

# The Adaptability of Six Introduced *Shorea* spp. to the Community Forest in Sleman, Yogyakarta

Sapto Indrioko<sup>1,\*</sup> Widiyatno<sup>1</sup> Birowo Aji Wicaksono<sup>1</sup>

<sup>1</sup>Faculty of Forestry Universitas Gadjah Mada Yogyakarta

\* Corresponding author. Email: [sindrioko@ugm.ac.id](mailto:sindrioko@ugm.ac.id)

## ABSTRACT

Dipterocarp species dominated tropical rain forests in Kalimantan. *Shorea* is one of the genera with the highest number of species. It supported the diversity of characters between species, including the possibility to develop outside their natural habitat as exotic species. The prospect of developing *Shorea* spp. plantations to produce meranti wood in Java is essential because the large market share of wood should come from sustainably managed plantations. Therefore, this research was carried out to evaluate the adaptability of six introduced *Shorea* spp., especially in the new habitats of Cangkringan area, Sleman, Yogyakarta. The study was carried out in two sites. The first site was in a slightly open area under *Falcataria moluccana* stands with *Kalanjana* grass (*Brachiaria mutica*), while another site was in a more sheltered garden by a denser canopy. Plantation trial on the first site was planted in February 2017, while the second site was planted in March 2018 due to limited seedlings stock and planting site. The plantations were established using a randomized complete block design, consisting of six species, namely *Shorea leprosula*, *S. selanica*, *S. johorensis*, *S. platyclados*, *S. dasphylla*, and *S. parvifolia*. The research resulted in the best survival of *S. leprosula* in garden areas (100%), while *S. selanica* well adapted (80%) in the more open site. The best initial growth is achieved by *S. leprosula* with shade conditions. This result explained that habitat suitability was essential to establish exotic species.

**Keywords:** growth, meranti, exotic species, introduction

## 1. INTRODUCTION

Dipterocarpaceae is a family of trees that grows predominantly in humid tropical forests in Indonesia. It has the most diversity in Kalimantan, namely nine genera, and 267 species [1], 155 species of which are endemic [2]. *Shorea* is one of the genera within Dipterocarpaceae with the largest number of species. It usually lives in tropical climates with an average annual rainfall of more than 1,000 mm and dry months less than six months a year [3]. They are found below an altitude of 1,000 m above sea level, usually living in lowlands with yellow or red soil, deep solum, and well drainage [4]. Based on the timber color, *Shorea* or Meranti is grouped into red meranti, yellow meranti, white meranti, and balau [5]. Some tested *Shorea* plantation in Kalimantan are proven to have high survival and known as fast-growing meranti, e.g., *S. platyclados*, *S. leprosula*, *S.*

*johorensis*, and *S. parvifolia* [6]. They also have high economic value of timber products.

*Shorea* can survive under shade circumstances because it has a gap-opportunist character [3]. In the seedling phase, *Shorea* requires shade, but it will need higher light intensity for growth when it enters the next stage [7]. Due to these characteristics, *Shorea* presumably can be used as an alternative for enrichment planting in community forests in Java to increase forest productivity and timber value in the future. Farmer groups at Cangkringan, Sleman, are very interested in trying to plant *Shorea*. However, species' suitability to a particular site is a prerequisite to developing the plantation as a competitive, efficient, and sustainable forest. Therefore, this research was carried out to evaluate the survival and early growth of six exotic *Shorea* species in the new habitat within community forest areas in Sleman, Yogyakarta.

## 2. MATERIALS AND METHODS

We conducted the research into two planting times, due to the limited seedling stocks and planting area. The first phase planting was carried out in February 2017, while the second phase was planting in March 2018. The species trial plantations located in the community forest, Cangkringan Area, Sleman Yogyakarta. The geographical location is  $7^{\circ}36'50.23''\text{S}$  and  $110^{\circ}27'03.15''\text{E}$ . It is located at 757 m above sea level. They were established using Randomized Complete Block Design (RCBD), consisted of six species, namely *Shorea dasyphylla*, *S. johorensis*, *S. leprosula*, *S. parvifolia*, *S. platyclados*, and *S. selanica*. Each species consisted of three tree plots and planted with a spacing of 4 m x 4 m. We set up the first phase with replications of 14 blocks, established within the 6 m x 6 m spacing of the *Falcataria moluccana* stand. The community also uses this site to plant Kalanjana grass, which is harvested periodically. The second phase comprised four blocks as replication. There are several grown plants that cover the planted *Shorea* seedlings, e.g. *Artocarpus altilis*, *A. heterophyllus*, *Swietenia macrophylla*, *Gnetum gnemon*, *Cocos nucifera*, and *Syzygium polyanthum*. The second site showed denser trees and more shade in comparison with the first site.

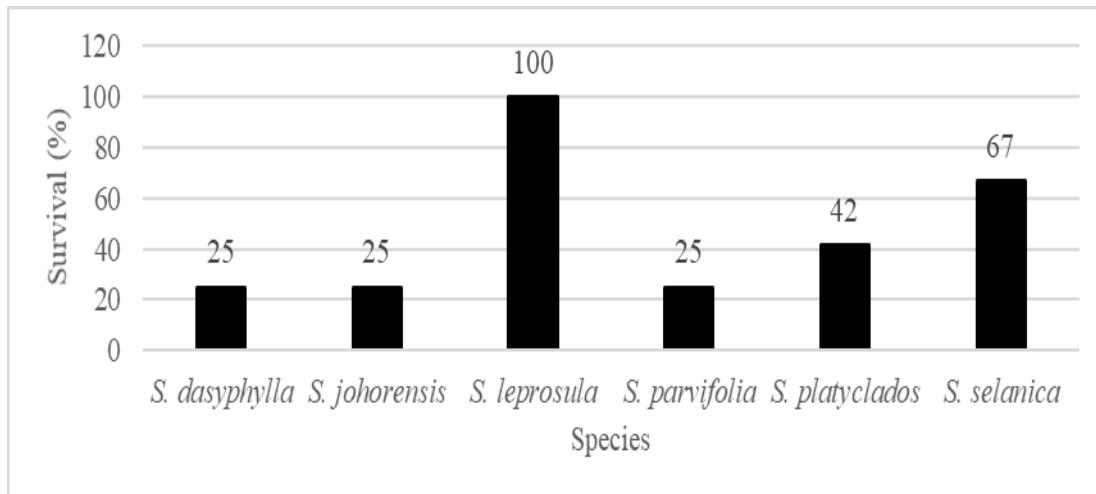
*S. selanica* seedlings were cultivated using collected seed originated from parent trees surrounding Universitas Gadjah Mada campus in Yogyakarta. While *S. dasyphylla*, *S. johorensis*, *S. leprosula*, *S. parvifolia*, and *S. platyclados*

propagules were collected as wildings originated from a forest concession area of P.T. Sari Bumi Kusuma, Nanga Nuak, Central Kalimantan. Observations of survival, health, height, and plant diameter of each individual were carried out in May 2019. Data for both plantations were analyzed using analysis of variance to determine the effect of species. If there is a significant difference, we proceed with the Duncan Multiple Range Test (DMRT) to locate the significant difference among species.

## 3. RESULT AND DISCUSSION

### 3.1. Survival Rate

In general, *Shorea* planted in garden areas showed a better survival rate (47%, Figure 1) than under *F. moluccana* stands (25%, Figure 2). The survival of *Shorea* seedlings under *F. moluccana* stands decreased by more than half compared to a year previously observed [8]. *S. leprosula* adapted best (all seedlings survived) in garden areas (Figure 1) but survived only one-fifth if planted in a more open space (Figure 2). All species tested (except *S. selanica*) showed better adaptability in the garden with more shade than under the *F. moluccana* stand. Species tests carried out in the natural distribution locations in Central Kalimantan also showed that *S. leprosula* had the highest survival (85%) observed until the plant was 12.5 years old [9]. In comparison, the test of 20 local *Shorea* species in West Kalimantan showed an average survival rate of 82.5% [10].

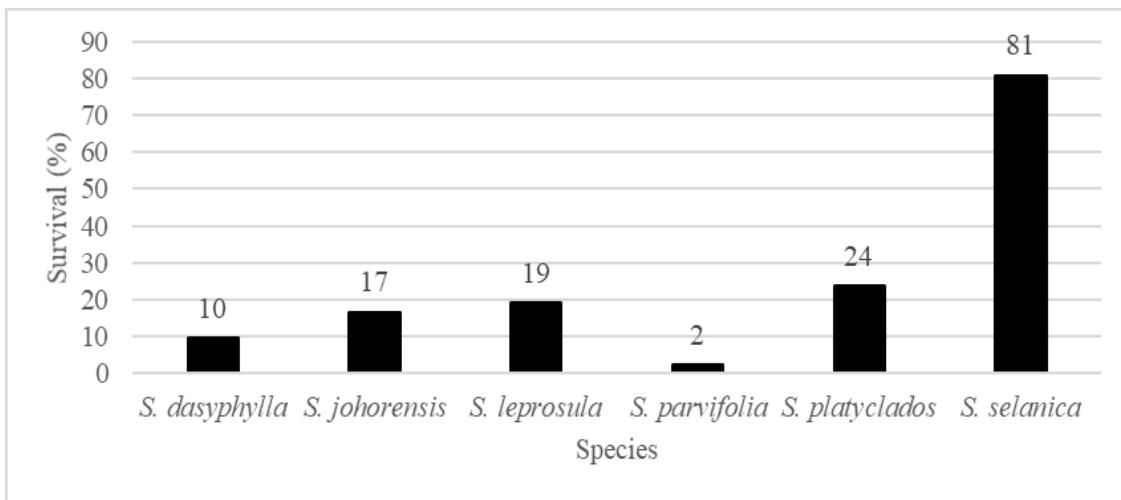


**Figure 1.** Survival rate of six exotic *Shorea* species planted in the garden

The high survival rate is natural, considering that native *Shorea* has undoubtedly adapted well to the site and the climate conditions in their natural distribution. The research location in Cangkringan area, Sleman has different climatic conditions with lower average rainfall, namely 2,500 mm/year [11]. Meanwhile, the rainfall at the location of the Dipterocarpaceae in Central Kalimantan is around 3,000 mm/year [12]. It suggests that Dipterocarp species naturally thrive in locations where rainfall is more or less evenly throughout the year. Even though the Cangkringan area, Sleman, has sufficient annual rainfall, there are still dry months, especially in the dry season, causing plant stress due to lack of water and reducing physiological processes' ability and even cause death. Water is essential for plants

because the physiological processes that take place in plants are related to the presence of water and materials dissolved in water [13].

*S. selanica* could survive (80%, Figure 2) better in more open sites than in more closed places (67%, Figure 1). It indicates that each species has specific site suitability to survive well. This species originated from the central part of the Moluccas, confined to Ambon, Buru, Obi, Seram, and Sula islands [14], with an average annual rainfall of less than 2,500 mm/year [15]. The present research location is likely to have environmental conditions, especially annual rainfall, similar to natural distribution. Furthermore, *S. selanica* grows well under limited shade trees [16] that support more adaptability to the lower site humidity.



**Figure 2.** Survival rate of six exotic *Shorea* species planted under *F. moluccana* stand

### 3.2. Initial Growth Rate

Analysis of variance could not be carried out for trial under *F. moluccana* stand due to very low of survival rate (25%). The results of the analysis of variance of species tested in the garden site showed significant differences in height and diameter growth among species (Table 1). *S. leprosula* had the best increase in height and diameter (Tables 2 and 3). The initial growth observed in the 6.5-year-old Dipterocaps species test in Central Kalimantan also showed that *S. leprosula* had the best increase in height and diameter [6]. *Shorea dasypylla*, *S. johorensis*, *S. leprosula*, *S. parvifolia*, and *S. platyclados* belong to red meranti [5]. Too intense sunlight would induce water-deficient, and red meranti seedlings frequently suffer from drought [3]. The suitable sunlight is very important to give an

optimum environment for supporting tree growth. Therefore, canopy density management above the enrichment planted of *Shorea* and other Dipterocarps [17] is essential, even they are established as a secondary forest within its natural distribution. The appropriate enrichment planting achievement will increase forest productivity [18] and maintain genetic diversity [19].

The exotic *Shorea* spp. have been introduced mainly to surrounding West Java since 1938 [20]. The addition of species and planting area continued until three species, i.e., *S. leprosula*, *S. selanica*, and *S. platyclados* reached the domestication stage. Forest state enterprise of Perhutani developed as commercial stands in the Forest Management Unit of Bogor and Banten [20]. It indicated that these exotic species have the best adaptability to West Java.

**Table 1.** Analysis of variance of species test planted in the garden

Source	df	Mean Square		F Value	
		Diameter	Height	Diameter	Height
Block	3	0.081	1676.916	3.33 ns	3.01 ns
Species	5	0.313	7288.912	12.93 **	13.09 **

Note: \*\*=significant at  $p \leq 0.01$ ; ns=not significant

**Table 2.** DMRT results of species test planted in the garden

Species	Diameter (cm)	Height (cm)
<i>S. leprosula</i>	0.98	a
<i>S. selanica</i>	0.98	a
<i>S. platyclados</i>	0.68	b
<i>S. dasphylla</i>	0.52	b
<i>S. parvifolia</i>	0.50	b
<i>S. johorensis</i>	0.46	b
		129.17
		89.50
		77.20
		52.00
		50.67
		47.75
		c

This fact is in line with the present results, *S. leprosula*, *S. selanica*, and *S. platyclados* are the best three species in terms of survival and diameter and height growth.

As all *S. dasphylla*, *S. johorensis*, *S. leprosula*, *S. parvifolia*, and *S. platyclados* seedlings were transferred directly from Central Kalimantan, they need some time to adjust to the local climate and site of the species test. Seedling roots did not respond quickly to grow and consume sufficient water to compensate for transpiratory water losses [21]. In contrast, *S. selanica* seeds were collected from the parent trees in Yogyakarta. This parent tree generation has successfully passed natural selection. They already adapted to the local environment during the establishment as ornamental trees on the roadside of the UGM campus in Yogyakarta until they grew and reproduced regularly. Therefore, *S. selanica* has a much better survival ability than the others on a more open site.

*S. selanica* and *S. leprosula* are promising for further research on their adaptability and growth in community forests in Sleman, Yogyakarta. Growth monitoring until the harvesting age is required to determine the productivity of these species. If we develop them, selecting an appropriate site is essential to grow optimally and produce high-value alternative timber for the community.

#### 4. CONCLUSION

Site use cannot be generalized to all *Shorea* species. It should be adjusted to the characters of each species. Precipitation is essential for supporting the plant survival. Furthermore, differences in shade

can cause variations in adaptation and growth. Based on the early evaluation, two out of six *Shorea* species are promising for further research on their adaptability and growth in community forests in Cangkringan area, Sleman, Yogyakarta. *S. leprosula* well adapted to shade garden, while *S. selanica* adapted to more light under *F. moluccana* stand.

#### ACKNOWLEDGMENTS

We sincerely thank Mr. Susilo Purnomo, P.T. Sari Bumi Kusuma, Nanga Nuak, Central Kalimantan, for providing the wildlings to this research.

#### REFERENCES

- [1] U. Hairah, A. Tejawati, E. Budiman, F. Agus, Borneo biodiversity: exploring endemic tree species and wood characteristics, in: L.S. Riza, A. Pranolo, A.P. Wibawa, E. Junaeti, Y. Wihardi, U.R. Hashim, S.J. Horng, R. Drezewski, H.S. Lim, G. Chakraborty, L. Hernandez, S. Nazir (Eds.), Proceeding of the 3rd International Conference on Science in Information Technology (ICSiTech), IEEE, 2017, pp. 435–440, DOI: <https://doi.org/10.1109/ICSiTech.2017.8257152>
- [2] M.A. Khan, R.A. Spicer, T.E.V. Spicer, S. Bera, Occurrence of *Shorea Roxburgh ex C. F. Gaertner* (Dipterocarpaceae) in the Neogene Siwalik Forests of Eastern Himalaya and its biogeography during the cenozoic of southeast asia, Review of Palaeobotany and Palynology 233 (2016) 236–254. DOI: <https://doi.org/10.1016/j.revpalbo.2016.07.011>.
- [3] J. Ghazoul, Dipterocarp biology, ecology, and conservation, Oxford University Press, Oxford, 2016.
- [4] Purwaningsih, E. Kintamani, The diversity of *Shorea* spp. (meranti) at some habitats in Indonesia, in: Miftahudin, B. Juliandi, W. Priawandiputra, M. Muttaqin (Eds.), Proceeding of the 2nd International Conference on Biosciences (ICoBio), IOP Conference Series: Earth and Environmental Science, vol. 197, 2018, 012034, pp. 1–10. DOI: <https://doi.org/10.1088/1755-1315/197/1/012034>
- [5] Y. Tsumura, T. Kado, K. Yoshida, H. Abe, M. Ohtani, Y. Taguchi, Y. Fukue, N. Tani, S. Ueno, K. Yoshimura, K. Kamiya, K. Harada, Y. Takeuchi, B. Diway, R. Finkeldey, M. Na’iem, S. Indrioko, K.K.S. Ng, N. Muhammad, S.L. Lee, Molecular database for classifying *Shorea* species (Dipterocarpaceae) and techniques for

- checking the legitimacy of timber and wood products, Journal of Plant Research 124 (2011) 35–48, DOI: <https://doi.org/10.1007/s10265-010-0348-z>.
- [6] Widiyatno, Soekotjo, M. Naiem, S. Purnomo, P.E. Setiyanto, Early performance of 23 dipterocarp species planted in logged-over rainforest, Journal of Tropical Forest Science 26(2) (2014) 259–266.
- [7] H.H. Rachmat, P. Pamoengkas, L. Sholihah, R.A. Fambayun, A. Susilowati, The effect of planting technique on the growth of two *Shorea* Species in Gunung Dahu, Bogor, Indonesia, Biodiversitas 21(9) (2020) 4131–4138, DOI: <https://doi.org/10.13057/biodiv/d210926>.
- [8] B.A. Wicaksono, Evaluasi awal pertanaman uji spesies Meranti di Bawah Tegakan Sengon di Desa Kepuharjo, Kecamatan Cangkringan, Kabupaten Sleman, Undergraduate Thesis, Fakultas Kehutanan Universitas Gadjah Mada, Yogyakarta, 2018. [In Bahasa Indonesia]
- [9] Widiyatno, F. Hidayati, S. Hardiwinoto, S. Indrioko, S. Purnomo, Jatmoko, N. Tani, M. Naiem, Selection of dipterocarp species for enrichment planting in a secondary tropical rainforest, Forest Science and Technology 16(4) (2020) 206–215, DOI: <https://doi.org/10.1080/21580103.2020.1831620>.
- [10] P. Gunawan, A. Muin, R.S. Wulandari, Uji spesies (*Shorea* spp.) di IUPHHK-HA PT. Suka Jaya Makmur Kabupaten Ketapang, Jurnal Hutan Lestari 4(4) (2016) 543–551. [In Bahasa Indonesia]
- [11] Pemerintah Desa Kepuharjo, Letak dan Luas Wilayah [Internet], 2020, Available from: <https://kepuharjo.slemankab.go.id/>. [In Bahasa Indonesia]
- [12] BPS Melawi, Jumlah curah hujan dan hari hujan bulanan di stasiun meteorologi Nanga Pinoh tahun 2014 [Internet], 2015, Available from: <https://melawikab.bps.go.id/statictable/2015/11/05/31/jumlah-curah-hujan-dan-hari-hujan-bulanan-di-stasiun-meteorologi-nanga-pinoh-tahun-2014.html>. [In Bahasa Indonesia]
- [13] J.D. Scharwies, J.R. Dinneny, Water transport, perception, and response in plants, Journal of Plant Research 132 (2019) 311–324, DOI: <https://doi.org/10.1007/s10265-019-01089-8>.
- [14] H.H. Rachmat, K. Kamiya, K. Harada, Contrasting cpDNA variation in two Indonesian endemic lowland dipterocarp species and implications for their conservation, Pakistan Journal of Biological Sciences 15(6) (2012) 783–788, DOI: <https://doi.org/10.3923/pjbs.2012.783.788>.
- [15] BPS Maluku, Jumlah curah hujan bulanan di stasiun meteorologi Kairatu, Amahai, Geser, Namlea, dan Dobo tahun 2016 [Internet], 2017, Available from: <https://maluku.bps.go.id/subject/157/iklim.html#subjekViewTab3.html>. [In Bahasa Indonesia]
- [16] R.D. Maripa, R.D. David, N.H. Daud, Response of *Shorea* species to drought stress, in: L.K. Chiang (Ed.), prospects and utilization of tropical plantation trees, CRC Press, Boca Raton, 2020, pp. 157–178. DOI: <https://doi.org/10.1201/9780429442773>.
- [17] J. Millet, N. Tran, N.V. Ngoc, T.T. Thi, D. Prat, Enrichment planting of native species for biodiversity conservation in a logged tree plantation in Vietnam, New Forests 44 (2013) 369–383, DOI: <https://doi.org/10.1007/s11056-012-9344-6>.
- [18] Widiyatno, S. Purnomo, Soekotjo, M. Na’iem, S. Hardiwinoto, Kasmujiono, The growth of selected *Shorea* spp. in Secondary tropical rain forest: the effect of silviculture treatment to improve growth quality of *Shorea* spp., Procedia Environmental Sciences, 7 (2013) 160–166, DOI: <https://doi.org/10.1016/j.proenv.2013.02.024>.
- [19] Widiyatno, S. Indrioko, M. Na’iem, K. Uchiyama, S. Numata, M. Ohtani, A. Matsumoto, Y. Tsumura, Effects of different silvicultural systems on the genetic diversity of *Shorea parvifolia* populations in the tropical rainforest of Southeast Asia, Tree Genetics & Genomes 12(73) (2016) 1–12, DOI: <https://doi.org/10.1007/s11295-016-1030-y>.
- [20] H. Alrasyid, Sejarah dan pengalaman pembuatan tegakan Dipterocarpaceae di Jawa, in: E.B. Hardiyanto (Ed.), Prosiding Seminar Nasional Status Silvikultur Indonesia 1999, Fakultas Kehutanan Universitas Gadjah Mada, Yogyakarta, 2000, pp. 87–92. [In Bahasa Indonesia]
- [21] Y. Osakabe, A. Kawaoka, N. Nishikubo, K. Osakabe, Responses to environmental stresses in woody plants: key to survive and longevity, Journal of Plant Research, 125 (2012) 1–10, DOI: <https://doi.org/10.1007/s10265-011-0446-6>.