ASSESSMENT OF GROWTH AND BIOMASS OF *SHOREA ROXBURGHII* G. DON IN SELECTED AREAS OF PENINSULAR MALAYSIA

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ABSTRACT

In Peninsular Malaysia, exotic timber species have been preferred as plantation species for the past few decades. However, some of these exotic species have been heavily infested by pests and/or diseases. With the increasing demand for pulp and wood, it is timely to consider and explore the possibilities of native species for plantations nationwide. Shorea roxburghii is a species from the Dipterocarpaceae family and is classified as 'Vulnerable' in the IUCN Red List of Threatened Species. It is a valuable commercial timber harvested and used as 'white meranti'. This species is native to the mixed dipterocarp forest of Malaysia and a few other Southeast Asia countries. This paper aims to 1) discuss on the growth and biomass accumulation in S. roxburghii, 2) determine suitable sites for S. roxburghii as a plantation species for wood production and 3) explore the possibility of S. roxburghii for rehabilitation of degraded or disturbed sites. The study areas selected were located in three different sites in Bukit Gantang, Bidor and Segamat. All the sites selected are either disturbed or degraded areas. Diameter at breast height (Dbh) and total height of five or six years old S. roxburghii were measured and analyzed. We found that six-year-old S. roxburghii in Segamat, planted on Renggam/Beserah soil series, had the best average Dbh and height of 23.6 cm and 16.6 m, respectively. It has also recorded considerably fast growth and could achieve increments up to 4 cm/year in Dbh and 3 m/year in height. Among the selected sites, this species was observed to perform poorly in Bukit Gantang on Gong Chenak soil series with comparatively lower average Dbh and height of 10.5 cm and 6.8 m, respectively. Stand biomass was estimated based on Dbh and trees from SGMT have the highest total aboveground biomass with an average of 168,131 kg/ha for a six-year-old stand. Results from this study have indicated the preference of S. roxburghii towards well-drained or sandy soils with better growth and biomass accumulation. In addition, the ability of S. roxburghii to survive and grow in degraded sites such as ex-tin mine suggests the possibility of using this species for rehabilitation programmes.

Keywords: meranti temak nipis, growth, biomass, degraded, soil

INTRODUCTION

In spite of various efforts to reduce consumption of paper through paperless initiatives, the demand for pulp as well as wood has seen increasing trends in Malaysia. Under conditions of increasing demand that may jeopardize the existence of natural forests, this situation requires imports of paper and wood products from other producing countries although Malaysia is progressively decreasing dependency of import. Forest plantations in Peninsular Malaysia for the past few decades have mostly preferred fast-growing exotic species, like rubber and acacia, to relatively slower growing indigenous species both for wood and pulp production. However, a few of these chosen exotic species have experienced rather severe attacks by pests and diseases. Examples include root-rot diseases and *Ceratocystis* wilt in *Acacia mangium* plantations as discussed by Lee (2018). This calls for serious efforts in identifying native timber trees as plantation species to reduce the incidences of attacks by pests and diseases.

In the past two decades, forest plantations in Malaysia have began exploring and promoting native species instead of exotic ones to reduce risks of pests and diseases. Due to rapid economic development in this country, available land for agriculture is limited and more so for forest plantations. As such, the latter is usually restricted to impoverished soils, abandoned areas, disturbed or degraded sites and even at steep slopes. Therefore, selection of suitable native species should consider those that require

minimum nutrients, light tolerant and have high survival but with considerable growth for economic production. In rehabilitation or reforestation efforts, it is important to accelerate natural successional processes in order to increase biological productivity, reduce soil erosion and increase soil fertility among others (Parotta, 1992). Thus, species survival and biodiversity will be of higher importance compared to biomass accumulation to provide a suitable environment for succession.

Growth of several Dipterocarp species have been studied over the years for possible alternative plantation species, enrichment planting or rehabilitation which include *Shorea leprosula* (Palmiotto, 1993), *S. materialis* (Sherzad *et al*., 2015), *S. curtisii* (Hoshino *et al*., 2016) and *Hopea odorata* (Sik *et al*., 2016, Ho *et al*., 2013). To-date, no Dipterocarp species have been recommended as a forest plantation species. This study explores on the potential *Shorea roxburghii* G. Don as a native species for forest plantation. *Shorea roxburghii* or locally known as 'meranti temak nipis' is native to Malaysia and belongs to the Dipterocarpaceae family. This species is predominantly found within dry, evergreen or semi-evergreen dipterocarp forest. It can also occur within lowland dipterocarp forests, *Schima*-bamboo forest and on limestone (Chua *et al*., 2010). This species was previously listed as endangered in 2010 in the IUCN Red List but is currently classified as vulnerable. It has recalcitrant seed which affects its viability due to dehydration thus requiring proper storage to conserve its vigor and vitality (Noraliza *et al*., 2017). *Shorea roxburghii* is a commercially valuable species harvested as a source of 'white meranti' timber which is categorized under very heavy class wood (>700 kg/m^3) based on wood density (Pande, 2008).

Nakamura (2006) has described *S. roxburghii* as a useful species for silviculture in the tropics due to its tolerance to heavy drought and high survivorship after forest fire. Although *S. roxburghii* has yet to be introduced or recommended as a plantation species, several trials have been conducted under different soil series or types. This paper aims to document the early growth and biomass accumulation of *S. roxburghii* and examine the potential of this species to be cultivated as a forest plantation species in view of its valuable timber as well as to reduce the pressure of harvesting from natural forests. The possibility of using this species for rehabilitation in degraded areas will also be evaluated and discussed in this paper.

METHOD AND MATERIALS

The three sites chosen for this study were FRIM Research Station Segamat (SGMT) in Johor, FRIM Research Station Bidor (SBDR) and Bukit Gantang (BTGT) in Perak. SGMT is a logged-over area while SBDR is an ex-tin mine. Both SGMT and SBDR are research stations of Forest Research Institute Malaysia. The site at BTGT was previously a paddy field.

SGMT has five and six years old trees, SBDR has only six year old trees while BTGT has only five year old trees. The soil series or types of the sites were identified and reported. In each site, diameter at breast height (Dbh) and total height of each tree were measured. According to Basuki *et al*. (2009), the inclusion of commercial bole height and wood density was not significant for *Shorea* species. Therefore, the following allometric equation developed by Basuki *et al*. (2009) was used to estimate the total aboveground biomass (TAGB) in all the chosen sites:

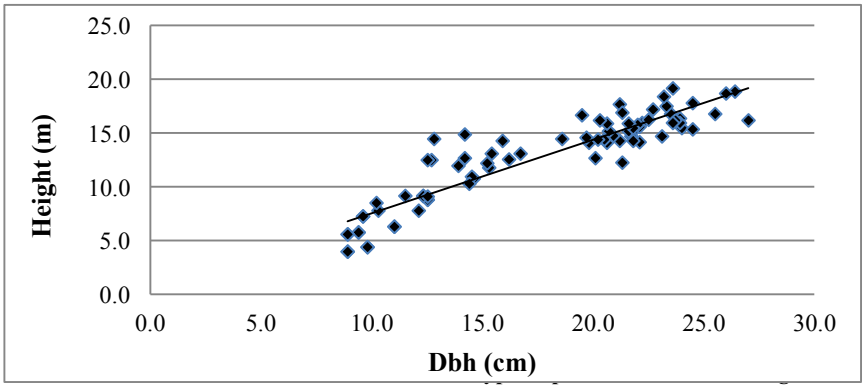
$$\ln(TAGB) = -2.193 + 2.371(\ln Dbh)$$

The TAGB was estimated based on dry weight (kg/tree). Stand TAGB was calculated based on an assumption of 100% survival and a planting density of 832 trees/ha or a spacing of 3 m X 4 m.

RESULTS AND DISCUSSION

Figure 1 illustrates the distribution of Dbh and height of measured *S. roxburghii* in all the selected sites. Smaller trees were observed in BTGT which are only five years old. There is a strong relationship between Dbh and height for the trees (R^2 = 0.8381).

Figure 1: Diameter at breast height (Dbh) and height distribution of *Shorea roxburghii* in selected sites



Site	Soil Series / Type	Soil Description
SGMT	Renggam/	Deep coarse sandy clay *soil* derived from granitic parent material.
	Beserah	Have similar features with Renggam series. A gravelly clay texture within 50 cm – gravel content exceeds 35% with loose soil structure.
SBDR	Sand tailings	Tin mine tailings with more than 90% sand including coarse and fine sand.
BTGT	Gong Chenak	Brown (7.5-10 YR), clay, imperfectly to somewhat imperfectly drained with varying clay content of 35-60%, derived from sub recent alluvium.

Note: SGMT: FRIM Research Station Segamat
SBDR: FRIM Research Station Bidor
BTGT: Bukit Gantang

Table 1 describes the soil series or type of the selected sites in which *S. roxburghii* trees were planted and measured. Soil in SGMT is a combination of Renggam/ Beserah series. The trees in SBDR were planted on sand tailings with >90% sand content thus having low water retention capacity. Sand tailings have been associated with harsh microclimate and low nutrient content that hinders succession and establishment of forest tree species. Meanwhile, soil BTGT is the Gong Chenak series which has more clay content is prone to saturation compared to the other two sites.

Table 2: Average diameter at breast height (Dbh), total height (H) and mean annual increment (MAI) of *Shorea roxburghii* at selected sites

Site	N	Age	Dbh (cm)	H (m)	MAI Dbh (cm)	MAI H (m)
SGMT	20	5	21.44 ± 1.31	15.04 ± 1.29	4.29 ± 0.26	3.01 ± 0.26
SGMT	20	6	23.59 ± 1.63	16.60 ± 1.44	3.92 ± 0.27	2.77 ± 0.24
SBDR	20	6	15.53 ± 2.57	13.00 ± 2.00	2.59 ± 0.43	2.17 ± 0.33
BTGT	20	5	10.45 ± 1.34	6.81 ± 1.82	2.09 ± 0.27	1.36 ± 0.36

Results in Table 2 showed that SGMT has the highest average Dbh and height for both five and six year old *S. roxburghii*. The Dbh for SGMT ranged from 21.6 to 27 cm while the total height ranged from 15.9 to 16.2 m. This is followed by six year old trees of SBDR. In another study on slime tailings of an ex-tin mine, the mean Dbh and height of five-year-old *S. roxburghii* with 86% survival in mixed species plots was 4.2 ± 1.9 cm and 4.8 ± 2.2 m, respectively (Ang *et al*., 2018). BTGT have the smallest trees among all the selected sites. It was observed that trees of the same age in SGMT were almost twice as big as those in BTGT.

Analysis of mean annual increment (MAI) for Dbh and height revealed that *S. roxburghii* can be considered as a fast-growing native species. In a suitable site with well-drained soil like SGMT, it could achieve increments of approximately 4 cm/year for Dbh and 3 m/year for height. From the same genus, *S. leprosula* in natural forest of Kalimantan had mean annual increments for Dbh and height at merely 2.9 cm/year and 2.1 cm/year (Widiyatno *et al*., 2013). The results of this study are also much better than those recorded for *H. odorata* with 2.2 cm/year for Dbh and 1.3 m/year for height (Lee *et al*., 2000). *Hopea odorata* has

also been associated with high survival and good growth which has been planted in the open for rehabilitation of degraded sites as well as for landscaping.

Fast-growing species have always been selected not only for plantations but are also beneficial for rehabilitation or reforestation projects so that the seedlings can establish quickly under the given conditions to provide shade and improve soil quality. Along with high survival rates, *S. roxburghii* may be considered for use as a nurse tree species in the aforesaid projects instead of planting exotic species. In addition, *S. roxburghii* has low nutrient uptake and should be considered for use in forest regeneration (Tong & Ng, 2008).

Table 3: Estimated average total above-ground biomass (TAGB) and stand biomass of *Shorea roxburghii* at selected sites

Site	Age	TAGB (kg/tree)	Total TAGB (kg/ha)
SGMT	5	160.76 ± 23.83	133,755
SGMT	6	202.08 ± 33.86	168,131
SBDR	6	77.65 ± 32.42	64,606
BTGT	5	29.81 ± 9.14	24,799

As the equation used for estimation of TAGB in this study is solely based on Dbh, trees with higher Dbh will have larger TAGB. SGMT has the largest TAGB with an average of 202.08 ± 33.86 kg/tree. while BTGT has a mere average of 29.81 ± 9.14 kg/tree. With a planting density of 832 trees/ha, results indicated that a six-year-old stand in SGMT could have an estimated 168,131 kg/ha in the above-ground biomass. This TAGB value is about 2.6 times the total in SBDR and 6.8 times higher than BTGT.

CONCLUSION

The results showed that SGMT has the fastest growth and largest TAGB for *S. roxburghii* compared to the other two sites. Despite the encouraging early growth rates, it should be noted that species performance can often be region or site specific. Slower growth as well as a more inferior biomass accumulation in BTGT was probably attributed to a lack of soil nutrients and unsuitable microclimate for the early establishment of *S. roxburghii* in these disturbed sites.

Findings from this study indicated that *S. roxburghii* has better growth in SGMT and SBDR with rather sandy soil compared to BTGT and slime tailings with clayey soil. This may imply a preference by *S. roxburghii* for well-drained soil and should be taken into serious consideration to avoid planting in areas with high clay content. This study also observed that *S. roxburghii* grows and survives well in open planting suggesting its suitability and potential as a forest plantation species. Nonetheless, the study on *S. roxburghii* as a suitable forest plantation species for Peninsular Malaysia is still at its infancy with many information gaps to be bridged including seed storage, silvicultural practices, harvesting and working properties of its wood to ensure its sustainability.

Since *S. roxburghii* has shown considerable growth performance in an ex-tin mine, it can thus be used as a nurse tree species for enrichment planting in rehabilitation projects. Species that are fast-growing are needed in such projects as they need to establish quickly to provide a friendlier environment that promotes subsequent natural succession or artificial natural regeneration. The use of native speices should be preferred in any tree planting or rehabilitation programmes nationwide to minimise risks of pests and diseases while reducing harvesting pressure of valuable timber species from natural forests.

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