ECOPHYSIOLOGY OF TWO *SHOREA* SPECIES IN A *PINUS CARIBAEA* ENRICHMENT TRIAL IN THE BUFFER ZONE OF SINHARAJA, SRI LANKA

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ABSTRACT

Shorea megistophylla (Thw.) Ashton and *Shorea disticha* (Thw.) Ashton belong to section *Doona* in the family Dipterocarpaceae. These two endemic and late successional canopy dominants co-exist in the lowland hill rain forests in the southwest of Sri Lanka. They are partially sympatric species differentiated from each other by their growth characteristics, leaf anatomy, morphology and physiological features. The species has been reported to co-exist within the same forest landscape in relation to different environmental conditions (Gunatilleke *et al*. 1996). Among members of section – *Doona*, these two species belong to the Beraliya group, members of which are locally recognized as multiple use species. Their fruits have edible cotyledons and they provide an additional source of carbohydrate to villagers in the vicinity of the forest. They also provide medium hardwood (Gunatilleke and Gunatilleke 1993).

These two *Shorea* species have the potential to respond to a range of ecologically different habitats, natural as well as manipulated systems, within the Sinharaja forest. An understanding of the biological, physiological, ecological and silvicultural features of these species in different ecological habitats is important. This information will facilitate their management in restoration trials of the degraded lowland rain forests in Sri Lanka. This study attempts to examine the growth performance and some physiological attributes of these two *Shorea* species in different size canopy openings of a *Pinus* enrichment trial at Sinharaja MAB reserve in order to understand the species adaptability to different light environments.

Growth performance and physiological attributes of the study species were examined using plants established in 1991 under four different light regimes created by canopy removal in a *Pinus caribaea* plantation in the buffer zone of Sinharaja forest. The canopy removal treatments and the daily photosynthetic photon flux (DPPF) received initially were as follows: 3 pine rows removed (22 mol/ m^2/ day), 1 pine row removed (10 mol/ m^2/ day), 3 pine rows under planting (5 mol/ m^2/ day) and the closed canopy (3 mol/ m^2/ day). This trial was set up as a split plot design with three replicates, twenty individuals per replicate per treatment as reported by Ashton *et al*. 1997. The allometric measurements related to growth of individuals were recorded for 8 years annually. The physiological measurements (photosynthetic rate, stomatal conductance, transpiration rate and water use efficiency) of the study species were recorded in February - March 2000 from 9.00 am - 3.00 pm on sunny days using a LiCor 6400 portable photosynthesis system under ambient conditions.

The results showed that root collar diameter (RCD), height and diameter at breast height (DBH) after 8 years and the annual increments of root collar diameter and height were significantly higher among the canopy removal treatments compared to the closed canopy control for both species (Table 1). In both *Shorea* species greatest DBH, RCD and its increment were in the three pine rows removal treatment and least in the closed canopy under planting. No significant difference in height was observed among the three pine rows and one pine row removal treatments and the three pine rows under planting treatment. Both study species raised under the pine removal treatments showed more or less similar trends where higher growth rates were associated with increasing light levels (Table 1).

In the physiological studies, *Shorea megistophylla* showed significant differences in the transpiration rate, stomatal conductance and water use efficiency when grown under different light regimes. *Shorea disticha* on the other hand did not show any significant difference in these measurements among the canopy removal treatments (Table1). Overall, with one exception, *S. megistophylla* always showed higher water use efficiency than that of *S. disticha*. If this trend continues up to the adult stage, the former would be a better species for *Pinus* enrichment programs.

The spatial and temporal light variation of the understorey is a major factor that affects the physiological processes of the two species investigated. It also demonstrates that changes between the initial

light intensities at the start of the experiment and that of present (8 years) due to the growth of the introduced plants can also affect the physiological responses of these plants. Studies are ongoing to determine the effects of the variations in light intensities at different height levels (top and middle of the crown and at ground level) on the growth of introduced species.

Previous studies demonstrate that seedlings of late successional canopy species can be established on formerly cleared forests by planting beneath the canopy of a *P. caribaea* plantation (Ashton *et al*. 1997; Gamage 1997). After 8 years both *S. megistophylla* and *S. disticha* showed a higher growth rate in canopy removal treatments compared to those in the *Pinus* underplanting (closed understorey). For these *Shorea* species the three pine rows removed treatment was the best, but in most instances was not significantly different from the other removal treatments.

Further more, the morphological plasticity and the ecophysiological responses of the two *Shorea* species to different canopy removal treatments revealed in this study will be beneficial to identify the silvicultural practices required to promote the introduction of these two endemic species to *P. caribaea* monoculture plantations in the lowland wet zone of Sri Lanka.

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Table 1. Growth and physiological measurements of *S. megistophylla* and *S. disticha* grown under different canopy removal treatments in an enrichment *P. caribaea* plantation. Letters qualitatively indicate significant differences (a>b>c) among the treatments for each species according to Duncan's Multiple Range Test (P<0.05).

	Canopy Removal Treatments			
	3 pine rows removed	1 pine row removed	3 pine rows under planting	Closed understorey (control)
Growth Measurements After 8 years				
Mean Height (m)				
Shorea megistophylla	8.1±0.37[a]	7.8±0.45[a]	7.2±0.27[a]	4.3±0.27[b]
Shorea disticha	7.3±0.39[a]	7.6±0.31[a]	6.7±0.34[a]	5.0±0.20[b]
Mean RCD (cm)				
Shorea megistophylla	6.75±0.23[a]	6.09±0.32[ab]	5.69±0.27[b]	3.68±0.17[c]
Shorea disticha	6.16±0.37[a]	5.61±0.23[ab]	5.11±0.26[b]	3.19±0.14[c]
Mean DBH (cm)				
Shorea megistophylla	6.05±0.26[a]	5.68±0.34[ab]	5.13±0.26[b]	2.62±0.19[c]
Shorea disticha	5.88±0.29[a]	5.47±0.23[ab]	4.60±0.28[b]	2.92±0.13[c]
Annual Growth Increments *				
Mean Height Increment (cm) / year				
Shorea megistophylla	92±4[a]	87±5[a]	74±4[b]	38±3[c]
Shorea disticha	78±4[a]	80±4[a]	70±4[a]	44±3[b]
Mean RCD Increment (cm) / year				
Shorea megistophylla	0.72±0.05[a]	0.68±0.03[ab]	0.61±0.03[b]	0.33±0.02[c]
Shorea disticha	0.72±0.07[a]	0.66±0.05[ab]	0.53±0.04[b]	0.26±0.02[c]
Mean DBH Increment (cm) / year				
Shorea megistophylla	0.67±0.05[a]	0.75±0.04[a]	0.66±0.04[a]	0.57±0.06[a]
Shorea disticha	0.65±0.04[a]	0.66±0.04[a]	0.59±0.04[a]	0.58±0.05[a]
Physiological Measurements †				
Net Photosynthetic Rate (μmol CO_2 m^{-2} s^{-1})				
Shorea megistophylla	1.67±0.19[a]	1.43±0.17[a]	1.34±0.14[a]	1.81±0.19[a]
Shorea disticha	1.17±0.14[a]	1.12±0.09[a]	1.14±0.12[a]	1.39±0.16[a]
Stomatal Conductance (mol H_2O m^{-2} s^{-1})				
Shorea megistophylla	0.050±0.011[a]	0.022±0.002[b]	0.035±0.003[ab]	0.031±0.003[b]
Shorea disticha	0.021±0.002[a]	0.026±0.002[a]	0.026±0.003[a]	0.028±0.002[a]
Transpiration Rate (mol H_2O m^{-2} s^{-1})				
Shorea megistophylla	0.80±0.05[a]	0.49±0.04[b]	0.65±0.05[a]	0.67±0.05[a]
Shorea disticha	0.61±0.04[a]	0.56±0.04[a]	0.53±0.05[a]	0.61±0.05[a]
Water Use Efficiency (μmol CO_2 /mol H_2O)				
Shorea megistophylla	2.33±0.21[b]	3.30±0.32[a]	2.48±0.27[b]	3.01±0.29[ab]
Shorea disticha	1.97±0.19[a]	2.37±0.22[a]	2.80±0.37[a]	2.70±0.29[a]

***** - Measurements were taken from all surviving individuals (ranging between 12-20 individuals per replicate per treatment) annually during the 8 year period.

† - Measurements were taken from 3 individuals per replicate per treatment from 9.00 am-3.00 pm at an ambient CO_2 concentration of approximately 340 μmol mol^{-1}, relative humidity 50-55% and when photon flux density was between 350 – 1200 μmol m^{-2} s^{-1}.