Effect of different *Acacia acuminata* variants as hosts on performance of sandalwood (*Santalum spicatum*) in the northern and eastern Wheatbelt, Western Australia

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Summary

The effect of seven 'jam variants' (*Acacia acuminata* typical variant, *A. acuminata* narrow-phyllode variant, *A. acuminata* small-seed variant, *A. acuminata*/*burkittii* variant 1, *A. acuminata*/*burkittii* variant 2, *A. burkittii* and *A. oldfieldii*) on the survival and growth of sandalwood (*Santalum spicatum*) was examined in two relatively low-rainfall locations, Dowerin and Morawa, in the northern and eastern Wheatbelt of Western Australia. During the course of the trial (2000–2008) the mean annual rainfall was only 326 mm at Dowerin and 259 mm at Morawa. In July 2000, seedlings from 84 families from 18 separate populations and representing each of the seven different jam variants were planted on cleared farmland at both locations. A total of 4032 host seedlings were planted at each site. At host age 2 y (April 2002), *S. spicatum* seeds were sown near 1807 host plants at the first site and near 1397 hosts at the second.

The different jam variants were associated with clear differences in sandalwood performance at both sites. At age 1 y, mean survival of sandalwood was significantly greater near *A. acuminata* small-seed variant (64%) and *A. acuminata* narrow-phyllode variant (50–54%) than near *A. acuminata* typical variant (21–34%). This pattern of sandalwood survival between the different jam variants was similar at age 6 y.

At age 6 y, the mean stem diameter (at 150 mm above ground) of sandalwood was the greatest near *A. acuminata* small-seed variant within each site: 62 mm at Dowerin and 47 mm at Morawa. The mean stem diameter of sandalwood near *A. acuminata* typical variant was 51 mm at Dowerin and only 25 mm at Morawa.

Stem borers were more common in *A. acuminata* typical variant than in the other jam variants at Dowerin. No borers were observed in the jam variants at Morawa. At both sites, gall rust was observed in each of the jam variants except *A. oldfieldii*.

Keywords: plantations; parasites; host plants; host parasite relationships; arid climate; families; provenance; jam variant; sandalwood; *Santalum spicatum*; *Acacia acuminata*; *Acacia burkittii*; *Acacia oldfieldii*

Introduction

Western Australian sandalwood (*Santalum spicatum* (R.Br.) A.DC.) is a root hemi-parasite (Hewson and George 1984) that occurs naturally with a range of vegetation types, including many *Acacia* species (Loneragan 1990). Sandalwood produces valuable aromatic oils within its heartwood and, due to its commercial value, silvicultural trials have been established over the past 30 y to determine suitable methods to grow plantations (Loneragan 1990; Brand *et al*. 2000; Fox 2002; Woodall and Robinson 2002). One of the preferred host species identified from these trials is called 'jam' (*Acacia acuminata* Benth.), which has consistently supported relatively fast sandalwood growth on a range of soil types (Brand 2002; Brand *et al*. 2004). *Acacia acuminata* is a suitable host because it is able to supply nutrients to sandalwood, including N, K, Ca and Cu (Struthers *et al.* 1986). *Acacia acuminata* is also relatively long-lived and should support the sandalwood through to harvesting at age about 20–25 y.

Although *A. acuminata* has been extensively used as a host, this species is variable in at least form and habit, and this variation may have the potential to affect sandalwood performance in plantations. To aid sandalwood research, Maslin *et al*. (1999) during 1998–1999 reviewed the taxonomy of the 'jam group', consisting of *A. acuminata* and two of its close relatives in Western Australia (WA), *A. burkittii* Benth. and *A. oldfieldii* F.Muell. They divided the jam group into seven taxa: *A. acuminata* typical variant, *A. acuminata* narrow-phyllode variant, *A. acuminata* small-seed variant, *A. acuminata*/*burkittii* variant 1, *A. acuminata*/*burkittii* variant 2, *A. burkittii* and *A. oldfieldii*. The different taxa or 'jam variants' were separated on differences in morphological characteristics including phyllode width, spike length, and pod and seed morphology, as well as patterns of genetic variation. The identification of the different jam variants and their distribution within WA (Fig. 1) provided the opportunity to collect seed from the seven different variants and grow seedlings that could be used to examine their effect on sandalwood performance.

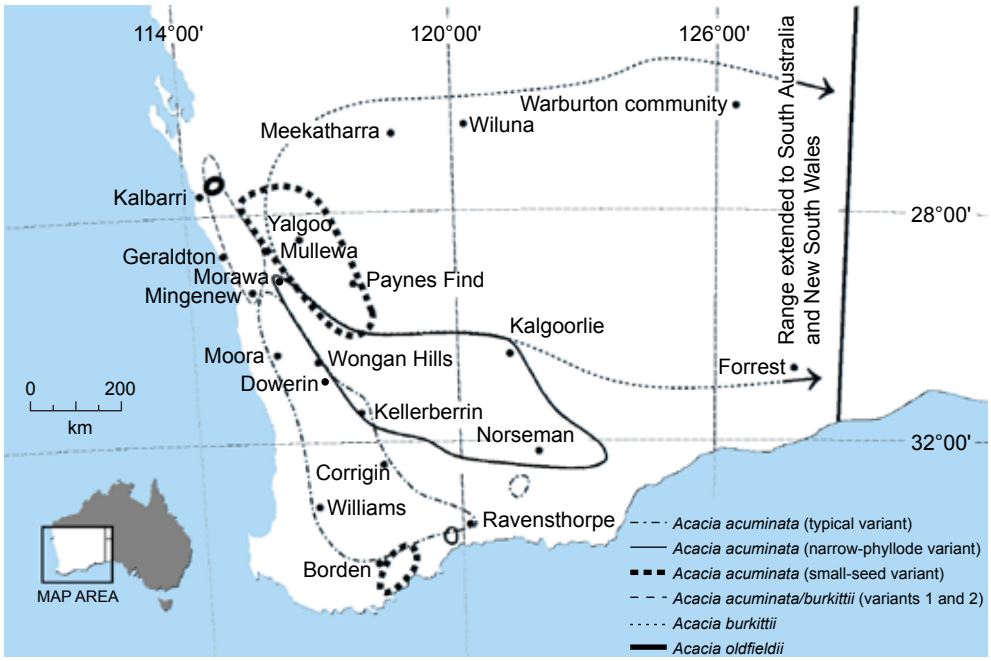

Figure 1. Distribution of the seven different jam variants in Western Australia (From Maslin *et. al*. 1999)

Of the seven defined jam variants (Maslin *et al*. 1999), *A. acuminata* typical variant, which occurs naturally mainly in the region of medium mean annual rainfall (400–700 mm) of the western 'Wheatbelt' (Fig. 1)[1], has been extensively planted throughout the Wheatbelt as a sandalwood host in plantations over the past 10–15 y (*pers. obs.*). However, other jam variants may be better suited as a sandalwood host, especially in regions of relatively low mean annual rainfall (300–400 mm) of the northern and eastern Wheatbelt. Observations of sandalwood plantations throughout the Wheatbelt indicate that some jam variants appear to be more stressed than others and are more prone to insect attack and diseases including stem borers and gall rust (*Uromycladium* genus). Stem borers include cossid moth larvae that feed on the cambium of *A. acuminata* stems and can ringbark the trees (The Avon Sandalwooder 2005). Gall rust is present in many forms of *A. acuminata* (Maslin *et al*. 1999), and *Uromycladium tepperianum* has been shown to reduce population densities of *A. saligna* in South Africa (Morris 1997). It may be possible to select jam variants that are more resistant to pests and diseases, and to use these jam variants as hosts to grow sandalwood plantations in the Wheatbelt and other areas of WA.

This study aimed to plant representatives of the seven different jam variants together on two separate sites as sandalwood hosts in the northern and eastern Wheatbelt of WA. The specific aims of this study were to compare:

- the effect of the different jam variants on *S. spicatum* survival and growth
- the level of disease (stem borers and gall rust) within the different jam variants.

[1] See also http://www.Wheatbelt.wa.gov.au/files/Wheatbelt_maps/map_Wheatbelt.pdf

Methods

Jam variant description and distribution

Maslin *et al*. (1999) provided a detailed description and distribution of each of the seven different jam variants; for the purposes of this study a summary of their review is given below:

1. *A. acuminata* (typical variant): occurs in the western part of the Wheatbelt from near Three Springs to Borden and Ravensthorpe (Fig. 1). Tall tree or shrub 3–10 m tall; phyllodes flat and 3–10 mm wide; seeds 3–4.5 mm long.
2. *A. acuminata* (narrow-phyllode variant): common in the northern, central and eastern Wheatbelt and into the arid zone from near Morawa to Kalgoorlie and Norseman. Rounded shrubs or small trees 2–7 m tall; phyllodes flat and 2–4 mm wide; seeds 3–4 mm long.
3. *A. acuminata* (small-seed variant): occurs near Yalgoo and Mullewa and also south of Borden. Rounded shrubs or small trees 2–5 m tall; phyllodes flat and 3–6 mm wide; seeds 2–3 mm long.
4. *A. acuminata*/*burkittii* (variant 1): small distribution near Mullewa. Tree form and height are variable; phyllodes flat and 2–3 mm wide; seeds 2.5–3.5 mm long.
5. *A. acuminata*/*burkittii* (variant 2): small distributions near Eradu and Northampton. Tree form and height are variable; phyllodes flat and 3–8 mm wide; seeds 4–5 mm long.
6. *A. burkittii*: widespread in the arid zone from Yalgoo to South Australia. Multi-stemmed shrubs or small trees, 1.5–8 m tall; phyllodes terete and 0.7–2 mm wide; seeds 3.5–6 mm long.
7. *A. oldfieldii*: small distribution along the Murchison River near Ajana. Rounded spreading shrubs or small trees 2–4 m tall; phyllodes flat and 3–5 mm wide; seeds 1.5–2 mm long.

Jam variant seed collection

During 1998–1999, Maslin *et al*. (1999) collected seeds from individual parent trees (families) growing in various populations to represent each of the seven jam variants. From this collection seeds were obtained from 10–15 families and 2–4 provenances of each variant for use in this study (Table 1). In total 84 families growing in 18 separate populations or provenances were used.

Site description

To examine the effects of jam variants on sandalwood performance, sites were selected near Dowerin (31°06′S, 117°02′E) and Morawa (29°05′S, 115°50′E). The Dowerin site is about 10 km north of Dowerin and 40 km south-east of Wongan Hills (Fig. 1); the Morawa site is about 12 km west of Morawa and 45 km east of Mingenew. Both sites are near the border where the geographic ranges of *A. acuminata* (typical variant) and *A. acuminata* (narrow-phyllode variant) meet, in the northern and eastern Wheatbelt. Each site was about 5 ha in area and was farmland previously used for cropping and grazing. The soil at Dowerin consists mainly of grey sand over clay loam at 0.1–0.5 m, while at Morawa it is mainly a red sandy loam over red clay at 0.1–0.3 m.

During the trial (2000–2008) the annual rainfalls were generally low, averaging 326 mm at Dowerin (range 277–391 mm) and only 259 mm (range 199–308 mm) at Morawa (Fig. 2). These falls were well below the long-term annual means of 364 mm at Dowerin (1904–2007) and 334 mm at Morawa (1911–2007). Besides having a relatively low mean annual rainfall, these locations also have relatively high mean annual evaporation rates of about 2300 mm at Dowerin and 2500 mm at Morawa.

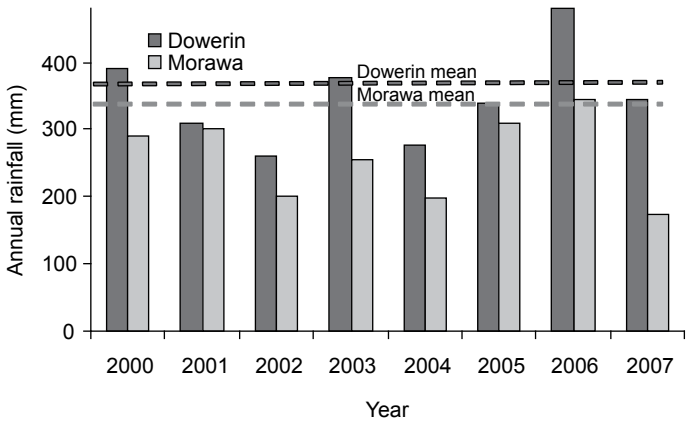

Figure 2. Annual rainfall during 2000–2007 near Dowerin (townsite) and Morawa (2000–2004 townsite; 2005–2007 airport). Long-term mean annual rainfalls for Dowerin (364 mm, 1904–2007) and Morawa (334 mm, 1911–2007) are also shown.

Host establishment

Before planting, both sites were ripped to a depth of 0.5 m in lines spaced 4 m apart, and sprayed with knock-down and residual herbicides to control weeds for the first 2–4 months after establishment. In July 2000, jam seedlings (age six months) were planted along the rip-lines at 3-m intervals (833 stems ha^{-1}). The seedlings from each of the 84 families were grown separately in 'Colmax' trays at the Department of Conservation and Land Management nursery in Narrogin, WA.

Table 1. Provenance, latitude, longitude and number of families from which seeds were collected from the seven jam variants

Jam variant	Provenance	Latitude	Longitude	Number of families
1. *A. acuminata* (typical)	Bolgart	31°13′S	116°29′E	4
	York	32°00′S	116°48′E	2
	Borden	34°05′S	118°13′E	4
	Brookton	32°24′S	116°53′E	5
2. *A. acuminata* (narrow)	Mukinbudin	30°44′S	118°21′E	5
	Latham	29°43′S	116°25′E	5
	Kalannie	30°26′S	117°23′E	5
3. *A. acuminata* (small seed)	Binnu	28°02′S	114°59′E	5
	Yalgoo	28°23′S	116o20′E	5
4. *A. acuminata/burkittii* (var. 1)	Murchison	27°49′S	114°42′E	5
	Mullewa	28°35′S	115°35′E	5
	Nerren Nerren	27°12′S	114°37′E	4
5. *A. acuminata/burkittii* (var. 2)	Northampton	28°18′S	114o37′E	5
	Greenough	28°43′S	115°02′E	5
6. *A. burkittii*	Wiluna	26°40′S	120°02′E	5
	Ninghan	29°24′S	117°14′E	5
7. *A. oldfieldii*	Murchison River	27°43′S	114°40′E	5
	Hawkes Head	27°47′S	114°28′E	5

At both sites, each jam family was planted separately in single-line plots of eight seedlings over a length of 24 m. Each of the 84 family plots was randomised within a block, and each site contained six blocks or replications. Although the jam seedlings were planted in separate family plots, they were also grouped into their seven respective jam variants (Table 1) for analysis. At each site, 480–720 seedlings from each of the seven different jam variants were planted, with a total of 4032 seedlings planted.

Sandalwood establishment

At host age 2 y (April 2002), four *S. spicatum* seeds (obtained from a sandalwood plantation near Narrogin, WA) were sown per 'spot' near every second surviving host plant, to obtain an approximate sandalwood-to-host ratio of 1 : 2. At each spot, the sandalwood seeds were buried 2–3 cm below the surface and 0.5 m from the base of each host stem. The seeds had no pre-treatment. Sowing spots were sprayed with glyphosate in early July 2002 to control weeds before the *S. spicatum* seedlings emerged in August–October 2002. A total of 1807 sowing spots were established at Dowerin and 1397 at Morawa.

Germination, survival and growth

Sandalwood germination was assessed at age three months (November 2002), and recorded as germinated if at least one seed germinated per sowing spot. At sowing spots where sandalwood seeds did not germinate or the seedlings died within a year, they were replaced with seeds in April 2003 to maintain the approximate sandalwood-to-host ratio of 1 : 2, but these new plantings were not included in the analysis. At sandalwood age 1 y, the sowing spots were thinned to leave only one sandalwood seedling at each spot.

Of the sandalwood seeds that germinated during August–October 2002, survival was recorded at age 1 y (November 2003) and 6 y (August–September 2008) at both sites. At age 6 y, sandalwood stem diameter at 150 mm above the ground and height from the ground to the tallest green leaf was measured for 768 trees at Dowerin and 385 trees at Morawa.

Host survival and height were assessed at age 8 y (August–September 2008). Height was measured for 388–664 trees at each site.

Diseases

Stem borer holes and gall rust (*Uromycladium* genus) were recorded as either present or absent from each jam tree at age 5 y (November 2005).

Statistical analysis

Plot means for germination, survival, growth and the presence of disease, from six replications, were compared between treatments (seven jam variants and two sites) using two-way analysis of variance (ANOVA). Proportions were angular transformed before analysis and Tukey's test was used to compare means. SYSTAT® version 10.2 was used for all statistical analysis.

Results

Hosts

Survival

At age 8 y, mean host survival differed significantly ($P < 0.001$) between different jam variants at both Dowerin and Morawa. At Dowerin, the mean survival of *A. oldfieldii* (51.1 ± 4.0%, Fig. 3a) was significantly lower than that of the other jam variants (80.2–85.3%). At Morawa, the mean survival of *A. burkittii* (70.0 ± 4.5%, Fig. 3b), *A. acuminata*/*burkittii* variant 2 (68.1 ± 3.1%) and *A. acuminata* narrow-phyllode variant (67.5 ± 4.8%) were significantly greater than that of *A. oldfieldii* (29.8 ± 3.6%) and *A. acuminata* typical variant (48.2 ± 4.5%).

Overall, the mean host survival at Dowerin (77.8 ± 2.0%) was significantly ($P < 0.001$) greater than at Morawa (57.8 ± 2.5%) at age 8 y.

Height

Mean host height at age 8 y also differed significantly ($P < 0.001$) between jam variants at both Dowerin and Morawa. At Dowerin, the mean height of *A. acuminata* typical variant (3.6 ± 0.1 m, Fig. 3c) was significantly greater than that of the other jam variants (1.9–2.5 m). At Morawa, the mean height of *A. acuminata* typical variant (2.7 ± 0.1 m, Fig. 3d) was again significantly greater than that of all of the other jam variants except for the narrow-phyllode form (2.5 ± 0.1 m).

Overall, the mean host height at Dowerin (2.4 ± 0.05 m) was significantly ($P < 0.001$) greater than at Morawa (2.2 ± 0.05 m).

Diseases

Stem borers

At Dowerin, the mean incidence of *A. acuminata* typical variant trees with stem borers (8.1 ± 1.9%) was significantly ($P < 0.001$) greater than in the other jam variants (0 – 0.4%) at age 5 y.

The mean fraction of host trees with stem borers at Dowerin was only 1.2 ± 0.5%, but was significantly greater than at Morawa ($P < 0.001$) where no borers were observed.

Gall rust

Gall rust was present at a low incidence (1.1–3.0%) in all of the jam variants growing at Dowerin except for *A. oldfieldii*, which had no visible signs. At Morawa, the mean incidence of gall rust differed between jam variants ($P < 0.001$), with significantly more present in *A. burkittii* (25.1 ± 4.7%) than in *A. acuminata* small-seed variant (9.7 ± 2.0%). The other variants had means of 11.2–23.0%, except for A. *oldfieldii* which had no visible galls.

The mean fraction of host trees with gall rust at Morawa (14.3 ± 1.7%) was significantly ($P < 0.001$) greater than at Dowerin (1.6 ± 0.3%).

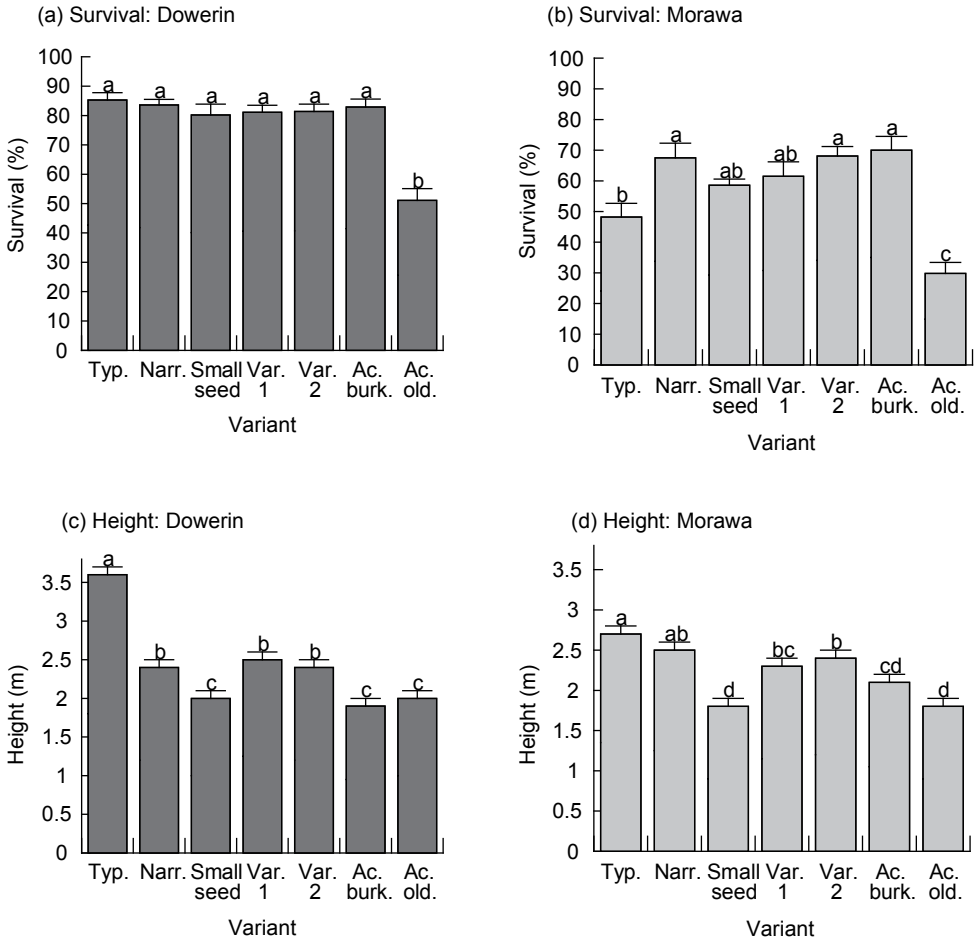

Figure 3a–d. Mean survival (% ± standard error) and tree height (± standard error) of the seven jam variants (age 8 y) planted at Dowerin and Morawa. Values with the same letter are not significantly different, using Tukey's test ($P > 0.05$).

Sandalwood

Germination

Mean sandalwood germination per spot near the different jam variants was 92–96% at Dowerin and 94–99% at Morawa. There was no significant ($P = 0.150$) difference in sandalwood germination between sites.

Survival

Dowerin

At age 1 y, the mean survival of sandalwood seedlings at Dowerin differed between jam variants ($P < 0.001$), with survival near *A. acuminata* small-seed variant (64.4 ± 2.9%) and narrow-phyllode variant (53.9 ± 2.1%) significantly greater than near *A. acuminata* typical variant (34.5 ± 2.4%) and *A. oldfieldii* (32.2 ± 6.4%). Mean survival near the other *A. acuminata* variants was 35.7–47.4%.

At age 6 y, the pattern of sandalwood survival near the different *A. acuminata* variants (Fig. 4a) was the same as at age 1 y. The mean survival of sandalwood trees was significantly greater near *A. acuminata* small-seed variant (63.1 ± 3.2%) and narrow-phyllode variant (53.3 ± 2.3%) than near *A. acuminata* typical variant (33.7 ± 2.4%) and *A. oldfieldii* (30.9 ± 6.4%).

Morawa

At Morawa, the mean survival of 1-y-old sandalwood seedlings differed between jam variants ($P < 0.001$), with survival near *A. acuminata* small-seed variant (64.0 ± 6.7%), narrow-phyllode variant (50.5 ± 4.4%) and *A. oldfieldii* (50.2 ± 5.5%) being significantly greater than near *A. acuminata* typical variant (20.6 ± 2.2%) and *A. acuminata*/*burkittii* variant 2 (29.7 ± 2.4%).

The 6-y-old sandalwood displayed a similar pattern of survival (Fig. 4b), except that sandalwood survival next to each of the variants dropped by 6.9–12.0%. The mean survival of sandalwood trees near *A. acuminata* small-seed variant (55.7 ± 7.3%), *A. oldfieldii* (40.9 ± 6.3%) and narrow-phyllode variant (34.5 ± 4.4%) was significantly greater than near *A. acuminata* typical variant (10.6 ± 1.9%).

Between sites

Sandalwood mortality was highest in the first year after germination, with a mean overall survival of 43.6 ± 2.3% at Dowerin and 40.6 ± 2.6% at Morawa, with no difference between sites ($P = 0.38$). By age 6 y, however, mean sandalwood survival at Dowerin (42.5 ± 2.2%) was significantly ($P < 0.001$) greater than at Morawa (29.9 ± 2.7%).

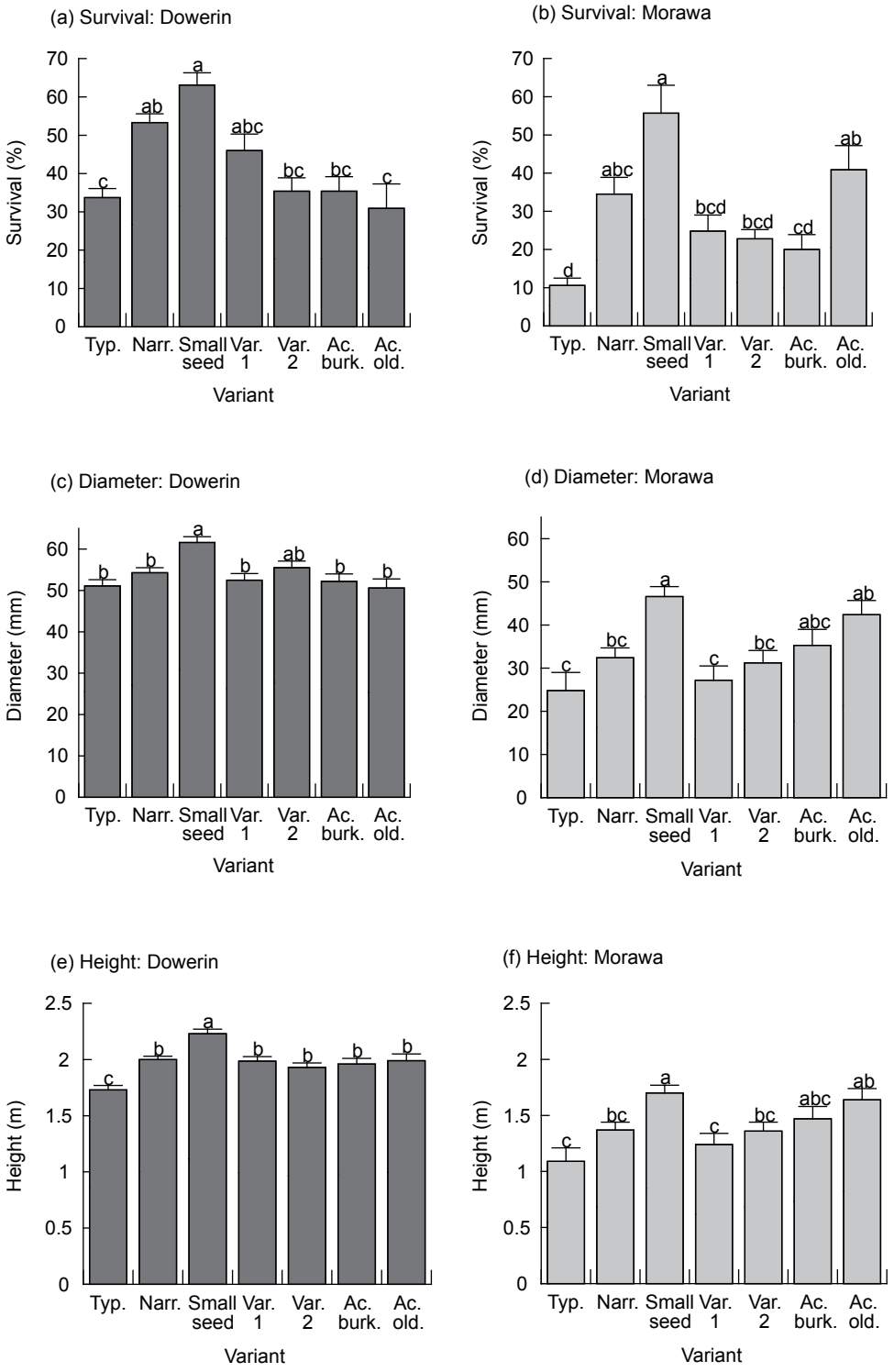

Figure 4a–f. Mean survival (± standard error), stem diameter at 150 mm (± standard error), and tree height (± standard error) of *Santalum spicatum* (age 6 y) growing near the seven different jam variants, at Dowerin and Morawa. Values with the same letter are not significantly different, using Tukey's test ($P > 0.05$).

Stem diameter

Mean stem diameter of 6-y-old sandalwood differed significantly ($P < 0.001$) between jam variants at both Dowerin and Morawa. At Dowerin, the diameter of sandalwood (Fig. 4c) was significantly greater near *A. acuminata* small-seed variant (61.6 ± 1.4 mm) than near the other variants (50.6–54.3 mm), except for *A. acuminata*/*burkittii* variant 2 (55.5 ± 1.6 mm).

Mean stem diameter of 6-y-old sandalwood at Morawa (Fig. 4d) was significantly greater near *A. acuminata* small-seed variant (46.6 ± 2.3 mm) and *A. oldfieldii* (42.4 ± 3.3 mm) than near *A. acuminata* typical variant (24.8 ± 4.2 mm) and *A. acuminata*/*burkittii* variant 1 (27.2 ± 3.3 mm).

Overall, the mean sandalwood stem diameter was significantly ($P < 0.001$) greater at Dowerin (54.0 ± 0.7 mm) than at Morawa (34.3 ± 1.0 mm) at age 6 y.

Height

Mean height of 6-y-old sandalwood differed significantly ($P < 0.001$) between jam variants at both Dowerin and Morawa. At Dowerin, the mean height of sandalwood (Fig. 4e) was significantly greater near *A. acuminata* small-seed variant (2.23 ± 0.04 m) than near the other variants. The mean height of sandalwood near *A. acuminata* typical variant (1.73 ± 0.04 m) was significantly less than near the other variants.

At Morawa, the mean height of 6-y-old sandalwood (Fig. 4f) was significantly greater near *A. acuminata* small-seed variant (1.70 ± 0.07 m) and *A. oldfieldii* (1.64 ± 0.10 m) than near *A. acuminata* typical variant (1.09 ± 0.12 m) and near *A. acuminata*/*burkittii* variant 1 (1.24 ± 0.10 m).

Mean sandalwood height was significantly ($P < 0.001$) greater at Dowerin (1.97 ± 0.02 m) than at Morawa (1.41 ± 0.03 m) at age 6 y.

Discussion

Sandalwood survival was significantly greater near *A. acuminata* small-seed and narrow-phyllode variants than near the typical variant at both Dowerin and Morawa. The marked difference in sandalwood survival between the different host variants occurred early, at age 1 y, and this pattern was maintained at age 6 y. The initial difference in sandalwood survival between variants may have been related to the below-average rainfall at both sites during the establishment year, 2002. The total annual rainfall in this year was only 260 mm at Dowerin and 202 mm at Morawa, well below their respective long-term averages of 364 mm and 334 mm. More importantly, the rainfall was low at both sites in the first winter, a critical stage of sandalwood germination and initial growth. The total rainfall in the 2002 winter was only 129 mm at Dowerin and 90 mm at Morawa, again well below their respective long-term winter averages of 172 mm and 153 mm. During this dry year the *A. acuminata* typical variant, which is derived from a region with greater mean annual rainfall than the *A. acuminata* small-seed and narrow-phyllode variants (Maslin *et al*. 1999), may have been under more stress and less capable of supporting a parasite during this critical establishment phase.

At age 6 y, there were also significant differences in sandalwood growth near the different jam variants. At each site, sandalwood stem diameter and height were significantly greater near *A. acuminata* small-seed variant than near *A. acuminata* typical variant. Interestingly, the differences in mean sandalwood growth near these two different jam variants did not appear to be related to host growth during the trial. At host age 8 y, the mean height of *A. acuminata* typical variant was significantly greater than that of the small-seed variant.

Although sandalwood performed best near *A. acuminata* small-seed variant at both sites, the sandalwood trees were significantly larger at Dowerin and the relative differences between jam variants were more pronounced at Morawa. At Dowerin the mean stem diameter of sandalwood near the small-seed variant (62 mm) was only 22% greater than near the typical variant, whereas at Morawa the mean stem diameter of sandalwood near *A. acuminata* small-seed variant (47 mm) was 88% greater than near the typical variant. The observed differences in sandalwood growth rate between sites is not likely to be due to soil type because both sites contained sandy-loam over clay soils which are considered to be suitable for growing both jam hosts and sandalwood (Anon. 2007). The difference in sandalwood growth between sites is more likely to be related to differences in rainfall and evaporation. During the years 2000–2007, the mean annual rainfall at Dowerin was 326 mm while at Morawa it was only 259 mm. The annual evaporation is also about 200 mm greater at Morawa than at Dowerin. The lower rainfall and greater evaporation at Morawa most likely explains why the sandalwood trees were smaller and why there was also a greater difference in sandalwood growth between host treatments. *Acacia acuminata* typical variant appeared not to be a suitable host for sandalwood at Morawa, but was a relatively better host at Dowerin after the sandalwood were a year old. This again appears to be related to *A. acuminata* typical variant being less suited to the more arid conditions at Morawa than some of the other jam variants.

Besides survival and growth, there were also some differences in the incidence of diseases within the different jam variants. At host age 5 y, there were significantly more borers in *A. acuminata* typical variant (8%) than in the other jam variants at Dowerin. Although not present in large numbers, the borers did appear to target the *A. acuminata* typical variant more than the other jam variants, with some trees completely ringbarked. At a similar age, borers were not observed in any of the jam variants at Morawa. Gall rust was also present in each jam variant except *A. oldfieldii*, but did not appear to be greatly reducing phyllode production or health of the trees at age 5 y.

To more effectively compare sandalwood performance near *A. acuminata* typical variant with that near the other variants, a trial should also be established in the medium mean annual rainfall region (400–700 mm) of the western Wheatbelt, where *A. acuminata* typical variant occurs naturally (Maslin *et al*. 1999, Fig. 1). Unfortunately this current study did not include a site in the medium annual rainfall region, but in previous trials in the western Wheatbelt *A. acuminata* typical variant has proven to be a suitable sandalwood host. In sandalwood trials planted with *A. acuminata* typical variant near Dandaragan, Narrogin and Katanning, sandalwood survival was 77–86% and mean stem diameter (at 150 mm) was relatively high (26–37 mm) at age 3 y (Brand *et al*. 2000, 2003). The combined results of this current study and previous trials indicate that *A. acuminata* typical variant is more suited for sandalwood plantations in the medium mean annual rainfall region of the western Wheatbelt than in the low mean annual rainfall regions of the northern and eastern Wheatbelt. *Acacia acuminata* small-seed variant appears to be the best suited of the jam variants to support good sandalwood survival and growth in relatively low-rainfall regions of WA, and should be further investigated for its use in the sandalwood plantation industry.

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