SURVIVAL AND EARLY GROWTH OF *ANISOPTERA MARGINATA, SHOREA ASSAMICA* AND *SHOREA PLATYCLADOS* IN GAP PLANTING ON LOW FERTILITY ACID SOIL

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ABSTRACT

The suitability of tree species to a given site is very important to determine the success of enrichment planting. A study to determine the survival rate, basal diameter and total height of three timber species namely Anisoptera marginata, Shorea assamica and Shorea platyclados in gap planting on low fertility acid soil was conducted in Ayer Hitam Forest Reserve, Selangor. This study was established in a one ha plot with five subplots of 20 m x 20 m. Opening was made in each subplot to create artificial gap by slashing trees in order to allow direct sunlight to reach the forest floor. The average canopy openness was 19.74 % with a range from 18.11% to 21.98%. Soil in this area was moderately acidic. Total N, available P and cation exchange capacity (CEC) were low, while exchangeable K, Ca and Mg were very low. At one year after planting, survival rates of A. marginata, S. assamica and S. platyclados recorded in this study were 99±1.20%, 91±4.49% and 85±6.03%, respectively. There was no significant difference (p>0.05) for survival rates among the species. In terms of basal diameter increment, there was also no significant difference (p>0.05). Basal diameter increment for S. platyclados was 4.09±0.24 mm, followed by A. marginata at 3.99±0.18 mm and S. assamica at 3.73±0.16 mm. However, total height increment among the species was found to be significantly different (p<0.05). Shorea platyclados showed the highest increment followed by A. marginata and S. assamica with 35.77±3.27 cm, 28.22±2.12 cm and 12.13±1.19 cm, respectively. Further studies using various gap sizes should be conducted to determine more accurately the suitable gap sizes for selected tree species.

Key words: Dipterocarp, Enrichment planting, Gap planting, Acid soil

INTRODUCTION

Enrichment planting is one of the most suitable approach and is often practiced to accelerate rehabilitation of poorly-stocked forest areas especially in Peninsular Malaysia. This approach promotes the recovery of degraded forest containing low value timber species compared to other approaches. Significant roles of enrichment planting are 1) introduction of selected and desired good quality timber species into the forest stand, 2) the manipulation of stocking through specified planting distance, 3) the enhancement of the rate of recovery of poorly stocked logged over forest and 4) improvement of residual stocking of a poorly stocked logged over forest for next cut (Noradli, 2013). However, the implementation of enrichment planting is more critical in natural gap (or open area) left after timber harvesting operation in Permanent Reserve Forests, such as in the skid trail and log yard. In these areas, the major focus of enrichment planting is to rehabilitate or reforestation with the planting of suitable indigenous species of highly marketable (Noradli, 2013).

Sakai et al. (2011) reported that the size and shape of a gap are critical for the growth of seedlings because they determine light conditions. It was also reported that direct strong sunlight will cause high mortality in seedlings and sometimes it will lead to the failure of forestation. In addition, several studies found that moderate light conditions promoted the growth of some dipterocarp seedlings (Hattori *et al*., 2009, Brown *et al*., 1999, Tuomela *et al*., 1996). Therefore, nurse trees are very important to mitigate the effects of strong sunlight on young seedlings. The key to success for successful dipterocarp planting is light control and species choice. Light control should correspond to the light requirements of a species during its growth stage, so planting methods should reflect site conditions and growth characteristics of the species (Mori, 2001).

Dipterocarp tree species, which dominate South-East Asian forests, are generally regarded as climax species but different species show different responses to canopy gaps and different strategies for regeneration in the same place (Numata et al., 2006). According to Kenzo *et al*. (2011), seedlings *Dipterocarpus baudii* planted in areas with large gaps showed the highest growth of diameter at 5 cm after four years of planting. In contrast, *Neobalanocarpus heimii* showed relatively poor growth performance under bright condition. However, based on a study revealed by Howlet and Davidson (1994), *Shorea parvifolia* seedlings showed faster growth at higher light levels while observations on *S. leprosula* and *Dryobalanops lanceolata* showed slowest growth in two darkest habitats. According to a study by Sakai *et al*. (2014) on growth performance of *Dipterocarpus alatus, D. tubinatus, Hopea odorata* and *S. henryana* under *Leucaena leucocephala* and open site on degraded land, the results suggested *D. alatus* and *H. odorata* can be planted in both open sites and forests where seedlings should retain a certain survival rate and growth. Nevertheless, *D. tubinatus* should be planted under shade rather than open sites. *Shorea henryana* exhibited equivalent growth in the leucaena and open plots.

Previous studies indicated that there are a variant of responses with different species and sizes of canopy openness. The choice of dipterocarp species is important to ensure success of large scale dipterocarp plantation because each species has different growth characteristics and micro-climate requirements to get high survival and growth (Widiyatnoa *et al*., 2013).

It is thus crucial to understand the suitability of a species to the environment as a guide in selection of species for planting. In this study, three species of dipterocarp were selected namely *Anisoptera marginata* Korth. (Mersawa paya), *Shorea assamica* Dyer Forma *globifera* (Ridl.) sym. (Meranti pipit) and *Shorea platyclados* v. Slooten ex Foxw (Meranti bukit) to determine their adaptability in gap planting on low fertility acid soil based on survival rate, basal diameter and total height. The results from this research will help to develop a better understanding on optimal gap size to promote the growth of the chosen species.

MATERIALS AND METHODS

Study site

This study was conducted in Ayer Hitam Forest Reserve (AHFR), Puchong, Selangor Darul Ehsan. This forest is situated about 20 km from Kuala Lumpur and 10 km from Universiti Putra Malaysia (UPM) Serdang campus. The AHFR is presently surrounded by development and is now about 1,248 ha land area. In the past, Ayer Hitam Forest Reserve was well known as a source of valuable timber to the Selangor State government and the community in terms of direct and indirect monetary and non-monetary benefits (Philip, 2002). This forest was selectively logged several times from 1936 to 1965. After logging operations, AHFR was classified as a secondary disturbed forest (Ahmad Ainuddin & Salleh, 1999). AHFR consists of Serdang-Kedah and Durian soil series. The air temperature ranged from 22.9 ˚C to 27.7 ˚C, mean relative humidity was 87.6%, wind speed between 0.15 m/s and 2.17 m/s and, mean soil temperature was 24.7 ˚C (Ahmad Ainuddin and Salleh, 1999).

Experimental plot

A one ha plot was established with five subplots measuring 20 m x 20 m. Each subplot was opened to by slashing of trees to create artificial gaps in order to allow direct sunlight to reach the forest floor. Three species of dipterocarp namely *Anisoptera marginata, Shorea assamica* and *Shorea platyclados* were planted at 2.5 m x 2.5 m spacing in June 2007. Each of the five subplots was planted with 49 seedlings of mixed species with a total of 245 seedlings in the one ha plot.

Canopy Openness

Canopy openness above the seedlings was estimated using hemispherical photographs (Nikon and fisheye converter). Photos were taken at each subplot. The camera was mounted on a tripod at 1 m from the ground and leveled prior to photographing and directed to the magnetic north. Images produced were analyzed using Gap Light Analyzer (GLA) Windows-based software version 2.0. This software transforms the colour of the photos to black and white in order to quantify the pixels before calculation of canopy openness.

Soil Analysis

Soil evaluation was conducted through sampling at 0 – 15 cm and 15 – 30 cm soil depth in each subplot. The chemical properties of the soil samples were examined. The soil samples were air-dried at room temperature, cleaned of root fragments before sieved through a 2 mm mesh sieve. Soil pH was measured with a glass electrode using a soil to solution (H_2O) ratio of 1:2.5. Total nitrogen (N) was determined by Kjedahl digestion method. Available phosphorus (P) was determined by Bray & Kurtz No. 2 procedure of extraction and colormetric determinated by Denige method. Soil exchangeable bases (K^+, Ca^{2+} and Mg^{2+}) and CEC were extratcted by leaching with 1 N ammonium acetate and 1 N Potassium sulfate, respectively. The concentrations of exchangeable cations were determined using inductively coupled plasma optical emission spectrometer (ICP–OES), while CEC was analyzed by distillation and titration method (Thomas, 1982).

Data collection

Observation on growth performance was carried out for one year after planting. The growth parameters measured were basal diameter and total height. Basal diameter was measured at 10 cm above the root collar or ground level using a digital calliper. A specific point on the stem was marked with red paint to indicate the point used for basal diameter measurement. The total height of tree is the length measured from the root collar to the base of the top bud. It was measured using a height pole. The data were analyzed using Statistical Package for Social Science (SPSS) program version 15.0. Analysis of variance (ANOVA) was used to determine the significant differences of basal diameter and height increment between species.

RESULTS AND DISCUSSION

Canopy Openness

Table 1: Canopy openness in Ayer Hitam Forest Reserve (AHFR)

	Sp1	Sp2	Sp3	Sp4	Sp5	Average
Canopy openness (%)	20.09	18.11	20.03	18.48	21.98	19.74

*Sp: Subplot

The sizes of canopy openness play an important role in affecting the growth of trees. Based on the results from this study, the average canopy openness was 19.74 % with a range from 18.11% to 21.98% (Table 1). According to Soerianegara and Lemmens (1994), growth and development of red meranti seedlings were often faster in open than in shaded sites. However, many seedlings were severely damaged due to prolonged exposure of sunlight. Meanwhile, white meranti seedlings required shade till they reach the height of 1.5 m. *Shorea* are slow growing and tolerant species. These species cannot grow well when planted in open areas, conversely very suitable to be planted under canopy of stand (Wahyudi *et al*., 2016).

Soil Nutrients

Table 2: Soil properties at depths of 0–15 cm and 15–30 cm

Soil Depth	pH	Total N (%)	Available P (ppm)	Exchangeable Cations ($cmol_{(+)}$/kg)			CEC ($cmol_{(+)}$/kg)
				K	Ca	Mg	
0 – 15 cm	4.58	0.14	4.47	0.02	0.04	0.02	6.16
15 – 30 cm	4.35	0.13	2.28	0.02	0.02	0.01	5.54

The assessment of soil fertility and site quality is important in forest management because it reflects the productive capacity of the forest area to support plant growth (Abdu *et al*., 2008). The results of soil nutrients are showed in Table 2. According to Andrew et al. (2006), extreme soil pH (<4.5 and > 8.5) can cause some nutrients become toxic to plants. At low pH levels (<4.5), aluminum, iron, and manganese are available for plant uptake but at high pH levels (>7.5), calcium and potassium are over abundant. Soil in this area was moderately acidic particularly in the 15-30 cm depth. Low pH may lead to an unfavourable carbon-nitrogen ratio. It may also have an effect on microbial activity leading to reduction in nitrate-nitrogen release (Lucas & Davis, 1961). Total N, available P and cation exchange capacity (CEC) were low, while exchangeable K, Ca and Mg were found to be very low. Soil with low CEC is always associated with low clay content, low organic matter and low water holding capacity. In this condition, the soil often cannot hold enough cations to maintain a sufficient level of fertility. In order to avoid nutrient leaching, these soils require small amounts of fertilizer applied on a frequent basis.

Survival Rate, Basal Diameter and Height Increment

Table 3: Survival rate, basal diameter increment and total height increment among species at 12 months after planting

	Anisoptera marginata	*Shorea assamica*	*Shorea platyclados*
Survival rate (%)	$99±1.20^{a}$	$91±4.49^{a}$	$85±6.03^{a}$
Basal diameter increment (mm)	$3.99±0.18^{a}$	$3.73±0.16^{a}$	$4.09±0.24^{a}$
Total height increment (cm)	$28.22±2.12^{b}$	$12.13±1.19^{c}$	$35.77±3.27^{a}$

Note: Means in the same row followed by same letter are not significantly different at p<0.05 as determined by Duncan's multiple range test

Survival rates of *A. marginata*, *S. assamica* and *S. platyclados* recorded in this study were 99±1.20%, 91±4.49% and 85±6.03%, respectively. There was no significant difference (p>0.05) on the survival rates among the three species in the different gap sizes (Table 3). This result indicated that all the species planted in this study have adapted well to the gap sizes created. From our observations, the mortality of *S. assamica* and *S. platyclados* were mainly caused by termites. The termites were often found to feed on roots of sapling. Damage of both these species was similar to that as reported by Kirton and Cheng (2007), where damage by the termite took the form of debarking of the tap root and, frequently, feeding on the woody tissue of the tap root, such that it formed a tapered, pencil-like shape or an hour-glass shaped region at the point of attack. According to Kirton *et al*. (2008), roots-feeding insects such as termites (Isoptera) and cricket (Orthoptera: Gryllidae) are often observed to damage the root system and can cause the death of plant. In contrast, *A. marginata* in the studied plots were healthy and were not attacked by termites.

In terms of basal diameter increment, there was no significant difference (p>0.05) in basal diameter increment among species recorded at 12 months after planting (Table 3). However, *S. platyclados* showed the highest basal diameter increment with 4.09±0.24 mm, followed by *A. marginata* at 3.99±0.18 mm and *S. assamica* at 3.73±0.16 mm. These results revealed that there was no competition among the three species in the subplots with 19.74% of canopy openness. All seedlings in these plots exhibited similar trend in terms of basal diameter increment. According to a study by Ang and Maruyama (1995), collar diameter of *S. platyclados, S. assamica, S. macroptera* and *Hopea nervosa* in open planting were significantly different after 26 months of planting. *Shorea platyclados* showed the highest collar diameter increment compared to other species indicating a better response to open planting. However, no significant difference on collar diameter increment was found in this study at one year after planting. Significant differences may be seen probably after several years and with canopy openness more than 19%. Many dipterocarps are shade demanding and slow growing in the early growth stages and have a long life span. Among the climax species, the dipterocarps have relatively rapid diameter growth and high light demand during their middle mature stages (Mori, 2001).

Results from this study showed that there was significant difference (p<0.05) in terms of total height increment between species at 12 months after planting (Table 3). *Shorea platyclados* showed the highest increment in height followed by *A. marginata* and *S. assamica* as indicated by 35.77±3.27 cm, 28.22±2.12 cm and 12.13±1.19 cm, respectively. These results suggested that *S. platyclados* showed more active development of height increment compared to other species. According to Hamzah *et al*. 2009, mean annual height increment of *S. assamica* was 65 cm/year in open planting area (30 x 150 m). This indicated that *S. assamica* showed the highest increment of height in bigger size of gap. Based on a study by Otsamo (1998), height and diameter increment of *A. marginata* at 19 months after planting were as in the following when planted under *Paraserianthes falcataria* (140.3 cm and 12.5 mm), *Acacia crassicarpa* (90 cm and 8.4 mm), *Acacia mangium* (57.7 cm and 5.5 mm) and *Gmelina arborea* (19.2 cm and 3.5 mm). The differences in levels of photosynthetic photon flux density that penetrate to the understory of different nurse trees were influencing the growth increment of *A. marginata*. Knowledge on the range of influence of canopy manipulation on planted seedlings is therefore important to forest managers to maximize seedling, survival and growth (Bebber *et al*. 2002).

CONCLUSION

Shorea platyclados was the best species in terms of growth performance compared to *A. marginata* and *S. assamica*. However, this species needs to be treated against termites at early stage of planting to increase its survival. Various gap sizes can be included in the future study to obtain a more extensive growth response data, especially on different tree species. The data will enable researchers to identify the most suitable gaps sizes to promote optimal growth for each species used in projects for rehabilitation of degraded forests. In addition, deficiency of nutrients could have affected the growth of trees in this study. Therefore, application of fertilizer to enhance the growth of planted species is much recommended as most of the areas that have been logged have very low nutrient content.

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