VARIATION IN DENSITY AND SAPWOOD PERCENTAGE OF FIVE-YEAR-OLD PLANTATION GROWN SENTANG (*AZADIRACHTA EXCELSA*)

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LIM, S. C., GAN, K. S. & ONG, T. H. 2001. Variation in density and sapwood percentage of five-year-old plantation grown sentang (*Azadirachta excelsa*). Five trees of five-year-old plantation grown sentang were studied. The sapwood percentage was found to be high and ranged from 59.8 to 88.5% with a mean of 75.7%. All trees showed an increase in the percentage of sapwood with height. For density, however, it was found in most cases to increase from the pith to approximately half radius, before decreasing towards the bark. Longitudinally, the density decreased to about midheight before increasing slightly towards the top of the tree. Overall, the density ranged from 336 to 580 kg m^{-3} with a mean of 470 kg m^{-3}. The density was about 25 to 40% lower than that of mature forest grown sentang.

Key words: Sentang – *Azadirachta excelsa* – age – density – sapwood percentage

LIM, S. C., GAN, K. S. & ONG, T. H. 2001. Variasi ketumpatan dan peratus kayu gubal pokok sentang (*Azadirachta excelsa*) berusia lima tahun yang ditanam di ladang. Lima pokok sentang berusia lima tahun yang ditanam di ladang dikaji. Peratus kayu gubal adalah tinggi dan berjulat antara 59.8 hingga 88.5% dengan purata sebanyak 75.7%. Semua pokok menunjukkan pertambahan peratusan kayu gubal dengan ketinggian pokok. Pada kebanyakan kes, ketumpatan bertambah dari empulur ke pertengahan jejari cakera sebelum berkurangan ke arah kulit kayu. Secara memanjang, ketumpatan menurun sehingga pertengahan tinggi pokok sebelum bertambah ke arah atas. Pada keseluruhannya, ketumpatan berjulat antara 336 hingga 580 kg m^{-3} dengan purata sebanyak 470 kg m^{-3}. Ketumpatan adalah 25 hingga 40% lebih rendah daripada sentang yang matang di hutan.

Introduction

Sentang (*Azadirachta excelsa*), a member of the family Meliaceae, is native to Peninsular Malaysia and many parts of Southeast Asia. More recently, it has also been cultivated in Peninsular Malaysia and Singapore, the Philippines, Hawaii, Fiji, Australia, tropical Africa and several other countries (Lemmens *et al.* 1995). In central and northern Peninsular Malaysia, sentang is a common village tree and has been reported to grow to 50 and 4 m in height and girth respectively (Mabberley & Pannell 1989). Recently, sentang has been a favourite plantation tree as it has been reported to have favourable growth (Lemmens *et al.* 1995). For example, sentang trees in Indonesia are reported to grow to between 19 and 24 m tall in nine years with a bole diameter of 22 to 27 cm. In Thailand, planted

trees reached a diameter of up to 30 cm in five years. Plantations of sentang in Java with a spacing of 2.5 × 4 m yielded 12 m^3 ha^{-1} of wood annually in the first 10 years. In Thailand, planted with a spacing of 2–4 × 4 m, sentang yielded 6 to 7.5 m^3 ha^{-1} of wood annually in the first 10 years on poor sites and 33 to 36 m^3 ha^{-1} annually on favourable sites. The 41-year-old sentang planted at the Forest Research Institute Malaysia had a mean diameter of 51.8 cm and a height of 33.2 m (based on 100 biggest trees per ha) (Ahmad Zuhaidi & Weinland 1995). The overall mean diameter was 34.9 cm and the overall mean height 26.0 m. The mean clear bole height was 20.9 m and the approximate standing volume (clear bole volume only), about 590 m^3 ha^{-1}.

With the shortage of log supply from the natural forests in Peninsular Malaysia, the pressure is on for the establishment of forest plantations. Besides rubber trees (*Hevea brasiliensis*), teak (*Tectona grandis*) and *Acacia mangium*, sentang is also being promoted as a plantation tree by FRIM and other forestry agencies in Malaysia (Baskaran 1997). Planted sentang has the potential to meet the log demand in the future for the following reasons: (a) fast growth, (b) favourable growth properties (shade tolerance and side competition, hardy, good natural bole form, natural self-pruning, prolific seed production and ability to regenerate and propagate easily) and (c) timber of acceptable quality and good economic value (Mohd. Noor *et al.* 1999).

The concept of planting sentang for commercial timber production is relatively new to Malaysia. It has been estimated that over the last four to five years, a total of about 1530 ha of sentang plantations has been established in Peninsular Malaysia (Mohd. Noor *et al.* 1999). Even though sentang is said to be a potential future source of timber, published information on its properties is still scanty. In view of this, this study was conducted to ascertain the quality of plantation grown sentang by examining two main parameters for wood quality study, namely, density and sapwood proportion. The information provides indication of the possible utilisation of the timber. The aim of this study is not to promote harvesting at an early age but rather to provide information on its properties should there be a need to utilise wood from the process of thinning.

Materials and methods

Five sentang trees of about five years of age and with heights ranging from 9 to 11 m were obtained from a plantation at Kampong Tasoh in the state of Perlis, Peninsular Malaysia. The trees, with seedlings from Thailand, were planted with a spacing of 1.83 × 3.66 m. No fertiliser was used.

Five discs of about 2.5 cm thick were obtained from positions 10, 30, 50, 70 and 90% of the clear bole of each tree (Figure 1a). The diameter of the discs and the length of the clear boles are given in Table 1. For sapwood determination, measurements were taken at four different points of each disc (Figure 1b). For density determination, a strip of about 2 cm wide was cut along the diameter and samples of about 1 cm wide were obtained along the left (marked L1, L2, L3, etc.) and right (marked R1, R2, R3 etc.) radii and marked accordingly as shown in Figure 1c.

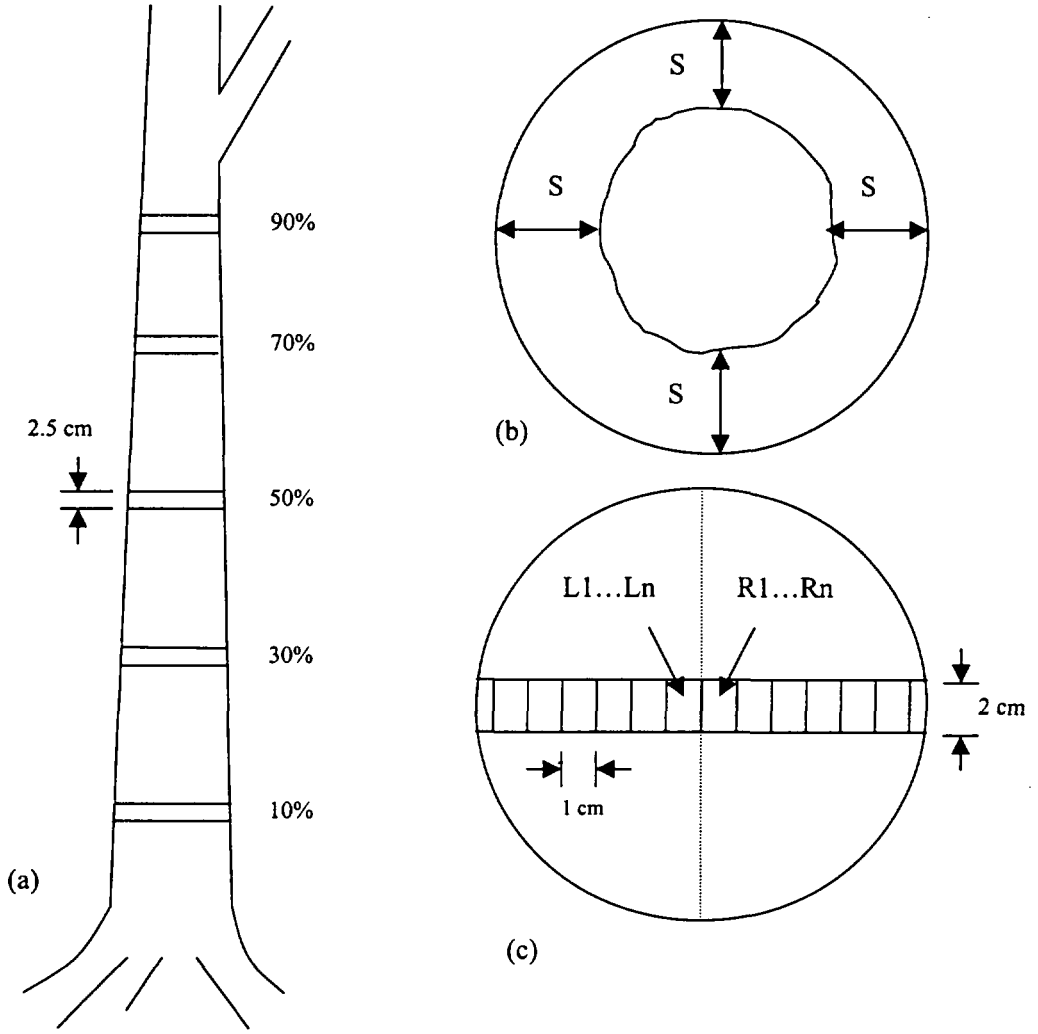

Figure 1. (a) The relative positions of discs, (b) measurement of sapwood and (c) sampling for density

The percentage of sapwood was calculated based on the following formula:

$$\% \text{ Sapwood} = \frac{(R^2 - r^2)}{R^2} \times 100$$

where

R = radius of the disc
r = radius of the heartwood

The density was determined by dividing the oven-dry weight of the sample by its green volume. The oven-dry weight was obtained by keeping the samples in an oven at 103 ± 2 °C for 48 hours or until constant weight was reached. The volume was obtained by the water displacement method.

Table 1. The height of clear boles and diameter of the discs

Clear bole (m)	Disc diameter (cm)				
	Height				
	10%	30%	50%	70%	90%
4.7	14.6	13.6	12.6	11.2	10.6
4.9	16.4	13.9	13.2	10.7	10.6
4.9	18.2	16.3	14.4	13.4	12.3
4.9	15.4	13.4	12.3	11.2	10.5
4.5	15.3	13.5	12.4	12.1	11.5

Results and discussion

Density variation

The density ranged from 336 to 580 kg m^{-3} with a mean of 470 kg m^{-3} for all trees (Table 2). This is rather low compared with the density of mature sentang which was reported to be 550 to 780 kg m^{-3} (Lemmens *et al.* 1995), 550 to 650 kg m^{-3} for air-dry density (Burgess 1966), 606 kg m^{-3} for samples obtained from Sabah (Mohd. Hamami *et al.* 1997), 560 to 770 kg m^{-3} (Wong 1982) and 482 to 648 kg m^{-3} for 8-year-old sentang (Lim & Gan 2000a). The reason for the low density of the young sentang may be attributed to the presence of juvenile wood. Lim and Ani Sulaiman (1999) reported that when a comparison of density is made for plantation grown rubberwood (*Hevea brasiliensis*) of similar clone, there is a tendency for the density to increase slightly with age. The density of 28-year-old teak (*Tectona grandis*) was about 6% higher than that of 8-year-old teak (Lim & Gan 1998).

Table 2. Density of 5-year-old sentang

Mean ± SD (kg m^{-3})	Range (kg m^{-3})
463 ± 12.5	431–507
504 ± 25.6	431–561
481 ± 19.3	407–532
484 ± 19.3	414–580
418 ± 9.3	336–528

Longitudinally, there was a tendency for the density to decrease from the basal to about 50% height and then increase slightly towards the top of the tree (Figure 2). This pattern of variation had been reported earlier for Malaysian grown teak (Lim & Gan 1998) and also for an 8-year-old sentang tree (Lim & Gan 2000a). However, Panshin and de Zeeuw (1980) reported that hardwood density variation with height shows very little consistency and there is no overall dominance of a single pattern. They suggested that the inconsistency may be due to the diversity of cell structure and other environmental factors such as site quality.

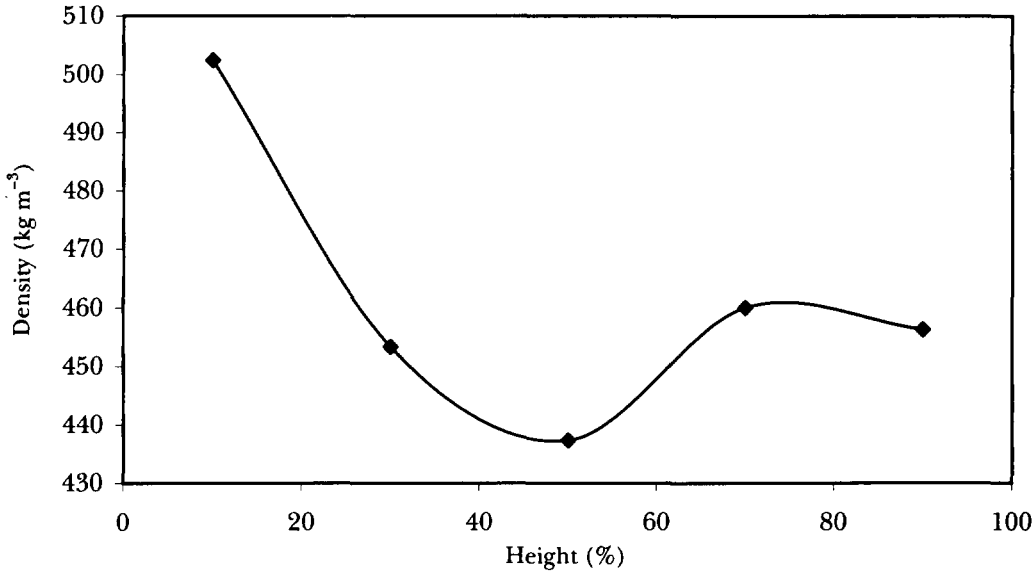

Figure 2. Density variation with height. Each point represents the mean value of samples taken along the diameter at each height

The radial pattern of variation was quite consistent at all heights (Figure 3). Generally, the samples near the pith had lower density. Then the density increased towards the middle of the disc before decreasing towards the bark. This pattern of variation has also been reported on 28-year-old teak but not on the 8- and 16-year-old teak which have higher density towards the bark (Lim & Gan 1998). In a study on rubberwood, Lim and Fujiwara (1997) reported that there is no fixed pattern of density variation in two clones, PB235 and PB260. However, Panshin and de Zeeuw (1980) reported that the most frequent pattern of density variation is an increase from the pith to the bark.

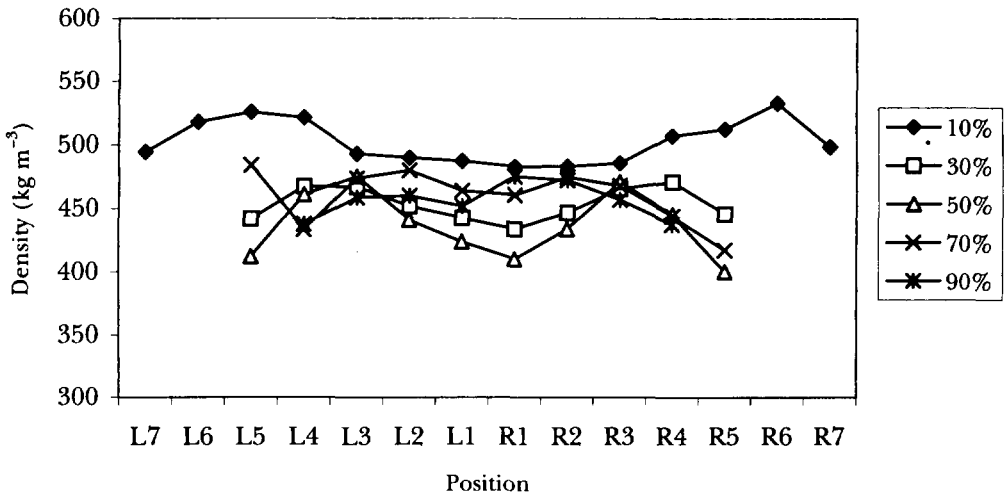

Figure 3. Density variation across the diameter

Sapwood percentage

Sapwood is a pathway for the movement of water and nutrients from the roots of the tree to the leaves. A stem must have a sufficiently large transverse area of sapwood to compensate evaporative water losses from the leaves (Sellin 1996). However, the sapwood-heartwood proportion is important, not merely from an academic point, but also from a technological point of view. The most significant feature of sapwood is its lack of resistance to insect and fungal attack (Brazier 1971).

The width of the sapwood of sentang ranged from 2.9 to 3.9 cm with disc diameter ranging from 10.5 to 18.5 cm. The percentage of the sapwood was calculated based on the sapwood thickness and stem radius. The percentage of sapwood ranged from 59.8 to 88.5% with a mean of 75.7% and all trees showed an increase in sapwood percentage with height (Figure 4). A high percentage of sapwood is expected for a young 5-year-old plantation grown tree as vigorous growth of the tree often results in a wide sapwood zone (Brazier 1971). However, the sapwood percentage depends very much on the age and timber species concerned. For example, in the study of the sapwood percentage of locally grown 14-year-old *A. mangium*, Lim and Gan (2000b) reported a range of 19.7 to 34.9% with a mean of 27.2%. All trees also showed an increase in sapwood percentage with height. Bhat (1995), in his study on 8-year-old teak, reported a mean heartwood percentage of 30.1% (sapwood 69.9%). He further reported that there is an increase in the heartwood percentage of teak with age as follows: 50.3, 61.2 and 83% for trees of 13, 21 and 55 years respectively. Lim and Gan (2000c) reported a sapwood percentage of 53.7 and 31.0% for 8- and 28-year-old Malaysian grown teak respectively.

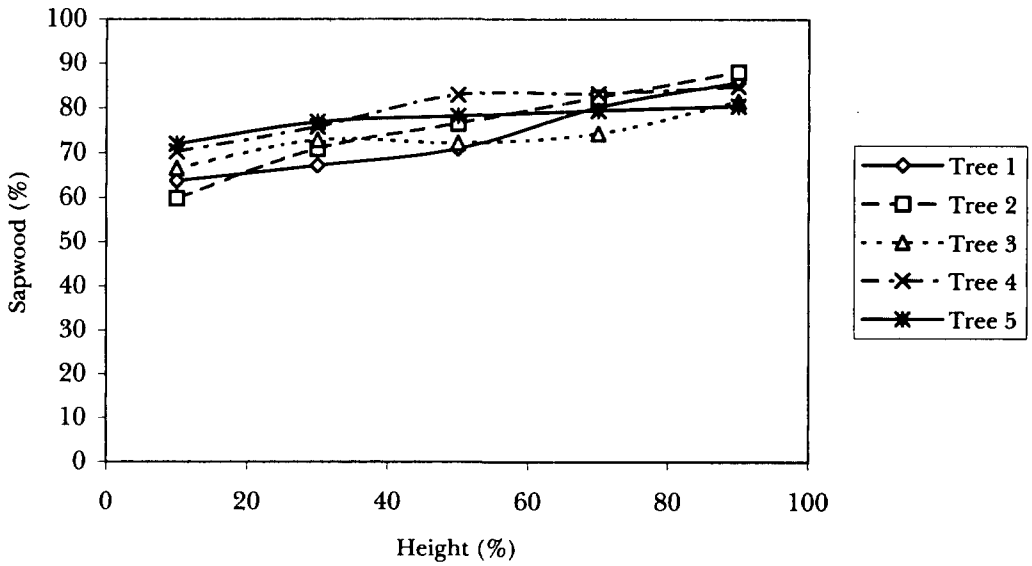

Figure 4. Percentage of sapwood with height

Conclusion

The density of 5-year-old sentang was about 25 to 40% lower than the density reported for mature sentang from the natural forest. At a mean density of 470 kg m^{-3}, the strength of sentang wood is expected to be low. The large percentage of sapwood found in 5-year-old sentang makes it less durable and thereby very susceptible to insects and fungi infestation. For timber with such a low density, large percentage of sapwood and small dimensional stock, preservative treatment similar to that of rubberwood should be carried out before the wood is utilised. It is also recommended that the materials be laminated so that a larger dimensional stock can be obtained.

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