

Troisième partie

Le bois de teck

La réputation du bois de teck s'est construite à travers l'utilisation des bois des forêts naturelles. Cette ressource, largement surexploitée depuis le XIX^e siècle, a été partiellement reconstituée grâce à des plantations réalisées en Asie, en Afrique et en Amérique. La majorité de ces plantations est aujourd'hui en production.

La sylviculture des plantations de teck repose sur une série d'éclaircies successives dans les jeunes peuplements. De fait,



Utilisation du bois dans la fabrication de produits haut de gamme.
Use of wood in the manufacture of upmarket objects.

les bois de plantation différent de ceux de forêt naturelle par l'âge, les dimensions, les qualités technologiques, la couleur... Cela conditionne les types d'utilisation et la valorisation de ces bois jeunes et de petites dimensions. A terme, c'est la rentabilité financière des plantations de teck qui est concernée par ces questions. Dans le même temps, il faut noter que le marché du bois de teck s'est diversifié et adapté à la ressource. Tous ces sujets sont abordés dans ce dossier sur le bois de teck.

Timber quality of teak from managed tropical plantations with special reference to Indian plantations

The author compares the technological properties of plantation-grown teakwood with reference to a study undertaken at Nilambur (India).

Contrary to general opinion, it was found that the quality of wood derived from dominant fast-growing trees was not inferior to that from slower-growing trees. Tips for intensive teak timber management are also put forward.

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In the tropics, teak (*Tectona grandis* L.f.) is clearly the most preferred timber species for the production of high quality sawn wood and veneer from fast-growing plantation hardwood (photo 1). "Among timbers teak holds the place which the diamond maintains among precious stones and gold among metals" (Sir DIETRIC BRANDIS). In addition to endemic countries, e.g. India, Myanmar, Thailand and Laos, teak has been introduced in exotic forestry contexts in almost all tropical parts of the world, including the following countries:

- Asia Pacific Region
Bangladesh, Nepal, Pakistan, Sri Lanka, Cambodia, Indonesia, Malaysia, Vietnam, Philippines, Taiwan, Japan, Australia, Fiji, etc.
- East and West African Region
Tanzania, Sudan, Somalia, Zim-



Photo 1. Intensively managed short rotation teak plantation.
Plantation de teck à rotation courte et exploitation intensive.

TABLE I
STATUS OF TEAK PLANTATIONS IN IMPORTANT TEAK PRODUCING COUNTRIES

Country	Extent of plantations (thousands ha)	Initial spacing (m)	Rotation (yr)	MAI (m ³ /ha/yr)	Number of CPT selected in tree breeding
Bangladesh		1.8 × 1.8	40	7.4	319
Brazil			25	10-13	
India	> 1 500	1.8 × 1.8 2 × 2 2.5 × 2.5 3.6 × 2.7/3.6	50-80	5-9	714
Indonesia	1 080.867	3 × 3	60-80	5-6	122
Côte d'Ivoire	21			5-7 to 10-16	
Malaysia	2.45	2.5 × 2.5 to 4 × 4.5	35-40		
Nigeria	> 70	2.44 × 2.44 to 2.96 × 2.96		27	
Sri Lanka	70.814	3 × 3	40	7	
Tanzania	5			12-19	
Thailand	170	2 × 4 4 × 4	40-60	13.52	260

CPT : candidate plus tree.
MAI : mean annual increment.
Source: BHAT, INDIRA (1997a).



babwe, Uganda, Kenya, Malawi, Senegal, Guinea, Côte d'Ivoire, Ghana, and Nigeria.

- Central and South American Region

Belize, Costa Rica, El Salvador, Cuba, Panama, Honduras, West Indies, Jamaica, Nicaragua, etc.

Per-country statistics on teak plantation area are scarce. The available data are given in table I.

TIMBER QUALITY CRITERIA

Teak timber quality, which could be affected by high input management, depends partly on tree form and partly on basic wood structure and strength properties. The major structural factors that should receive plantation managers' attention are: tree height and diameter, bole shape (taper, buttressing, fluting, etc.), knot size and frequency, grain angle (degree and pattern of spirality), tension wood and juvenile wood proportions, heartwood-sapwood proportions and characteristics (colour and extractives), grain and texture, i.e. the proportion and arrangement of tissues, including earlywood and latewood proportions (growth ring width) and cell dimensions.

Comparative suitability indices were drawn up in India with the aim of developing a system for end-use classification of a large number of tropical hardwoods, using teak as the reference species (RAJPUT, GULATI, 1983). With the renowned natural durability and decorative values of heartwood, teak is eminently suitable for multiple end uses, including construction, furniture and cabinets, railway sleepers, decorative veneer, joinery, ship and vehicle body building, mining, reconsti-

tuted products, etc. Indeed, teak is suitable for a wide range of end uses.

HEARTWOOD PROPORTION IN FAST- AND SLOW-GROWN TREES

In plantation-grown timber, end users seek a maximum volume of heartwood with a minimum amount of non-durable sapwood. FERGUSON (1934) observed that for the same stem diameter there was a higher proportion of sapwood in trees with faster growth rates due to improved site quality. According to BHAT (1998), trees selected for faster growth ("candidate plus trees") did not show marked heart-

wood percentage differences in mature trees at ages 55 and 65 years (figure 1). In contrast, in young trees at age 13 years, faster growth was correlated with higher heartwood percentage. The effects of growth rate on the timber heartwood-sapwood ratio seemed to decline with age, resulting in negligible differences between fast- and slow-grown trees. Figure 1 clearly shows that longer rotation is more important than slower tree growth with respect to producing a higher percentage of heartwood. Nevertheless, lower heartwood content due to young age would be acceptable for improving pulp quality and preservative treatment of thinned material.

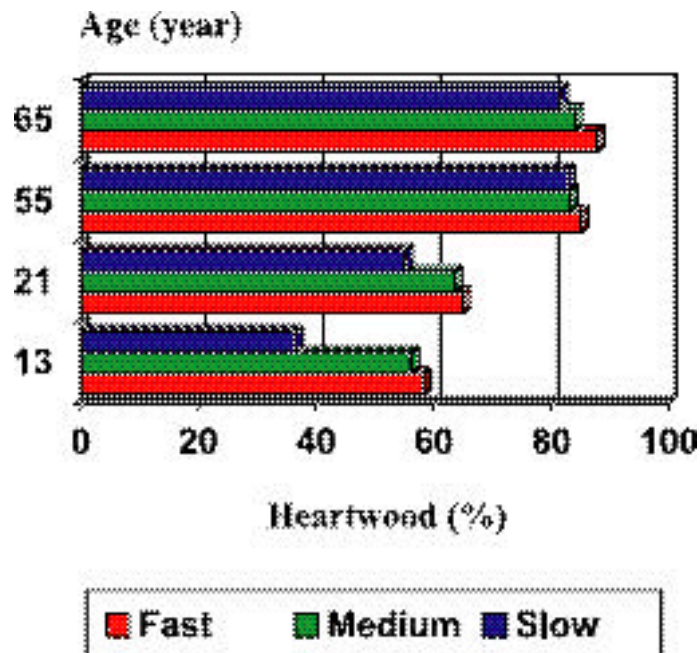


Figure 1. Comparison of mean heartwood percentages (at breast height) of fast-, medium- and slow-grown teak from the same plantations at different ages within the same geographic location in India (Nilambur).

Comparaison des pourcentages moyens de bois de cœur, à hauteur d'homme, pour des tecks à croissance rapide, moyenne et lente issus des mêmes plantations, à différents âges dans un même lieu géographique de l'Inde (Nilambur).

TIMBER WEIGHT AND STRENGTH

The general assumption among teakwood users is that fast-grown teak produces only light, weak and spongy wood. On the contrary, new data available from an ongoing research project (figures 2-4) revealed that trees selected for faster growth in forest plantations of different ages (21, 55 and 65 years) mostly display non-significant differences in wood specific gravity and mechanical properties, including fibre stress at elastic limit, Young's modulus, modulus of rupture and maximum crushing stress (parallel to grain). These results support the findings that wood specific gravity (at 12% moisture content) and mechanical properties are independent of growth rate and fast-grown trees of ring-porous species have higher wood specific gravity and strength. Furthermore, figures 2 to 4 clearly indicate that wood specific gravity and strength properties of young trees (e.g. 13- and 21-years-old) are not necessarily inferior to older trees at ages 55 and 65 years. This offers scope for reducing the rotation age of fast-grown wood without affecting timber strength. Test results on teak samples obtained from different countries such as Bangladesh, India and Myanmar indicate that the strongest wood is produced from trees with modest radial growth of 4-5 mm annually. Timber samples should therefore be collected and tested from plantations where trees were forced to grow very rapidly with high silvicultural inputs such as continuous irrigation and fertilisation before assessing growth-property relationships. Considerable evidence is available from different parts of the world which shows that plantation-grown teak is not inferior to naturally-grown timber in terms of strength properties, but in some localities naturally-grown teak shows superiority or vice versa. Discrepan-

cies in research findings could mainly be attributed to different tree responses during wood formation to different growth-enhancing factors such as spacing/thinning, site conditions including moisture and nutrient status, as well as heredity and genetic interactions with the environments. Furthermore, very heavy and moderate thinning treatments did not alter the strength properties of teak in India and Myanmar (KADAMBI, 1972).

Growth enhancement due to the control of insect defoliation in juvenile trees did not alter cell wall percentage and specific gravity of wood formed at ages 6, 7, and 8 years. Similarly, when trees from the same plantation were analysed, faster growth in the juvenile wood (within 8 rings from pith) did not alter the specific gravity and cell wall percentages, while there was a significant positive correlation between the ring width and cell wall percentage in mature wood. This is because the relative proportions of latewood and fibre wall substance are more pronounced in wider rings of mature wood (60-65 rings from pith) than in juvenile wood (BHAT, 1998). However, without regard to juvenile and mature wood zones, RAO *et al.* (1966) concluded that there was no significant relationship between ring width and tissue proportions.

The effects of growth rate in juvenile and mature woods are clearly of different magnitudes, particularly heartwood percentage and strength. The general belief that fast-growing ring-porous hardwoods produce denser and stronger wood is thus not applicable to very young juvenile teak trees, i.e. 5-8 years or less.

INTENSIVE MANAGEMENT

In India, 2 × 2 m initial spacing followed by two early mechanical thin-

nings and then silvicultural thinnings is the most common strategy for managing forest plantations. However, wider spacing, such as 2.5 × 2.5 m, 3 × 2.5 m or 4 × 5 m, is now more common in commercial teak plantations set up by private operators, e.g. in Indonesia, Malaysia and Thailand. Previously, the 2.5 × 2.5 m spacing pattern was also recommended in India since pruning was found to be useful for achieving the desired grade and for recovery of sawn wood with fewer defects. In high forest zones of Nigeria, the recommended spacing is between 2.44 × 2.44 m and 2.9 × 2.9 m although percentage survival, dbh and specific gravity were found to increase with spacing up to 3.96 × 3.96 m. Data available on the effects of spacing/thinning regimes on wood quality are insufficient for designing an efficient management strategy, although very heavy and moderate thinning treatments were found to not alter the strength properties of timbers in India and Myanmar (KADAMBI, 1972).

FERTILIZER TREATMENT

In India, fertilizer (mixture of nitrogen, phosphorus and potassium) treatment of 5-year-old trees prompted a greater than twofold increase in ring width and a 15% increase in wood specific gravity, while vessel diameter and fibre wall thickness did not show significant changes (table II). The increase in ring width was accompanied by a slight reduction in vessel percentage and a minor increase in fibre percentage, resulting in a slight increase in specific gravity. Similarly, apart from a 20% lower modulus of elasticity and slightly higher shrinkage rates due to juvenility, the similar bending and compression (parallel to grain) strength levels of treated 5-year-old trees relative to mature wood indi-

**TABLE II**

WOOD PROPERTIES OF AN INTENSIVELY MANAGED 5-YEAR-OLD PLANTATION COMPARED WITH CONTROL (based on sampling of 10 dominant trees each)

Property	Control		Fertilized trees		Test of significance
	Mean	SD	Mean	SD	
Diameter at breast height (cm)	7.8	0.9	11.0	0.6	**
Basic specific gravity	0.444	0.035	0.522	0.03	**
Ring width (mm)	2.8	1.1	7.7	3.2	**
Vessel element length (mm)	0.270	0.06	0.300	0.01	*
Vessel diameter (µm)	116	9	118	16	ns
Fibre percentage	56.4	3.2	63.5	1.6	*
Vessel percentage	18.5	3.9	12.5	1.8	*
Parenchyma percentage	17.8	2.2	24.0	1.7	ns
Fibre length (mm)	0.80	0.02	0.895	0.04	*
Fibre wall thickness(µm)	4.3	0.6	4.6	0.5	ns
Microfibrillar angle(°)	19	1	21	1	ns
Radial shrinkage (%)			4.1	2.0	
Tangential shrinkage (%)			5.9	1.2	
Vol. shrinkage (%)			10.0	2.9	
FS-EL (N/mm ²)			86	10	
MOR (N/mm ²)			111	12	
MOE (N/mm ²)			8 141	2 612	
MCS (N/mm ²)			45.9	5.5	

cates that timber produced in fertilized stands is not necessarily weaker.

This suggests that there is no cause for concern with regard to the wood

quality of fertilized stands, at least for juvenile wood production, but further data are required to be able to prescribe suitable fertilizer dosages.

IRRIGATION EFFECTS

As compared to standard teak, while some studies revealed high values for bending and compression

TABLE III

MEAN VALUES OF SELECTED MECHANICAL PROPERTIES (AIR-DRIED CONDITIONS) FOR IRRIGATED TEAK IN THREE LOCATIONS (INDIA) COMPARED WITH MEAN CONTROL VALUES FOR STANDARD INDIAN TEAK

Property	Control	Locations of irrigated plantations in India		
		Tamilnadu	Karnataka	Maharashtra
Specific gravity	0.645	0.591	0.564	0.479
Static bending (MORN/mm ²)	86.5	121.2	129.4	60
Stiffness (MOE N/mm ²)	10 745	17 215	17 147	6 921
Max. compressive stress parallel to grain (N/mm ²)	47.7	57.9	51.2	29

Source: BHAT (1998).

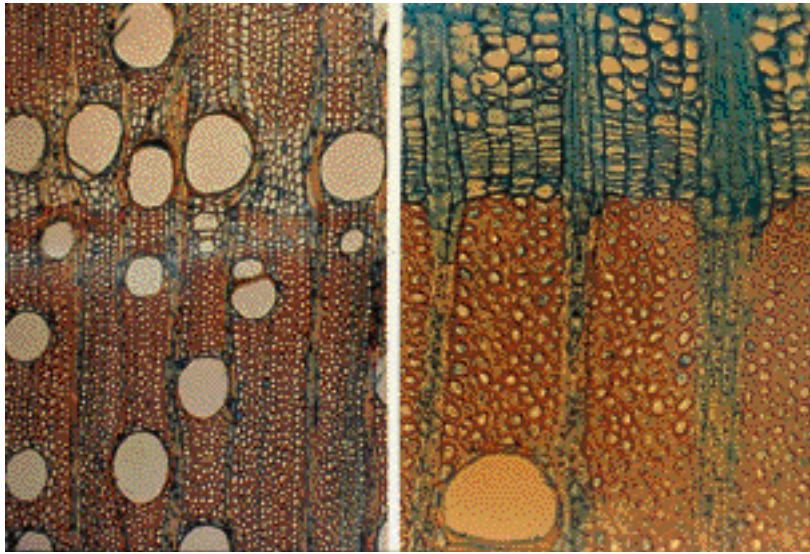


Photo 2. Microphotography of juvenile wood (left) and mature wood with bark tissue (right).
 Microphotographie de bois juvénile (à gauche) et de bois mature (à droite) montrant le tissu cortical.

strength of irrigated plantation timber from two different states in India, another study reported lower values in trees irrigated with sewage water in Maharashtra (table III). More research data are required to be able to draw up an irrigation schedule for faster growth of plantation teak trees.

JUVENILE WOOD

In commercial teak plantations, trees are grown very rapidly to reduce rotations to 20-30 years from the traditional practice of 50-80 years (table I). This results in a higher proportion of juvenile wood in harvested timber. Problems commonly associated with juvenile wood are excessive longitudinal shrinkage, warp and reduced strength with lower specific gravity. New evidence suggests that differences between juvenile and mature wood are not sufficient to affect meeting many end-users' requirements. Compared to mature wood, juvenile teakwood is characterised by wide rings, short fibres, small diameter vessels, low vessel percentage, high cell wall percentage, wide microfibrillar angle and relatively low or almost similar mechanical properties (photo 2). With regard to timber strength, there is scope for reduction of rotation periods to about 20 years as recent results indicate that the mechanical maturity of teakwood occurs at this age and further improvement of strength properties with age is practically negligible (figures 2-5). The only anticipated problems are reductions in natural resistance (due to lower heartwood content and extractives) and lower recovery of sawn wood and veneer, owing to growth stresses and smaller log diameter as well as a higher proportion of knots. These results indicate that a better understanding of juve-

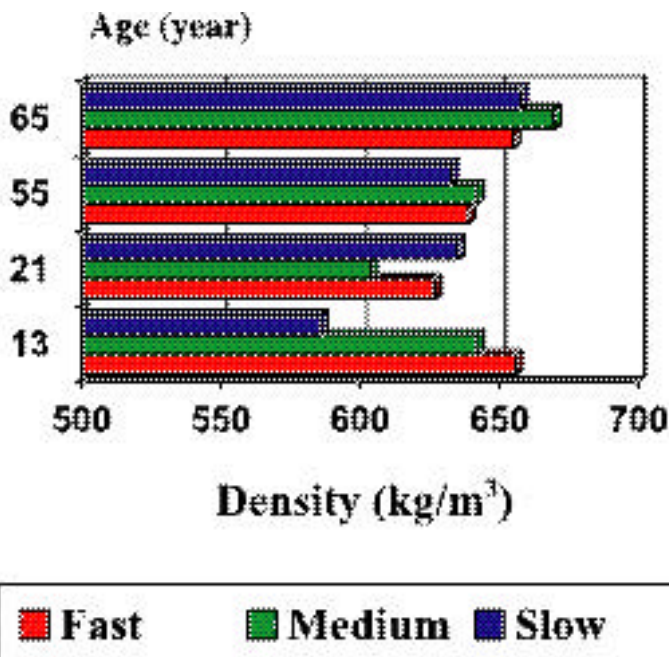


Figure 2. Comparison of air-dried wood density (kg/m^3) of fast-, medium- and slow-grown teak within the same geographic location (Nilambur) at different ages.
 Comparaison de la densité du bois séché à l'air (kg/m^3) de tecks à croissance rapide, moyenne et lente, à différents âges, issus du même lieu géographique (Nilambur).

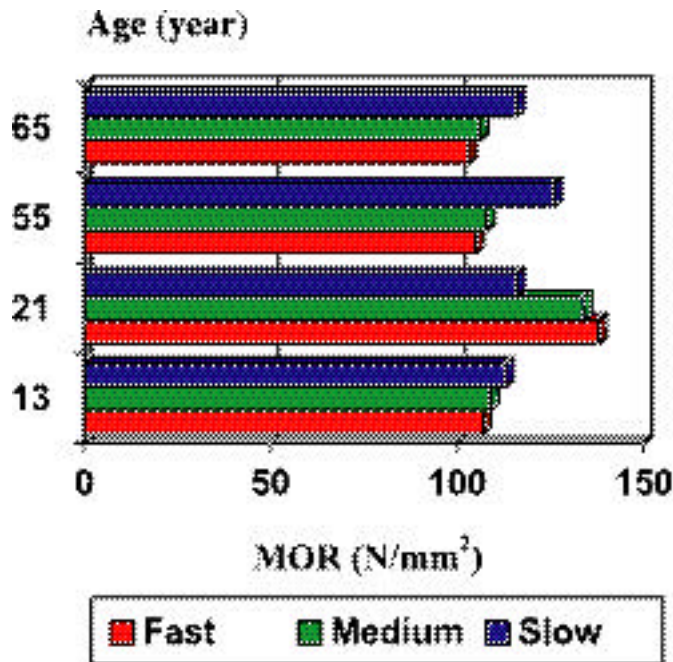


Figure 3. Comparison of maximum bending strength (N/mm^2) of fast- and slow-grown teak within the same geographic location (Nilambur) at different ages. *Comparaison des contraintes de rupture en flexion (N/mm^2) de tecks à croissance rapide, moyenne et lente, issus du même lieu géographique (Nilambur) et à différents âges.*

nile wood structure and properties is needed for efficient utilisation of juvenile teakwood resources in future tropical plantations.

HIGH SAPWOOD VOLUME IN SHORT ROTATION TIMBER

Results showing a consistent increase in heartwood volume with tree age suggest that sapwood yield per tree will be higher from thinnings and relatively small timber harvested from short rotation plantations. The mean sapwood proportion at breast height of 21-year-old trees is 40%, in contrast to 16% and 15% in 55- and 65-year-old trees, respec-

tively (figure 1). This means that the sapwood yield from existing plantations is considerable although this wood is not necessarily inferior with respect to all strength properties. The main concern is reduced natural durability of sapwood for structural/solid wood uses unless the material is adequately treated with environment-friendly preservatives. With higher penetrability, sapwood is easier to treat with preservatives than refractory heartwood. The utilisation potential of short rotation teakwood is also evident from the following observations:

- Teak can attain optimum timber strength properties in 21-year-old forest plantations, as recorded in India.
- The mean annual increment (MAI) recorded for shorter rotations of

20-30 years is almost twofold ($10-20 m^3/ha/year$) that of traditional 60-year-rotations.

- Faster growth is correlated with the higher heartwood percentage of juvenile trees. Plantation managers therefore can aim at producing larger diameter logs with greater heartwood yield (larger cylinder) per tree by accelerating tree growth of short rotation plantations. This means that growers can get better timber prices for each fast-grown tree of larger size if it can meet the property/processing requirements of high-value products such as veneer and sawn wood of desired dimensions.

FIGURE (COLOUR, GRAIN, TEXTURE) OF TEAKWOOD FROM MANAGED STANDS

Wood colour differences between managed stand trees and control trees are small compared to differences due to geographic location (photo 3). For instance, teak grown in Nilambur (India) is golden brown or yellow, while that from Konni is a darker golden brown colour. The figure shows that heartwood of 5-year-old teak from a managed stand is almost similar in colour. However, grain and texture is slightly different since rapidly grown juvenile teakwood loses its typical ring porosity, and vessels become more uniform in size (photo 4). Fast-grown juvenile wood is thus likely to be finer and more evenly textured than traditional teakwood, which will have some influence on the market value of the timber, although the price will not necessarily be much lower.

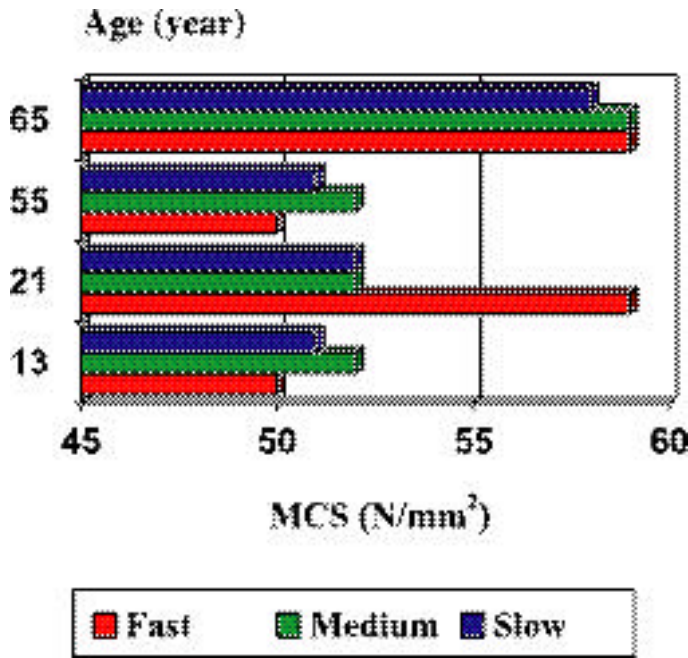


Figure 4. Comparison of maximum crushing strength parallel to grain (N/mm²) of fast- and slow-grown teak within the same geographic location (Nilambur) at different ages.
Comparaison de la contrainte de rupture en compression parallèle (N/mm²) de tecks à croissance rapide, moyenne et lente, issus du même lieu géographique (Nilambur) et à différents âges.

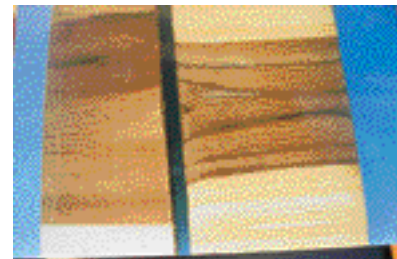


Photo 3. Plain sawn wood sample from intensively managed 5-year-old juvenile wood (left) compared with 8-year-old wood (control), displaying colour, grain, and texture on a tangential surface.
Echantillon de bois scié normalement provenant de bois juvénile (5 ans) d'exploitation intensive (à gauche), comparé à du bois de 8 ans (contrôle) et montrant la couleur, le grain et la texture sur une surface tangentielle.

found that the percentage of logs with flutes and knots was greater in generally quicker growing locations (Nilambur) than in slow-growing areas (Konni) of India (BHAT, 1998).

GENETIC SELECTION

GEOGRAPHIC/PROVENANCE/ CLONAL EFFECTS

The quality of Myanmar teak is considered to be superior because of the straighter cylindrical stems—although trees from northern parts of the country are often crooked and cross-grained (TINT, KYU PE, 1995). Teak also displays wide variations under different growing conditions and regions in India. Malabar teak (Nilambur, Kerala), generally having good growth and log dimensions with desirable figure, is commonly used for ship-building. Slow-growing trees from drier localities, which resist forest fire and tend to develop twisted/wavy grain, are known to yield heavier, stronger close-grained wood with a beautiful figure. In a preliminary study, it was

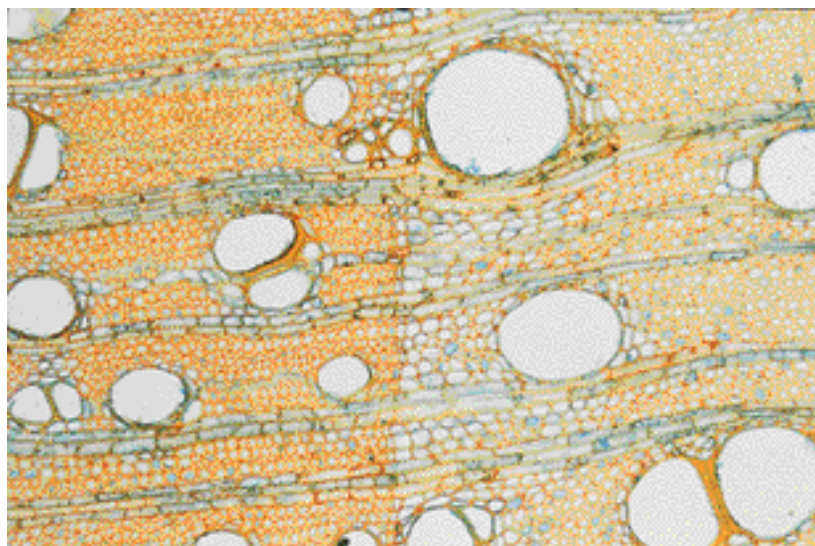


Photo 4. Transverse section showing a resumption of ring porosity in fast grown teak after 5 years of growth.
Coupe transversale montrant la zone semi-poreuse dans du teck à croissance rapide après 5 ans de croissance.

Timber produced in plantations from Trinidad was not inferior in terms of mechanical properties to samples from Myanmar (SMEATHERS, 1951). According to BRYCE (1966), the mechanical properties of 51-year-old Tanzanian-grown teak were 15% inferior to teakwood from Myanmar and Trinidad. Teak samples from West Africa were found to be harder and heavier than those from Asian regions (SALLENAVE, 1958).

Considerable evidence is available from different parts of the world which show that plantation-grown teak is not inferior to naturally grown timber in terms of strength properties, although in some localities naturally grown teak is superior or vice versa (BHAT, 1998).

SELECTION OF CLONES/ PROVENANCES FOR WOOD SPECIFIC GRAVITY

Recent tests conducted in the Kerala Forest Research Institute showed that there was no significant difference between clones; and the phenotypic coefficient of variation was as low as 8% (BHAT, INDIRA, 1997). The estimated genotypic coefficient of variation was 0.3%, which is almost negligible. The relative indication of genetic control over wood specific gravity is seen from low values of broad-sense heritability.

The genetic gain was found to be 1.7% of the mean on an individual tree basis and 3.3% of the mean on a clonal basis. Although heritability on a clone-mean basis was higher than on an individual tree basis, the genetic gain was only 3.3%. This was due to the low coefficient of variance shown by the clone. If good clones are identified and environmental conditions are suitable, wood specific gravity can be improved.

Among the six provenances, the wood specific gravity of 60-year-old trees was not significantly correlated

Provenance	dbh (cm)		Specific gravity	
	mean	cv (%)	mean	cv (%)
Nilambur	40.1	21.8	0.539	11.9
Anamalais	39.0	18.6	0.528	10.9
Travancore	36.3	15.7	0.486	13.5
South Bombay	37.6	14.7	0.488	6.5
South Burma (Myanmar)	39.9	21.2	0.524	7.9
North Burma (Myanmar)	31.5	10.9	0.538	9.1

cv: coefficient of variation.

with dbh, although the Nilambur provenance had the highest specific gravity and tree diameter (table IV). The North Burma (Myanmar) provenance displayed poor growth with relatively high wood specific gravity. Selection of provenances and individual trees for faster growth would not likely adversely affect the strength or solid wood uses. PURKAYASTHA and SATYAMURTHI (1975) also reported that seed origin contributed to only 1.5% of the variation, while the locality factor contributed to 31.4% of the variation—but the analysis was based solely on limited data from two provenances. These results imply that provenance selection will not be very effective for genetic improvement of specific gravity, but the within provenance variation (tree-to-tree variation) should be exploited. For instance, two dominant trees of the same age and grown in the same plantation showed different patterns of pith-to-bark variations in specific gravity, probably due to genetic differences (BHAT *et al.*, 1989). It is important to take advantage of this source of variation in selecting and producing structural timber of desired weight and strength with more uniform specific gravity distribution from pith to bark regions. However, selection of specific gravity alone in

genetic improvement of timber quality will be misleading due to the inconsistent relations with mechanical properties (BHAT, INDIRA, 1997b).

While much literature is available for some temperate tree species, e.g. poplar, radiata pine and loblolly pine, knowledge is limited on geographic/seed source/provenance variations in specific gravity and strength of teak (PURKAYASTHA *et al.*, 1975). Nevertheless, according to BRYCE (1966), the mechanical properties of 51-year-old Tanzanian-grown teak were 15% inferior to those of Myanmar and Trinidad. Once the best provenances are identified for certain regions/countries, individual trees with superior wood quality traits could be selected for future planting stock. It has been shown that wood specific gravity variation patterns with age are not the same in fast-growing trees. Two dominant teak trees of the same age and grown in the same plantation showed different radial variation patterns, probably due to genetic differences (BHAT *et al.*, 1989). This source of specific gravity variation should be tapped for selecting and producing timber of desired weight with more uniform specific gravity distribution from pith to bark regions for structural purposes since specific

gravity has proven to be a heritable property in many species.

PROCESSING SMALL DIMENSIONAL TIMBER

Sawing trials undertaken to evaluate small timber yields for furniture stock and strips gave satisfactory results in plantation grown teak from Côte d'Ivoire (DURAND, 1983). The two major factors that influenced sawn wood grade and recovery were unsound hollow knots and deep flutes in the logs. SANGKUL (1995) reported 51% sawn wood recovery from 20-year-old trees, with a log diameter range of 9-20.5 cm, by through and through sawing. In a preliminary study, it was found that the percentage of logs with flutes and knots was greater in a generally quicker growing location (Nilambur) than in a slow-growing area (Konni) in India. However, no relevant data are available for timber grown with intensive silvicultural practices, including pruning.

FURTHER RESEARCH

Because of the complexity of site conditions as well as genetic and environmental interactions, the results of a short-term study from one country are not sufficient to develop a specific strategy for high input management. Nevertheless, they offer scope for using intensive techniques such as genetic selection and fertilizer treatment to obtain higher

TIPS FOR TEAK TIMBER MANAGEMENT

Plantation managers can aim at producing larger diameter logs with greater heartwood yield (larger cylinder) per tree by accelerating tree growth in short rotation plantations of about 20 years.

Teak can produce timber of optimum strength in relatively short rotations of about 20 years.

Fast-growing provenances/clones can be selected for teak management without reducing timber weight/specific gravity.

Selection of individual trees within a specified provenance can offer greater potential than selection of provenances in breeding programmes for the improvement of teakwood specific gravity.

Wood specific gravity is not always the best single indicator of overall genetic improvement of timber quality.

Faster growth in relatively young forest plantations with judicious fertilizer application/genetic inputs can turn out to be advantageous in terms of heartwood volume per tree and timber strength.

More research is required on timber durability, preservative treatment of sapwood, strength properties, as well as quality standards/grading rules for fast-grown teak under high input management conditions.

yields without reducing timber value. One possible option would be to grow teak in the most suitable sites in order to tap the maximum biological potential of trees and assess the economic returns of high input management.

Interventions with appropriate processing technologies are needed for conversion (sawmilling) of small dimensional timber, solar drying and treatment with environment-friendly preservatives—in this way, quality products can be manufactured that meet market standards. They also include processing of early thinnings and small dimensional materials for

the manufacturing value-added products such as finger-jointed structures (for buildings), decorative veneer, furniture components, handicrafts/toys/souvenirs, etc. Revision of grading regulations and drawing up industrial codes of conduct are necessary for internal quality control and to ensure the quality of products derived from sustainable plantation management.

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R É S U M É

QUALITÉ DES BOIS DE TECK ISSUS DE PLANTATIONS TROPICALES AMÉNAGÉES

Avec une mention particulière aux plantations indiennes

Depuis le développement récent des plantations commerciales dans la plupart des pays tropicaux, la qualité des bois de teck à croissance rapide suscite un intérêt grandissant. Du fait du peu de données disponibles, des critères de la qualité de ces bois ont été choisis afin de faciliter le contrôle de leurs propriétés. Contrairement à l'opinion générale, les arbres dominants (phénotypiquement supérieurs) à croissance rapide comportent une proportion plus élevée de bois de cœur pendant la phase juvénile de croissance, jusqu'à la 21^e année, les différences ne sont plus significatives pour des arbres adultes âgés de 55 et de 65 ans. La rapidité de la croissance a eu très peu d'effet sur la résistance des bois de teck issus de plantations de 13, 21, 55 et 65 ans. Le teck a l'avantage de produire du bois de très grande résistance dans des conditions de rotation relativement courtes de 21 ans, dans les plantations favorables à sa croissance. Les données sur des plantations de tecks juvéniles sous une exploitation intensive montrent que: (a) les provenances à croissance rapide peuvent être sélectionnées pour l'exploitation du teck sans une réduction de la densité du bois; (b) la sélection d'arbres individuels au sein d'une même provenance offre de meilleures possibilités d'améliorer la densité du bois que la sélection de provenances relevant de programmes d'amélioration; (c) la densité du bois n'est pas toujours, par elle-même, le meilleur indicateur d'une amélioration génétique globale de la qualité du bois; (d) une croissance plus rapide dans des plantations forestières relativement jeunes, favorisée par l'utilisation judicieuse de matériel génétique et d'intrants, peut être avantageuse sur le plan du volume de bois de cœur produit par arbre et de la résistance du bois; (e) il est probable que le bois juvénile issu de plantations d'exploitation intensive diffèrera du bois de teck classique par le grain et la texture, ce qui modifiera la valeur marchande du bois; (f) la recherche sur la durabilité du bois, le traitement préventif de l'ubier, les propriétés de résistance et les normes de qualité ainsi que les règles de classement du teck à croissance rapide doit être approfondie dans des conditions d'exploitation intensive.

Mots-clés : *Tectona grandis*, plantation forestière, arbre plus, opération forestière, propriétés technologiques.

A B S T R A C T

TIMBER QUALITY OF TEAK FROM MANAGED TROPICAL PLANTATIONS

With special reference to indian plantations

With the recent development of commercial plantations throughout most of the tropics, there has been renewed interest in fast-grown teak timber quality. Some selected wood properties of fast-grown teak are appraised on the basis of current limited data to determine the quality of timber from intensively managed plantations. Contrary to common opinion, fast-growing dominant (phenotypically superior) trees were found to yield a higher percentage of heartwood per tree during the juvenile period (up to 21 years), whereas the differences were not significant in the mature period (55 and 65 years). Faster growth had very little effect on the strength of timber from 13-, 21-, 55- and 65-year-old plantations. Teak offers potential for producing timber of optimum strength with relatively short rotations of 21 years at suitable plantation sites. Data from intensively managed juvenile teak plantations indicate that: (a) fast-growing provenances/clones can be selected for teak management without reducing wood specific gravity. (b) Selection of individual trees within a specific provenance offers greater potential than selection of provenances in breeding programmes for the purpose of improving wood specific gravity. (c) Wood specific gravity is not always the best single indicator of overall genetic improvement of timber quality. (d) Faster growth in relatively young forest plantations with judicious fertilizer application/genetic inputs can be advantageous in terms of heartwood volume per tree and timber strength. (e) Juvenile wood from intensively managed plantations will likely differ from traditional teakwood with respect to grain and texture, thus influencing the market value of the timber. (f) More research is required on timber durability, preservative treatment of sapwood, strength properties, and quality standards/grading rules of fast-grown teak under high input management conditions.

Key words: *Tectona grandis*, forest plantation, dominant tree, forestry operation, technological properties.

R E S U M E N

CALIDAD DE LA MADERA DE TECA DE PLANTACIONES TROPICALES MANEJADAS

Con especial referencia a las plantaciones indias

El reciente desarrollo de las plantaciones comerciales en la mayoría de los países tropicales ha provocado un creciente interés por la calidad de la madera de teca de crecimiento rápido. Algunas propiedades de la teca de crecimiento rápido se evalúan en función de los limitados datos actualmente disponibles para determinar la calidad de la madera de plantaciones de explotación intensiva. Se ha observado que, al contrario de lo que se pensaba, los árboles plus de crecimiento rápido (fenotípicamente superiores) producen un porcentaje más alto de duramen por árbol durante el periodo juvenil (hasta los 21 años), mientras que las diferencias eran insignificantes en árboles maduros (55 y 65 años). La rapidez de crecimiento apenas afecta a la resistencia de maderas de teca de plantaciones de 13, 21, 55 y 65 años. Una de las cualidades de la teca es la producción de madera de muy alta resistencia en rotaciones relativamente cortas (21 años) en plantaciones adecuadas para su crecimiento. Los datos procedentes de plantaciones de teca juvenil de explotación intensiva indican que: (a) las procedencias/clones de crecimiento rápido pueden seleccionarse para la explotación de la teca sin reducir la densidad de la madera; (b) la selección de árboles individuales dentro de la misma procedencia proporciona mejores posibilidades para mejorar la densidad de la madera que la selección de procedencias dependiente de los programas de mejora; (c) la densidad de la madera no es siempre el mejor indicador de una mejora genética global en la calidad de la madera; (d) un crecimiento más rápido en plantaciones forestales relativamente jóvenes, favorecido por el empleo razonable de fertilizantes e insumos genéticos puede ser ventajoso en cuanto al volumen de duramen producido por árbol y a la resistencia de la madera; (e) es posible que la madera juvenil de plantaciones de explotación intensiva difiera de la madera clásica de teca en su grano y su textura, lo que modificará el valor comercial de la misma; (f) la investigación sobre la durabilidad de la madera, tratamiento preventivo de la albura, propiedades de resistencia y normas de calidad/ reglas de clasificación de la teca de crecimiento rápido debe intensificarse en condiciones de explotación de alta producción.

Palabras clave : *Tectona grandis*, plantación forestal, árbol plus, operación forestal, propiedades tecnológicas.