THE GROWTH OF *PHYLLAGATHIS ROTUNDIFOLIA* UNDER DIFFERENT LIGHT CONDITIONS

Philip E.[1*], Jaafar H.Z.[2] and Rizal M.K.M.[1]
[1]Forest Research Institute Malaysia (FRIM), Kepong, 52109 Selangor, and
[2]Crop Science Department, Faculty of Agriculture, 43400 UPM Serdang, Selangor
*Tel: 603-62797249; Fax: 603-62797878: Email: philip@frim.gov.my

ABSTRACT

P. rotundifolia is a medicinal plant that is used in Peninsular Malaysia. The leaves and roots are used to treat malaria, fever in children and after child-birth to give strength to mothers. This perennial herb is common in the lowland forest. A study was conducted to document the growth requirement of the plant. The physiological growth and leaf development in different light conditions was studied. It was noted that when grown under very low light intensities, the leaf size was larger. The leaf size reduced significantly when planted under partial shades. Besides, light, moist condition is preferred. This paper would prescribe the optimum growth conditions for large scale planting.

Keywords: medicinal plant, physiological growth, light intensities, optimum growth condition

INTRODUCTION

P. rotundifolia is a perennial herb that is often used for post natal care amongst rural folks. They are common in lowland forest. It has been reported that *P. rotundifolia* contained eight cyanogenic glucosides, one alkyl glycoside, two aromatic compounds and seven hydrolyzable tannins (Ling *et al*, 2002). These compounds are noted in the leaves, roots and stems. Hence, in the pursuit for a healthy and 'green' lifestyle, demand for plant based compounds and supplements is increasing. The objective of this paper is to document the light saturation level for optimum physiological growth of *P. rotundifolia*.

MATERIAL AND METHODS

The growth rates of *P. rotundifolia* were evaluated at Sg Congkak and Sg Tekala Forest Reserves. The growing conditions of these plants are described in Table 1. Light response curves were derived with a portable photosynthesis machine (LICOR 6400, USA). The leaves were subjected to light intensities between 0 to 1500 μmol m^{-2} s^{-1}. These curves were generated at 80% RH, leaf temperature, 28°C and carbon dioxide concentration, 380 ppm. In addition, chlorophyll fluorescence was also measured at light saturation (I=100%) using fluorescence meter (Hansatech Plant Efficient Analyser, U.K). The excitation light for fluorescence was given at about 500 μmol m^{-2} sec^{-1} for 5 sec. Measurements of F_o, (Initial fluorescence) F_M, (Maximum fluorescence) and F_v (Variable fluorescence) were obtained from this procedure. F_v is derived as the difference between F_M and F_o. F_v/F_m: Represents the maximum quantum yield of PSII, which highly correlated with the quantum yield of net photosynthesis. (Owens 1994). Leaf area was measured with a portable leaf area meter (CID, Canada) while chlorophyll content was determined using a portable chlorophyll meter (SPAD 502, Minolta Co. Ltd, Japan).

Table 1. Site description and growing condition at each site.

Growing condition	Sg. Congkak F.R.	Sg. Tekala F.R.	Sg. Tekala F.R.
Light intensity	100 µmol m^{-2} s^{-1}	60 µmol m^{-2} s^{-1}	1000 µmol m^{-2} s^{-1}
Relative humidity	90%	90%	60%
Occurrence	Planted on forest floor	Growing naturally	Planted in the open

FF= planted on forest floor   P= planted in the open

Physiological values are means of three replicates taken from each of the six plots. Comparisons between means were evaluated by *t-test* as indicated at P = 0.01 and 0.05 level using SAS Statistical package. Measurements were done between 9.30 to 11.30 am and on a monthly basis for a period of three months.

RESULTS AND DISCUSSION

The response of Photosynthesis (*A*) to photon flux density (PFD) describes a curve progression, consisting of two phases as demonstrated in Figure 1. An initial linear phase of an increase in photosynthesis with Photon Active Radiation (PAR) through the light compensation point, a progressive decrease in the slope of the curve with increase in PAR to a plateau and decline. Light becomes saturated at above 300 µmol m^{-2} s^{-1} (Figure 1).

The light saturated rate of CO_2 uptake declined when planted in the open when compared with plants growing on forest floor. A_{max} for plants planted in the open was about 70 % of that on forest floor (Figure 1). Though there was a decline in $A_{max,}$ there was no difference in the light saturation of CO_2 uptake. Although the light became saturated at above 300 µmol m^{-2} s^{-1}, but the efficiency of light utilization by photosynthesis (ϕ_{co2}) reduced for plants planted in the open. This inferred from the initial slope of the light response curve was between 50of that of the planted on forest floor (Table 2). Comparing between A_{max} and ϕ_{co2} showed that there was a greater reduction in ϕ_{co2} than A_{max}.

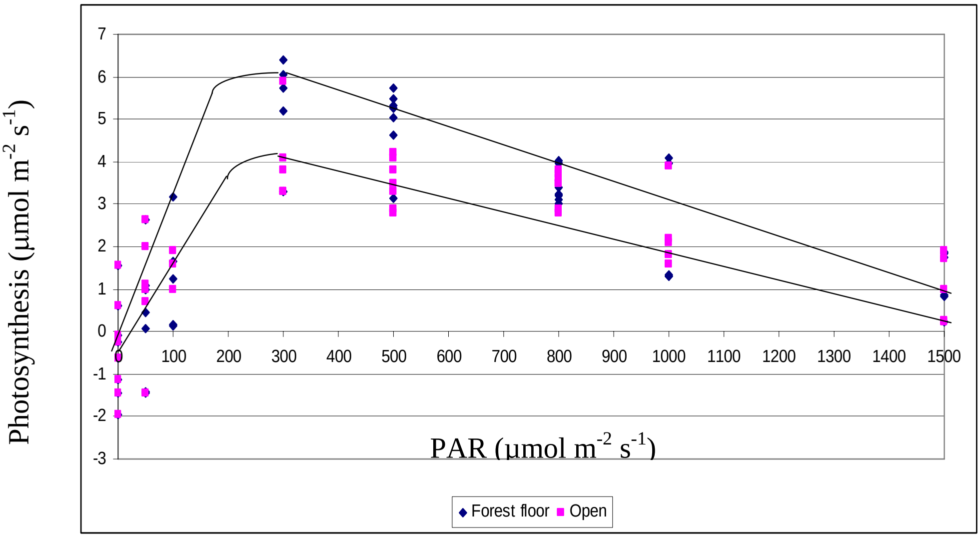

Figure 1: Light response curve for *P. rotundifolia* at 80% RH and 28° C and 380 ppm CO_2.

Photoinhibition can occur when understorey plants are exposed to high light intensities (Gray et al. 1996; Dodd et al. 1998). Above this, the process is impeded and carbohydrates are used for respiration (Larcher 1995). Secondary metabolism like flavonoids, organic acids and phenol derivatives would be affected when carbohydrates productions are reduced in plants (Schlee 1992).

Table 2. Estimated values of CO_2 assimilation at light saturation (A_{max} ± S.E. µmol m^{-2} s^{1}), and apparent quantum yield for CO_2 (ϕ_{co2} ± S.E.) fixation of light response curve of *P. rotundifolia*. Values are means of 6 replicates. Values in the same column having the same superscript are not significantly different from each other ($p \leq 0.05$).

Species	A_{max}	ϕ_{co2}
Planted in open	6.0 ± 0.7^{a}	0.04 ± 0.003^{a}
Planted on forest floor	4.2 ± 0.4^{b}	0.02 ± 0.002^{b}

P. rotundifolia grown at RH of about 80 -90% gave the highest Fv/Fm ratio (Table 3). Plants growing natural on forest floor in Sg. Tekala (FF) had a lower ratio because the light was the limiting factor, while at Sg. Congkak (PFF) the physiological parameters were all in their optimum levels. Maxwell and Johnson (2000) reported that most plants had 83% when not subjected to environmental stress. At plants planted in the open in Sg. Tekala, the energy transfer efficiency was about 65% thus suggesting that the conversion from solar energy to chemical has resulted in some lost as heat (Percival & Fraser 2001). This is further illustrated by the higher Fo value for plants planted in the open. The decrease in dark-adapted F_v/F_m and increase in F_o indicated the occurrence of photoinhibition damage in response to high temperature (He et al. 1996; Valladares & Pearcy, 1997).

Table 3. Physiological and morphological parameters *of P. rotundifolia* planted in different light conditions.

Parameter	Sg Congkak F.R	Sg. Tekala F.R. (FF)	Sg Tekala F.R. (PO)
Fm	765	730	1120
Fv/Fm	83%	82%	70%*
Chlorophyll content	70.5	68	29.1*
Leaf area	502.0 cm^2	480 cm^2	185.2 cm^{2*}

FF= planted on forest floor P= planted in the open * significant at p=0.01

Significant difference in leaf size and chlorophyll content was noted when plants were planted under different environmental conditions. Leaves were smaller and of lighter green when planted under full light as compared with those under close canopy (Table 3). Heat stress directly reflects structural changes within the membrane and hence alters the chlorophyll content levels (Schreiber & Bilger 1987).

CONCLUSION

It is concluded that the light saturation level for both these understory species is about 300 µmol m^{-2} s^{-1}. These plants grow well under high relative humidity of 80% and 90% shade.

ACKNOWLEDGEMENT

The authors would like to express gratitude to ‘Pejabat Hutan Daerah Selangor Tengah’ for the approval to conduct research. This project was supported by IRPA 09-0401-0040-EA001.

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LIGHT INTENSITY PREFERENCES OF SOME COMMERCIAL PEAT SWAMP FOREST SPECIES

Ismail, P. and Abdul Razak, O.
Forest Research Institute Malaysia, Kepong 52109 Selangor, Malaysia
Email: ismailp@frim.gov.my

ABSTRACT

A light intensity study was conducted in nursery for seedlings of six peat swamp forests species. Main objective was to determine preferences of the plants to the light intensity to be suited for field planting. Species studied were *Anisoptera marginata*, *Callophyllum ferrugineum*, *Durio carinatus*, *Gonystylus bancanus*, *Madhuca motleyana* and *Shorea platycarpa*. The experiments were carried out in nursery in two years by using three different light intensities; 100, 70 and 30% of relative light intensity. Parameters recorded and observed throughout the periods were plant survival, total height, basal diameter and plant vigorousity. Results of seedlings performances obtained from the experiment indicating that there were differences in light preference needed by these species for survival and better growth. In general, survival results of the species in two years were ranging from 85 to 100%. Growth of the seedlings, in term of basal area and total height were varies between the species based on different light intensities. Outputs of these studies are useful in selecting suitable species for field planting in different types of degradation in peat swamp areas.

Keywords: Peninsular Malaysia, nursery experiment, survival, growth increments, wetland

INTRODUCTION

Light is the most important factor for the survival and development of seedlings in the tropical moist forests (Jeyarai 1987; Lee et al. 1994). In fact, according to Nicholson (1958), apart from planting and weeding the most critical factor that influences the composition of a regenerating dipterocarps forest is the conditions of light within the stand that can be manipulated to favour the growth of certain species according to their light requirements. The observation was supported by Sasaki and Mori (1981) who reported that growth of dipterocarps seedlings depends on the conditions of light in the forest and different species required different light intensities. They also reported that usually after heavy fruiting most dipterocarps seeds will germinate on the forest floor but seedlings are often disappear within one year after germination due to high mortality. This high mortality of young seedlings is very much related to the conditions of the light under dense canopy of dipterocarps forests.

There is no report on peat swamp forest (PSF) species on related to light intensity study except one that by David et al. (1997) who study in details on seedling development of *Gonystylus bancanus* (ramin melawis) in response to light intensity and spectral quality. From the study, they concluded that seedlings of *G. bancanus* are intolerant of extreme shade and direct sunlight, growing most rapidly in partial shade, with daily percentages of 40% and more of full sunlight. There are about ten commercial timber species of PSF, including the *G. bancanus*, which is the most valuable (Chong & Latifi 2003).

Nonetheless, only some of the species has been used in rehabilitation works as only their planting materials are available (Ismail et al. 2006). However, their light preferences are yet to be determined to be suited with the field planting, except for the *G. bancanus*. Therefore, this study was conducted to have some information of light preferences of some commercial PSF species. Nevertheless, the *G. bancanus* was also included in this study as their planting materials are readily available and it is also the most important timber species in PSF (Soerianegara & Lemmens 1994; Chong & Latifi 2003). Others PSF species used in this study are *Anisoptera marginata* (mersawa paya), *Calophyllum ferrugineum* (bintangor gambut), *Durio carinatus* (durian paya), *G. bancanus*, *Madhuca motleyana* (Nyatoh ketiau) and *Shorea platycarpa* (meranti paya). Degradation of PSF was found to be varied depending on the causes (Ismail et al. 2005; 2006), therefore findings of this study could be as a guide in selecting species to be used for the rehabilitation works.

MATERIALS AND METHODS

The experiment was conducted at nursery of Forest Research Institute Malaysia (FRIM). Three different relative light intensities (RLI) of 30%, 70% and 100% from the full sunlight were used in this study. The selection of the amount of RLI was based on the following criteria; the 30% RLI is to represent common condition in natural undisturbed PSF, 70% RLI for condition of logged-over and secondary PSF, while the 100% RLI is to represent condition of open areas in PSF such as highly degraded or grass-occupied areas. Two shade chambers of 3 m height, 4 m wide and 12 m long were constructed and the chambers were fully covered with sarlon net of 30 and 70% RLI, respectively (Plates 1 and 2), while an entirely open area was used for the 100% RLI site (Plate 3).

Twenty seedlings of each species aged about one-year old were placed in the shade chambers as well as in the open area. The seedlings were germinated from seeds collected from Pekan Forest Reserve in Pahang. All the seedlings, either in the shade chambers or open area was given similar treatments with respect to watering, fertilizer applications and weeding. The watering was done by using automatic sprinkler twice a day and the plants were fertilized with about a gram of Nitrophoska blue every month, while the weeding was carried out when necessary. Data on plant survival, basal diameter (measured at 5 cm above the soil surface) and total height was collected in three months interval for duration of two years.

Additional information on vigorous and formation of new shoots were also observed.

Plate 1. Shade chamber with 30% RLI.

Plate 2. Shade chamber with 70% RLI.

Plate 3. Study site with 100% RLI

RESULTS AND DISCUSSIONS

Survival and *v*igorousity

Results of plant survival of all seedlings in the nursery after two years are shown in Table 1. The survival were ranging from 85 to 100% and indicating that, in general all the species are able to survive in all different light condition, provided water and nutrients are enough. There was three species have 100% survival after two years; *A. marginata, D. carinatus* and *G. bancanus,* while only *C. ferrugineum* produced lowest survival with 85% in the 100% RLI.

Table 1. Plants **s**urvival after two years.

Species	100% RLI	70% RLI	30% RLI
A. marginata	100	100	100
C. ferrugineum	85	95	100
D. carinatus	100	100	100
G. bancanus	100	100	100
M. motleyana	100	95	100
S. platycarpa	100	100	95

Based on the additional observation, it was found that the different light intensities will affects the seedlings physically especially in term of plants vigorous, shoot development and leaf sizes (Plate 4). Obviously, *D. carinatus* and *C. ferrugenium* have good plant condition (look very healthy with greenish and big leaves) at 30% RLI but in poor condition (yellowish and small leaves) at 100% RLI. However, the other species showed moderate physical differences in the all lights intensities. It showed that, the other species are more adaptable to different light intensities compared to the *D. carinatus* and *C. ferrugenium*. The observation was also found that shoot productions for all species are generally similar except for *M. motleyana*, which most active in producing new shoots in all light conditions. Light intensities are also show obvious affect on leaf size sizes as it was found that generally seedlings in open area (full sunlight) have smaller leaf sizes compared with the seedlings in under shade (inside the shade chambers).

Based on the results of the plant survival, *D. carinatus* was found could adapt in various light condition, however the species was observed of having better physical condition in lower light intensities. While, *C. ferrugineum* clearly showed that its preferred low to moderate light conditions of 30 to 70% RLI. Therefore, both species could be considered as shade tolerant species. This indicated that *D. carinatus* and *C. ferrugineum* are not suitable for field planting in open areas such as the highly degraded PSF. Other species are relatively has high survival and vigorousity in all light condition. They are suitable to be used for field planting in different condition of the PSF, including in an open areas. Nonetheless, Otsamo et al. (1996) reported that *A. marginata* was the best dipterocarps with 80% survival after two years of field planting. This is a clear indication for *A. marginata* that the species is suitable for the field planting in the open areas.

Plate 4. Generally bigger leaves were produced by seedlings in shade chambers compared to open area (note: seedlings inside the shade chamber of 70% RLI).

Average basal diameter increment

Results of average of basal diameter increment (BDI) in two years are shown in Table 2 and Figure 1. It shows that in term of BDI, *A. marginata*, *G. bancanus* and *M. motleyana* have ranges of adaptability to the light condition. Meanwhile, *C. ferrugineum*, *D. carinatus* and *S. platycarpa* were preferred less light intensities. *Madhuca motleyana* has big BDI in all RLIs compared to the other species. However, *D. carinatus* has biggest BDI with 8.1 at 30% RLI, while *S. platycarpa* has the smallest BDI with 2.6 mm at 100% RLI.

Table 2. Average of basal diameter increment (BDI) in two years.

Species	100% RLI	70% RLI	30% RLI
A. marginata	6.0 ± 0.3 mm	5.0 ± 0.3 mm	6.0 ± 0.6 mm
C. ferrugineum	4.7 ± 0.5 mm	6.0 ± 0.6 mm	6.0 ± 0.4 mm
D. carinatus	6.0 ± 0.6 mm	5.3 ± 0.3 mm	8.1 ± 0.5 mm
G. bancanus	4.9 ± 0.5 mm	5.0 ± 0.5 mm	4.7 ± 0.4 mm
M. motleyana	7.2 ± 0.8 mm	7.7 ± 0.8 mm	6.8 ± 0.7 mm
S. platycarpa	2.6 ± 0.2 mm	4.7 ± 0.3 mm	4.2 ± 0.3 mm

± = standard error

Ismail et al. (2006) reported average BDI increments of 2.5 mm and 0.5 mm nine months after planting using line planting method (RLI at about 70%) for *A. marginata* and *G. bancanus*, respectively. Comparably, results of this study showed relatively higher BDI for both species in the nursery study due to longer period of time (two years) and sufficient supply of water and nutrients in the nursery.

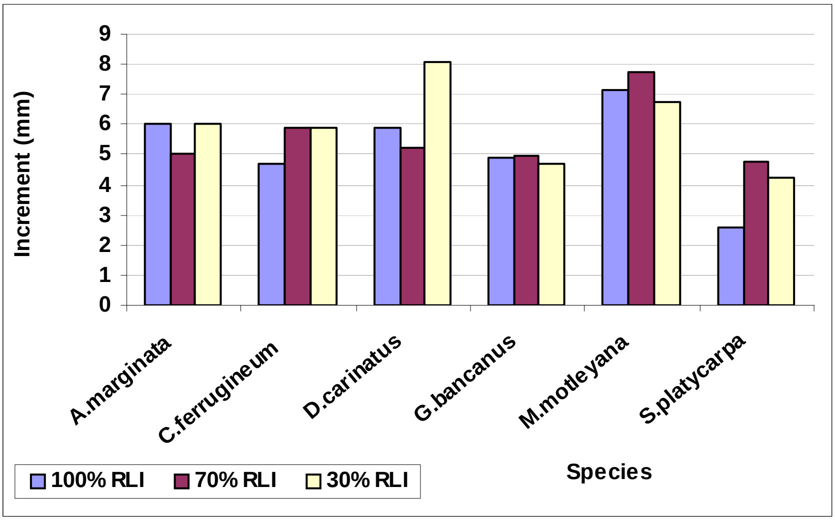

Figure 1. Average basal diameter increment (BDI) in two years

Average total height increment

Results of average of total height increment (THI) in two years are shown in Table 3 and Figure 2. The figure showed that in general all species have an increased pattern of THI from 100% to 30% RLI, except for *A. marginata*, which lower THI in 70% RLI. Nevertheless, all species in this study grew taller in 30% RLI. Nonetheless, it was observed that higher THI will produce low BDI as shown in Table 2. Therefore, moderate light condition of 70% RLI was found to have moderate THI and BDI.

Madhuca motleyana has high THI as compared to the others species, particularly in RLI of 30% where it is has highest THI of 86.2 cm. While, among lowest THI in the 30% RLI were *G. bancanus* and *D. carinatus* with 42.8 and 46.4 cm, respectively. In fact, compared to other species, both *G. bancanus* and *D. carinatus* have low THI in the all light conditions. Based on study by Ismail et al. (2006), *A. marginata* and *G. bancanus* planted in the logged-over PSF have an average of 17.9 and 8.9 cm of THI, respectively nine months after planting. Apparently, results of this nursery study reflect the results of performances of the both species in the field.

Table 3. Total height increment (THI) in two years.

Species	100% RLI	70% RLI	30% RLI
A. marginata	56.5 ± 4.6 cm	44.3 ± 4.4cm	57.6 ± 5.7 cm
C. ferrugineum	42.5 ± 3.6 cm	58.6 ± 7.0 cm	75.2 ± 6.5 cm
D. carinatus	22.5 ± 3.3 cm	26.4 ± 3.6 cm	46.4 ± 4.2 cm
G. bancanus	20.3 ± 1.7 cm	32.6 ± 3.8 cm	42.8 ± 5.2 cm
M. motleyana	56.3 ± 6.0 cm	63.7 ± 7.5 cm	86.2 ± 10.3 cm
S. platycarpa	23.2 ± 1.4 cm	48.0 ± 3.7 cm	50.2 ± 3.4 cm

± = standard error

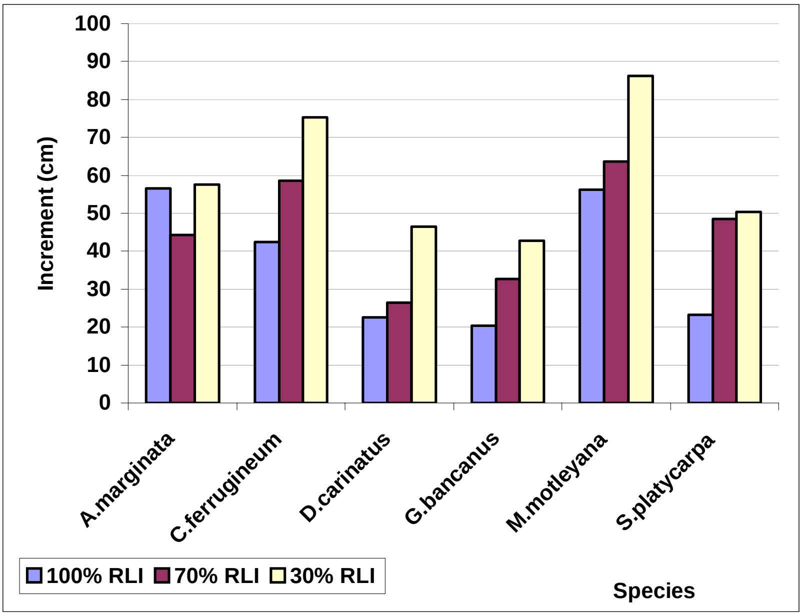

Figure 2. Average total height (THI) increment in two years.

CONCLUSIONS

Results of plant survival in two years were ranging from 85 to 100%. Meanwhile, based on results of BDI and THI showed that light preferences for survival and growth are different between species, where the growth is varies. The BDI and THI of all species were significantly affected by different light intensities. It shows that in order to have better growth performances, tree species have their own preferences and some could extend in wider ranges of light conditions. Though, some species could adapt in all type of light conditions, it still has a preferred light condition for their optimum growth.

Species tested in this study are recommended be used in rehabilitation works in degraded PSF mainly due to its commercial value. Nonetheless, their selection should be based on site matching. Based on the findings of this study, species recommended to be planted in moderately shade to open areas are *A. marginata*, *G. bancanus*, *M. motleyana* and *S. platycarpa*, while *C. ferrugenium* and *D. carinatus* are more suitable for under-canopy planting.

Interestingly, number of species were found could grow well in all light conditions. However, it is no necessary they suitable in open planting such as in highly degraded or grass-occupied areas due to lack of water supply and excessive sunlight. For example, though from the study *G. bancanus* was found survived in all light condition, the species was demonstrated to be more suitable in under-canopy planting with survival of 81% nine months after planting compared only 30% survival in open planting (Ismail et al. 2006). It is in line with findings of light intensity study by David et al. (1997), who found that *G. bancanus* is more suitable in partially shaded areas. In general, findings of this study are useful for selecting suitable species for planting works in the field that varies in term of light condition based on their degree of degradation.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to staff of the Natural Forests and Forest Plantation Programmes, FRIM for providing assistance on the data collection and analysis.

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