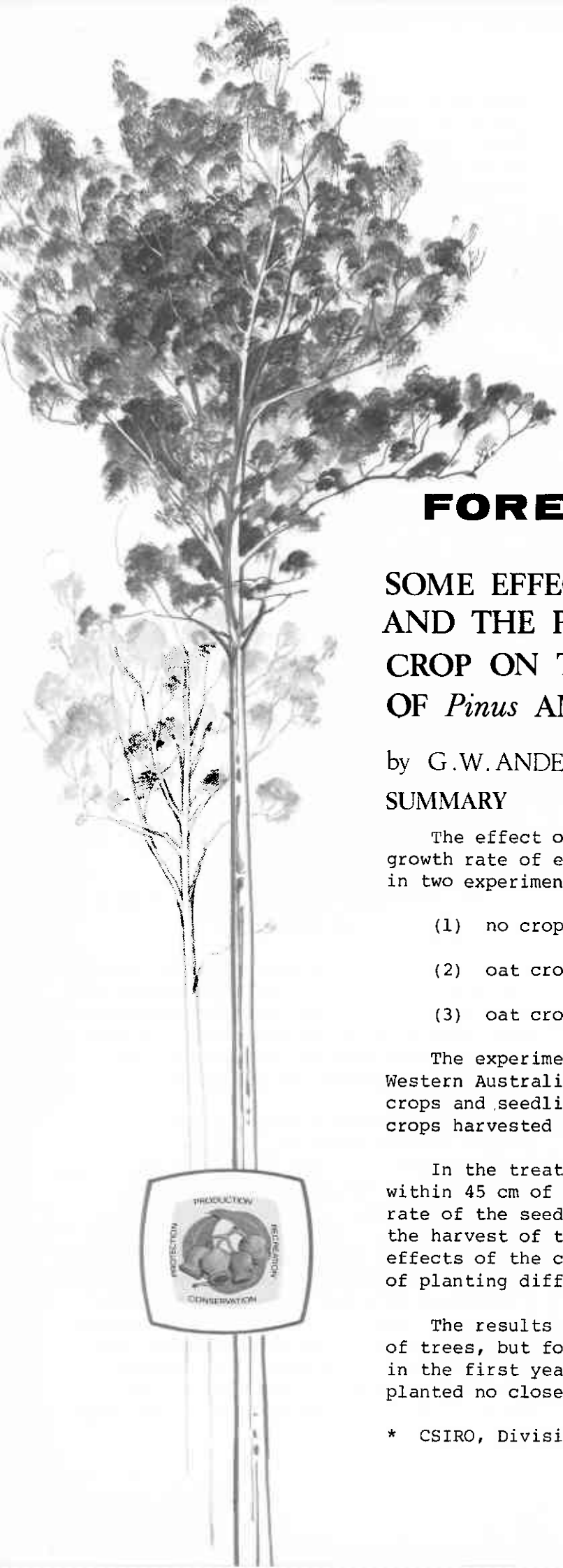

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SOME EFFECTS OF SITE AND SEASON AND THE PROXIMITY OF AN OAT CROP ON THE SURVIVAL AND GROWTH OF *Pinus* AND *Eucalyptus* SEEDLINGS

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SUMMARY

The effect of three treatments on the survival and growth rate of eucalypt and pine seedlings was compared in two experiments. The treatments were:

(1) no crop sown between tree rows,

(2) oat crop sown to within 90 cm of the tree rows,

(3) oat crop sown to within 45 cm of the tree rows.

The experiments were conducted at Bakers Hill, Western Australia, in 1976/77 and 1977/78. In each year, crops and seedlings were planted in early July and the crops harvested to a height of 20 cm in December.

In the treatment where the oat crops had been sown to within 45 cm of the tree rows, the survival and growth rate of the seedlings were considerably reduced following the harvest of the crops. It was also found that the effects of the crop treatments, soil drainage and season of planting differed considerably between tree species.

The results show that crops can be grown between rows of trees, but for satisfactory tree growth and survival in the first year it is advisable that the crops are planted no closer than 1 m from the tree rows.

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INTRODUCTION

Trees may be planted on farmland to provide shade and windbreaks, to control soil erosion and secondary salinity, to beautify the landscape or to create extra income.

The major problems in establishing trees amongst pasture are competition for moisture and nutrients from the pasture itself and damage caused by livestock. The former can be reduced by the use of herbicide and the latter either by the exclusion of stock during the first two to three years, or by fencing.

To minimize loss of income, the area between the tree rows can be cropped or utilized for meadow hay production (McKinnell*, personal communication). However, the planting of crops close to developing seedlings is likely to have a greater shading effect than pasture, thereby reducing the seedlings' growth and survival.

This paper reports two experiments designed to examine some of the effects of the site, and proximity to oat crops, on the survival and growth of trees in the year following planting.

METHODS

Two experimental sites were located on the CSIRO Yalanbee Experiment Station, at Bakers Hill in Western Australia, 70 km east of Perth. This area has a mediterranean climate and an average rainfall of 635 mm. Both sites had undergone 12 years of a ley system using annual clover-based pastures and cereals, with at least three cereal crops sown on each site. Copper and zinc were applied when the first crop or pasture was sown, and the cumulative total of annual applications of single superphosphate over the 12 years was approximately 2 t ha^{-1}.

Experiment I

Experiment I was located on a mid-to-lower slope in a brown, loamy sand over yellow mottled clay.

The preparation of the site included heavy grazing by sheep, and killing the pasture by applying 0.1 kg ha^{-1} of active ion of bipyridil herbicide over the entire site. The soil was then ripped to a depth of 40 cm in lines 6 m apart, then partly compacted by driving a tractor along each line. Holes were dug to a depth of 20 cm in each line at 2.5 m intervals. Fertilizer containing 9 g nitrogen, 9 g phosphorus and 8 g sulphur was placed in each hole and mixed with added soil.

On the 20 July 1976, twenty tree seedlings were planted in the prepared holes, with one tree species in each row. The soil between the tree rows was cultivated only once with single superphosphate at 80 kg ha^{-1} , one day after the trees were planted. This area was then sown with oats at 75 kg ha^{-1}.

The tree species used were *Eucalyptus camaldulensis*, *E. citriodora*, *E. globulus*, *E. robusta*, *Pinus pinaster* and *P. radiata*. The pine seedlings were open rooted stock and the eucalypts were raised in 300 ml pots.

There were three crop-spacing treatments:

(1) T^1 No crop between tree rows (Control),

(2) T^2 Crop sown to within 0.90 m of each tree row,

(3) T^3 Crop sown to within 0.45 m of each tree row.

A split plot, randomized block design was used. In each of the tree blocks that were set up, the cropping treatments were allocated to the main plots (6 tree rows); single rows of individual tree species constituted the sub-plots.

Both experiments were located on gently sloping paddocks, and the blocks were situated at right angles to the slope, to sample the variation of the site's characteristics.

The number and height of the surviving trees were recorded on 16 September 1976, 8 December 1976 and 15 April 1977. The trees that died during the "establishment phase", the period between planting and mid-September, were replaced. However, these losses were not included in the survival data, as the effects of the crop

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treatments were expected to commence after this phase.

The moisture content of the top 10 cm of soil for all blocks was estimated gravimetrically from bulked samples that were collected from 12 randomly selected positions in the tree rows. These measurements were carried out on 22 October 1976, 3 November 1976 and 30 November 1976. The oat grain was harvested on 8 December 1976, leaving behind 20 cm high stubble.

Experiment II

Experiment II was located on a mid-slope position in a well drained sandy gravel over sandy clay. Site preparation varied from Experiment I in that the soil was not ripped but the holes were dug by a posthole digger to a depth of 50 cm, then partly refilled, compacted and fertilized prior to planting.

On 15 July 1977 the tree seedlings were planted. The design was similar to that adopted for Experiment I, except that there were only four tree species (*E. camaldulensis*, *E. robusta*, *E. wandoo* and *P. radiata*) planted and each row contained 15 trees.

The trees were measured at the end of the establishment phase on 16 August 1977, and subsequently on 15 December 1977 and 11 May 1978. Soil moisture content was estimated as in Experiment I on 18 October 1977, 8 November 1977 and 22 November 1977. The oats were harvested on 15 December 1977.

In each year, annual grasses germinated after the herbicidal treatment and developed into a thin stand wherever crop was absent. Here they provided some competition with the trees for available moisture and nutrients, but provided negligible shading. In October 1977 the grass plants which had grown to within 50 cm of each tree were removed by hoeing or pulling.

RESULTS

Experiment I

Although the total rainfall for 1976 was 577 mm (nine per cent below average), only 35 mm fell in July so the trees were hand watered twice soon after planting. In August, 135 mm of rain was recorded and waterlogging developed on all blocks. Waterlogging on Block 1 (lower slope) was much more extensive and of a longer duration than on the other two blocks. During this establishment phase three times as many trees died on Block 1 as on Blocks 2 and 3 (Table 1). This was attributed to the waterlogging, the extent of which was

TABLE 1

The influence of waterlogging on tree deaths in the two months following planting in Experiment I (Per cent deaths).

Tree Species	Waterlogged Block 1	Not Waterlogged Block 2	Not Waterlogged Block 3	Species Means
E. camaldulensis	12	3	2	6
E. citriodora	25	22	13	20
E. globulus	63	30	15	36
E. robusta	7	2	0	3
P. pinaster	25	8	15	16
P. radiata	67	8	15	30
Mean	33.2	12.2	10.0	

clearly indicated by the poor growth of the oats in the lower slopes. Some of the *E. citriodora* and a few of the *E. globulus* failed because they were inferior stock.

By early September 1976, the oat crops were about 30 cm high, which was similar to the mean height of all trees. Shortly after, rapid growth occurred, the crops reaching a height of 1.1 m (± 0.2 m) by early November, twice the height of the tallest trees. The crops were not visibly affected by the trees, and there was no difference in yield per unit area between the two crop treatments, the average yield being 2000 kg ha^{-1} of grain.

In late October the surface soils of the tree rows contained 12, 10 and 8.5 per cent moisture in T^3, T^2 and T^1 respectively. By the end of November all soils contained about 5 per cent moisture.

Prior to harvesting, the oat crop did not significantly affect the survival of any tree species (Figure 1), but did significantly increase the height of *P. radiata* ($T^3 > T^2 > T^1$; $P < 0.05$) (Figure 2).

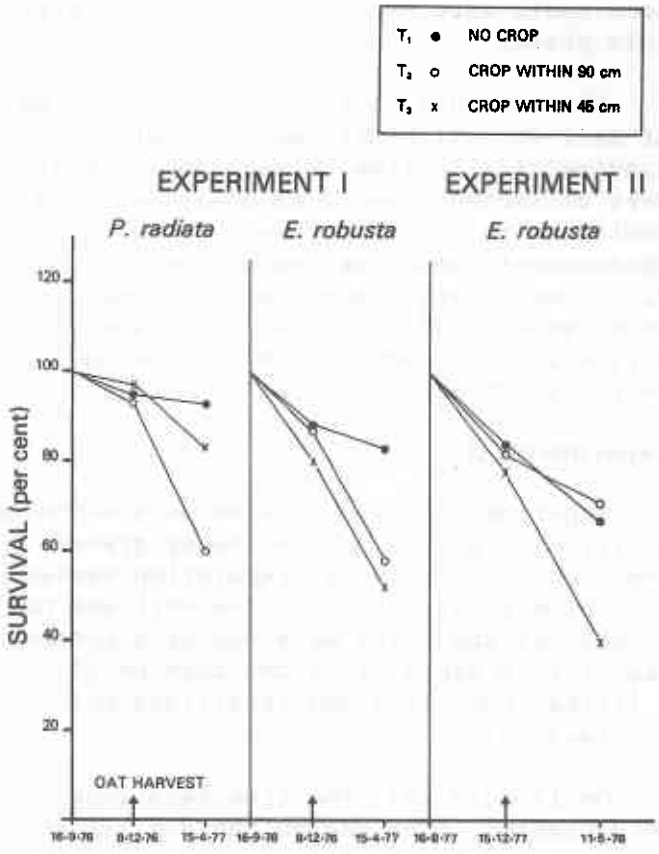

Figure 1. Effects of crop treatments on seedling survival.

TABLE 2

Percentage of trees surviving at the final counts for each crop treatment.

	Expt I 15/4/77			Expt II 11/5/78		
Tree Species	T^1	T^2	T^3	T^1	T^2	T^3
E. camaldulensis	97	87	83	100	91	100
E. citriodora	62	67	54	n.p.	n.p.	n.p.
E. globulus	52	22	16	n.p.	n.p.	n.p.
E. robusta	83	58	51	67	71	40
E. wandoo	n.p.	n.p.	n.p.	96	89	67
P. pinaster	32	43	18	n.p.	n.p.	n.p.
P. radiata	93	60	84	82	80	56
Mean	70	56	51	84	83	66

n.p. = not planted

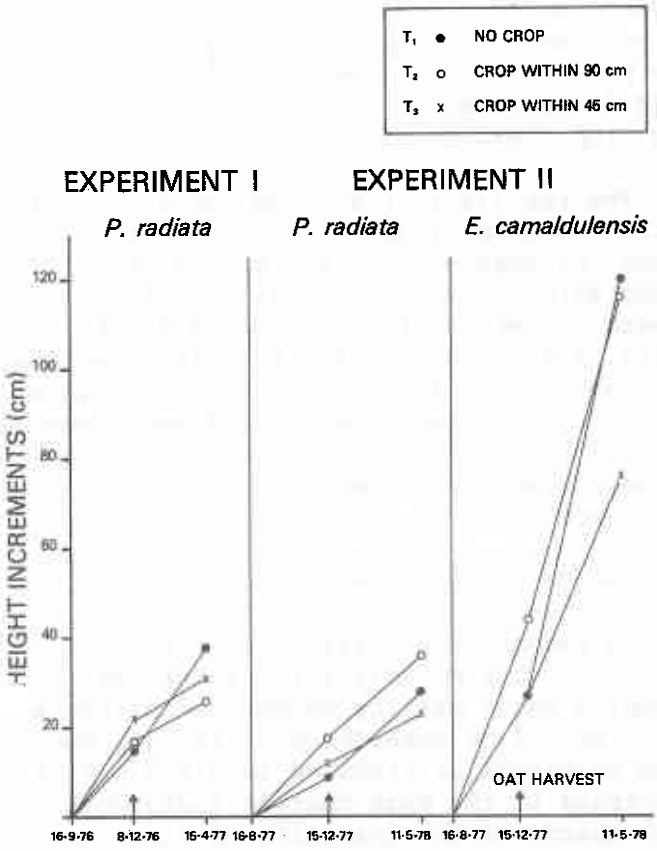

Figure 2. Effects of crop treatments on height growth.

In the four months following the harvest of the oat crop, tree survival was generally greater in the control treatment (T^1) and significantly so for *E. robusta* and *P. radiata* ($P < 0.01$) (Figure 1 and Table 2). Height increments were usually greater in the T^1 treatment and were significantly greater for *P. radiata* ($P < 0.01$) (Figure 2 and Table 3). Generally the eucalypts grew at a faster rate than the pines, particularly in summer.

Experiment II

In 1977, the total rainfall was only 486 mm (24 per cent below average), but it was well distributed and the site had better drainage than Experiment I. No seedlings died in the six weeks following planting and, after this establishment phase, less deaths occurred than in Experiment I.

In December 1977, the final crop height was 0.9 m (± 0.1 m), about twice the mean height of all trees, except for *E. camaldulensis*, which was 0.66 m. The crops yielded 1650 kg ha^{-1} of grain.

TABLE 3

Height increments (cm) for eight and nine months for Experiment I and II respectively for each crop treatment.

	Expt I			Expt II		
Tree Species	T^1	T^2	T^3	T^1	T^2	T^3
E. camaldulensis	66	54	52	120	92	76
E. citriodora	52	45	35	n.p.	n.p.	n.p.
E. globulus	50	52	44	n.p.	n.p.	n.p.
E. robusta	70	52	38	80	79	78
E. wandoo	n.p.	n.p.	n.p.	69	60	41
P. pinaster	14	16	14	n.p.	n.p.	n.p.
P. radiata	38	26	31	28	36	23
Mean	48	41	36	74	67	55

n.p. = not planted

As with Experiment I the control soils contained slightly less moisture than the other treatments, during spring. However, Block 1 dried more quickly than the rest of the site in all treatments.

Prior to harvest, the presence of oats did not significantly decrease the survival of the trees. After harvest, more trees died in the T^3 treatments, with a significant number of deaths recorded for *E. robusta* ($P < 0.05$) (Figure 1). *Eucalyptus camaldulensis*, *E. wandoo* and *P. radiata* showed better survival than *E. robusta* in all treatments (Table 2).

During winter and spring the height growth of two species was stimulated by proximity to the oat crops: *E. camaldulensis* $T^2 > T^1$ and T^3 ($P < 0.05$) and *P. radiata* $T^2 > T^3 > T^1$ ($P < 0.05$) (Figure 2). During summer and autumn, the eucalypts continued to show substantial growth and all species, except *E. robusta* showed significantly more growth in T^1 than in T^3 ($P < 0.05$) (Table 3).

DISCUSSION

In both experiments, the results showed considerable variance between species. The pines grew more slowly than the eucalypts, particularly during the summer period. *Eucalyptus robusta* and *E. camaldulensis* grew the tallest in each year. The final height increments achieved were greater in Experiment II than Experiment I but the results from Experiment II were gained over a one month longer period of measurement (Table 3).

Survival differed between tree species, with *E. camaldulensis*, *E. wandoo* and *P. radiata* surviving best, and *E. globulus* and *P. pinaster* performing poorly.

Eucalyptus camaldulensis, *E. robusta* and *E. wandoo* showed considerable early promise, and *P. radiata*, which has not usually been recommended for planting in an area that receives less than 700 mm of rainfall, continued to make good progress early into 1979. *Eucalyptus robusta* showed the greatest site preferences, being least affected by the waterlogging in Experiment I and most affected by the early drying out of one block in Experiment II. In both experiments, *P. radiata* showed the poorest height growth, indicating that it was the species most sensitive to the crop treatments.

The results indicate the importance of correct choice of species, of planting stock, of season and site, and of site preparation to tree survival and early growth. However, in practice, a farmer would have greater flexibility in selecting tree species, site and planting techniques than was possible in replicated experiments, where the location of species is dictated by design and random allocation of treatments.

The data also show that during tree establishment a large proportion of an arable paddock can still be used for cropping. The potential for inter-row cropping until grazing becomes practicable again should be considered by farmers who wish to establish trees on farmland but are concerned at the high cost of individual tree guards or the inability to utilize the land for two to three years. If cropping or haymaking is carried out, production will be proportionate to the spacing between the tree rows, such that the further apart the rows, the less land is wasted.

As oats are the tallest growing of the major cereals, it is likely that the results are also applicable to wheat or barley.

The data show that oat crops grown within a metre of establishing trees can have a detrimental effect on the trees, especially in the summer following the harvest of the crops.

In both experiments, the moisture content of surface soil in the tree rows sheltered by crops was higher in spring. This indicates that oat crops act as a barrier to sun and wind for the establishing trees and, as with pine trees (Farnsworth and Male, 1973; and Anderson and Batini, 1979), can also modify the soil moisture content. The conservation of moisture and shading effects would probably explain the improved growth rates of *P. radiata* in the two crop treatments.

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