Congo. Inst. natu. l'Etude Agron. Congo. Brux.

Lowe, R.G. (1975): An appraisal of silviculture practices to meet wood requirements in Nigeria. Obeche (1975) 11 (26-37).

Morgan, J.W.W. (1964): 4-Hydroxy-N-methyl-L-proline from Afrormosia elata heartwood. Chem. Ind. 1964 (13) (542-3).

Nairn, P. (Ed.) (1957): Wood specimens: A second collection. Tothill Press, London.

Okigbo, L. (1964): Some Nigerian Woods. 2nd ed. Fed. Min. of Info., Lagos.

Oliver, A.C. (1974): Timber for marine and fresh water construction. Timb. res. dev. ass., High Wycombe, England. (Revised.)

Organisation for Economic Co-operation and Development (1955-68). Tropical timbers: detailed statistics on production and trade. Org. Econ. Co-op. & dev., Paris, France.

Parry, M.S. (1956): Tree planting practices in tropical Africa. Dev. pap. No. 8, FAO, Rome.

Persson, R. (1975): Forest Resources of Africa: part I, country descriptions. Inst. For. Skogshogskolan, NR18, 1975.

Pieters, A. (1958): Premiers resultats de quelques etudes particulieres sur la regeneration naturelle en forêt dense equatoriale. Proc. 2nd Conf. For. Interafric., Pointe Noire 1958, Vol. 1.

Rendle, B.J. (1969): World timbers: Europe and Africa. Ernest Bern Ltd., U.K.

Sallenave, P. (1964): Physical and mechanical properties of tropical timbers. Publ. 23, Cent. Tech. For. Trop., Nogent-sur-Marne, Paris.

Taylor, C.J. (1960): Synecology and silviculture in Ghana. Thomas Nelson & Sons, Ltd.

U.K., Forest Products Research Laboratory (1952): Trials of timber for plywood manufacture. Progress Rep. 17. Preliminary report on six African species. Princes Risborough, U.K. For. Prod. Res. Lab.

U.K., Forest Products Research Laboratory (1963): Wood extractives: Afrormosia (P. elata). Rep. Dir. For. Prod. Res., London, 1962 (11).

U.K., Forest Products Research Laboratory (1965): Wood extractives: natural durability. Rep. Dir. For. Prod. Res., London, 1964 (12).

U.K., Timber Research and Development Association. (1959): Wood flooring. (Revised.) Timb. res. dev. ass., High Wycombe, U.K.

Vital, B.R., Lehmann, W.F. and Boone, R.S. (1974): How species and board densities affect properties of exotic hardwood particle boards. For. Prod. J. (1974) 24 (12) (37-45).

Wyatt-Smith, J. (1968): Determination of a cutting period for T.H.F. in Nigeria. Obeche (1968) 4 (36-48).