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Growth Increments of Indigenous Species Planted in Secondary Forest Area

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Abstract: Evaluation on the growth of five indigenous timber species was performed after nine years after planting. The selected species was *Azadirachta excelsa*, *Cinnamomum iners*, *Hopea pubescens*, *Intsia palembanica* and *Shorea leprosula* planted under open area planting technique on secondary forest area were carried out in Pasoh Forest Reserve Area, Negeri Sembilan. The assessment involving measurements of Diameter at Breast Height (DBH), height of the species and the survival rate were carried out. An experimental design of Randomized Complete Block Design (RCBD) was adapted. The result shows that the higher growth increments for the DBH were found at *A. excelsa* (1.06 cm year^{-1}) and the lowest at, *I. palembanica* (0.97 cm year^{-1}). For the height increment, *A. excelsa* was 1.38 m year^{-1} which was the higher and the lowest was the *C. iners* (0.77 m year^{-1}). However, the survival rate found higher at *C. iners* (76.3%) and the lowest was at the *S. leprosula* (20.7%). This indicates that some indigenous species can be adapted to rehabilitate secondary forest area.

Key words: Growth increments, indigenous species, secondary forest, survival rate and rehabilitation

INTRODUCTION

Forest area has been in demand for agricultural land, timber and housing development, which has accelerated deforestation in Malaysia. Deforestation is a worldwide environmental issue (Sayer *et al*., 2004). In the tropics, deforestation often leads to land degradation under tropical climatic conditions (Eden and Parry, 1996). Logging has a major impact on the structural and compositional development of forests. The extraction of large trees usually damages neighboring trees and influences the development of the under storey vegetation (Langenberger *et al*., 2005). Bischoff *et al*. (2005) defined that secondary forest mean forests, which are recovering from logging and not those recovering from large natural disturbances. After forest conversion to agriculture or pastureland, forest recovery may occur through secondary succession. However, when the probability of recreating initial conditions is low or recovery time to long, human intervention may be required to ameliorate land degradation (Pedraza and Williams-Linera, 2003).

As globalization increases, the forest plantation has the potential to contribute to industrial wood and fiber in the coming decades. However, natural forest will not be able to supply all the demands. Therefore, plantations are expected to provide an increasing share of total industrial requirements and may even contribute a larger than natural forests by the end of this period (Hummel, 2001). The establishment of plantations has been proposed as a tool for forest restoration of degraded lands through their effects on vegetation structure, microclimate and soils (Pedraza and Williams-Linera, 2003). In response to this, the selection of the right species played a very important in determining

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the successful rehabilitate of the degraded forest land (Mulizane *et al*., 2005; Jong *et al*., 2006). The degraded forest land is referred to forests where trees are removed and are being farmed in an unsuitable manner.

In such degraded areas, the native plant species is prone to fail in surviving because the degraded soil conditions are different from the original conditions (Kanowski *et al*., 2005). Hence, continuing to explore, evaluate and domesticate tree species for reforestation, especially on degraded lands, where not all introduced species perform well and yet there is urgent need to restore productivity and ecosystem services (Calvo-Alvarado *et al*., 2007). To rectify the situation, fast growing indigenous tree species were introduced extensively for plantation establishment (Andrew *et al*., 2004). Furthermore, their wood is generally more valuable and useful than that of fast growing trees (Sakai *et al*., 2009). Indigenous trees have some important biological advantages, such as adaptation to the local environment, resistance to pests and disease and the conservation of local fauna and flora (Evans, 1992). However, rehabilitation using indigenous timber species on a larger scale usually encountered the following obstacles; irregular supply and recalcitrance of seeds and high variability in growth of seedlings of as yet unknown genetic potential, as seedlings are raised from stumps or wildings (Appanah and Weinland, 1993). The growth of tropical secondary forest vegetation responds quickly to changes in environmental conditions (Romell *et al*., 2007). Therefore, the aim of this study was to investigate the best species through growth parameters for plantation and rehabilitation among selected wood species.

MATERIALS AND METHODS

Five indigenous species were selected for the study comprising of *Azadirachta excelsa*, *Cinnamomum iners*, *Intsia palembanica*, *Hopea pubescens* and *Shorea leprosula*. The study area was located in Pasoh Forest Reserve Area, Negeri Sembilan (about 120 km from Kuala Lumpur). The experimental plot chosen (42 ha) was a degraded logged-over forest established in August, 1995. The mean annual rainfall for a ten years period (1994-2003) was 1233.83 mm and the area experiences rainy season in November, October and April. The mean daily temperature was 20.3-30.7°C. The mean monthly relative humidity of the area was about 80%. The soil composed mainly of the Paleozoic sedimentary rocks, which is principally characterized by limestone, quartz and shale (Wyatt-Smith, 1963). Randomized Complete Block Design (RCBD) was used to analyze the data obtained from three replications of 30×150 m block. Each block has 30 subplots with 5×10 m each. In each subplot, a total of 15 seedlings were line-planted at a spacing of 2×2 m. The total number of potted-seedlings planted was 1,350. Open planting technique had been used. The growth criteria measured was the diameter at breast height, total height and the survival rate of the planted wood spp. Diameter Breast Height (DBH) taken at 1.3 m from root collar by using Digmatic Diameter Caliper. The height of the plants measured from the root collar to the base of the top bud by using Height poll and Haga. Three plots (45 trees) from each block were counted for survival rate. Measurement of the data was recorded to two decimal points. The survival percentage of each species was also noted. Data were subjected to the Analysis of Variance and Duncan's Multiple Range test. An Analysis of Variance was used to evaluate the growth performance of the species.

RESULTS AND DISCUSSION

Statistical analysis showed that there were significant ($p<0.05$) differences in survival rate of the species (Table 1). The highest survival rate was *C. iners* (76.35), followed by *A. excelsa* (74.1%), *I. palembanica* (48.2%), *H. pubescens* (44.4%) and the lowest was *S. leprosula* (20.7%). The present study indicated in the secondary forest area showed dipterocarp species like *S. leprosula* and

Table 1: Mean for total diameter at breast height (cm), total height, diameter and height increment and the survival rate (%), after 9 years of planting

Species	Block	No. of trees	Total DBH	Mean total DBH	Mean increment (2002-2004)
A. excelsa	1	37	9.71	12.67[a]	2.11
(*74.1%)[a]	2	32	13.69		
	3	31	15.16		
C. iners	1	37	9.03	9.36[c]	1.96
(*76.3%)[a]	2	33	10.41		
	3	33	8.68		
H. pubescens	1	21	7.97	7.28[d]	2.02
(*44.4%)[b]	2	29	7.42		
	3	16	5.42		
I. palembanica	1	20	5.79	5.91[d]	1.93
(*48.2%)[b]	2	26	6.07		
	3	19	5.83		
S. leprosula	1	11	9.28	11.15[b]	2.05
(*20.7%)[c]	2	9	10.95		
	3	8	13.92		

Species	Mean increment diameter (cm $year^{-1}$)	Total height	Mean total height	Mean increment (2002-2004)	Mean increment height (m $year^{-1}$)
A. excelsa	1.06	11.28	12.98[a]	2.75	1.38[a]
(*74.1%)[a]		13.85			
		14.12			
C. iners	0.98	6.04	6.00[d]	1.54	0.77[d]
(*76.3%)[a]		6.47			
		5.47			
H. pubescens	1.01	7.01	7.43[c]	2.07	1.04[c]
(*44.4%)[b]		8.07			
		6.46			
I. palembanica	0.97	5.42	5.82[d]	1.61	0.81[d]
(*48.2%)[b]		6.07			
		5.90			
S. leprosula	1.03	11.46	11.18[b]	2.32	1.16[b]
(*20.7%)[c]		10.15			
		11.95			

Mean for total DBH, total height and increment height (by column) are significantly different ($p \leq 0.05$) by Duncan's New multiple range test noted: *Percentage of survival trees

H. pubescens were poor survival rate. Most earlier studies involving planting dipterocarp in logged and degraded forests have reported substantially higher mortality rates (Vincent and Davies, 2003). For example, Suhaili *et al*. (1998) reported that seedling mortality rates of 39% for *Dryobalanops aromatica* and 22% for *Shorea parvifolia* over the first 6 months in degraded land in Peninsular Malaysia. Adjers *et al*. (1995) registered survival rates between 40 and 85% for *Shorea johorensis*, *S. leprosula* and *S. parvifolia* 2 years after planting. However, Sakai *et al.* (2009) found that *Hopea odorata* is a useful sivicultural species with high survival (>70%) in both shaded and open sites if the regular maintenance like weed cutting is carried out. As the cause, *S. leprosula* and *H. pubescens* considered as a shade-tolerant species and need the shading at early stage of planting.

However, for non-dipterocarp species such as *A. excelsa* and *C. iners* showed high survival rate. Similar study done by Suhaili *et al*. (1998) mentioned that *C. iners* the highest rate of survival. Another study, Azani *et al*. (2003) reported that *A. excelsa* was exhibited the highest survival rate in gap planting with 83.5%. The survival of *A. excelsa* in the present study also coincided by Andrew *et al*. (2004) that the survival rate of *Azadirachta indica* provenances at the age of 58 months was ranged from value from 75-95%. Another earlier study regarding to non-dipterocarp species was reported by Hashim (2005) that the survival of *Araucaria cunninghamii* trees at Mata Ayer Forest Reserve, Perlis, Malaysia was greater than that of *Araucaria hunstenii*. The high survival rate could be due to the adaptability of the species with site conditions like water stress and soil poor nutrient. In degraded forests and in open areas, a combination of increased run-off and higher light levels may lead to increased water stress on planted seedlings (Malmer, 1992).

Unapplied treatment in this experiment significantly affected the mortality rates, environmental conditions, other than those manipulated in the experiment must have had a large impact on survival. Environment factors like weather condition, pest attack and animal distribution, planting technique, weed competition and poor soil condition are the factors possibly lead to variation in survival rate and growth performance (Evans, 1992). Furthermore, growing space also contribute to the growth performance (Mohd Zaki *et al*., 2003).

The study showed that there were not significant different ($p>0.05$) in increments of DBH (Table 1). However, it is found that the highest mean increment of DBH was *A. excelsa* (1.06 cm year^{-1}), followed by *S. leprosula* (1.03 cm year^{-1}), *H. pubescens* (1.01 cm year^{-1}), *C. iners* (0.98 cm year^{-1}) and *I. palembanica* (0.97 cm year^{-1}), respectively. However, statistical analysis conducted showed that there was significant difference ($p<0.05$) for height. From the ANOVA analysis, *A. excelsa* was greater (1.38 m year^{-1}), followed by *S. leprosula* (1.16 m year^{-1}), *H. pubescens* (1.04 m year^{-1}), *I. palembanica* (0.81 m year^{-1}) and *C. iners* (0.77 m year^{-1}), respectively.

The growth data of *A. excelsa* were also supported by Azani *et al*. (2003) that the highest mean basal diameter increment (3.49 mm year^{-1}) and height increments (46.44 cm year^{-1}) at 36 months old tree. According to Symington (1974), the 25 year old *S. leprosula* have an average annual diameter increment of 1.2 cm year^{-1}. Ahmad Zuhaidi *et al*. (2002) found that individual trees in their early years grow at a rate of between 0.8 and 1.6 cm year^{-1} in diameter. *I. palembanica* is a slow growing species (Appanah and Weinland, 1993) with annual diameter increment of 0.6 cm year^{-1} only (Lee *et al*., 2002) which is lower as in comparison to the present study. However, Appanah and Weinland (1993) stated that; mean annual increment of height for *S. leprosula* and *I. palembanica* were 0.8 and 1.0 m year^{-1}, respectively.

Better height and diameter growth of the species could be due to adapt well to the locality or species-site matching and ability to tolerate water stress and other unfavorable site conditions. Azani *et al*. (2003) also supported that the variation in growth of planted species due to specific reaction of the species to environmental conditions. Experiences in Indonesia and Malaysia, growth in terms of height and diameter increment are influenced by the big growing space (Mohd Zaki *et al*., 2003). However, this would be most likely to promote weed or climbers to grow and invade the site.

CONCLUSION

Azadirachta excelsa has the highest mean increment of diameter at DBH at 1.06 cm year^{-1}, followed by *Shorea leprosula*, *Hopea pubescens*, *Cinnamomum iners* and *Intsia palembanica* which are 1.03, 1.01, 0.98 and 0.97 cm year^{-1}, respectively. In terms of height increment, *Azadirachta excelsa* possess at 1.38 m year^{-1} and followed by *Shorea leprosula*, *Hopea pubescens*, *Intsia palembanica* and *Cinnamomum iners* at 1.16, 1.04, 0.81 and 0.77 m year^{-1}, respectively. Overall performance indicates that *Azadirachta excelsa* and *Cinnamomum iners* have good performance both in survival rate and growth in the open planting technique. Slashing, silvicultural treatment and continuing monitor have the potential to improve the survival, height, diameter at breast height and biomass increment of under secondary forest area.

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