Sandal and Its Products

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Nitrogen-fixing and Non-nitrogen-fixing Woody Host Influences on the Growth of the Root Hemi-parasite Santalum album L.

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Abstract

The growth responses of S. album grown with nitrogen-fixing and non-nitrogen-fixing woody hosts as single plant pairings in large nursery containers were compared over time at Kununurra, Western Australia. S. album growth was greater, and the root:shoot ratio lower, when it was attached to three nitrogen-fixing woody hosts (Sesbania formosa, Acacia trachycarpa, and A. ampliceps) compared with both unattached S. album seedlings and S. album grown with Eucalyptus camaldulensis. S. album shoot dry-weight increment per unit dry-weight of host shoot was greatest when attached to S. formosa. The growth of parasitised hosts was lower than that of unparasitised hosts. For Santalum, host quality is the single most important silvicultural component influencing early growth. Therefore, heartwood yield may be dependent on host species associated with Santalum.

Sandal hosts can be divided into three categories—pot-hosts, intermediate hosts, and long-term hosts—the function of the former (Alternanthera nana R.Br.) having been described elsewhere (Radomiljac, 1998; Radomiljac et al., 1998a,b; Radomiljac and McComb, these proceedings). The intermediate host acts as a 'bridging agent' between the pot-host and long-term host, and by stimulating early growth may be an important determining factor in the future heartwood production of S. album.

Early growth in softwood species has been shown to be positively correlated with the extent of heartwood production in Pinus radiata D.Don (Hillis and Ditchburne 1974; Hillis 1987; Wilkes 1991; Climent et al. 1993). In this paper we examine the effect of various leguminous and non-leguminous woody hosts on the growth of S. album seedlings.

Methods

The experiment was conducted at the Department of Conservation and Land Management's nursery at Kununurra (lat. 15° 46' S, long. 128° 44' E), Western Australia and examined the effect S. album growth of four intermediate host species (Sesbania formosa (F. Muell.) N. Burb. (Papilionaceae), Acacia trachycarpa E. Pritzel (Mimosaceae), Acacia ampliceps Maslin, Eucalyptus camaldulensis Dehnh. (Myrtaceae)) and a no-host control.

Six-month-old S. album seedlings propagated following Radomiljac (1998) were transferred to 25-litre pots, with a mix of sand:peat:perlite (3:2:2) and 10 g of slow-release fertilizer. At the time of transplanting, the S. album seedlings were 40.5 (± 2.99) cm high and 3.9 (± 0.58) mm in diameter. Seedlings of the intermediate hosts inoculated with appropriate Rhizobium strains were positioned in the 25-litre pots about 15 cm from the S. album seedlings. Four replicate pots of unparasitised intermediate hosts were also established. At the time of transplanting, A. nana pot-hosts were cut to soil level; four weeks later they were completely removed.
The experiment comprised eight complete randomised replicates with five pots per *S. album*: host association in each replicate. Plants were assessed and a sample of three pots from each treatment was harvested at five intervals: immediately before setting up the association, and 13, 24, 33 and 38 weeks afterwards.

At each harvest *S. album* height and diameter at 20 mm were measured, and (for the plants that were harvested) host and *S. album* shoot, root and leaf dry-weight and leaf area were assessed.

### Results

The growth of *S. album* (height and diameter) in 25-litre pots ceased after Week 33, except for those plants grown in combination with *A. trachycarpa* which continued to grow (Fig. 1(i)). (Data is not shown for diameter growth.)

Growth of *S. album* attached to leguminous hosts was markedly better than for those grown with *E. camaldulensis*. When *S. album* was attached to

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Figure 1. Growth of *Santalum album* when attached to: (△) *Sesbania formosa*, (○) *Acacia ampliceps*, (□) *A. trachycarpa*, and (◇) *Eucalyptus camaldulensis*; or grown as a no-host control (▽) cultured in 25-litre pots. (Means followed by the same letter are not significantly different (p>0.05) using Tukey’s pairwise t-test.)

(i) Height growth of *S. album* (data from 8 replicates)
(ii) Leaf dry-weight of *S. album* (3 replicates)
(iii) *S. album* root:shoot ratio (3 replicates)
(iv) Leaf area of the host plants parasitised by *S. album* (solid symbols); and Week 33 leaf area of unparasitised *S. formosa* (open symbol) (3 replicates)
E. camaldulensis, its growth was less than when grown without a host.

The dry-weight of leaves and leaf area of S. album began to decline after Week 33, except for plants attached to A. trachycarpa (Fig. 1(ii)). As with height and diameter growth, the leaf area and dry weight of S. album attached to E. camaldulensis was less than that of the unattached controls. (Data is not shown for S. album leaf area.)

When S. album was grown without a host, the root:shoot ratio increased exponentially during the 38-week study. The root:shoot ratio of S. album attached to the poorest host, E. camaldulensis, was higher than those attached to the leguminous hosts (Fig. 1(iii)). At the end of the study the root:shoot ratio declined for those seedlings attached to A. trachycarpa and A. ampliceps.

After Week 33, leaf dry-weight and leaf area of parasitised Sesbania formosa and E. camaldulensis declined, while that of A. ampliceps continued to increase and that of A. trachycarpa remained constant (Fig. 1(iv)). The leaf dry-weight and leaf area of unparasitised S. formosa was far greater than that of the parasitised S. formosa. (Data are not shown for host leaf dry-weight.)

Discussion

This study showed that leguminous species promoted higher S. album biomass growth than the non-nitrogen-fixing E. camaldulensis. This is consistent with work by Rai (1990) and Taide et al. (1994) who reported Casuarina equisetifolia L. (Casurinaceae) to be a good S. album host, although in these experiments several non-nitrogen-fixing species were better hosts than the leguminous Albizia lebbeck (L.) Benth., A. auriculiformis Cunn. Ex Benth., Leucaena leucocephala (Lam.) De Wit (all Mimosaceae) and Cassia fistula L. (Caesalpinaceae).

S. album grew most when attached to Sesbania formosa as an intermediate host; but after 33–38 weeks S. album growth on this host declined in comparison with those seedlings attached to A. trachycarpa. It is possible that A. trachycarpa is a more durable host than S. formosa, which may be too short-lived.

The observation that S. album growth is poorer when attached to E. camaldulensis than when grown without a host suggests either that within the pot environment E. camaldulensis roots are better competitors for mineral nutrients than the S. album roots or that E. camaldulensis has allelopathic properties.

There are other reports of root hemi-parasites performing particularly poorly on non-leguminous hosts, such as Olax phyllanthi (Labill) R. Br. attached to Amaranthus caudatus L. and Portulaca oleracea L. (Tennakoon and Pate 1996).

The changes in root:shoot ratio confirm the observation that unattached S. album directs dry-matter to the root system at the expense of its shoot (Radomiljac, McComb and Shea 1998a). After attachment, dry-weight partitioning then shifts from root to shoot, as a result of which the root:shoot ratio falls.

This study shows that S. album is a debilitating parasite. For S. formosa there was a 96 per cent decrease in leaf area as a result of parasitism. Other root hemi-parasites have also been shown to have deleterious affects on their hosts (Graves et al. 1990; Graves 1995; Tennakoon and Pate 1996).

Conclusion

A nitrogen-fixing intermediate host increased early S. album growth. S. formosa was the best host of the species tested over a 38-week period, but A. trachycarpa may be a more sustainable host. E. camaldulensis was a poor host, resulting in lower S. album growth than that of unattached S. album. The longer-term performance of S. album on these intermediate hosts is being tested under field conditions.

References


Radomiljac, A.M. 1998. The influence of pot host species, seedling age and supplementary nursery nutrition on Santalum album Linn. (Indian sandalwood) plantation establishment within the Ord River Irrigation Area, Western


