FACTORS AFFECTING THE ROOTING ABILITY OF *DRYOBALANOPS OBLONGIFOLIA* AND *SHOREA SPLENDIDA* (DIPTEROCARPACEAE) STEM CUTTINGS

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BRODIE, J. F. 2003. Factors affecting the rooting ability of *Dryobalanops oblongifolia* and *Shorea splendida* (Dipterocarpaceae) stem cuttings. Dipterocarp propagation research to date has mainly focused on vegetative (asexual) methods. Studies on several important timber species have shown that unique propagation conditions are needed for each species. Two species, *Dryobalanops oblongifolia* ("kapur paya") and *Shorea splendida* ("engkabang bintang"), were chosen for this study because they have potential economic and ecological importance, and their propagation conditions have not hitherto been analysed. Two important parameters for rooting success of dipterocarp stem cuttings are propagation medium and exogenous application of auxins. This study tested the effects of four propagation media, three indole butyric acid (IBA) treatments, and two Benlate treatments on rooting and mortality of *D. oblongifolia* and *S. splendida* leafy stem cuttings. Cuttings of *S. splendida* had a significantly higher rooting percentage than those of *D. oblongifolia* ($p < 0.001$), but also showed a higher overall mortality. This could be due to a higher metabolic rate in the former species. No significant differences were observed among the medium and auxin treatments, suggesting that other parameters (e.g. condition of stock plant individuals) could be more important for the rooting of these species. The Benlate significantly lowered the initial rate of mortality for *S. splendida*, with the 0.10% solution showing reduced mortality (at week 12) over the 0.05% solution and the control ($p < 0.05$). By week 16 however, the total mortality rates were the same. Periodically repeated applications of fungicide could reduce overall mortality rates of *S. splendida* cuttings.

Key words: Dipterocarp - *S. splendida* - *D. oblongifolia* - Indole butyric acid - propagation medium - fungicide - vegetative propagation

BRODIE, J. F. 2003. Faktor-faktor yang mempengaruhi keupayaan pengakaran keratan batang *Dryobalanops oblongifolia* dan *Shorea splendida* (Dipterocarpaceae). Penyelidikan pembiakan dipterokarpa setakat ini banyak tertumpu kepada kaedah pembiakan tampang (aseks). Kajian terhadap beberapa spesies balak yang penting menunjukkan bahawa keadaan pembiakan yang unik diperlukan bagi setiap spesies. Dua spesies, *Dryobalanops oblongifolia* (kapur paya) dan *Shorea splendida* (engkabang bintang), dipilih untuk kajian ini kerana kedua-duanya mempunyai nilai ekonomi dan nilai ekologi. Selain itu keadaan pembiakannya belum pernah dianalisis. Dua parameter penting untuk menjayakan pengakaran keratan batang dipterokarpa ialah

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media pembiakan dan penggunaan auksin. Kajian ini menguji pengaruh empat media pembiakan, tiga rawatan asid indola butirik (IBA) dan dua rawatan Benlate ke atas pengakaran dan kematian keratan batang berdaun *D. oblongifolia* dan *S. splendida*. Keratan *S. splendida* menunjukkan peratusan pengakaran yang lebih tinggi daripada *D. oblongifolia* ($p < 0.001$), tetapi juga menunjukkan kematian keseluruhan yang lebih tinggi. Ini mungkin disebabkan oleh kadar metabolik *S. splendida* yang lebih tinggi. Tiada perbezaan bererti dicerap dalam rawatan media dan auksin. Ini menunjukkan bahawa parameter lain (contohnya keadaan stok tanaman) mungkin lebih penting bagi pengakaran spesies ini. Benlate menurunkan dengan bererti kadar awal kematian bagi *S. splendida*, dengan larutan 0.10% menunjukkan kematian berkurangan (pada minggu ke-2) berbanding larutan 0.05% dan kawalan ($p < 0.05$). Bagaimanapun, pada minggu ke-16, jumlah kadar kematian adalah sama. Penggunaan racun kulat secara berkala dapat mengurangkan kadar kematian keseluruhan keratan *S. splendida*.

Introduction

Hardwood trees in the family Dipterocarpaceae are the primary constituents of many Southeast Asian rain forests, and are the most important export timbers of the region (Ashton 1982). Dipterocarps are notoriously difficult to propagate sexually because they reproduce only in infrequent mass-fruiting events (Ng 1976) and the seeds, once fallen, are highly recalcitrant (Sasaki 1980). Therefore, emphasis has been placed on vegetative means of propagation (Halle & Kamil 1981, Srivastava & Manggil 1981). Some research has been performed on important timber species such as *Dryobalanops lanceolata* (Moura-Costa & Lundoh 1994a, b), *Shorea bracteolata* (Aminah 1990), *S. leprosula* (Aminah *et al.* 1995, 1997, 1999), *S.* cf *obtusa* (Smits 1983), *S. macrophylla* (Lo 1985), and *Hopea odorata* (Aminah 1991a, b, Kantarli 1993). However, there are many other important species that have not been studied. This paper focuses on two of these, *Dryobalanops oblongifolia* ("kapur paya") and *Shorea splendida* ("engkabang bintang"). The former is an emergent tree from mixed dipterocarp forest of southern Sarawak (Ashton 1982), the latter a timber tree and alternative to *S. macrophylla* as a source of oil-bearing "illipe" nuts (Blicher-Mathiesen 1994).

Studies on dipterocarp vegetative propagation have identified many parameters that affect the rooting success of the stem cuttings. Node position of the cuttings (Lo 1985, Aminah 1990), leaf number (Aminah 1991a), irradiance and carbon flux (Aminah *et al.* 1997), fertiliser levels and irradiance of stock plants (Aminah *et al.* 1999), and humidity regime (Lo 1985, Sakai *et al.*, 1995), have all been identified as important factors for root formation in stem cuttings. The use of growth regulators such as auxins has also been widely studied for many tree families (Moura-Costa & Lundoh 1994a, b, Aminah *et al.* 1995, Tchoundjeu & Leakey 1996, Ofori *et al.* 1996, 1997, Uniyal *et al.* 1993, 1995, Mesen *et al.* 1997). Moura-Costa & Lundoh (1994b) demonstrated higher rooting rates for *D. lanceolata* cuttings with certain concentrations of indole-3 butyric acid (IBA) and 2,4-dichlorophenoxyacetic acid (2,4-D) than with α–naphthalene acid (NAA). However they noted that 2,4-D had phytotoxic qualities at higher concentrations. They obtained the highest rooting rates with the control group (no applied hormone). In contrast, IBA significantly increased rooting rate of *S. leprosula* cuttings over the control group, especially in the lowest concentration tested (Aminah *et al.* 1995). It appears that the effects of auxin application, and optimal concentration levels, vary between species.

Propagation medium has been studied in *Cordia alliodora* (Mesen *et al.* 1997) and in *Milicia excelsa* (Ofori *et al.* 1996) and results showed that different types of media significantly affect rooting rate. However, this parameter has not been studied for *D. oblongifolia* or *S. splendida.*

Fungicide application has also been used on the basal end of dipterocarp cuttings (Moura-Costa & Lundoh 1994a, b). However, whether this technique significantly affects rooting or mortality is not known.

This paper examines the effects of IBA treatments, medium types and fungicide (Benlate) treatments on the rooting of *D. oblongifolia* and *S. splendida* leafy stem cuttings. It is hoped that this study will help in the determination of optimal rooting conditions that can be used in vegetative propagation programmes for these species.

Materials and methods

Parent stock plants were two-year-old individuals grown from seeds collected on a timber concession in the Kapit area (south-western Sarawak, Malaysia). They were grown in plastic polybags with potting soil under shade-netting (c. 50% full sun) at the Malesiana Tropicals Sdn. Bhd. nursery in Bau, Sarawak. Cuttings were taken at the end of June. After each batch of 36 cuttings the razor was washed in diluted bleach. Cuttings were taken from axillary shoot tips, with a cutting angle of 45°. For *S. splendida,* the upper-most tips of the cuttings were the second or third node below the shoot apex; for *D. oblongifolia* they were the first or second set of mature leaves below the apex. Cuttings were two to three nodes, occasionally four if the internodes were very short. This was to reduce variance in stem volume, which has been shown to have a significant effect on rooting ability (Aminah *et al.* 1997, 1999). Cuttings were placed in water immediately after being removed from the stem. Cuttings had two to three leaves and the leaf area was trimmed to 1/4 the original area. Shoot apices and persistent stipules for *S. splendida* were removed.

IBA solutions were prepared by dissolving powdered hormone (Sigma Aldrich, Australia) in 75% ethanol to form concentrations of 500, 1000 and 1500 ppm. The control was 75% ethanol, 25% distilled water. Benlate (Benomyl 50% w/w) powder was dissolved in distilled water to form 0.05 and 0.10% (w/v) solutions. Cuttings were dipped in the appropriate solutions for 10 seconds. Cuttings for the fungicide treatment were first dipped in hormone, then by Benlate.

Media components were either standard horticultural products or else native materials available locally. Medium A consisted of perlite and vermiculite (1:1 by volume), medium B was coarse river sand and coconut-peat (1:1), medium C was granite "chipping" gravel/sand/coconut-peat (3:2:2), and medium D was gravel/sand/coconut-peat/perlite/vermiculite (3:2:2:2:2).

After preparation, the cuttings were placed in a closed-chamber mist propagation tent modelled according to Moura-Costa and Lundoh (1994a). The chamber was 9 m long, 1.15 m wide, and 1.1 m high at the apex. It was covered by clear plastic sheeting, had oscillating fans at either end, and had nine atomising mist nozzles along the length (KES Scientific "Red Nozzles"; Kennesaw, Georgia, U.S.A.). Mist was continuous, following the methodology of Lo (1985). The temperature range was 25 to 29 °C, and the relative humidity was 92 to 100%. Cuttings were placed in 16 systematically arranged blocks (four per medium treatment) near one end of the chamber. Each block was divided into 12 cells (one for each IBA/Benlate combination treatment). Each cell received two *S. splendida* cuttings and two (three for all cells in the four middle blocks) *D. oblongifolia* cuttings for a total of 288 and 336 respectively. Cuttings were examined every two weeks, and rooting and mortality recorded. Cuttings were considered to be rooted if they had at least one root > 0.5 cm long, or dead if both leaves had been shed and the entire stem turned brown. At week 20 all cuttings were removed from the blocks and cuttings which had roots > 1 cm were counted. Differences among treatments and species were analysed using ANOVA. Data on number of roots per cutting were square root-transformed prior to analysis.

Results

Cuttings of *S. splendida* rooted more quickly than those of *D. oblongifolia* (Figure 1). Rooting at week four was minimal for both species, but by week six, it was significantly higher in *S. splendida* than in *D. oblongifolia* ($df = 1, p < 0.001$). Overall rooting percentage, for all treatments combined, was higher in *S. splendida* than in *D. oblongifolia* ($df = 1, p < 0.05$).

Application of Benlate to the cuttings did not affect rooting percentage for either species, but did affect mortality rate for *S. splendida*. Mortality was negligible for the *D. oblongifolia* cuttings (0.02% overall, Figure 2). Overall mortality (at week 16) of *S. splendida* was very similar among the fungicide treatments (Figure 3); however, the rate of mortality was significantly affected by fungicide treatment ($df = 2, p < 0.05$). At week 12, the 0.10% Benlate treatment had a lower level of mortality than the 0.05% treatment, which in turn was lower than the control.

Individual treatments of propagation medium and auxin application did not significantly affect rooting or mortality rates for either species. The combined effects of medium/auxin treatments showed that 500 ppm IBA in medium A (perlite/vermiculite) resulted in the highest overall rooting percentage (57.1%) for *D. oblongifolia* (Table 1). Results were more mixed for *S. splendida*; the highest overall rooting percentage (66.7%) was observed in the IBA control group with medium B (sand/coconut-peat) and also in the 1500 ppm IBA in medium C (sand/coconut-peat/gravel).

Combined effects of Benlate and medium treatments (Table 2) gave the highest rooting percentage (60.7%) for *D. oblongifolia* at 0.10% fungicide in medium A (perlite/vermiculite). The highest per cent for *S. splendida* (66.7%) was recorded with 0.10% Benlate in medium B (sand/coconut-peat).

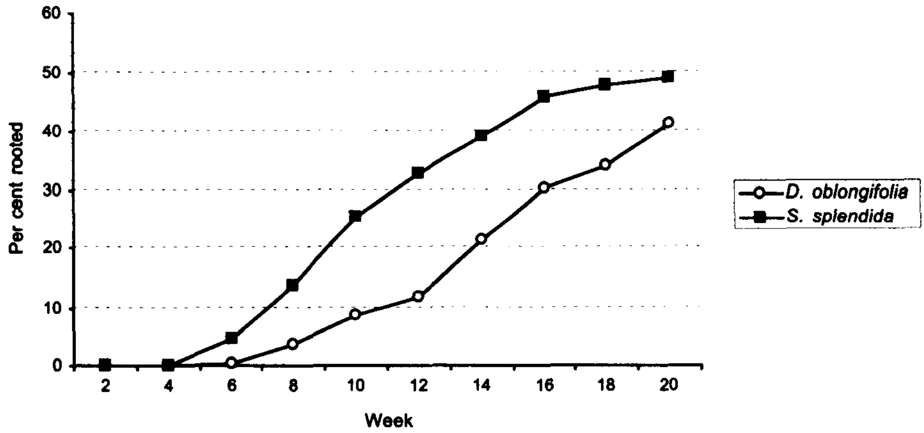

Figure 1 Overall rooting percentages for *Dryobalanops oblongifolia* and *Shorea splendida*

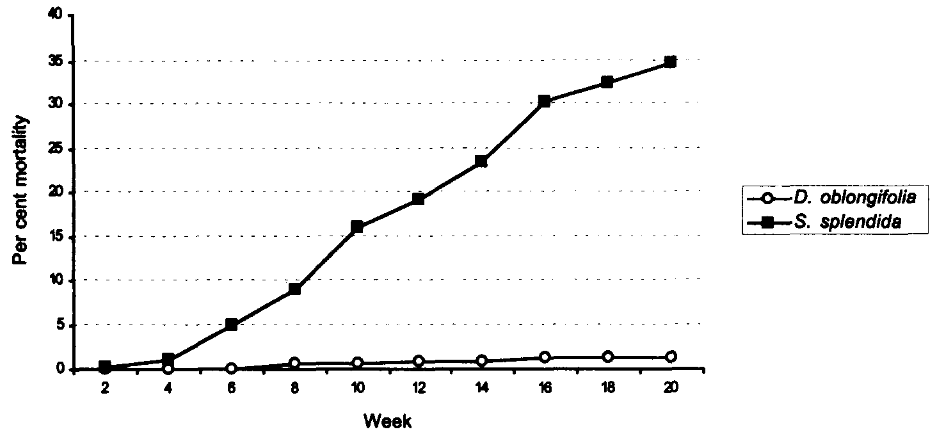

Figure 2 Overall mortality percentages for *Dryobalanops oblongifolia* and *Shorea splendida*

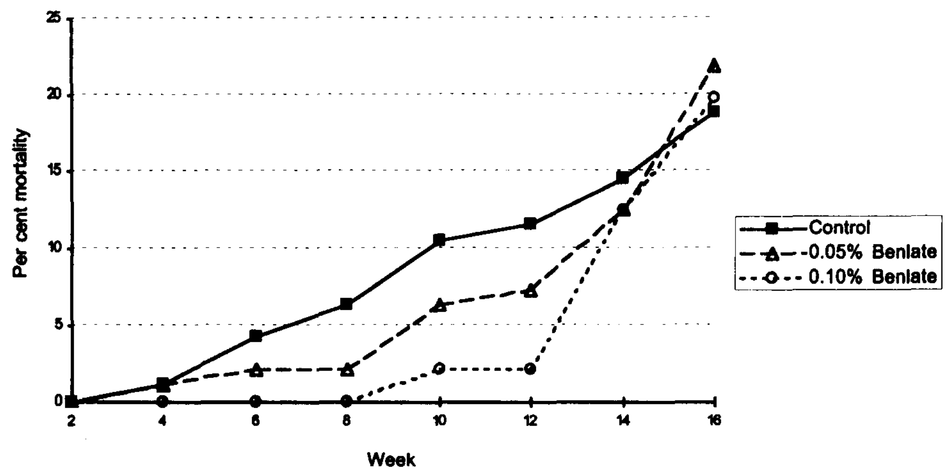

Figure 3 Effects of treatments on *Shorea splendida* mortality

Table 1 Interactions of medium and auxin application on total rooting percentage for *Dryobalanops oblongifolia* and *Shorea splendida*

(a) *D. oblongifolia* (n = 21)

IBA (ppm)	Medium A	B	C	D
Control	47.6	33.3	33.3	42.9
500	57.1	47.6	52.4	42.9
1000	38.1	28.6	33.3	33.3
1500	52.4	47.6	38.1	38.1

(b) *S. splendida* (n = 18)

IBA (ppm)	Medium A	B	C	D
Control	61.1	66.7	50.0	33.3
500	22.2	61.1	44.4	33.3
1000	44.4	50.0	44.4	44.4
1500	55.6	44.4	66.7	44.4

Medium A = perlite/vermiculite, B = sand/coconut-peat, C = sand/coconut-peat/granite-gravel, D = perlite/vermiculite /sand/gravel/coconut-peat

Table 2 Interactions of medium and fungicide application on total rooting percentage for *Dryobalanops oblongifolia* and *Shorea splendida*

(a) *D. oblongifolia* (n = 28)

Benlate (%)	Medium A	B	C	D
Control	39.3	39.3	25.0	25.0
0.05	42.9	46.4	39.9	53.6
0.10	60.7	32.1	53.6	42.9

(b) *S. splendida* (n = 24)

Benlate (%)	Medium A	B	C	D
Control	37.5	62.5	50.0	41.7
0.05	45.8	41.7	45.8	50.0
0.10	54.2	66.7	58.3	29.2

Medium A = perlite/vermiculite, B = sand/coconut-peat, C = sand/coconut-peat/granite-gravel, D = perlite/vermiculite /sand/gravel/coconut-peat

Discussion

It should be noted on the per cent rooting graph (Figure 1) that by week 20 the curve for *S. splendida* had levelled off whereas the *D. oblongifolia* curve remained steep. Mortality also occurred at a higher rate (and to a higher overall level) in *S. splendida* than in *D. oblongifolia*. The faster rooting and mortality rates of *S. splendida* could be indicative of a higher metabolic rate in that species. If this is the case, a vegetative propagation programme using *S. splendida* would require less time to produce cuttings than one using *D. oblongifolia*.

The Benlate treatments showed no effect on rooting, which suggests that fungal attack is not an important inhibitor of rooting for cuttings of these species. However, fungal attack appeared to be a cause of mortality among *S. splendida* cuttings, and fungicide application significantly lowered the incidence of attack on this species, though only initially, i.e. until the 12th week of this study. Possibly, intermittent applications throughout the rooting period, rather than a single application when the cuttings were taken, could maintain lower levels of mortality. If further research shows this to be the case, periodic fungicide application could be used to raise cutting yields in *S. splendida* propagation programmes.

The fact that the auxin and medium treatments did not yield significant results leads to the conclusion that other factors must be present to explain the differential rooting and mortality within each species and between the two. An important parameter that was not accounted for in this study is variation among individual stock plants in terms of light-compensation points and endogenous auxin and nutrient levels. If these factors do prove to be important components for rooting success of cuttings, it is recommended that dipterocarp timber plantations establish careful screening procedures for the selection of their parent stock inventory. Interesting research could also be conducted to determine whether inoculation with mycorrhizal fungi can improve root production of cuttings.

This study should help Malaysian foresters in the establishment of optimal rooting protocols for two species of native dipterocarp trees that have good potential for use in natural reserves or timber plantations.

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