GROWTH OF TEAK (*TECTONA GRANDIS*) ON LATERITIC SOIL AT MATA AYER FOREST RESERVE, PERLIS

Hashim Md Noor*

Forest Research Institute Malaysia (FRIM), Kepong, 52109 Kuala Lumpur, Malaysia

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HASHIM, M. N. 2003. Growth of teak (*Tectona grandis*) on lateritic soil at Mata Ayer Forest Reserve, Perlis. Teak (*Tectona grandis*) stumps were transplanted in a lateritic site at a spacing of 3 x 3 m at Mata Ayer Forest Reserve, Perlis. About 50% mortality occurred in the first three years after planting. Mechanical impediment to root growth and water stress were suspected to be the main factors for high mortality. Intersections of mean annual increment and current annual increment curves of height and diameter showed that maximum height and diameter increments were reached at ages four to five years after planting. This growth stage was also the best time to conduct the first thinning. Recommendations to improve survival and productivity of teak grown on lateritic soils are given.

Key words: Monsoon climate - Gajah mati series - moisture stress - stumps - survival - growth increment - first thinning

HASHIM, M. N. 2003. Pertumbuhan jati (*Tectona grandis*) di atas tanah laterit di hutan simpan Mata Ayer, Perlis. Anak benih tunggul jati (*Tectona grandis*) telah ditanam di kawasan tanah laterit pada jarak tanaman 3 x 3 m di Hutan Simpan Mata Ayer, Perlis. Kira-kira 50% kematian terjadi dalam tempoh tiga tahun pertama selepas ditanam. Halangan mekanikal ke atas pertumbuhan akar dan tegasan kelembapan disyaki sebagai punca utama kadar kematian yang tinggi. Penyilangan garis lengkung tambahan tahunan purata dan garis lengkung tambahan tahunan kini bagi ketinggian dan diameter menandakan kadar pertumbuhan maksimum ketinggian dan diameter tercapai pada usia antara empat hingga lima tahun. Peringkat pertumbuhan ini juga merupakan masa terbaik untuk menjalankan penjarangan pertama. Cadangan-cadangan untuk meningkatkan kadar kehidupan dan produktiviti jati di tanah laterit diberikan.

Introduction

Teak (*Tectona grandis*) was planted at Mata Ayer Forest Reserve in Perlis since 1953 (Wyatt-Smith 1957, Vincent 1962). Due to encouraging early growth, the planting of teak has been expanded to other parts of the forest reserve. However, performance of the latter plantings were below expectation, possibly due to poor lateritic soil of the site (Tang & Kadir 1979). Experience in India indicated that teak performed poorly on shallow laterite soils (Troup 1921, Kadambi 1972, Rajan & Rao 1978).

In 1981 a sample plot was established at Mata Ayer Forest Reserve in Perlis to monitor the growth and yield of teak on lateritic soils. This paper reports the survival and growth of the sample plot up to nine years of age.

Key name of author: Hashim

Materials and methods

Site description

The site is located at Compartment 17 of the Mata Ayer Forest Reserve (6 ° 40' N and 100° 15' E, Figure 1), at an elevation of 75 m asl. The area experience a monsoonal climate with two to three months of dry season, from December to March. The site receives an annual rainfall of 1611.6 mm with two maxima and minima each in a year. The low maximum occurs in April to May while the high maximum in October. The low minimum occurs in February and the high minimum in June. The mean daily temperature range from 26.0 to 29.3 °C. Mean maximum daily temperature, however, can exceed 35 °C. The soil is classified as a "Gajah Mati" series (Orthoxic Tropudult), a lateritic type soil. The soil in the plot is sandy, having low nutrients and cation exchange capacity (Tables 1 and 2).

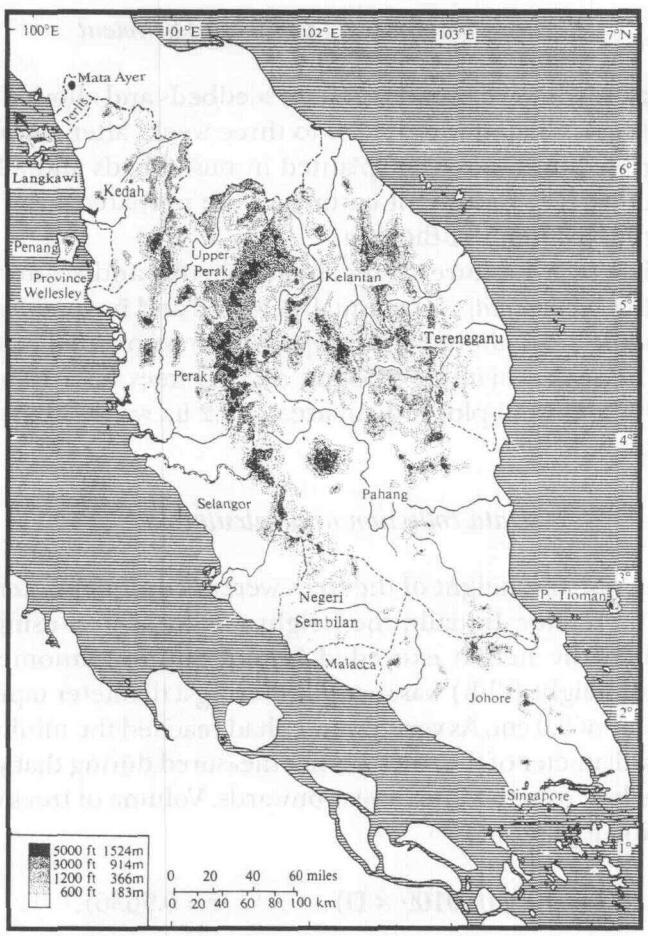

Figure 1 The location of the study site in the Compartment 17 of Mata Ayer Forest Reserve, Perlis

Table 1 Physical properties of lateritic soil at Mata Ayer Forest Reserve, Perlis

Depth (cm)	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Wet pH	Available water (mm/m)
0–15	23	42	16	22	4.97	106.4
15–30	22	35	12	24	5.15	110.7
30–45	20	40	12	24	5.25	116.6

Table 2 Chemical properties of lateritic soil at Mata Ayer Forest Reserve, Perlis

Depth (cm)	N (%)	Available P (ppm)	K (meq/100 g)	Ca (meq/100 g)	Mg (meq/100 g)	CEC (meq/100 g)	C (%)
0–15	0.17	0.95	0.10	0.69	0.57	7.63	0.60
15–30	0.16	0.80	0.14	0.74	0.27	7.01	0.28
30–45	0.16	0.94	0.09	0.51	0.31	8.11	0.30

Planting materials and plot establishment

Pretreated teak seeds were broadcasted on seedbeds and allowed to germinate. Most of the seeds germinated within two to three weeks after sowing. At two-leaf stage, the young seedlings were transplanted in raised beds and allowed to grow for one year. Stumps, i.e. root-shoot cuttings, were prepared from the seedlings for use in the establishment of the plot.

A site occupied by a mixture of secondary shrubs and scattered clumps of bamboo (*Gigantochloa ligulata*) was manually cleared and burned in June 1981. In September the same year, about 500 stumps were transplanted at the site with a spacing of 3 × 3 m, giving an initial stocking of 1111 trees ha^{-1}. Immediately after planting, a growth and yield plot with an area of 0.2 ha was established within the experimental site.

Data collection and calculation

The survival count and height of the trees were recorded quarterly for the first year and yearly thereafter. Initially, the height was measured using a graduated height stick. When the height exceeded 3 m, a Suunto clinometer was used. Diameter at breast height (dbh) was measured using a diameter tape on trees with minimum diameter of 3.0 cm. As very few trees had reached the minimum diameter at age three years, diameter of the trees was not measured during that year. Diameter was instead recorded from the fourth year onwards. Volume of trees was calculated using the following equation:

$$V = -0.06579 + (0.0109 \times D) \qquad (r = 0.9636),$$

where,

V = over bark volume
D = dbh

Results and discussion

Survival

The survival of teak trees decreased sharply during the first three years after planting; thereafter mortality rate began to level off (Figure 2). During this establishment period about 50% of the initial stocking died. This early establishment phase seems to be very critical for survival and growth of teak planted using stumps in lateritic site. Unlike potted seedlings, stumps require a period of time to develop feeding roots to enable them to seek moisture and nutrients from the soil. Water stress and soil properties may impede root growth and, thus, contribute to early tree mortality (Awang & Sawal 1987, Kozlowski 1999). The onset of the dry period in December, about three months after planting of stumps, may have aggravated the condition as the young plants may experience some extent of water stress. As a comparison, survival of teak stumps on moist alluvial soil, 15 years after establishment, was between 77.7 and 83.5% (Hashim *et al.* 2000). To minimise planting failure caused by moisture stress, teak should be planted during the semi-wet months of June and early July to allow ample time for the young plants to develop a sufficient root system and to adapt to the planting site (Cerra 1965). Thus, the result of this study suggests that the season of planting is very critical for teak plantation established from stumps in areas with seasonal dry climate. In non-seasonal sites of Malaysia, the season of planting may not be as critical.

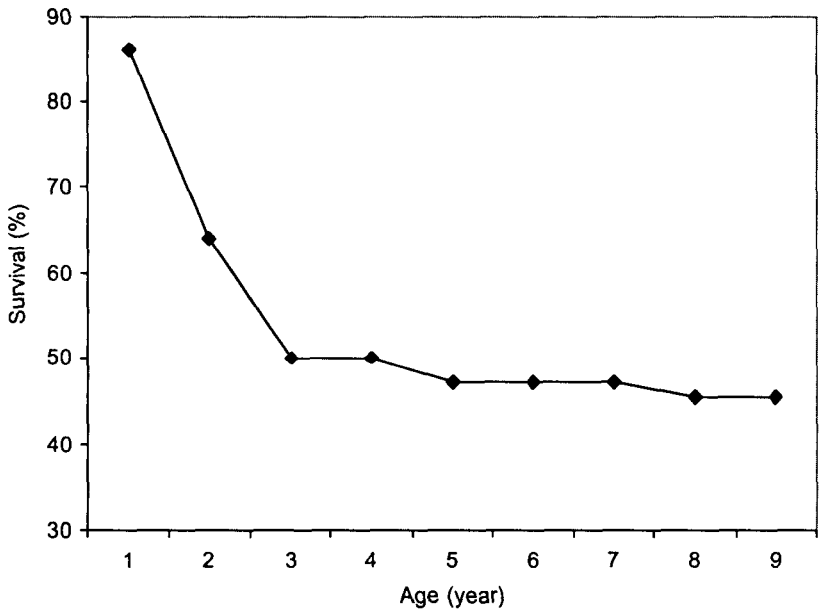

Figure 2 The survival of stump-planted teak on lateritic soil at Mata Ayer Forest Reserve, Perlis

Growth performance

The height of teak in this study increased steadily with age (Figure 3). However, the height began to taper off at about five years after planting. At this stage (i.e. between ages 4 and 5 years), the curves of height mean annual increment (HMAI) and height current annual increment (HCAI) intersect (Figure 4). The intersection point of the curves indicates the best time to initiate the first thinning. Delaying the thinning could impose the stand to intense inter-tree competition, resulting in poor stand growth and yield (Hashim 1996, 2002).

Diameter, basal area and volume of teak in the plot increased with age (Table 3, Figure 5). For instance, at age four years, only 8.4% of the trees reached a dbh > 10 cm. However, this proportion of trees increased with age and at nine years, 96.6% of the survived trees attained a dbh > 10 cm.

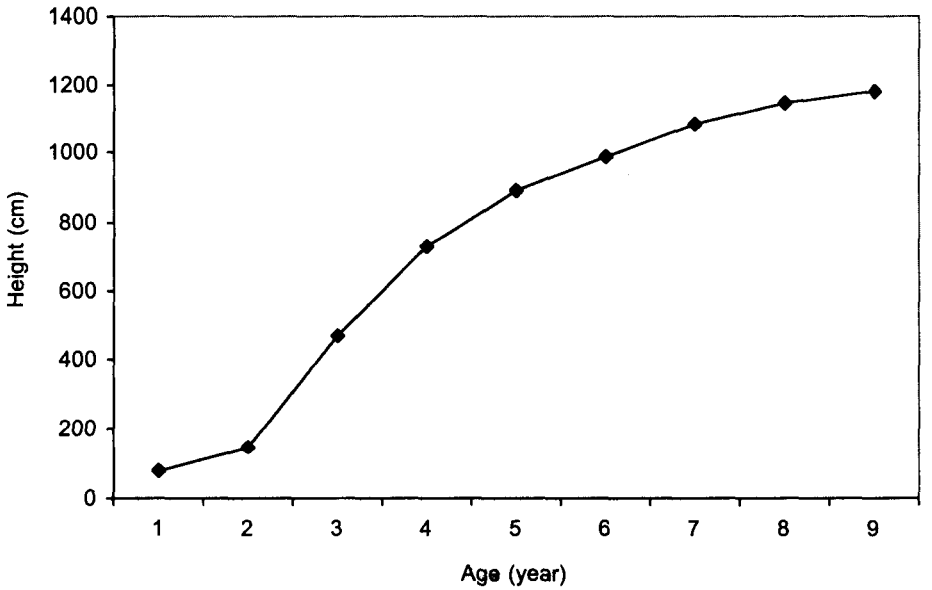

Figure 3 The height of teak grown on lateritic soil at Mata Ayer Forest Reserve, Perlis

Table 3 Stem size, basal area and volume of teak grown on lateritic soil at Mata Ayer Forest Reserve, Perlis

Age (year)	Dbh < 10 cm (%)	Dbh > 10 cm (%)	Basal area (m^2 ha^{-1})	Volume (m^3 ha^{-1})
4	90.6	8.4	2.80	6.87
5	53.1	46.9	4.58	22.66
6	38.8	61.2	6.32	38.68
7	20.0	80.0	8.35	47.92
8	10.4	89.6	10.64	57.44
9	3.4	96.6	11.91	66.87

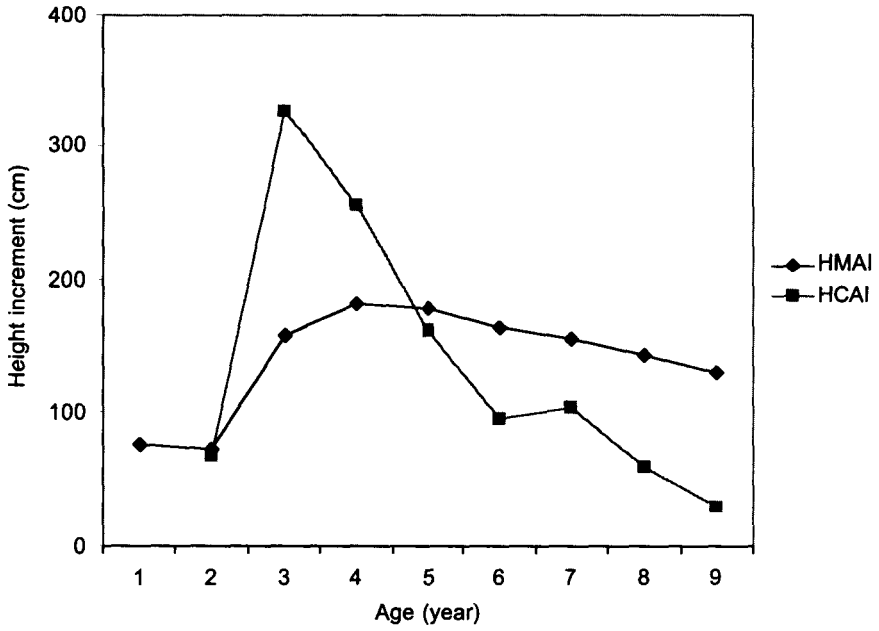

Figure 4 The height increment of teak grown on lateritic soil at Mata Ayer Forest Reserve, Perlis

HMAI : Height mean annual increment
HCAI : Height current annual increment

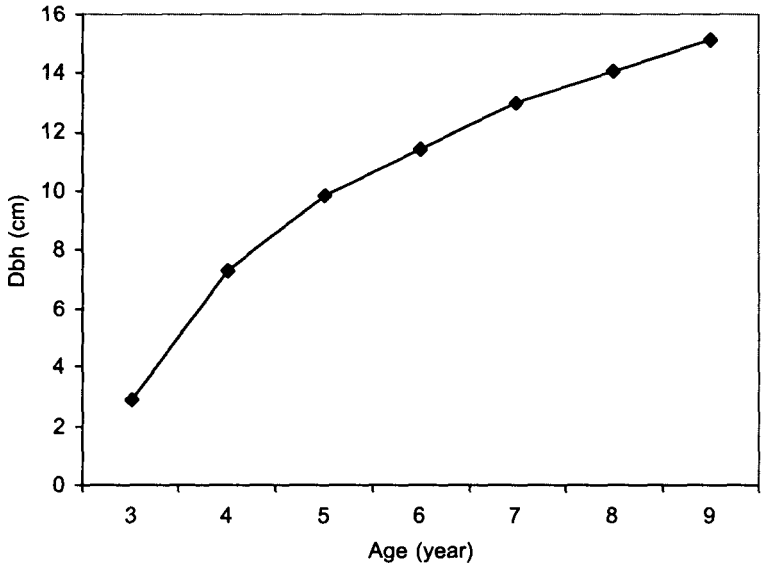

Figure 5 The diameter growth of teak grown on lateritic soil at Mata Ayer Forest Reserve, Perlis

Similar to height, the curves of dbh mean annual increment (DMAI) and dbh current annual increment (DCAI) intersect at age four to five years (Figure 6). If diameter and tree volume at age three years are available, the curves of volume mean annual increment (VMAI) and volume periodic annual increment (VPAI) are expected to intersect at a similar point (between four and five years) (Figure 7). The points of intersection of the curves indicate the optimum diameter and volume increments and the best time to conduct the first thinning. Delaying thinning treatment could jeopardise the stand growth and productivity.

Lateritic soil can be considered as poor soil for teak because of its low water retention ability and nutrient status. In the present study, the survival of teak decreased considerably in the first three years after planting; 50% of the stocking died. High mortality in the first three years after planting is unlikely caused by inter-tree competition, as competition normally sets in when the crowns of individual trees touch one another. In our sample plot, the trees that survived were not evenly distributed but occurred in groups (i.e. clumping pattern). The spacing used in the present study is considered suitable for teak. Ola-Adam (1990) reported that a spacing of 2.9 × 2.9 m was the best for teak grown in Nigeria, with survival of 57.09% and mean total height of 13.5 m at age 18 years. Thus, impediment to root development and low moisture supply were suspected to be the main factors for the high mortality of teak trees in the present study. As the depth of topsoil in the plot was not uniform, individuals planted on shallow topsoil would have died earlier than those grown in deeper soil. Lateritic layer in Gajah Mati soil series can be found 15 cm from the soil surface and lateritic nodules comprise between 50 and 70% of soil volume (Mohd. Ghazali *et al.* 1994). Shallow topsoil will impose greater water stress to young seedlings especially during the dry season. Thus, it is important to plant teak during the rainy season when the soil moisture supply is non-limiting. To improve root growth and development, which is important for high survival rate, the stumps can be pretreated with commercial rooting hormones (e.g. IBA or NAA). Bigger planting holes can be used to ensure better growth and development of the root. Mulching with paddy husk can retain sufficient moisture and, thus, improve the soil conditions.

The growth of teak on lateritic soil in the present study was not as good as those grown on more fertile sites (Amir Husni & Suhaimi 1996). The authors showed that trees established on alluvial soil (Penambang series) had 42.5 and 70% greater dbh and height respectively than those found on lateritic soil (Gajah Mati series). Hashim (1996) reported that the total volumes of a teak stand grown on deep alluvial soil at ages five and 10 years were 81.45 and 163.9 m^3 ha^{-1} respectively. However, the total volumes at ages five and nine years in this study were much lower, i.e. 27.8 and 40.8% of the values reported by Hashim 1996. Vincent (1962) showed that teak grown on alluvial soil had a total basal area of 16.22 m^2 ha^{-1} at nine years which is 36.2% higher than the basal area in the present study. In order to improve the fertility of lateritic soil at Mata Ayer Forest Reserve, commercial fertilisers should be given periodically, especially during the critical establishment period. It has been recommended that a dose of 60 g NPK (15:15:15) per tree be given quarterly to newly established teak (Hashim 1996).

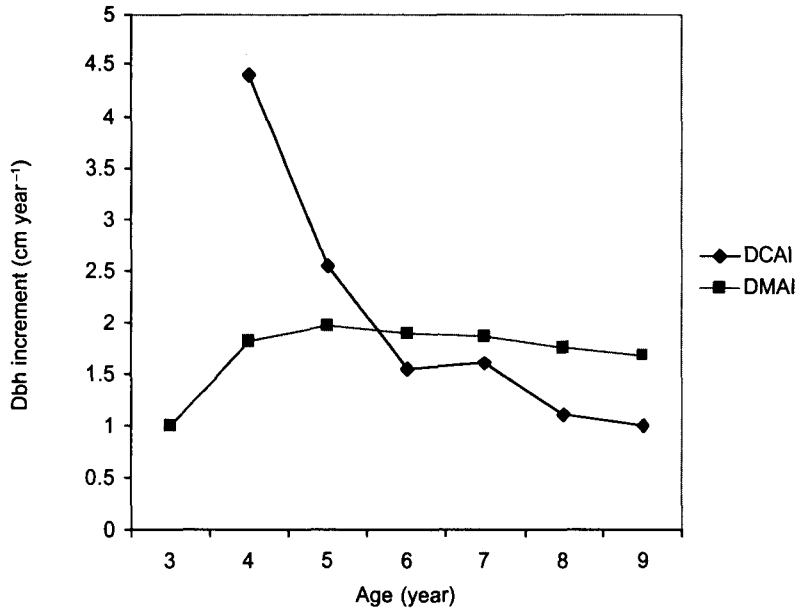

Figure 6 The diameter increment of teak grown on lateritic soil at Mata Ayer Forest Reserve, Perlis

DMAI : Dbh mean annual increment
DCAI : Dbh current annual increment

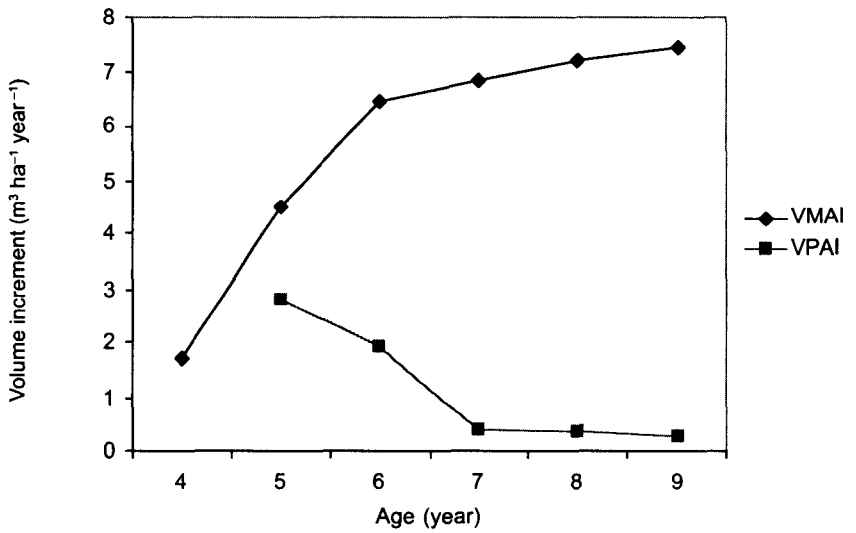

Figure 7 Volume increment of teak grown on lateritic soil at Mata Ayer Forest Reserve, Perlis

VMAI : Volume mean annual increment
VPAI : Volume periodic annual increment

The culmination of growth increment of teak stand suggests that the best time to initiate first thinning is between ages four and five years. Delaying the thinning would cause unnecessary inter-tree competition, which could reduce wood production and quality. Thus, planting and thinning need to be scheduled at the right time to ensure high productivity of teak plantation.

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