CALMScience 1(1): 47–55 (1993)

Growth of *Populus deltoides* and some related clones in the south-west of Western Australia

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ABSTRACT

In 1972, an unreplicated trial of seven selected clones of poplar, (*Populus deltoides* Bartr.ex Marsh and *Populus euramericana* (Dode) Guinier) was planted near Balingup in the south-west of Western Australia.

The trial aimed to demonstrate the growth performance and timber potential of the clones on a site previously used for grazing, and was considered to be excellent for timber growing in W.A. Clones planted were:

'I-214'
'I-154'
'I-488' (1-year-old sets)
'I-488' (2-year-old sets)
'G-48'
'Canberra'
'Bassendean'
'Angulata' planted 1973

Trees were planted at 5 m by 5 m spacing (400 stem ha^{-1}) in 1972 and were thinned to approximately 235 stems ha^{-1} in 1984 at 12 years. Final pruning was carried out at 11 years to a height averaging 9.8 m.

By age 19.2 years, 'I-488' (1-year-old set) produced the largest volume (136 m^3 ha^{-1}) in the pruned section of the tree and 'Angulata', the smallest (59 m^3 ha^{-1}). At this age, 'I-488' also attained the best height of 20 m and was ranked third in diameter (28.4 cm).

A visual assessment of tree form showed that the clones, 'G-48', 'I-488', 'Canberra', 'I-154' and 'I-214' had acceptable log straightness and therefore were utilizable for millable timber.

Milling of two logs from trees at 13.5 years gave recovery rates of 31 per cent of high grade timber (furniture and select).

Overall, the poplar clones that showed the most potential in terms of growth and log quality were 'I-488' and 'G-48'.

INTRODUCTION

World-wide, poplars (*Populus* spp.) have been grown extensively in plantations and as ornamental, amenity or shelterbelt plantings. They have been used to stabilize hillsides and river banks in New Zealand (Pryor 1969). Shelterbelts of poplars have been shown to increase productivity in beef cattle by 20 per cent because of higher protein and mineral levels when poplar leaves were used as fodder (Reid and Wilson 1985). Treeby (1978) also found that poplar leaves are a useful fodder crop supplement for livestock. In Australia, most poplar agroforestry has been aimed at combining wood production with grazing beef and dairy cattle (Reid and Wilson 1985). Timber from poplar is used for match splints or woodwool and skillets, pulp, peelers, furniture or general purpose sawlogs (Pryor 1969).

In 1972 an unreplicated demonstration trial was planted with seven clones of hybrid *P. deltoides* near Balingup in the south-west of Western Australia, with the aim of demonstrating the growth potential of commercial clones of *P. deltoides.*

METHODS

Establishment

The trial area was located on brownish fine sandy loams over yellowish-brown sandy loams at 50 to 60 cm depth, adjacent to the Balingup Brook. The site was ploughed prior to planting in 1972. Spacing was 5 m by 5 m (400 stems ha^{-1}) in a grid pattern of 7 by 7 trees (for most plots) in an area of 1.2 ha.

Clones planted were:

'I-214'
'I-154'
'I-488' (1-year-old sets)
'I-488' (2-year-old sets)
'G-48'
'Canberra'
'Bassendean'
'Angulata' (planted 1973)

The clones 'I-214', 'I-154' and 'I-488' are hybrids derived from crossing the two black poplar species, *Populus deltoides* and *P. nigra*. *P. deltoides* is native to northern America while *P. nigra* is from Europe. These clones are generally known as *P. 'euramericana'* (Pryor and Willing 1983) and have the International Poplar Commission registration numbers. The clone, 'Angulata', is *P. deltoides* subsp. *angulata*. 'G-48' is based on a seedling of *P.deltoides* from Texas (Pryor[1], personal communication) and was produced by the Federal Match Company in eastern Australia.

'Canberra' and 'Bassendean' are local Australian clones of unknown origin. All clones planted in the trial were deciduous.

Cutting material was obtained by the Seed Store of the then W.A. Forests Department, and the origin of the material is uncertain (Dalton[2], personal communication). The cutting material was set into nurseries at West Manjimup and Nannup prior to planting out in 1972 or 1973 as bare-rooted cuttings (barbatelles). Owing to poor initial survival in 1972, it was decided to replace a plot of 'I-488' (1-year-old sets) with 'Angulata' cuttings the following year. Another plot of 'I-488' (1-year-old sets) was retained and most other plots were also infilled in 1973.

Prior to replanting in 1973, the site was reploughed and an attempt was made to control weeds (wild oats, *Avena* spp.; kikuyu grass, *Pennistum clandestinum;* couch, *Cynodon dactylon;* and paspalum, *Paspalum dilatatum*) by boom spraying 'Vorox AA' (320 g L^{-1} amitrole and 320 g L^{-1} atrazine) at 9 kg ha^{-1}. However, only the western half of the plot was sprayed because the other was too wet for tractor access.

Fertilizing

Two months after infilling in 1973, all trees received a spot application of Agras 18:18 (17.5 per cent N, 7.6 per cent P, 600 ppm Zn, 16 per cent S) at 500 g/tree. The trial also received the following broadcast applications:

(1) age 11.8 years[3] (1983) - superphosphate (9.1 per cent P, 10.5 per cent S) at 100 kg ha^{-1}.

(2) age 13.2 years (1985) - Agran 34-0 (34 per cent N) at 440 kg ha^{-1}.

Further applications of fertilizer may have occurred because the area was leased for sheep grazing from 1978 to 1990.

Previous fertilizer history is unknown, however, the site probably received some fertilizer during its period as a grazing property.

Tending

Four months after planting in 1972, pruning of side branches was carried out to encourage a dominant leader and remove potential defects.

At 3.1 and 6.2 years, pruning to half tree height was carried out. Tree height at the latter age was 7 to 10 m.

At 11.1 years, trees were pruned to a 10 cm stem diameter, or to a point at which multi-leaders or malformations occurred. Epicormic shoots were also removed at this stage. A further pruning to 10 m occurred at 12.3 years using a 'Squirrel', a mobile hydraulic pruning platform, and epicormic shoots were again removed from the bole section. Pruning to 10 m was aimed at producing a high quality knot-free sawlog. Above this height, the tree was considered to be non-merchantable, owing to malformations, kinks, large branches or general crown development. To maintain the knot-free sawlog objective, it was necessary to remove epicormic shoots thereafter at 11.1, 12.3, 13.5, 14.5, 15.5 and 18.2 years. The 'Squirrel' was used in all instances, except at age 15.5 years when a 7.5 m polesaw was used.

Thinning was carried out at 12.8 years, reducing overall stocking by 27 per cent (see Table 1). Poplar stumps were sprayed with a 10 per cent solution of 'Roundup' herbicide (glyphosate 360 g L^{-1}) to prevent coppicing. *Eucalyptus rudis* regrowth was also felled at this time and stumps treated the same as those of poplars. Stocking rates before and after thinning are shown on Table 1, and survival percentage at this age is also presented.

Mensuration

In November 1978 (6.3 years) five trees were randomly selected within each plot, and total height and diameter at breast height over bark (d.b.h.o.b.) were measured. These parameters were measured again three years later at 9.3 years. Measurement plots were established in 1984 (12.3 years). Plots 1 to 6 and 9 were 24 m x 24 m (0.06 ha), Plot 7 was 19 m x 19 m (0.04 ha), and plot 8 was 22 m x 14 m (0.03 ha). Measurement plots had a one-row, one-tree buffer between plots. D.b.h.o.b. was measured at 12.3, 13.3, 15.2, 17.2 and 19.2 years and tree height was measured at 12.3, 15.2 and 19.2 years. Volume of the pruned section of trees was estimated at 19.2 years, using Smalian's method (Carron 1968) where d.b.h.o.b. was used as the butt measurement. Crown diameter over bark was measured at the top end of the pruned bole average height at 9.8 m.

Form Assessment

A visual assessment of tree form was carried out when the stand was 19.2 years old, to determine whether there were any differences between clones that would downgrade their commercial timber potential. Form was defined as the degree of straightness within: (a) Butt section – from ground level to 2.5 m height; and

[1] Emeritus Professor L. Pryor, C/- Australian National University, Canberra.

[2] Mr M Dalton, Department of CALM, Manjimup.

[3] Ages used in the text are based on initial plantings in 1972.

TABLE 1

Survival percentage and stocking rates before and after thinning of 12.8-year-old *P. deltoides* clones.

CLONE	OVERALL SURVIVAL (%) BY 12.8 YEARS	STOCKING (stems ha^{-1}) PRE-THIN	POST-THIN
I-488 (1-YEAR-OLD SETS)	96	382	260
I-488 (2-YEAR-OLD SETS)	84	330	243
BASSENDEAN	96	382	243
I-514 (1)[a]	74	295	243
I-514 (2)[a]	83	332	249
G-48	87	349	222
I-214	87	347	260
ANGULATA	87	347	243
CANBERRA	39	156	156
MEAN	81	324	235

[a] Replicates

(b) stem section – from 2.5 m to crown height. Trees had been pruned previously from 8 m to 11 m in height (as discussed in 'Tending').

The butt and stem sections were assessed on a 1 to 4 scale where: 1 = perfectly straight log section; 2 = slight – some minor log sweep or deviation; 3 = moderate – some kinks, stem sweep or malformation; 4 = severe – considerable number of kinks, some wobble or sweep and numerous malformations (including twist, bends, bumps). The amount of sweep or unacceptable stem malformation (based on visual appraisal) is directly related to sawlog potential of logs. Classes 1 and 2 would therefore produce ideal long length sawlogs, but class 3 would be confined to short length sawlogs. Most trees in Class 4 would be unmerchantable owing to unacceptable sweep or malformations.

Mill Study

Two 2.6 m logs from 13.5-year-old trees from 'I-488' (plot 9) were sent to the Department's Wood Utilization Research Centre at Harvey for a sawmill study. Small end diameter under bark was 17 and 18 cm and large end diameter under bark was 19 and 22 cm respectively.

The logs were cut 'heart-in' using the twin edger, band-saw and circular re-saw into 25 mm thick boards with 75 mm, 100 mm or 120 mm width. Following cutting, the boards were placed in a low temperature tunnel kiln and dried at ambient temperatures for 11 weeks to below fibre saturation point. Following initial pre-drying, the boards were combined with a regrowth jarrah (*Eucalyptus marginata*) bundle and seasoned to equilibrium moisture content in the laboratory high temperature kiln using a conventional drying schedule. Board bow and spring were measured after sawing, after tunnel kiln drying and after high temperature kiln drying. The boards were graded using the Western Australian Industry Standard for furniture timber (Forest Products Association(W.A.))1985 and Australian Standard 2796 – 1985 (Standards Association of Australia 1985).

Analysis

D.b.h.o.b. and tree height data were analysed using analysis of variance, and comparisons between clones were made using least significant differences (L.S.D.). Analysis of these parameters was done on a single tree basis owing to the lack of replication of clones and the fact that the data were normally distributed. The basal area per ha data were not analysed owing to lack of replication.

RESULTS AND DISCUSSION

By 6.3 years diameter growth trends of 'I-488' (both sets), 'Bassendean' and 'I-514'(Plot 5) clones were better than others, averaging 12.6 to 11.1 cm (Table 2). This trend also continued to 9.3 years. The best diameter increment over this period was achieved by 'I-488' (1-year-old set)(6.7 cm).

Height growth trends were also similar by 9.3 years with 'I-488' (1-year-old set) (13.8 m), 'I-488'(2-year-old set) (13.2 m) and 'Bassendean' (12.0 m).

By 12.3 years, the mean diameters of 'G-48','I-488' (both plots, 'I-154' (Plot 5) and 'Bassendean' were significantly larger ($P<0.05$) than other clones (Table 3). This diameter trend continued at 15.2 years except that 'Canberra' and the above clones were significantly larger ($P<0.05$) than 'I-154', 'I-214' and 'Angulata'. By 19.2 years, the mean diameters of 'Canberra', 'G-48', 'I-488' (both plots), 'I-154' (Plot 5) clones were significantly larger ($P<0.05$) than 'I-154' (Plot 7), 'I-214' and 'Angulata' clones (Table 3). At this age (19.2 years), 'Canberra' had the largest mean diameter at 29.9 cm, and 'Angulata' the smallest at 21.3 cm. Basal area trends also followed this growth pattern over the same period (12.2 to 19.2 years) (Table 4).

The basal area mean annual increment (M.A.I.) of 'I-488' (1-year-old set) at 19.3 years was the best clone with 0.89 m^2 ha^{-1} per year and 'Angulata' the worst with 0.45 m^2 ha^{-1} per year. Although the tree stocking was low (156 stems ha^{-1}) for the 'Canberra' clone, compared with others, its basal area increment at 19.3 years was similar to 'I-488'(2-year-old set), 'Bassendean', 'I-214' and 'I-514'(one replicate).

Tree height of 'I-488' (1-year-old set) at 19.2 years was significantly larger ($P<0.05$) than 'Canberra',

TABLE 2

D.b.h.o.b. and height of *P. deltoides* increments from 6.3 and 9.3-years-old (based on 5 trees per plot).

CLONE	D.B.H.O.B. (cm)			HEIGHT (m)		
	6.3YRS	9.3YRS	INCREMENT	6.3YRS	9.3YRS	INCREMENT
I-488 (1-YEAR-OLD SETS)	11.1	17.8	6.7	9.3	13.8	4.5
I-488 (2-YEAR-OLD SETS)	12.6	18.2	5.6	9.9	13.2	3.3
BASSENDEAN	11.8	16.4	4.6	9.1	12.0	2.9
I-154[a]	11.5	16.7	5.2	8.0	11.8	3.8
CANBERRA	9.2	15.3	6.1	7.6	11.7	4.1
G-48	9.8	15.0	5.2	8.1	11.5	3.4
I-214	8.9	13.9	5.0	6.8	10.8	4.0
ANGULATA	8.8	12.6	3.8	7.1	10.8	3.7
I-154[a]	9.0	13.3	4.3	7.0	9.9	2.9

[a] Replicates

TABLE 3

Tree D.b.h.o.b. increments of *P. deltoides* clones from 12.3, 15.2 and 19.2 years (based on plots).

CLONE	D.B.H.O.B. (cm)[a] AGE (YRS)[b]			INCREMENT (cm)	
	12.3	15.2	19.2	1ST	2ND
CANBERRA	18.3AB	23.0A	29.9A	4.7	6.9
G-48	19.7A	24.0A	28.6A	4.3	4.6
I-488 (1-YEAR-OLD SET)	20.0A	24.1A	28.4A	4.1	4.3
I-154[c]	18.8A	22.1A	27.3A	3.3	5.2
I-488 (2-YEAR-OLD SET)	19.6A	23.5A	26.8A	3.9	3.3
BASSENDEAN	19.7A	22.7A	26.0A	3.0	3.3
I-154[c]	15.5BC	19.3B	22.9B	3.8	3.6
I-214	15.8BC	19.0B	22.5C	3.2	3.5
ANGULATA	15.3C	18.3B	21.3C	3.0	3.0

[a] Common capital letters indicate non-significant differences at P<0.05 level. [b] Since initial planting in 1972. [c] Replicates.

'Bassendean', 'I-154' (both plots), 'Angulata' and 'I-214'. 'Angulata' tree height was significantly larger ($P<0.05$) than 'I-214' and 'I-154' (Plot 7). By 19.2 years, 'I-488' (1-year-old set) attained the largest mean height at 20.1 m and 'I-154' the smallest mean height of 15.4 m (Table 5).

The clone 'I-488' (1-year-old set) produced the largest over bark volume (135.9 m^3 ha^{-1}) in the pruned section of the tree and 'Angulata' the smallest (59.1 m^3 ha^{-1}) by 19.2 years (Table 6).

Assessment of external form characteristics showed that for the butt sections, of clones 'G-48', 'I-488' (both sets)','Canberra' and 'I-154' (both reps) all trees were in the straight and slightly affected classes (Table 7).

TABLE 4

Basal area increments, M.A.I. and stocking of *P. deltoides* clones from 12.3 to 15.2 and 19.2 years.

CLONE	BASAL AREA (m^2 ha^{-1}) AGE (YRS)			INCREMENT		M.A.I. (19.2 YRS)	TREE STOCKING (19.2 YRS)	
	12.3	15.2	19.2	1ST	2ND	(m^2 ha^{-1}/yr)	PER HECTARE	PER PLOT
I-488 (1-YEAR-OLD SET)	8.6	12.3	17.1	3.7	4.8	0.89	260	15
I-154[a]	6.9	10.4	14.4	3.5	4.0	0.75	243	14
G-48	6.8	10.1	14.2	3.3	4.1	0.74	222	7
I-488 (2-YEAR-OLD SET)	7.5	10.7	13.9	3.2	3.2	0.72	243	14
BASSENDEAN	7.6	10.0	13.2	2.4	3.2	0.69	243	14
I-214	5.3	7.7	10.8	2.4	3.1	0.56	260	15
I-154[a]	5.0	7.6	10.8	2.6	3.2	0.56	249	9
CANBERRA	4.5	7.6	10.8	3.1	3.2	0.56	156	9
ANGULATA	4.5	6.4	8.7	1.9	2.3	0.45	243	14

[a] Replicates

TABLE 5

Tree height of *P. deltoides* clones at 12.3,15.2 and 19.2 years.

CLONE	PLOT NO.	HEIGHT (m)[a]		
		12.3 YRS	15.2 YRS	19.2 YRS
I-488	1	14.2A	17.5AB	20.1A
G-48	8	14.3ABC	18.1A	19.7AB
I-488	9	13.7A	17.4AB	19.6AB
BASSENDEAN	3	14.3AB	16.7ABC	18.7B
I-154	5	13.5ABCD	16.1CD	18.6B
CANBERRA	6	13.0BCD	16.2BCD	18.6B
ANGULATA	2	12.8CD	14.9DE	16.9C
I-214	4	11.6DE	14.2E	15.5D
I-154	7	10.1E	14.1E	15.4D

[a] Common capital letters indicate non-significant differences at $p<0.05$ level.

However, 57 per cent of the butt sections of 'Angulata' trees were in the moderate and severely affected class. The percentage of trees in the stem section of the following clones were in the straight and slightly affected classes: 'G-48' (100 per cent), 'I-488' (2-year-old set) (93 per cent), 'I-488' (1-year-old set) (80 per cent) and 'I-214' (93 per cent).

Green sawn recoveries for the two logs milled were 59.2 and 56.6 per cent respectively. The graded recovery rates of board grades in the study were: Furniture, 30 per cent; Select, 1 per cent; Standard, 30 per cent; Utility, 29 per cent. Reasons for downgrading of boards included the following faults:

Grade	faults in board
Select	heart and knots
Standard	heart and knots, sapwood and wane
Utility	heart and knots, wane, undersize

In terms of diameter growth by 19.2 years (Table 3), 'I-488', 'Canberra', 'I-154', 'G-48' grew significantly larger than other clones, ranging from 26.80 cm ('I-488' Plot 1) to 29.90 cm ('Canberra'). The 'I-488' (Plot 1) clone also grew the tallest, reaching a height of 20.1 m. By contrast, 'I-488' (Plot 9) clone produced the largest over bark volume in the pruned section (136 m^3 ha^{-1}), followed by the same clone (Plot 1) which produced 117 m^3 ha^{-1}.

Although the analysis of diameter and height showed significant differences between the clones, this is probably an unfair estimate on the performance of them due to lack of replication, low numbers of trees analysed (Table 4), and site variation.

Based on external characteristics (within the butt section of the tree), all clones had greater than 86 per cent of utilizable timber, except for 'Angulata' which had only 43 per cent of the butt log utilizable (form rating 1 and 2). Within the pruned stem section of the tree, 'Angulata' and 'Bassendean' were considered to have unacceptable sweep with 50 per cent and 64 per cent respectively.

TABLE 6

Overbark volumes[a] (m^3 ha^{-1}) of pruned log sections and pruned bole lengths of 19.2-year-old *P. deltoides* clones.

	PLOT NO.	VOLUME (pruned log)		STOCKING[a]	M.A.I. PRUNED LOG	PRUNED BOLE LENGTH
		(m^3)	(m^3 ha^{-1})	(stems ha^{-1})	(m^3 ha^{-1} yr^{-1})	(m)
I-488	9	7.83	135.8	260	7.04	11.0
I-488	1	6.76	117.39	243	6.08	11.0
G-48	8	3.37	107.09	222	5.65	9.8
I-154	5	5.90	102.36	243	5.30	10.0
BASSENDEAN	3	5.35	92.95	243	4.82	9.6
CANBERRA	6	4.61	80.02	156	4.15	10.0
I-214	4	4.26	73.99	260	3.13	8.1
I-154	7	2.63	72.77	209	3.77	9.3
ANGULATA	2	3.41	59.13	243	3.06	9.7

[a] Volumes calculated by Smalian's method.

TABLE 7

Stem form within butt and stem sections of 19.2-year-old *P. deltoides* clones.

CLONE	FORM CLASS[a] P/N	BUTT SECTION % OF TREES				STEM SECTION % OF TREE				NO. OF STEMS ASSESSED
		1	2	3	4	1	2	3	4	
G-48	8	71	29			57	43			7
I-488	1	93	7			33	60	7		15
I-214	4	13	73	7	7	33	60	7		15
I-488	9	87	13			33	47	13	7	14
CANBERRA	6	56	44				67	22	11	9
I-154	7	44	56				67	11	22	9
I-154	5	64	36			7	57	22	14	14
ANGULATA	2	7	36	36	21		50	29	21	14
BASSENDEAN	3	29	64		7		36	57	7	14

[a] Form Class: Butt section – ground level to 2.5 m; Stem section – 2.5 metres to crown (10 m) } Pruned Log

1 = perfectly straight log section.
2 = slight – some minor log sweep or malformation.
3 = moderate – some kinks, stem wobble or malformation.
4 = severe – considerable number of kinks, stem wobble or sweep, or numerous malformations.

Utilization of the two clones would therefore be limited to short, rather than long log sections owing to downgrade.

Overall, the 'I-488' clone produced the best growth and potential of all clones tested. Pruned volumes from trees in the 2 plots were 136 (Plot 9) and 117 m³ ha⁻¹. The 'I-488' clone also had some moderate and severe stem sweep or malformations, which was mostly the result of the earlier removal of part of a fork during pruning.

The fact that the 'Canberra' clone grew best in terms of diameter is probably the result of the low stocking of the plot, which had been growing at 156 stems ha^{-1} from an early age following poor initial survival. Basal area by 19.2 years was low at 10.8 m^2 ha^{-1}. Its volume production by this age was average, attaining 80 m^3 ha^{-1} within the pruned section. The butt section was fully utilizable, while the stem section was 67 per cent utilizable, based on external visual assessment.

The two plots of the 'I-154' clone had similar tree form but growth parameters varied. This was probably owing to site variation between the plots and the heights reflect this: Plot 5 was 18.6 m by 19.2 years, whereas Plot 7 was significantly lower ($P<0.05$) at 15.4 m. Only 9 trees were measured in Plot 7 compared with 14 in Plot 5.

The 'G-48' clone produced one of the best volumes (107 m^3 ha^{-1}) and had 100 per cent utilizable timber in the butt and stem sections of the pruned bole. The stocking rate of 222 stems ha^{-1} for the 'G-48' plot is deceiving, however, as there were only seven trees measured, owing to small plot size. This is probably too low to fairly assess the potential of the clone. By 19.2 years, this clone ranked third in basal area (14.2 m^2 ha^{-1}) and second in d.b.h.o.b. (28.6 cm).

As well as demonstrating poor tree form, 'Angulata' grew the slowest, and by 19.2 years had produced a volume in the pruned section of 59 m^3 ha^{-1}, and grown to a height of 16.9 m. Basal area was the lowest of the clones tested at 8.7 m^2 ha^{-1}.

Although 'I-214' demonstrated slower diameter and height growth than most other clones except 'Angulata', it has potential for commercial timber production as it has straight butt and stem sections. By 19.2 years, it had grown to 15.6 m and produced a volume of 74 m^3 ha^{-1} in the pruned section.

Epicormic shoots have been a constant problem over the life of the trial and constituted the largest tending expense. As one of the objectives of the trial was to produce a knot-free log section to 10 m, shoots were removed at 11.1, 12.3, 13.5, 14.5, 15.5 and 18.2 years. Attempts were made to vary the seasonal timing of pruning to reduce epicormic development, but this had no effect. It is possible that previous pruning operations damaged cambial tissue which led to shoot development. However, at age 19 years, it was observed that epicormic shoots and buds were developing from areas of the bark that had not previously been disturbed by pruning. This indicates that the clones tested are highly vulnerable to the production of epicormics when subjected to heavy pruning (to 10 m).

Sun scorch caused some damage to trees in the 'I-214' and 'I-514' plots. This may reflect the poorer growth rates of these clones compared with others. Sun scorch occurred only on the western side of the butt section of affected stems, and these two plots were located on the western side of the trial, adjacent to an open paddock. This damage to the butts made them non-merchantable for timber use.

Timber utilized from the mill study can be used for panelling or furniture. The major reasons for downgrading the boards to a lower grade were: heart wood, knots, amount of sapwood, wane and undersizing. Other log defects were small bumps and some rot associated with the bumps. All bow and spring measurements were within the specified limits in the grading standards (Forest Products Association (WA) 1985; Standards Association of Australia 1985). Green sawn recovery rates for the two logs were 59.2 per cent and 56.6 per cent respectively, and the study showed that good sawlog recoveries and useful utilization of boards can be produced by a thinning at 13 years. However, the timber would not have much potential for structural uses because of its low strength properties (Bootle 1983).

In summary, *Populus deltoides* clones that showed most potential in this trial were 'I-488' and 'G-48'. Better growth rates would be expected from regular applications of fertilizer, and perhaps irrigation. Pryor (1969) reported that good growth rates have been achieved in Chile and South Africa by flood irrigation or irrigation by town sewerage. Similar sites without irrigation produced approximately one quarter of the volume. The best sites in South Africa can reach 29.4 m^3 ha^{-1} M.A.I. over 20 years. The trial site, which has an annual rainfall of 950 mm, is considered to be excellent for tree growing in Western Australia. The site also dries out over the summer months and this may have inhibited poplar growth to some extent. I would suggest that better overall growth rates could have been achieved in the trial if summer irrigation were present, or that a better moisture relationship had occurred during the drier months. The soils were brownish fine sandy loams over yellowish-brown sandy loams at 50 to 60 cm depth. Pryor and Willing (1983) believe that good growth rates can be achieved on light textured soils where irrigation or rainfall from 750 mm to 1000 mm per annum is present. They also indicate that poplars grow best on moist, fertile agricultural grade land which is generally associated with alluvial soils on river systems. These sites, which attract premium land prices and are generally used for horticultural or orchard production, are limited in area in Western Australia.

In recent years, tree improvement programs have led to a wider range of poplar clones showing superior qualities of tree growth, stem and branch form and increased resistance to poplar rust (*Melampsora medusae* and *M. larici-populina*). The clones 'I-488', 'I-154', 'G-48' and 'Angulata' are extremely sensitive to

Melampsora (Pryor and Willing 1983). This may limit their potential in W.A. In fact, some of these clones have been withdrawn from cultivation in eastern Australia (Pryor and Willing 1983) because of this.

Shivas (1989) reported *Melampsora larici-populina* in W.A. in 1974 and also recorded a case of yellow leaf blister (*Taphrina populina*) at Dale River in 1982. There is little other evidence of poplar rust in W.A., but we should be cautious about large-scale plantings of these clones here.

Further testing of newer, improved clones could be tried on a range of suitable soil types and rainfall zones in the south-west of Western Australia. Trial plantings could be incorporated with systems associated with sewerage or irrigation dispersal and (as previously discussed) growth rates would be greatly improved. Recent local interest may justify these trials.

ACKNOWLEDGEMENTS

This study was part of the research program of the Department of Conservation and Land Management, Busselton. I wish to thank Dr F.H. McKinnell for establishing the trial, R. Fremlin for technical assistance and B. Read for statistical analysis. I also thank G. Brennan and staff of CALM'S Wood Utilisation Research Centre, Harvey for carrying out the mill study and C. Fremlin for typing the drafts. I also appreciate useful suggestions to the drafts by Dr J.F. McGrath and referees, Dr G. Siemon and Dr L. Pryor. Dr Pryor identified the origins of certain poplar clones, for which I am grateful.

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