High-quality timber species production under multi-storey forest management approach in Malaysia

N J N Jemali1,*, J Yahya2, H N R Bam3, S Majid1 and M Muhammad1

1Faculty of Earth Science, Universiti Malaysia Kelantan Jeli Campus, 17600 Jeli, Kelantan, Malaysia
2Forest Department of Peninsular Malaysia, Kuala Lumpur, Malaysia
3Faculty of Agriculture (Subtropical Agro-Environmental Sciences), University of the Ryukyus, Okinawa, Japan.
*Corresponding author: janatunnaim@umk.edu.my

Abstract. The multi-storey forest management project (MFMP) intended to identify the best silvicultural practices for tropical forest tree species as well as producing high-quality timber and seeds in a multi-storey forest. Plots were established to examine the transition of existing forest plantations and secondary forest to multi-storey forest type. The study aims to evaluate the current performance of the growth rate and productivity of selected local species through a multi-storey forest management approach. Based on the growth performance and productivity obtained, it was found that the method of planting under shading is a practical approach compared to the open planting method. *Acacia mangium* is planted 3 - 4 years earlier which acts as shade trees. Five study designs implemented using crop strip at a distance of 3.0 x 3.7m alternating between three different local species and shade trees with a ratio of A (1: 1), B (2: 2), C (4: 4), D (8: 8) and E (16:16). From this study, we found that Malaysia’s local timber species can grow under the shade at the beginning of establishment and it can grow well on narrow crop lines such as crop design A and B. On the other hand, these local species need sufficient levels of sunlight as well as other environmental requirements such as humidity, soil and weather changes over time as they grow. For that reason, these three local species namely *Shorea leprosula*, *Shorea parvifolia* and *Neobalanocarpus heimii* showed good performance in crop design C, D and E. This multi-storey forest management concept can be practised for the establishment of forest plantations and silvicultural treatment in degraded areas with high-quality local timber species.

1. Introduction

Sustainable forest management practices began in 1980 to control the production of forest resources economically [1]. Alternatively, forest plantation has been introduced to maintain the quality and quantity of timber supply hence to reduce the dependency of timber harvesting in the natural forests [2]. However, the establishment of these monoculture forest plantations resulted in extensive clearing of forest areas which had caused environmental destruction such as soil erosion, floods and global warming [3]. The importance of forests and preserving a quality environment is a hot topic nowadays. Various efforts were carried out such as conservation activities, tree planting and reforestation to ensure the sustainability of forest resources and environmental stability. For that reason, a Multi-storey Forest Management (MSFM) project was implemented in collaboration with the Department of Forestry in Peninsular Malaysia and the Japan International...
Cooperation Agency (JICA) in 1991. Malaysia was chosen to implement this project due to its location in the middle of a tropical rainforest and has suitable environmental conditions required to implement this MSFM [4]. The aim of MSFM is to establish a multi-level forest management model for sustainable forest management in tropical rainforests and to attract the private sector to invest in reforestation activities. MSFM consists of various timber species that are planted in two or more layers of canopy to form a complex forest structure. There are two types of planting done through this approach, namely open and shaded planting technique. The open planting method is done by planting fast growing species such as *Acacia mangium* and local species simultaneously in the open area, while the shaded-planting method is done by planting local tree species among the rows of *A. mangium* trees. In this project, the shaded-planting method was adopted to evaluate the growth performance of three selected local timber species to produce a high quality timber in the future.

2. Materials and Methods

The study was conducted in a plantation area of lowland dipterocarp forest specifically in Block B92, Chikus Forest Reserve, Perak. Five study designs implemented using crop strip at a distance of 3.0 x 3.7m alternating between three different local species of *Shorea leprosula*, *Shorea parvifolia* and *Neobalanocarpus heimii* with shade trees by a ratio of A (1: 1), B (2: 2), C (4: 4), D (8: 8) and E (16:16). Local species were planted alternately under the shade of 3-4 year old *A. mangium* as shade trees at a planting distance of 3.0 x 3.7m. Figure 1 shows the planting design which was adapted in this study.

![Figure 1. The planting design for multi-storey forest management project](image)

Table 1 shows the chronology of planting activities in this project. Prior to planting the three local species, the shade trees of *A. mangium* were planted in the first year of plot establishment. In the second year, weeding and liana cutting was carried out as the silvicultural treatment for shade trees followed by pruning activity in the fourth year of plantation. In the 5th year, site preparation was done to get the site ready for the local species plantation using the planting design as in Figure 1. Thinning of 30% from planted local trees was done in the following year. Trees planted were left out to grow for five years. After 5 years of planting, in 2013-2014, a field survey was carried out to measure the size of diameter-at-breast-height (DBH) and height of standing tree in all plots.
Table 1. Sequence of planting activity and silvicultural treatments applied to the study site.

| Year (n) | Activity                                      |
|---------|-----------------------------------------------|
| 1       | Planting shade trees (*A. mangium*)           |
| 2       | Weeding and liana cutting                     |
| 3       | Pruning                                       |
| 5       | Site preparation and plant local tree species |
| 6       | Thinning (30%)                                |
| 10      | Complete tree measurement                     |

3. Results and Discussion

A total of 4,898 local tree species were measured within 30 plots set up in this project after a 5 years planting period. Table 2 summarizes the average DBH of the high quality local timber species in 5 different treatments after 5 years of planting. Meanwhile, the growth of these local species in terms of tree height at different treatments is shown in Table 3. From this study, we found that Malaysia’s local timber species can grow under the shade at the beginning of establishment and it can grow well on narrow crop lines such as crop design A and B. On the other hand, these local species need sufficient levels of sunlight as well as other environmental requirements such as humidity, soil and weather changes over time as they grow. For that reason, these three local species of *Shorea leprosula*, *Shorea parvifolia* and *Neobalanocarpus heimii* showed good performance in crop design C, D and E based on estimated volume and growth performance as presented in Table 4 and Table 5 respectively.

Table 2. Average DBH increment (in cm) for three local species in different planting design.

| Species name        | A   | B   | C   | D   | E   |
|---------------------|-----|-----|-----|-----|-----|
| *Shorea leprosula*  | 19.4| 23.6| 27.0| 24.9| 24.2|
| *Shorea parvifolia* | 24.4| 27.1| 27.0| 32.2| 32.1|
| *Neobalanocarpus heimii* | 13.9| 13.8| 14.9| 16.9| 19.6|

Table 3. Average tree height (in m) for three local species in different planting design.

| Species name        | A   | B   | C   | D   | E   |
|---------------------|-----|-----|-----|-----|-----|
| *Shorea leprosula*  | 20.99| 21.10| 26.31| 24.26| 23.79|
| *Shorea parvifolia* | 19.00| 24.13| 22.93| 28.80| 26.89|
| *Neobalanocarpus heimii* | 10.13| 13.01| 14.27| 16.79| 13.53|

Table 4. Estimated tree volume (in m³) for three local species in different planting design.

| Species name        | A   | B   | C   | D   | E   |
|---------------------|-----|-----|-----|-----|-----|
| *Shorea leprosula*  | 3.035| 1.994| 3.892| 2.533| 2.414|
| *Shorea parvifolia* | 2.247| 2.537| 2.563| 4.615| 3.625|
| *Neobalanocarpus heimii* | 0.802| 0.650| 1.059| 1.237| 1.113|

*S. parvifolia* has a good growth rate. Referring to Goran et al [5] this species needs shading and its growth rate is relatively slow compared to *S. leprosula*. The average DBH increment is 1.3cm/year and could reach 60cm at the age of 50 years. In this study, *S. parvifolia* showed the highest survival rate with 66% followed by *S. leprosula* (52%) and *N. hemii* (29%) in the 5 years planting period. *S. parvifolia* also has the highest average of height growth with 135cm/year followed by *S. leprosula* (127 cm/ year) and *N. hemii* (118cm/year). Meanwhile, for the diameter growth, *S. leprosula* leads all species with the diameter increment reaching 0.23cm/year. *S. leprosula* is a species of Red Meranti that has a fast growth rate at the beginning of its cultivation. This species could reach an average increment in diameter of 0.8cm/year and an increase in volume of 8m³/ha/year. Hence the one that grows in the Forest Research Institute of Malaysia (FRIM) arboretum can reach an average diameter of 45cm in 15 years (3cm/year) [6,7]. The premium-quality local species of *Neobalanocarpus heimii*
have a very slow growth rate and require shading during its cultivation period. This species grows very slow at the beginning of planting and will cultivate rapidly after the diameter of the tree reaches 25cm [8]. The growth performance for selected species planted in the Block B at Chikus Forest site is shown in Table 5.

**Table 5.** Growth performance of three local species.

| Species name              | Height (cm/year) | DBH (cm/year) | Survival rate (%) |
|---------------------------|------------------|---------------|-------------------|
| *Shorea leprosula*        | 127              | 0.23          | 52                |
| *Shorea parvifolia*       | 135              | 0.18          | 39                |
| *Neobalanocarpus heimii*  | 118              | 0.13          | 29                |

The multi-layered forest management is a forest rehabilitation strategy that uses high-quality tree species to build two or more levels of the canopy [9, 10]. The introduction of selected and desired good quality timber species into the forest stand are among the important roles of enrichment planting. This MSFM model can provide benefits when compared to monoculture tree planting in terms of resistance to pests and diseases [11]. The model emphasizes strategically producing a variety of high quality timber while considering several environmental factors such as sunlight and plantation gap as proven in [12]. Hence, this plantation concept can be practised for the establishment of forest plantations and silvicultural treatment in degraded areas to produce high-quality local timber species.

4. Conclusion

The multi-storey forest management (MSFM) method showed promising planting success with an exceptional growth performance rate on the tested local species. This method allows for intense forest silvicultural activities to improve the quality of poorly stocked forests, degraded lands, and production zones. However, additional work is needed, and the study should be spread to other sites, because the tropical forest contains a variety of local species and forest types that require diverse management approaches and strategies. Hence, MSFM is a potential rehabilitation strategy for promoting tropical forest regeneration and management. In this study, *S. leprosula* had shown to be a promising species for reforestation and replacing invasive species with type C planting design is recommended for optimum growth performance, volume estimation and stand productivity in tropical forest of Peninsular Malaysia.

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