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NOTES

GROWTH PERFORMANCE OF INDIGENOUS TREE SPECIES PLANTED USING POT-HOLE PLANTING TECHNIQUE

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Reforestation efforts in Malaysia have been intensified in recent years to restore the large areas of degraded forest. Among the major causes of forest degradation are degazettement of forest areas, excessive logging and shifting cultivation. It was reported that the total area of degraded secondary forest in Malaysia in mid 1980s is 4.604 million ha (Ahmad Zainal 1992).

In general, most of the reforestation efforts with indigenous tree species have been carried out using the four planting techniques; open planting, planting with nurse tree, under shade planting and line planting. The open planting technique has shown good results for many species, including *Dryobalanops lanceolata*, which, in a study in Sabah, recorded about 84% survival compared to only 44.6% survival when planted under shade (Rahim & Annuar 1992). However, *D. lanceolata* seedlings planted in the open in Bidor, Perak, recorded a survival rate of < 30% four months after planting (Euda *et al.* 1995).

Universiti Putra Malaysia, Universiti Malaysia Sarawak and the Japanese Center for International Studies in Ecology conducted a research project to rehabilitate a severely degraded area in Bintulu, Sarawak with indigenous tree species. The open planting technique used in this project is based on that by Miyawaki *et al.* (1987), and has shown promising results for many indigenous tree species, especially the dipterocarps (Mohd Zaki *et al.* 1993, 1994, Nik Muhamad & Mohd Zaki 1995). However, as this technique involves intensive site preparation including soil cultivation and the construction of wooden lattices, it becomes very expensive and is therefore considered not economical for large-scale rehabilitation projects.

The pot-hole planting, which involves open planting with minimum site preparation is a low cost alternative to the open planting technique. This study examines the feasibility of the pot-hole planting technique for use in establishing indigenous tree species.

The study site is located in Bintulu, situated about 600 km north-east of Kuching, Sarawak (Figure 1). The site receives an annual rainfall of 2900 to 4430 mm and annual temperature of 26.4 to 27.8 °C. Heaviest rainfall is during the north-east monsoon in the months of November to January. The average annual humidity is 80%.

The site was cleared in 1980–82 for the purpose of converting it into agricultural plots, but was left idle. As a result, the site was heavily eroded and weathered. Prior to planting the site was dominated by weedy vegetation, such as *Ischaemum magnum, Miscanthus floridulus, Imperata cylindrica* and *Dicrynopteris linearis.*

According to Peli *et al.* (1984), the soil at the site is of Nyalau and Bekenu Series. The Nyalau Series is characterised by a coarse loamy texture and is classified as kaolinitic, isohyperthermic Typic Dystropept. Meanwhile, the Bekenu Series is classified as fine loamy, mixed, isohyperthermic Typic Paleudult. Both soils are well drained.

Three study plots measuring 6 × 5 m each were prepared on open and sloping compacted soils. The pot-hole planting, which was tested in this study only constituted simple and minor site preparations, which included the clearing of weed species and digging of planting holes,

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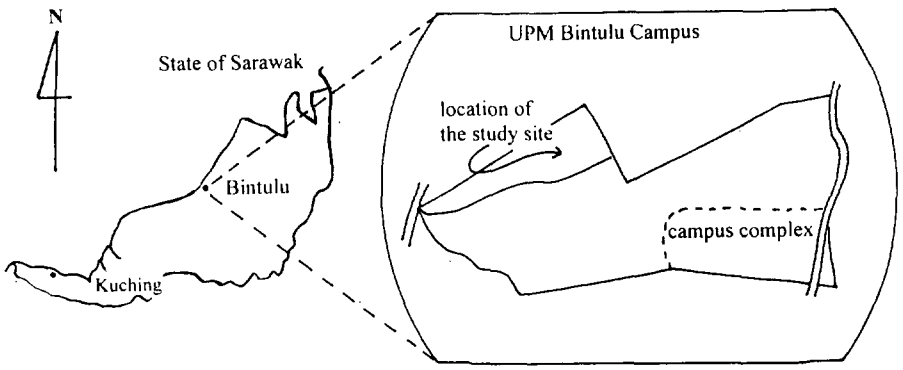

Figure 1. Location of the study site in Bintulu, Sarawak

each measuring 15 × 15 × 25 cm. Site preparation was done only on study plots while the remaining area remained dominated by weedy species. A total of 270 one-year-old seedlings of *Barringtonia* sp., *Cotylelobium burckii, Durio zibethinus, Eugenia* sp., *Eusideroxylon zwageri, Shorea macrophylla, S. maxwelliana* and *S. ovata* of uniform size (average height was 60 cm) were raised, nurtured and hardened in the nursery for 12 months before transplanting. These seedlings were then mix-planted in a cluster of three plants per square meter inside the three plots using a completely randomised design. Dried *Imperata cylindrica* was laid on the soil around the planted seedlings to reduce soil erosion and to retain soil moisture.

Basal diameter (2 cm above ground), total height and survival percentage were measured at three-month intervals for one year. Growth parameters (total one-year increment) were subjected to the analysis of variance. The main objective of this trial was to examine the feasibility of using this technique as opposed to ordinary open planting with intensive site preparation. Therefore results of this study were compared to the ones from the intensively-prepared sites, which have similar features and characteristics as in this trial.

The survival rate of all species planted ranged from 91 to 100%, with six species attaining 100% survival, while two species, *Barringtonia* sp. and *Eugenia* sp., attaining 91.4 and 91.1% respectively (Table 1).

Based on the previous studies by Mohd Zaki *et al.* (1993), the inability of some seedlings to adapt to the microclimate of the site may cause some seedling mortality especially during the

Table 1. Survival percentage of the eight species in the study plots

Species	Number of seedlings planted	Number of seedlings after 12 months	% of survival
C. burckii			
D. zibethinus	31	31	100
E. zwageri	34	34	100
Macrophylla	34	34	100
S. maxwelliana	36	36	100
S. ovata	35	35	100
Barringtonia sp.	35	32	91.4
Eugenia sp.	34	31	91.1

first six months after planting. However, the survival rate of most of the species in this study was better than those planted in the open on intensively- prepared sites, which are located approximately 500 m away and have similar features as in this study. *Eugenia* spp., for example, recorded only 6% survival on prepared sites (Mohamad Azani & Fujiwara 1994). According to Ismail & Othman (1992), *S. ovata* planted on prepared site (mound planting) attained only 82% survival, whereas in this study, the survival rate of the species was 100%.

According to Smith (1962), seedlings planted on unprepared sites have higher mortality rate due to the inability of the roots to penetrate deeper into the soil. Moreover, planting of seedlings in the open exposes them to extreme heat and low humidity, the two limiting factors for seedling survival. However, the indigenous tree seedlings planted in this study survived well under such harsh environmental conditions indicating that indigenous seedlings can adapt well to the microclimate of the site.

In terms of growth performance, there was a significant difference ($p < 0.05$) between the height increment of eight species tested during the first 12 months, except for *D. zibethinus* and *Barringtonia* sp. (Table 2). The greatest height increment was exhibited by *S. ovata* with 108.9 cm, followed by *S. maxwelliana* (94.7 cm). *Eugenia* sp. recorded the lowest height growth increment with 22.1 cm.

Table 2 also shows that *Eugenia* sp., which exhibited the slowest height growth, attained the highest diameter increment of 1.5 cm, followed by *S. maxwelliana* and *S. ovata* with 1.27 cm and 1.19 cm respectively. *Durio zibethinus* showed slightly higher diameter increment than *C. burckii*, but the difference was insignificant at the 0.05 probability level. The lowest diameter increment was recorded by *Barringtonia* sp. with 0.45 cm.

Shorea ovata, classified as a light demander by Wood and Meijer (1964), performed very well in the open since it could utilise the full sunlight to increase its photosynthetic activities, and hence its growth. Similarly *S. maxwelliana*, which according to Appanah and Weinland (1993) normally predominates large openings of logged-over forests, also exhibited favourable growth rates in this study.

Based on earlier reports by Mohamad Azani & Fujiwara (1994) who worked in the same experimental area, *Eugenia* sp. planted in the open, intensively-prepared site recorded a much lower diameter increment of 0.66 cm (Table 3). Tables 2 and 3 also show that seedlings of *S. ovata* and *C. burckii* planted on this site in this study exhibited better height and diameter growth compared to the ones planted on prepared site.

This minimal site-preparation area (e.g. the study site) was expected to be heavily compacted after forest harvesting in the early 1980s. This would lead to poor soil aeration and consequently poor seedling root penetration. In addition, the fertility of degraded site is generally very poor (Kamaruzaman & Nik Muhamad 1987). However, findings from this study

Table 2. Mean height and diameter increments of the eight species in the study plots

Species	Mean total increment (cm)	
	Height	Basal diameter
S. ovata	108.9 a [x]	1.19 c [x]
S. maxwelliana	94.7 b	1.27 b
C. burckii	83.6 c	0.67 e
S. macrophylla	54.5 d	1.05 d
D. zibethinus	32.7 e	0.72 e
Barringtonia sp.	31.6 e	0.45 f
E. zwageri	25.1 f	0.51 f
Eugenia sp.	22.1 g	1.52 a

(Note: x ranking of species according to Duncan's new multiple range test.
Means with the same letters are not significant at the 0.05 probability level)

Table 3. Mean height and diameter increment of species planted on open intensively-prepared site after one-year growth

Species	Mean total increment (cm)	
	Height	Basal diameter
Hopea kerangasensis	121.79	0.88
Parashorea parvifolia	40.70	0.90
S. mecistopteryx	60.34	1.06
S. leprosula	71.72	0.89
S. materialis	73.82	1.00
Whiteodendron moultonianum	77.32	1.67
Dryobalanops aromatica	129.29	1.95
S. ovata	65.56	0.91
H. beccariana	59.29	0.79
C. burckii	61.57	0.87
Calophyllum ferrugineum	46.47	0.71
Durio carinatus	56.96	0.55
Eugenia sp.	43.53	0.66

(Source: Mohamad Azani & Fujiwara 1994)

indicate that intensive site preparation is not always essential to improve initial seedling growth as most seedlings planted on the site without intensive study site preparation managed to attain favourable growth rates.

The results of the study showed that the open planting technique without intensive site preparation (pot-hole planting technique) could be used as a method to rehabilitate large areas of degraded tropical rain forest. The overall survival and growth performance of the seedlings planted in this study were better than those attained by seedlings planted on other more intensively-prepared sites. Of the eight species tested, *S. ovata* and *S. maxwelliana* were the most successful with high survival rates and favourable growth performance.

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