check them in early morning. Fungal hyphae and fruiting bodies will often develop which makes for easier identification. Use your references to narrow down your search to problems that affect the specific species.

Is it a Pest? Close examination may reveal symptoms. Look for adults, larvae, and/or eggs. Look in the soil and damaged portions of the plant. Many pests are plant species specific so use your references to narrow them down. Use yellow and blue sticky traps around your propagation area to keep a check on insect activity. If in doubt seek further assistance and observe their techniques for future reference.

ELIMINATE THE CAUSE

Most common pests and diseases are not that difficult to identify and subsequently control. But as part of the long-term control and prevention of pests, diseases, and environmental problems the diagnostics process should also identify the CAUSE of the problem not just the problem itself.

Use an understanding of the optimal conditions, spread, and life cycle of pests and diseases to identify the real cause and change these to eliminate further infection. Where errors in staff practice are identified, train the staff properly and develop new practices. Look for poor mother stock, contaminated seed sources, poor hygiene practices.

Remember, if a pest or disease is common in your nursery it is likely to be your practices that are at fault. So root out the cause of the problem and fix it!

Results of a *Corymbia maculata* Provenance Trial Using Street Tree Selection Criteria©

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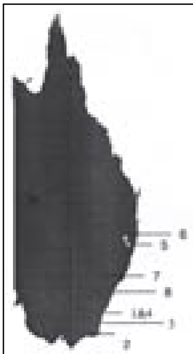
A quality urban tree is the product of a good genotype, suitable conditions for growth, and sensitive management. A study was undertaken to determine the appropriate mix of these for the widely planted *Corymbia maculata* (syn. *Eucalyptus maculata* Hook.). This paper presents some results of experimental research in which provenances of spotted gum were compared for differences in heritable traits relevant to urban planting situations.

Eight spotted gum types (six provenances of *C. maculata* and one each of the species *C. variegata* and *C. henryi*) were assessed in field- and container-grown provenance experiments undertaken in the grounds and nursery of Burnley College, The University of Melbourne. Differences in growth rate, stem structure, tree form and health of the provenances were recorded. Provenances of *C. maculata* from Bodalla, NSW, and the Mottle Range, Victoria, were identified as the superior provenances for urban tree development. These can be recommended to the tree-growing industry as the better provenances to grow for urban planting, and may also be recommended for potential breeding or clonal propagation research in the species.

INTRODUCTION

Urban tree improvement through the selection of superior provenances is an underutilised tool in Australian amenity horticulture. Our native trees have received relatively little attention in street tree improvement programs to date. With the growing trend of municipalities selecting alternatives to eucalypts for street plantings (Lawry and Gardner, 2001), the need for reliable data on the performance of our eucalypts, and the production of superior stock for urban landscape situations is now greater than ever. The performance of *Corymbia maculata* in urban sites was evaluated through the development of an urban tree survey, in which 1000 specimens were assessed for predetermined arboricultural traits. The survey showed that the species performs well under the constraints of the urban landscape, but revealed structural weaknesses (namely the tendency to develop a bifurcated or forked stem) that could be improved (Bone, 2002). An ecological study of 11 forests in the species' natural range identified population variation in key arboricultural selection criteria. With characters for potential tree improvement selected, and natural variation within the species identified, the strength of genetic control over the structural development and general performance of spotted gum provenances was then determined.



Number (experiment and seed lot)	Species	Origin	Latitude/ Longitude
1 19102	*C. maculata*	Bodalla SF	36° 11' 150° 06'
2 19382	*C. maculata*	Mottle Range	37° 37' 148° 13'
3 19421	*C. maculata*	Mumbula SF	36° 38' 149° 15'
4 19422	*C. maculata*	Bodalla SF	36° 11' 150° 06'
5 19468	*C. henryi*	Myrtle Creek	29° 09' 152° 59'
6 19469	*C. variegata*	Richmond Range SF	28° 50' 152° 44'
7 19663	*C. maculata*	Curryall SF	32° 04' 149° 50'
8 20324	*C. maculata*	Wingello	34° 44' 150° 11'

Figure 1. Map of Australia showing provenance locations (left), seed lot numbers and origins of spotted gum provenances (right). SF = State Forest

MATERIALS AND METHODS

Selection of Material. Eight spotted gum provenance seed lots were purchased from the Australian Tree Seed Centre — a division of CSIRO. Provenances of *C. maculata* and one each of two other spotted gum species previously known as *C. maculata* — *C. henryi* (syn. *E. henryi* Blake) (broad-leaved spotted gum) and *C. variegata* (syn. *E. variegata* Muell.) (spotted gum) were selected. Details of provenances grown can be found in Fig. 1.

TRIAL DESIGN AND ESTABLISHMENT

Germination was undertaken in August 2000 and seedlings were raised in a glasshouse for a period of 4 months before field planting. A total of 160 trees (20 replicates of each provenance) were planted at 1 × 1.3-m spacing in an 8 × 35-m plot of sandy loam soil in the grounds of Burnley College, The University of Melbourne. Trees were planted following a randomised block design consisting of four blocks of 40 trees. Each block contained five replicates of each provenance, occurring as a randomly planted row. The trees remained in the ground for a period of 8 months. After an establishment phase of 3 months, measurements commenced and continued until mid July 2001 when trees were harvested and the bulk of data was collected.

MEASUREMENTS

Trees were assessed on numerous traits of growth and early structural development — categorised as either growth rate, stem form, tree form, or health and stress response. The structural development of the trees was of particular interest, as was the potential for the development of tree forks following loss of apical control. These measures are highlighted in the results presented in this paper. Table 1 lists some of the categories and methods of measurement in the provenance trial.

RESULTS

Data Analysis. Data were analysed with the statistical software package Minitab (release 13.3). Three deaths recorded in Provenance 1 (Bodalla SF Site 1) were removed from the data set prior to analysis. All parametric data were analysed with Two-way Analysis of Variance (ANOVA)- General Linear Model (GLM) to establish differences of significance ($P < 0.05$). Fisher's method of the least significant difference (LSD) was used to identify pair-wise differences of significance for all variables that were significant in the ANOVA model. Nonparametric data were analysed using Friedman's sum of ranks test. Pair-wise significant differences were also identified using Fisher's method of LSD.

HEIGHT AND STEM DIAMETER

Analysis of Variance revealed significant differences between provenances for mean heights ($P < 0.05$: $P = 0.000$). The leading provenances, 1 (*C. maculata* - Bodalla SF Site 1), 4 (*C. maculata* - Bodalla SF Site 2), and 6 (*C. variegata* - Richmond Range) differed significantly from provenances 5 (*C. henryi* – Myrtle Creek), 7 (*C. maculata* - Curryall SF), and 3 (*C. maculata* - Mumbula SF). Figure 2 shows mean provenance heights. Significant differences were also found between provenances for stem diameter ($P < 0.05$: $P = 0.006$). Provenances 4 (*C. maculata* - Bodalla SF Site 2), 1 (*C. maculata* - Bodalla SF Site 1), and 8 (*C. maculata* - Wingello) were significantly different from Provenances 2 (*C. maculata* - Mottle Range), 7 (*C. maculata* - Curryall SF), and 3 (*C. maculata* - Mumbula SF). Figure 3 displays provenance means for stem diameter.

TREE CONDITION AND APICAL SHOOT DEATH

Significant differences were found between provenances for the tree condition ($P < 0.05$: $P = 0.018$). Figure 4 shows provenance means in rank order. Provenance Number 4 (*C. maculata* - Bodalla SF site 2) was significantly different from all other provenances except Provenance 8 (*C. maculata* - Wingello). The proportion of trees that exhibited damage to the apical growing point (tip death) was significantly different between provenances ($P < 0.05$: $P = 0.008$). Provenances 5 (*C. henryi* - Myrtle Creek) and 7 (*C. maculata* – Curryall SF) exhibited the highest proportion of trees with apical shoot damage, significantly different from all provenances except for Number 1 (C. maculata - Bodalla SF Site 1). Provenances 2 (*C. maculata* - Mottle Range), 4 (*C. maculata* - Bodalla SF Site 2), and 8 (*C. maculata* -Wingello) showed the least proportion of trees with loss of the apical shoot.

Table 1. Some traits measured in the spotted gum provenance trial.

Category	Trait	Method
Growth rate	Fresh weight of shoots and stem	Stems were lopped roughly 5 mm from the base, above the lignotuber if one was exhibited. Material was chopped and weighed on site (in kg).
	Fresh weight of root systems	The root ball was reduced to a 250 mm radius and lifted from a depth of roughly 200 mm. Soil was removed with a wire brush and high-pressure hose. The root ball was allowed to dry and then weighed (in kg).
	Stem diameter	Measured with callipers immediately above the lignotuber or 50 mm from the root crown if no lignotuber was observed (in mm).
	Height	Measured from base to the living apex with a measuring tape on three separate occasions (in mm).
	Root mass	Count of lateral and plunging roots and count of lateral roots based on orientation at harvest.
Tree form	Crown shape	Categorical assessment: 1(round), 2 (oval), 3 (conical), 4 (rounded to conical) in the final week.
	Branching pattern	Ranked on the scale: 1 (good radial balance), 2 (slight imbalance), 3 (severe imbalance) in the final week.
Stem form	Stem structure	Categorical assessment: 1 (single), 2 (bifurcated), 3 (multi-stemmed) at 2-month intervals.
	Number of tree forks in each stem	Count of the number of forks observed in the central leader, or a leading stem in the final week.
	Stem straightness (single stems only)	Ranked on the scale of 1 (very poor) to 6 (excellent) in the final week.
Health/vigour	Condition	Ranked on the scale 1 (dead/dying) to 5 (no apparent problems) at 2 week intervals.
	Tip death	Following cold temperatures experienced at the site, susceptibility of provenances to loss of the apical shoot was observed. "Yes or No" assessment in Week 20.

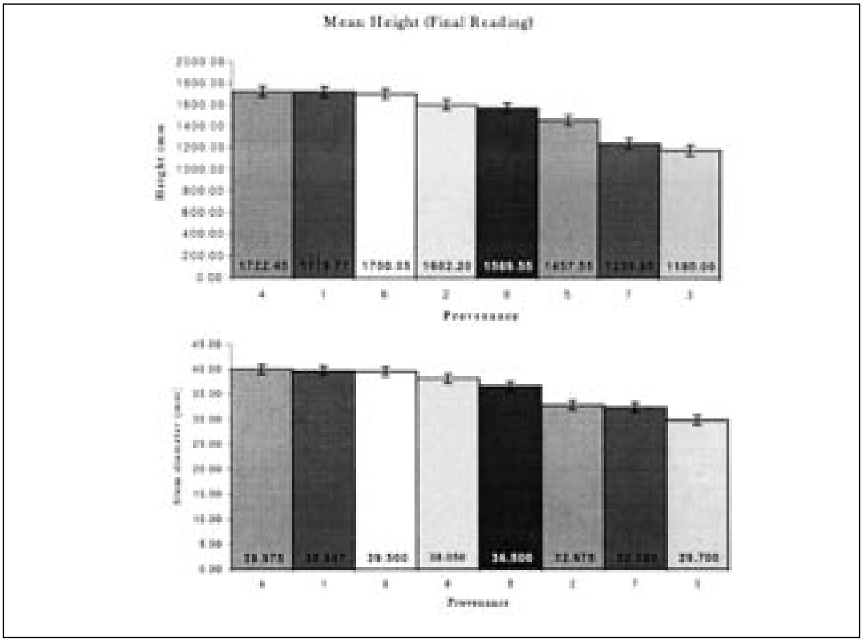


Figure 2. Provenance means for height presented in rank order. Error bars show the standard error of the mean (47.2).

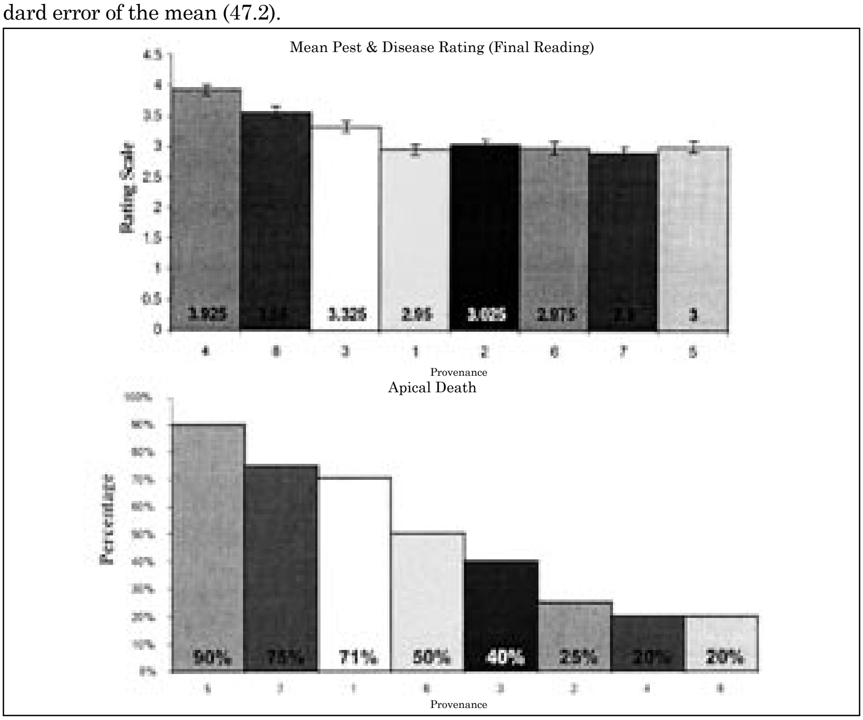


Figure 3. Provenance means for stem diameter presented in rank order. Error bars show the standard error of the mean (0.857).

STEM STRUCTURE AND TREE FORKING

Significant differences ($P < 0.05$, $P = 0.006$) were found between provenances in the proportion of trees with a single stem habit (Table 2). Provenance 6 (Richmond Range had a significantly greater proportion of single stemmed specimens than all provenances except for Number 2 (Mottle Range). Provenance Numbers 2 and 5 (Myrtle Creek) also showed a significantly greater proportion of trees with a single stem than Numbers 8 (Wingello), 3 (Mumbula), 1 (Bodalla Site 1), and 7 (Curryall) (these provenances exhibited a greater proportion of bifurcated or multi-stemmed specimens).

Significant differences ($P < 0.05$, $P = 0.038$) were found between provenances in the proportion of trees exhibiting forks in any region of the stem. Provenance 2 (*C. maculata* -Mottle Range) exhibited the lowest proportion of forked trees and was significantly different from all provenances except for 5 (*C. henryi* - Myrtle Creek). The provenance with the greatest proportion of forked trees was provenance Number 8 (*C. maculata* - Wingello) (significantly different from five other provenances), while Numbers 7 (*C. maculata* - Curryall SF) and 6 (*C. variegata* - Richmond Range SF) also exhibited a high proportion forked trees (significantly different from four other provenances).

Table 2. Provenance ranking, value of sum of ranks and significant differences for "proportion of trees with single stems". Provenance ranks which do not share letters are significantly different.

Provenance (in rank order)	6	2	5	4	8	3	1	7
Sum of ranks	29.5	28.0	23.0	19.0	15.5	11.0	10.5	7.5
Significant ?	a	ab	bc	cd	d	de	e	e

Table 3. Provenance ranking, value of sum of ranks and significant differences for "proportion of trees with forks in a leading stem". Provenance ranks which do not share letters are significantly different.

Provenance (in rank order)	8	7	6	3	1	4	5	2
Sum of ranks	28.5	25.0	20.5	19.5	17.0	16.5	10.0	7.0
Significant ?	a	ab	ab	bc	cd	de	ef	f

DISCUSSION

Provenance Numbers 6 (*C. variegata* – Richmond Range SF), 4 (*C. maculata* - Bodalla SF site 2), and 8 (*C. maculata* – Wingello SF) were consistently the highest ranked provenances in measures of growth rate (Bone, 2002). In stem structure and tree form Provenances 4 (*C. maculata* – Bodalla SF site 2) and 2 (*C. maculata* Mottle Range) were considered the superior provenances, while Provenance 7 (*C. maculata* - Curryall SF) was identified as having poor structure. In the measures of health and condition, Provenances 4 and 8 were the better performers, while Provenance 7 exhibited the lowest degree of stress tolerance (Bone 2002).

Provenance 4 (*C. maculata* - Bodalla SF Site 2) performed in the top of the range for all three categories and as such is named the best provenance in this spotted gum provenance trial. While Provenances 6 (*C. variegata* - Richmond Range SF) and 8 (*C. maculata* -Wingello SF) exhibited excellent growth rates, the tendency for tree forking was a draw back of these provenances for urban tree selection. Fast growth rates, while desirable in forestry improvement programs, are less important than structural characteristics in ornamental trees. Provenance 2 (*C. maculata* - Mottle Range) is perhaps the best choice for specific improvement of stem form in the species due to the very low level of forking demonstrated.

The variation within the spotted gum group appears to be random for arboricultural traits selected for study. No clinal or altitude-related pattern of variation was found. While provenance differences were revealed in susceptibility to apical death and the development of a forked stem, further research into the strength of genotypic control over forking, and patterns of shoot recovery following apical death is required.

CONCLUSION

The spotted gum provenance studies undertaken (Bone, 2002) identified superior provenances for urban tree selection. Two provenances of spotted gum are recommended to the tree growing industry for the production of urban trees; *C. maculata* (Bodalla SF Site2) and *C. maculata* (Mottle Range) demonstrated better form, stem structure, and stress tolerance than other provenances tested.

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