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Form Factor, Yield, Structure and Properties of Shanthabye (*Eucalyptus grandis*) Planted in Burma

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Forest Research Institute
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မြန်မာနိုင်ငံတွင် စမ်းသပ်စိုက်ပျိုးခဲ့သော ရှမ်းသပြေသစ်၏ သစ်ထွက်နှုန်း၊ သစ်အင်္ဂါနှင့် သစ်ဂုဏ်သတ္တိများ

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စာတမ်းအကျဉ်းချုပ်

ရှမ်းသပြေသစ်မျိုးအား စမ်းသပ်စိုက်ခင်းအဖြစ် လွန်ခဲ့သော(၁၀)နှစ်ကျော်က စမ်းသပ်စိုက်ပျိုးခဲ့ပါသည်။ လတ်တလော မျက်မြင်အနေအထားအားဖြင့် ၄င်းသစ်မျိုးသည် ပေါက်ရောက်မှုနှုန်းကြီးထွားမှုကောင်းသည်ကို တွေ့ရပါသည်။ သို့သော် ယခုအချိန်အထိ မြန်မာပြည်တွင် စိုက်ထားသော ရှမ်းသပြေ၏ ကြီးထွားမှုနှုန်း ဂုဏ်သတ္တိများအား သုတေသနပြုဖော်ထုတ်ခဲ့ခြင်း မရှိသေးပါ။ သို့ပါ၍ မျှော်မှန်းသကဲ့သို့ ထင်းစိုက်ခင်းအဖြစ် သင့်မသင့်သိသာရန်၊ ၄င်းသစ်၏ ထင်းထွက်နှုန်းနှုန်းကြီးထွားမှုကို သုတေသနပြု၍ စာတမ်းပြုစုထားပါသည်။ ထို့အပြင် စီးပွားရေးအရ စိုက်ခင်းအပေါ် လေ့လာတင်ပြထားသည့်အပြင် ၄င်းသစ်၏ဂုဏ်သတ္တိများကို စမ်းသပ်ဖော်ထုတ်၍ ၄င်းသစ်၏ မူရင်းဒေသထွက် သစ်၏ဂုဏ်သတ္တိများနှင့် နှိုင်းယှဉ်ဖော်ပြထားပါသည်။

Form Factor, Yield, Structure and Properties of Shanthabye (*Eucalyptus grandis*) Planted in Burma

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Abstract

Shanthabye was introduced into this country as a trial species in plantation. Observations showed growth characteristics of Shanthabye to be highly satisfactory. Comprehensive studies on growth properties of the planted timber have yet to be made. This paper presents the results of yield studies of over 10-year-old Shanthabye and an analysis of the rate of return. In addition, a comparison of the mechanical physical and anatomical properties of this species with several native grown species are presented.

Contents

1. Introduction

The eucalyptus are tree species well known to the developing world. Eighty countries have reported interest in genus due to its many uses, for sawnwood, pulpwood, wood-based panels, poles and post, as well as for environmental and amenity planting. Eucalyptus is also becoming important in the production of fuelwood resources for its excellent combination of specific gravity and volume production. (FAO, 1979).

Burma is one of the countries interested in promoting eucalyptus. The Forest Department has been establishing plantations of fast growing eucalyptus since 1922, as well as valuable indigenous species such as Teak (*Tectona grandis*) and Pyinkado (*Xylia dolabriformis*). [1*]

Shanthabye (*Eucalyptus grandis)* was one of the eucalyptus species first introduced into Burma at Maymyo, from Australia, for trials starting in 1966-67. The objectives of these plantation trials were to find out whether eucalyptus adapts well to Burmese climatic conditions and to identify its potential end-uses to meet the increased demand for forest products as a result of population increase and the need of raw material by industry.

This study is an assessment of the growth, from and yield, the anatomical structure, and the physical and mechanical properties of Shanthabye over 10 years old, grown in compartment 4, Maymyo Fuel Reserve. Rate of return analysis was made for information for decision- makers in selecting suitable species for extensive plantation programs. The present study also seeks to determine the suitability of the timber for structural purposes from the anatomical, physical and mechanical properties examined.

Part I - Study of Form Factor and Yield

Literature Review

Shanthabye is a native tree species of Australia, usually with an excellent trunk and wide spreading rather thin crown attaining 148-180' (45-55 m) in height. It has been grown successfully as industrial plantations in Brazil, South Africa and India. This species is considered the best which no other eucalyptus can compare if planted on suitable sites. (FAO 1979)

The mean annual increment (M.A.I) and age curve for medium site quality of various eucalyptus species planted in different countries indicate that Shanthabye is the fastest growing species with a M.A.I of 25-30 m^3/ha (357-428 ft^3/acre) at the age of 10 on medium sites. (FAO 1979)

This species is widely grown in plantations around the world and have been more successfully established than in Australia. Yield from the native plantations of Australia is not as high as that from countries such as South Africa and Brazil. (CSIRO, 1978). Carter (1974) reported yields ranging from 15.0 m^3/ha/year on low quality site to 31.9 m^3/ha/year on high quality sites for 10 years old plantations in Southern Queensland. Trial plots established in plantations at Coffs Harbour in Australia have shown yields of 22-25 m^3/ha/year over 0-10 year age period.(Clarke, 1975).

[1*] See Appendix V for scientific names for species discussed in this paper

In India, Shanthabye occupies an important place among the successfully grown exotics. It has proved to be fast growing in the hills of Kerala and parts of Tamil Nadu with high rainfall. Shanthabye plantations in India are differentiated into 3 site qualities based on age and top height (See Appendix I).

The mean annual increment for volume over-bark of the first quality crops is highest as the age of 9 years, ranging from 33.91 m^3(485 ft^3) to 42.23 m^3 (603 ft^3) depending on the spacing adopted which varies from 800 stems per acre to 1600 stems per acre. In the second quality crops, the M.A.I. is highest at the age of 11 years, within a range of 19.07 m^3 (273 ft^3) to 23.99 m^3 (343 ft^3). For quality III crops the M.A.I. culminates at age of 12, yielding 8.34 m^3 (149 ft^3) to 10.15 m^3 (145 ft^3). (G.C. Pande, 1978).

Concerning the possible introduction of Eucalyptus in Burma, Wint (1978) advised that climatic, edaphic and topographical variants should be given due consideration for the successful establishment of the species. His suggestion was to divide the country into 3 different zones. Zone I consisting of Coastal Areas, Zone II Irrawaddy Valley and Zone III of Mountainous Areas of roughly over 3000'. Zone II is further divided into sub-zones, namely, Zone II (a) moist areas along the Irrawaddy Valley and II (b) drier parts in the Irrawaddy Valley. He predicted that Shanthabye would be performing well in Zone II (a) and III.

Among the experimental eucalyptus plantation laid out in Maymyo Fuel Reserve (which falls in Zone III according to Wint's classification), Shanthabye was observed to be the most promising species after 5 years, with an intermediate thinning yield producing almost 10 tons/acre. (Thwin, 1974).

The Forest Department of Burma in 1981 forecasted a M.A.I. of 327 ft^3 per acre (22.8 m^3/ha) for Shanthabye at Maymyo managed at 10 years rotation. This figure was based on 0.119 acres of temporary sample plots laid out subjectively on good, medium and poor types.

A recent study of Shanthabye pulpwood availability by the staff of Maymyo Township, gave an average volume yield of 49 tons/acre (solid) on moderate sites. The average height was 62 feet and the mean diameter was about 7.6 inches. The mean annual increment per acre was about 250 ft^3 (18 m^3 / ha).

This finding was based on 3 one-acre plots, selected subjectively on good, moderate and poor sites from 10 years old plantation in compartment 10/11 Maymyo Fuel Reserve from an area of 59 acres. (Maung,1984).

Materials and Methods

The area under study is situated in compartment 4, Maymyo Fuel Reserve, having an area of 25 acres. This plantation was formed in 1969 at a spacing of 9' x 9', and thinned twice in 1974 and 1979 (?).

The original forest cover was dry hill forest type with *Quercus* spp. and *Castanopsis* spp., comprising the major tree species and was managed under the coppice with standards system.

As the area is quite close to Maymyo, it has been subjected to excessive encroachments for cultivation and illicit fuelwood cutting not only from the rural people but also from the urban dwellers. As such, the original forest was almost depleted at the time of planting. (Wint, *et.al.* 1970).

Soil profile descriptions based on good and poor stands of adjacent 1969 *E.robusta* plantation, are stated in appendices II and III (Wint 1972).

A ten percent systematic sampling within an area of 25 acres was carried out in October 1984. The first 6-8 rows of trees along the fringes of the survey area were left out to avoid over estimation of volume. Altogether there are 25 sampling units each having an area of 0.119 acres spaced at 72' x 207' apart. The shape of the sampling units was square with 72' on each side.

Within each plot, measurements of diameter at breast height were made both for the main crop and regrowth of the coppice from thinnings. Although height estimates were to be made on each and every tree in the plot using appropriate height measuring devices, the dense undergrowth up to 6' or more in height, made the requirement impractical. Instead height measurements were taken on 2-3 trees per plot using a Sunnto clinometer and relative height estimates made ocularly for the rest.

Trees tallied in the 25 sampling units were grouped into 2"diameter classes and within each class 1-9' trees were felled for volume assessment leaving 6"stumps. Forty-nine sample trees were selected to represent the good, medium and poor diameter distribution and height, growth for the area. The trees selected were divided into 10' sections and diameter over-bark and under-bark determined for each section to a top diameter limit of 1.5".

Based on the felled tree data, volume functions were developed using volume over-bark and under bark (solid) as the dependent variable and total height (length) as the independent variable.

Results

1 **The Area** – Data on the area is as follows:

Location	Maymyo, Burma
Altitude	3400' above sea level
Latitude	22°-01' N
Temperature	Maximum 92.3° (F) April
	Manimum 33.3° (F) January
	Average 66.9° (F) Yearly
Rainfall	Average rainfall per annum 62.61"

2. Form Factor

The form factor averaged 0.47. An acceptable correlation was not found for diameter and form factor as the form factor remained constant as the trees grew older and bigger.

3. Relationship between height and diameter at breast height

Four different types of single variable regression analyses of height on diameter were tried. The four types were:

Regression types	**Coefficient of determination(R^2 value)**
1. $H = a+b\ (D)$	0.80
2. $H = a+\exp b\ (D)$	0.72
3. $H = a+b \ln (D)$	0.82
4. $H = aD^b$	0.79

Of the four, the third type gives the best fit, where height is expressed in terms of diameter breast height as;

$$H = 12.6948 + 0.8989 \ln (D)$$

where, H = total height in feet

D = Diameter at breast height in inches

4. Volume Formulae

The following volume functions were developed for volume over-bark and volume under-bark (top diameter limit 1.5" over-bark) based on diameter and total height.

Volume with bark

$$V_{ob} = 0.0941 + 0.002386\ D^2H \quad (R_2 = 0.98)$$

Standard error of + estimate - 3.14 ft^3

Volume without bark

$$V_{ub} = 0.45654 + 0.0021305\ D^2H \quad (R_2 = 0.97)$$

Standard error of + estimate - 2.84 ft^3

V_{ob} = volume over - bark in ft^3

V_{ub} = volume under - bark in ft^3

D = diameter in inches

H = total height in feet

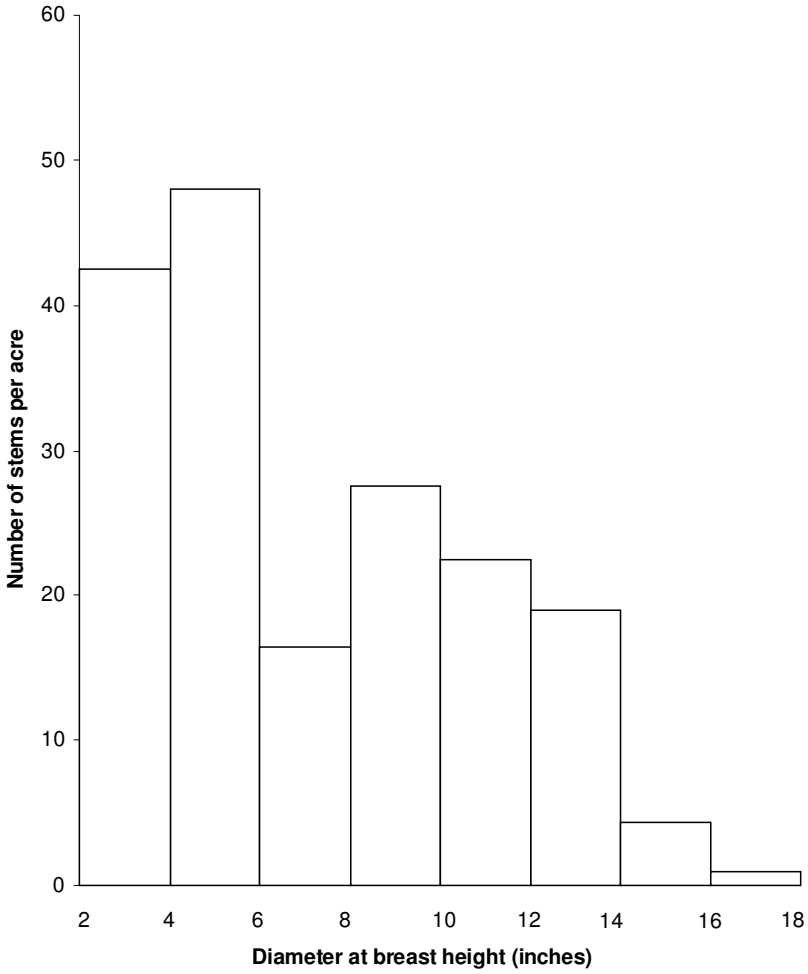


Fig.1 Diameter distribution of *E. grandis* 15 years old at Maymyo

5. Other stand variables

1. Maximum diameter	17.1 inches
2. Minimum diameter	2.0 inches
3. Average diameter (See Table 1)	8.00 inches
4. Average height of dominants	108 feet
5. Maximum height	133 feet
6. Minimum height	24 feet
7. Average height-all trees	66 feet
8. Average number of stems per acre	179 stems
9. Average solid volume (over – bark)	2603 ft^3 (5,200 tons)/acre
10. Average solid volume (under– bark)	2262 ft^3 (45.24 tons)/acre
11. Average bark percent	14 %
12. Average stacked volume per acre	4320 ft^3 (86.42 tons)/acre
13. Average number of stacks (12' x 6' x 3' = 216 ft^3/stack)	17.5 stacks/acre
14. Mean annual increment per acre	173.53 ft^3/acre

Rate of Return- In order to compare the commercial feasibility of Shanthabye plantations with other plantations established in Burma, rate of return analyses were made using three different investment alternatives. The first alternative was to treat the stand as producing pulpwood, the second providing post and poles and the last for fuelwood production.

Based on expenses and incomes from comparable data, the internal rate of return (IRR) (the break-even point where the discounted revenue equals discounted expenditures) for three different alternatives were calculated. Sensitivity analysis has been calculated with the assumption of a 20% increase in costs. (See Appendix IV)

Profitability of 10 years old Shanthabye

Alternative	Internal Rate of Return Percent
1. Pulpwood	23.29
2. Post and Poles	29.0
3. Fuelwood	22.01

Profitability of 15 years old Shanthabye

Alternative	Internal Rate of Return Percent
1. Pulpwood	15.64
2. Post and Poles	19.35
3. Fuelwood	14.97

Discussion

In terms of volume production Shanthabye at 15 years, produced 52.0 (solid tons), per acre with a M.A.I of 173 ft^3/acre. A comparison of growth and yield data of Shanthabye grown in Burma and other countries is stated below.

Comparison of Shanthabye Plantations

Source	Locality	Spacing	Age	M.A.I ft^3/acre	Remarks
F.A.O	Country (estimates all over the world)	-	10	357 - 428	-
Australia	Southern Queensland	-	10	214 - 456	-
Australia	Coffs Harbour	-	10	314 - 357	-
South Africa	Transvaal	10' x 10'	10	643 - 184	-
India	Kerala Tamil Nadu	8.8' x 8.8'	9-12	603 - 145	-
Forest Dept.Burma	Maymyo	9' x 9'	11-13	108 - 185	THINNED
	Maymyo	9' x 9'	10	250	THINNED
Present Study	Maymyo	9' x 9'	15	174	THINNED

As the Table indicates, there are considerable differences in yield among different sources. This probably may have arisen from a combination of factors such as systems of management, site, and methods of estimating volumes. Nevertheless, the yield figures from Burma based on thinned data appears to be within the acceptable minimum volume production figures so far recorded.

Although Shanthabye appeared to be highest in productivity among species put on trial in Maymyo, it probably could have given better yields in soils better suited to this species.

According to a report on planting Eucalyptus (FAO), soils best suited for this species are considered to be deep, free draining soils such as, fertile loam or clay loam. The soils of the trial site is termed as clayey soil (Wint, 1972).

Rate of return analysis of 15 years old Shanthabye produced a I.R.R. values of 15.64%, 19.35%, 14.97% for pulpwood, posts and poles and fuelwood respectively. At the guiding rate of interest (alternative rate of return) of 8% (currently prevailing bank rate) or 10.90% (local savings interest rate), all three alternatives appear to be profitable for the capital invested.

With a ten years old Shanthabye stand, the rate of return gives better results 23.29% for pulpwood, 29.0% for post and poles and 22.01% for fuelwood crops.

Projections made by the Forest Department of Burma (1978) on rate of return for Teak, Pyinkado and Eucalyptus plantations (mainly *Eucalyptus camaldulensis*) were 7.47 %, 5.71 % and 11 % respectively, on 50 years rotation for Teak, Pyinkado and Eucalyptus for 12 years rotation.

Hence, Shanthabye is one of the Eucalyptus species desirable for growing in Burma, either for local consumption (fuelwood, post and poles) or as pulpwood.

Bell (1984) observed that Shanthabye put on trail at lower elevations, at Thagaya, Toungoo, appeared to be unsuitable due to very variable height growth and survival based on initial results.

As the Forest Department is currently engaged in establishing plantations extensively throughout the country both for export and internal use, Shanthabye is one of the species worthy for consideration in areas over 3000 ft elevation with an average rainfall of 60" where there is a need for forest products especially by the local population.

Part II - Study of Anatomical Properties of Shanthabye

Microscopic characteristics

Tracheids and fibres: Tracheids vasicentris; thinwalled; 5-7 μ thick; the length ranges from 260.4-756 μ, mostly from 289-504 μ. Fibre tracheids and libriform fibres abundant, thick to very thick walled, 5-8 μ thick; size of pits small; the length ranges from 462-1092 μ, mostly from 588- 756 μ; mean length 15.738 μ.

Vessel elements: Number per sq.mm. ranges from 17-34, in radial pore distribution solitary, pore multiples or in clusters; diffuse porous; circular oval or elliptical in shape as seen in cross section, tangential diameter ranges from 33.2-116 μ; tyloses absent; perforation plate simple; end walls oblique or transverse; intervascular pitting opposite to nearly alternate, size of pits usually less than 6μ; shape of pits circular or oval, vessel parenchyma pitting alternate or opposite, crowded, size of pits ranges from 5-7 μ ; shape of pits oval or elongated; length of vessel elements ranges from 116.2-232.4 μ, and most frequently from 132.8-215.8 μ, mean length is 177.1 μ, pit to vessel alternate or opposite, crowded, circular or angular in shape, 6-8 μ, in size, pits to parenchyma opposite or alternate in arrangement, oval in shape, 2.6 μ in size.

Vascular rays : Number per mm. ranges from 12-18, heterogeneous type I, 1-2 cells wide, mostly uniseriate, height of uniseriate rays ranges from 49.8-256.6 μ, height of biseriate rays ranges from 116.2 – 288.2 μ and most frequently from 149.4 – 166 μ; pitting between ray parenchyma cells small and few in number to many.

Xylem parenchyma : Sparse; apotracheal parenchyma diffuse, scattered; paratracheal parenchyma scanty, pitting between xylem parenchyma cells small and few in number.

Part III – Study of the Physical and Mechanical properties of Shanthabye

Objective

The objective of investigating the physical and mechanical properties is to obtain technical data on this newly introduced species, which has now attained an age of 10-15 years. Such data are available for timber of native grown of Australian trees, but is lacking in Burma. From this examination possible end-uses of this timber may be suggested.

Literature Review

Shanthabye is a fast growing species in its native land. Self pruning of the branches is one of its natural advantages of the species for timber quality. (Hillis, 1978). It coppices vigorously when young although trees over 10 years of age may be less easily coppiced. It is a tall tree in good form and attains a height up to 18o feet in Australia. The timber of this species is lighter, softer, more liable to split and easy to cleave than that of most Eucalyptus. It is extensively used for house construction and young material is said to be good for packing case timber and paper pulp. It is also said to have a potential for plywood. Plantation of this species overseas is mainly for pulp production.

Hillis pointed out that the main problems that oftenly been faced in the utilization of solid Eucalyptus wood from young, rapidly gown trees are the excessive shrinkage and drying defects and splits which tends to be worse in wood of low density. (Hillis).

The durability of the heartwood of Shanthabye in contact with the ground was 8-15 years in Australia and Malysia, whereas in South Africa it is found to be only 1-8 years (Kingston and Bolza) namely:

(1) Structural (both heavy and light)
(2) Flooring (Light)
(3) Mine timber
(4) Ship and boat building
(5) Vehicle body
(6) Furniture, cabinet work
(7) Handles and ladder parts
(8) Agriculture implements
(9) Plywood veneer
(10) Pulpwood
(11) Sleepers
(12) Poles and piles
(13) Turnery

The timber is stated to be somewhat difficult to season, but checking can be controlled in early state of drying by careful schedule. Warping is reported in timber from fast – grown trees, but generally is not common. It is also pointed out that immediate conversion should be made soon after felling to avoid losses. Timber from younger trees is mentioned to work easily and old material may produce certain surface picking and tends to split. Defect-free timber is stated to take good polish, but is liable to split in nailing. The sapwood of *E. grandis* is reported to be permeable, whereas the heartwood is resistant to impregnation (Keating and Bolza).

Plate 1. 15 years old *E.grands* plantation at Maymyo.

Plate 2. 10 years old *E. grandis* under extraction

Plate 3. A stack of *E. grandis* pulpwood 6' x 12' x 3' (216 cubic feet)

Materials and Methods

Three trees were selected at random and selection of bolts for testing was made in accordance with the A.S.T.M. Standard D.143. Preparation of all test specimens and the method of tests are in accordance with the classification laid down by the American Society for Testing and Materials. The authenticity of the species collected for testing was made from the taxonomical identification.

The bolts were converted to make 2 ½" x 2 ½" x 4' sticks and then matched specimens were selected for tests in green and dry conditions. Green specimens were immediately planed to get 2" x 2" specimens and tested as quickly as possible.

The specimens to be tested dry were stacked properly and air dried. The air-dried specimens were reconditioned to get nearest to 12 % m.c before testing as there was no facility to kiln-dry at the Institute.

Physical Properties

Twelve samples of size 1" x 1" x 4" were taken at random from the tested samples to determine the radial and tangential shrinkage. Some eighteen specimens were taken to find out the density using a water displacement method.

Measurements in linear dimensions were taken to the nearest thousandth of an inch and the weight were taken correct to 0.001 gm.

Mechanical Properties

The dimensions for the various test specimens both green and dried are shown below. Cleavage and Impact Bending tests were not carried out as the appropriate machinery was not available in the Institute. The Avery Universal Testing Machine and the Riehle Universal Testing Machine were used for the tests.

Dimension of the test specimens

No.	Type of test	Size of specimens
1.	Static Bending	2" x 2" x 30"
2.	Compression parallel to grain	2" x 2" x 8"
3.	Compression perpendicular to grain	2" x 2" x 2"
4.	Hardness	2" x 2" x 6"
5.	Shear	2" x 2" x 2"

The properties of interest computed from these principal tests are given below : -

1. Static Bending :

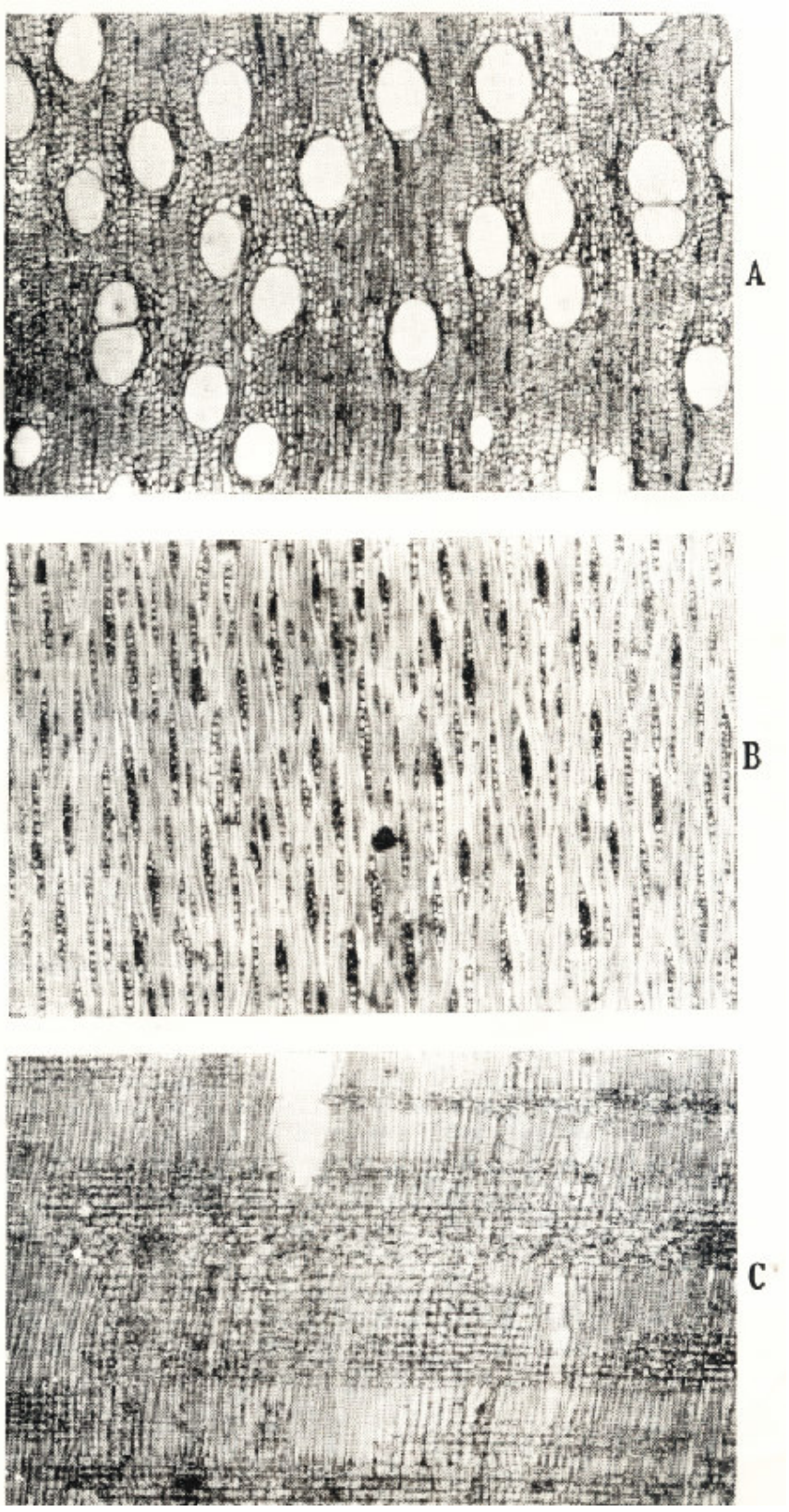
(i) Fibre Stress (a) Proportional Limit FS (at)PL. (Not stated)
(ii) Modulus of Rupture (MR)
(iii) Modulus of Elasticity (ME)

Explanation of the Plate

Eucalyptus grandis (X 83)

A. Transverse section showing paratracheal parenchyma scanty and apotracheal parenchyma diffuse.
B. Tangential longitudinal section view of multiseriate and uniseriate rays.
C. Radial longitudinal section showing composed of upright cells and square cells.

Eucalyptus grandis



2. Compression parallel to grain

(i) Fibre Stress (a) Proportional Limit FS (at)PL. (Not stated)
(ii) Maximum Stress
(iii) Modulus of Elasticity (ME)

3. Compression perpendicular to grain

(i) Fibre Stress at Proportional Limit (FS (at) PL.)

4. Hardness

(i) Radial
(ii) Tangential
(iii) End

5. Shear

(i) Radial
(ii) Tangential

The moisture content of all test specimens were determined by the Oven Dry Method.

Results

The test specimens were taken from three trees planted in 1973-74 in Maymyo. The trees were felled and their respective measurements are as follows :-

1.	Tree Number	1	2	3
2.	Height (ft)	106	105	102
3	DBH (inch)	11.7	12.1	13.0
4.	Clear Bloe (ft)	64	11	21
5.	Crown Diameter average (ft)	24	26	26
6.	No. of bolts tested	1, a, b, c, d, i, j, o, p	2, a, b, c, d, g, h, m, n	3, a, b, c, d, i, j, n, o

Test results on the physical and mechanical properties of Shanthabye are tabulated in Table 1. To compare the test results with Shanthabye grown in Australia and another Eucalyptus, *E. camaldulensis* grown in Burma, their respective strength data are also stated (Hillis,; Kingston; Ral Lian Sum).

To get comparative strength data, a few indigenous species of three different strength levels, namely Teak, Kanyin and Leza are also given. The strength values are the means for the species.

In Table (2). the suitability of Shanthabye for various uses is given as a percent of the teak value. The figures in Table (1) indicate the suitability of various species for different aspects of utility as compared to Teak (Limaye and Seamen).

Table 1. Physical and Mechanical Properties of *E. grandis* as compared to other species

Species	Locality	Moisture Content	Density lb/c.ft	Shrinkage % (G-OD)			Static Bending		Comp.// to grain	
				Tan	Rad.	Vol.	MR psi	ME 103x psi	Maxm psi	ME 103 psi
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
E. grandis	Australia	Green	75	5.1-6.5	3.1-4.0		11700	1940	5970	2340
		AD 12%	47				17300	2280	9690	2720
E. grandis	Maymyo Burma	Green	54	16.07	6.8		8190	1482	5460	2170
		AD 12%	36.6				11274	1770	8110	2260
E.camaldulensis	Kyaukpadaung Burma	Green	71	9.1	4.4	13.6	11874	1570	5380	
		AD 12%	52				15798	1581	8916	
Teak	Burma	Green	55	2.1	3.3	6.8	11460	1640	5710	1937
		AD 12%	40				14465	1830	8350	2033
Kanyin	Burma	Green	68	4.2	8.9	15.0	11020	2320	5865	2272
		AD 12%	49				15605	2240	7745	2379
Leza	Burma	Green	64	4.2	6.4	12.1	11005	1695	5115	1715
		AD 12%	42				13265	1940	7145	2389

Table 1 (Cont.) Physical and Mechanical Properties of *E. grandis* as compared to other species

Species	Locality	Moisture Content	Density Lb/c.ft	Shear. Rad.psi	Maxm. tan.psi	Comp. per.to grain FS (at)PL	Hardness. Lb		
							Rad.	Tan.	End.
(1)	(2)	(3)	(4)	(12)	(13)	(14)	(15)	(16)	(17)
E.grandis	Australia	Green	75	1200	1350	860	1240	1240	1300
		AD 12%	47	1750	2110	1345	1640	1640	1910
E.grandis	Maymyo	Green	54	1098	1235	688	992	992	1175
	Burma	AD 12%	36.6	1470	1757	1070	1328	1366	1082
E.camaldulensis	Kyauk-padaung	Green	71	1707	1927	1424	1680	1620	1710
	Burma	AD 12%	52	2789	2599	3136	2678	2769	3034
Teak	Burma	Green	55	990	1080	930	960	960	860
		AD 12%	40	895	1390	1280	980	990	910
Kanyin	Burma	Green	68	885	1055	950	1020	1010	1060
		AD 12%	49	1160	1345	1185	1395	1285	1315
Leza	Burma	Green	64	1200	1425	955	985	990	1055
		AD 12%	42	1315	1325	1245	1125	1076	1120

Table 2. Relative Suitability of *E. grandis* and other Species as a percentage of Teak

Sr. No.	Species	Weight	Strength as a beam	Stiffness as a beam	Suitability as a post	Retention of shape	Shear	Hardness
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1.	Teak	100	100	100	100	100	100	100
2.	*E.grandis* (Burma)	91.5	85	97	102	42	109	92
3.	*E.grandis* (Australia)	125	108	118	115	85	124	103
4.	*E.camaldulensis* (Burma)	130	101	83	83	74	176	188
5.	Kanyin	122	99	122	102	56	91	112
6.	Pyinkado	140	128	135	135	70	155	187
7.	Pyinma	95	73	78	76	67	100	110
8.	In	140	104	110	100	57	105	147
9.	Binga	102	90	83	92	69	111	107
10.	Hnaw	102	77	74	81	88	111	110
11.	Sagawa	75	62	72	69	88	83	68
12.	Taungthayet	102	73	100	80	74	108	77
13.	Yemane	75	60	68	61	85	80	65
14.	Leza	105	91	103	95	70	110	104
15.	Nabe	90	55	51	51	85	76	76
16.	Sit	95	85	80	85	75	130	105
17.	Yinma	95	75	80	70	75	120	110

Discussions

The trees of Shanthabye introduced in Burma and used for the present investigation were observed to be smaller in diameter and the density lower than that of native-grown trees by about 20%. This may be due to the fact that the specimens have a large proportion of sapwood. Judging from the height the trees have attained, the species may be considered fast growing as pointed out by Hillis (1978). The low density may also be due to the wood being immature as the plantation is only 10-15 years old.

Excessive shrinkage was noted and this also may be due to fast growth and immaturity of sapwood. It can be seen that *E. camaldulensis* grown in Burma (Kyaukpaduang in the Dryzone) has lower shrinkage than Shanthabye.

In general, Maymyo grown Shanthabye is inferior in physical and mechanical properties to either Australian grown Shanthabye, or Burma grown *E. camaldulensis* (18 years old), or even Kanyin. Apart from its fast growth, young age and small diameter, the knots formed by natural pruning of branches may be one of the reasons for the weaker strength quality of species planted in Burma.

From the Table 2, it may be said that Shanthabye at this age is definitely inferior to the Burmese species Pyinkado, In and Leza. Yet it is camparable to Binga, Hnaw, Sagawa, Taungthayet, Yemane, Nabe, Sit and Yinma.

The strength properties of the introduced species of Shanthabye as indicated in Table 2, shows that even at this age, the timber can be put into some uses suggested by Keating and Bolza, (1982), namely structural use (Light), mine timber, and poles and piles. The experience overseas indicates that the timber can be utilized for pulpwood production. The timber can also be put into some other uses if the felling cycle is extended to 25 or 30 years. There are evidence that sawn timber of construction size can be obtained from trees of 30 years age. (Turnbull and Pryor, 1978). The strength properties are likely to increase in

proportion to the age of the tree, there by improving the quality of timber (Keating and Bolza).

Part IV Conclusion

Shanthabye, used as a plantation species in Burma on areas of high elevation (above 3000 feet) with 60 inches of rainfall, grows fast (average 170-175 cu.ft./acre/yr), and has good form. It has demonstrated its suitability for use as fuelwood, posts and poles, and even in light structural use. It displayed certain draw backs in structural use in that it must be converted rapidly and seasoned, as it has a tendency to split and warp due to excessive shrinkage. Still, the species is quite comparable to Binga, Hnaw, Sagawa, Yemane, Nabe, Sit and Yinma in physical and mechanical properties.

The pulpwood yield from a 10-year-old clear-felled area in Maymyo was approximately 70 stacked tons per acre. The No.1 Paper Mill at Sittang is using Shanthabye in pulp production and their estimates of pulp yield are about 52 % (Hla). Thus a good potential for pulpwood production is indicated.

An economic study of capital invested in Shanthabye plantations indicated very acceptable rates of return in both 10-year and 15-year ratations when fuelwood, posts and poles, and light structural forest products are produced.

Thus Shanthabye appears to be a most useful species when planted in the proper site in Burma. The canopy of tree cover protects the soil and reduces erosion. The sustained yield of forest products for use can provide fuel and economic stability for the local citizens and the Nation.

Investigations into the value of Shanthabye should continue. As young plantations approach maturity, there is evidence that sawn timber of construction size with a greater value can be obtained. The role of short coppice rotations, depending upon the vigour of coppice shoots for maximum cellulose production, needs to be examined for feasibility.

Appendix I

Age/Top height relationship of Shanthabye in India

Age (years)	Quality I	Top height Quality II	Quality III
	feet	feet	feet
5	64.0	48.2	31.8
6	76.1	56.4	37.1
7	87.6	71.9	42.0
8	97.8	71.9	46.6
9	105.9	78.1	51.2
10	111.6	83.3	55.4
11	115.5	87.6	59.4
12	118.4	90.6	62.7
13	121.1	92.9	64.5

Source: Yield Tables for *Eucalyptus grandis* by G.C. Pande, April, 1978. FRI Dehra Dun.

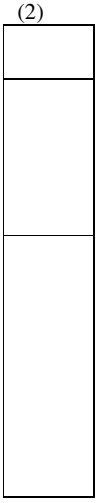
Appendix II

Analysis of the Soil Profile No. 3 from Good Stand of 1969 *E.robusta* Plantation in Compartment 4, Maymyo Fuel Reserved Forest, Maymyo Forest Division

Depth	Profile	Profile Horizon Symbols	Colour	Texture	Physical Properties				Minerals			
					Sand %	Silt %	Clay %	pH Value	N (P.P.M)	P (P.P.M)	K (Meqv)	$CaCo_3$ %
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1'		A	Brownish red	Clay Soil	14.9	20.7	61.3	5.5	112	7.0	0.20	0
6'		B	Yellowish red	-`-	9.3	17.8	64.2	5.5				0
		C	Yellowish red	-`-	11.3	16.0	62.2	7.0				1.7

Appendix III

Analysis of the Soil Profile No. 4, Poor Stand of 1969 *E.robusta* Plantation in Compartment 4, Maymyo Fuel Reserved Forest, Maymyo Forest Division

Depth	Profile	Profile Horizon Symbols	Colour	Texture	Physical Properties				Minerals			
					Sand %	Silt %	Clay %	pH Value	N (P.P.M)	P (P.P.M)	K (Meqv)	$CaCo_3$ %
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
2'		A	Brownish red	Clay Soil	9.1	13.2	72.5	5.2	112	0.3	0.36	0
6'		B	Dark Brick red	-`-	10.8	5.0	79.4	5.5				2.4
10'		C	Brick red	-`-	19.2	10.0	76.0	6.0				0.5

Appendix IV

10 year old stand

Costs and Benefits streams

Year	Costs		Total	Benefits		
	Direct	Indirect		Alternative (1)	Alternative (2)	Alternative (3)
1	194.62	83.38	278.00			
2	28.00	17.76	45.76			
3	19.00	17.76	36.76			
4	10.00	2.25	12.25			
5	30.00	5.91	35.91		648.00	450.00
6	10.00	2.25	12.25			
7	10.00	2.25	12.25			
8	10.00	2.25	12.25			
9	10.00	2.25	12.25			
10	10.00	2.25	12.25	3185.00	4079	2205

Rate of Return	IRR %	=	23.29 %	29.00 %	22.01 %
Increase Cost by 20%			21.06 %	26.72 %	19.77 %

Appendix IV (Contd.)

15 years old stand

Costs and Benefits streams

Year	Costs		Total	Benefits		
	Direct	Indirect		Alternative (1)	Alternative (2)	Alternative (3)
1	194.62	83.38	278.00			
2	28.00	17.76	45.76			
3	19.00	17.76	36.76			
4	10.00	2.25	12.25		648.00	450.00
5	30.00	5.91	35.91			
6	10.00	2.25	12.25			
7	10.00	2.25	12.25			
8	10.00	2.25	12.25			
9	10.00	2.25	12.25	650.00	832.00	450.00
10	30.00	5.91	35.91			
11	10.00	2.25	12.25			
12	10.00	2.25	12.25			
13	10.00	2.25	12.25			
14	10.00	2.25	12.25			
15	10.00	2.25	12.25	3380.00	4343.00	2340.00

Rate of Return	IRR %	=	15.64 %	19.35 %	14.97 %
Increase Cost by 20%			14.25 %	17.91 %	13.58 %

Appendix IV (Contd)

Explanation of Costs and Benefits

Costs (Per acre)

Direct Costs	Site Preparation	K	90.00
	Planting	K	64.29
	Pesticide application	K	3.33
	Weed control per weeding (Three weedings the first year, two the second and one for the third year)		
	Fire protection -yearly	K	10.00
Indirect Costs	Staff, Buildings, Vehicles-yearly (depending on the nature of operation)	K	2.25 to 83.38

Benefits (Per care)

Age	Operation	Plupwood		Posts & Poles		Fuelwood	
		Vol. tons	Value K	Vol. tons	Value K	Vol. tons	Value K
5	Thinning	-	-	10	648	10	450
10	Thinning	10	650	10	832	10	450
10	Final Felling	49	3185	49	4079	49	2250
15	Final Felling	52	3380	52	4343	52	2340

Note :

The revenue from the sale of the following forest produce per ton (solid) was estimated as :

(a)	Small size sawn timber	K. 100
(b)	Posts and poles	K. 75
(c)	Fuelwood	K. 45

Source : Social Forestry Sector, Forestry for Rural Community Development and Supply 1978, Forest Department, Burma.

For pulpwood, revenue from the paper factory was calculated as K. 40 per stacked ton or K. 65 per solid ton.

Appendix V

Botanical Names of Some Tree Species

Sr. No.	Burmese Name	Botanical Name
1.	Binga	*Mitragyna rotundifolia* O.Ktze
2.	Hnaw	*Adina cordifolia* Hook. f.
3.	In	*Dipterocarpus tuberculatus* Roxb.
4.	Kanyin	*Dipterocarpus turbinatus* Gaertn. f.
5.	Leza	*Lagerstroemia tomentosa* Presl.
6.	Nabe	*Lannea grandis* Engler.
7.	Pyinma	*Lagerstroemia speciosa* Pers.
8.	Pyinkado	*Xylia dolabriformis* Benth.
9.	Sagawa	*Michelia champaca* Linn.
10.	Shanthabye	*Eucalyptus grandis*
11.	Sit	*Albizzia procera* Benth.
12.	Taungthayet	*Swintonia floribunda* Griff.
13.	Teak	*Tectona grandis* Linn. f.
14.	Yemane	*Gmelina arborea* Roxb.

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