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Preliminary Report

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Development of Silvicultural Techniques Under National Afforestation Program Project 15

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DEVELOPMENT OF SILVICULTURAL TECHNIQUES UNDER NATIONAL AFFORESTATION PROGRAM PROJECT 15

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1. Objectives of Research and Development

The major aim of *E. globulus* research and development under NAP project 15 was to gain rapid improvement in survival and growth performance in the field. Earlier eucalypt planting had helped identify several critical areas in need of improvement. The NAP work was therefore designed to rapidly provide scientifically sound information and demonstration to guide field operations.

The research was also designed to feed directly into the growth modelling, by providing input for "what if" scenarios and to allow fine tuning of the working model.

2. Growth Modelling - The Importance of a Good Start

CALM has initiated the development of a computerized model of the growth of *E. globulus*. This model will be capable of predicting growth patterns and wood yield over time for any site, based on environmental, edaphic and silvicultural variables.

Early results from studies supporting the development of this model have consistently shown the benefit of good establishment i.e. more uniform plantation growth and higher yields earlier in the rotation. Well established seedlings appear able to dominate the site more quickly, gaining early weed suppression, more rapid crown closure, full site occupancy and increased growth rates. This means increased yields over time or a decrease in rotation length for a given target yield. It appears that a reduction in rotation length by one to two years may be possible. The economic implications of this are potentially very large.

It is intended that the *E. globulus* growth model serve as a useful management tool to guide decisions on the silvicultural treatment of plantations following establishment. A series of "what if" scenarios will be integrated into the model, allowing, for example, the yield benefits of fertilizing at some point in time to be determined. Coupled with optimization models, management decisions may be made on rational economic grounds.

3. Research Method

Five experiments were established in 1988, fifty nine in 1989 and forty in 1990. All experiments were designed for statistical analysis and conform to the standard CALM 'Research Project Plan'. Each has a central file into which a full record the experiment, on-going observations and results are entered. Many of the 1990 experiments were a logical progression from preliminary results obtained from the earlier experiments. A full list of experiments is given in appendix 1.

The experimental work, much of it involving detailed small plot designs, occupied some 200 ha of planting in total. Sites were selected to cover the full climatic and edaphic range, to provide good security over the plots and to gain maximum demonstration value. Standardized inputs such as seed source, nursery stock, planting and management technique were used to minimize these as a source of variation in the results.

A range of establishment (nursery practices, site preparation, weed control and nutrition) and on-going management (density and species selection) variables were investigated.

Results to date relate to very young plantations only, but have been used as appropriate to upgrade specifications for planting. Results gathered to date are presented in the following section.

It should be noted that many experiments have been designed to run for the full rotation length to provide information on final yield impact of improved establishment practice. Long term information like this is critical in justifying investment into plantation establishment and management.

4. Establishment Practices

4.1 Nursery Practice: Nursery work involved investigation into the following:

- raising seedlings in different sorts and sizes of containers (including those which had been painted with root inhibiting paint), different potting mixtures and different forms of top dressing. Liquid feeding was also investigated. Measurements of seedling heights, shoot dry weights and root dry weights over time were taken to monitor the effects of containers on growth.

- root systems of seedlings were washed free of soil and photographed to show the effects of pot type and paint on their development.

- root growth potential testing in tanks was undertaken to investigate the development of root systems in the various pots.

- all pot and paint combinations were planted at double densities to allow excavation of seedlings over time to monitor root development.

- paint brands and rates of water and copper carbonate were investigated to note the effect on seedling growth and the effectiveness of root inhibition.

- the performance of a number of eucalyptus species and provenances raised in the Ropak 6 Multipot was monitored. Seedling measurements were taken prior to despatch to give an indication of relative growth rates.

Much of this work was carried out early in the project and a separate report presenting initial results is given in appendix 2.

4.1.1 Seedling container field experiments: Aspects such as container type (e.g. peat pot vs paper vs plastic), container volume, container diameter and depth and the role of root inhibiting paint were investigated. Field experiments were established over a range of soil types in 1988 and 1989.

In 1988 two experiments were established to test 5 container types and open rooted stock (Table 1) on two sites:

1. a deep sand (on the Swan Coastal Plain west of Yarloop) and
2. a lateritic gravel (Blackwood Valley east of Greenbushes).

Table 1

Stock and container types and container volumes used in the 1988 field experiments with *E. globulus*

Treatment Number	Container or Stock Type	Volume (ml)
1	Jiffy 515 Danish Peat Pot	22.5
2	Smith's 48 cell painted plastic	46.8
3	42 cell kwikpot painted plastic	92.0
4	Jiffy 522 Danish Peat Pot	102.0
5	Open Rooted Stock	n.a.

Note: Treatments 2 and 3 were coated in a copper carbonate impregnated paint applied by dipping the plastic tray into the paint mixture.

In 1989 4 experiments were established to test 9 container types (table 2) at four locations:

1. a deep white sand on the Swan Coastal Plain west of Yarloop,
2. a grey sand to 1m over coffee rock in the Unicup area 70km east of Manjimup,
3. a lateritic gravel north west of Manjimup and
4. a gravelly loam north of Pemberton.

Table 2

Container types and volumes used in the 1989 field experiments with *E. globulus*

Treatment Number	Container or Stock Type	Volume (ml)
1	NAP Jiffy 515 peat pot	22.5
2	Control Jiffy 515 peat pot	22.5
3	64 cell kwikpot painted plastic	45.0
4	42 cell kwikpot painted plastic	92.0
5	42 cell kwikpot unpainted plastic	92.0
6	Ropak 6 Multipot painted	98.0
7	Ropak 6 multipot unpainted	98.0
8	Lannen 149 cell Ecopot	103.0
9	QFD Tube	170.0

Note: 1. Painted pots were coated by dipping into copper carbonate impregnated paint.

2. "NAP Jiffy" refers to seedlings which were not top dressed until late in May. Seedlings were very small and of poor quality.

3. "Control Jiffy" refers to seedlings grown in the general production line. Trays with the largest seedlings were chosen for direct comparison with the small NAP Jiffy stock.

Seedlings were measured at various times after planting for total height and stem diameter at ten cm above the ground or at breast height (depending on age). Tree volume index was calculated assuming the stem volume approximates the volume of a cone with a base equal to stem diameter and height equal to stem height.

4.1.2 Results of Container Experiments

The survival of seedlings planted in each of the 1988 and 1989 experiments are presented in table 3 and table 4 respectively.

Table 3:

Mean survival% of *E. globulus* in 1988 pot experiments 25 months after planting, according to container type and planting site.

Treatment Number	Container Type	Volume (ml)	Planting Site 1	Planting Site 2
1	Jiffy 515	22.5	58^{b}	87^{b}
2	Smith 48 **P**	46.8	60^{b}	86^{b}
3	42 kwikpot **P**	92.0	72^{ab}	97^{a}
4	Jiffy 522	102.0	77^{ab}	90^{b}
5	WG7	215.0	88^{a}	91^{b}
6	Open Root	n.a.	59^{b}	92^{b}
Mean Survival %			69	90

Note: Treatments denoted with the same letter are not significantly different at the p = 0.05 level of probability. **P** denotes painted pot.

Table 4:

Mean survival of *E. globulus* in the 1989 pot experiments 14 months after planting, according to container type and planting site.

Treatment Number	Container Type	Volume (ml)	Planting Site Number 1	2	3	4
1	NAP Jiffy	22.5	41^{ab}	59^{bc}	97^{a}	89^{abc}
2	T T Jiffy	22.5	35^{b}	53^{c}	97^{a}	75^{c}
3	64 kwik **P**	45.0	70^{a}	81^{ab}	96^{a}	88^{abc}
4	42 kwik **P**	92.0	63^{ab}	71^{abc}	99^{a}	99^{a}
5	42 kwik **UP**	92.0	63^{ab}	70^{abc}	95^{a}	90^{abc}
6	Ropak 6 **P**	98.0	61^{ab}	80^{ab}	96^{a}	91^{abc}
7	Ropak 6 **UP**	98.0	75^{a}	84^{a}	99^{a}	93^{ab}
8	149 Ecopot	103.0	53^{ab}	83^{a}	93^{a}	94^{ab}
9	QFD	170.0	73^{a}	80^{ab}	98^{a}	95^{ab}
Mean Survival %			59	73	97	90

Note: 1. Treatments annotated with the same letter were not significantly different at the $p = 0.05$ level of probability.
2. **P** denotes painted pot and **UP** unpainted pot.

The trends in survival evident from the experiments to date are:

1. The lowest survival occurred on sandy sites which experience relatively low mean annual rainfall and probably greater soil moisture deficits during summer.

2. The seedlings with the lowest mean survival tended to be those grown in the small jiffy peat pot, with open rooted stock (1988) faring poorly on the sandy site. This trend was less pronounced on the gravelly sands and loams.

3. It appears that container size is important on dry sandy sites or sites where conditions for growth are harsh. This is supported by the 1988 result on the deep sand (site 1) where seedling survival improved with an increase in container volume. The other result to note is that on site 4 (1989), a highly fertile loam site in the "karri belt". Residual weed control was very poor, resulting in a lower overall survival and initial growth compared to site 3 and significantly poorer survival in one of the small peat pot lines (75% versus a trial mean of 90%).

The growth performance of seedlings planted in the 1988 experiments were not measured at the time of planting, however nursery measurements suggest that those grown in the WG7 container (treatment 5) were probably up to six times the seedling dry weight of the seedlings raised in the small jiffy peat pot. Table 5 shows the tree volume indices at age 25 months in relation to container type for sites 1 and 2 respectively.

Table 5:

Mean tree volume index (cm^3) of *E. globulus* in the 1988 pot experiments 25 months after planting, according to container/stock type and planting site.

Treatment Number	Container Type	Volume (ml)	Planting Site 1	Planting Site 2
1	Jiffy 515	22.5	3260^{a}	8955^{b}
2	Smith 48 **P**	46.8	615^{b}	9570^{ab}
3	42 kwikpot **P**	92.0	2210^{ab}	8930^{b}
4	Jiffy 522	102.0	2355^{ab}	7880^{b}
5	WG7	215.0	2340^{ab}	11230^{a}
6	Open Root	n.a.	3120^{a}	8880^{b}
Mean T.V.I.			2483	9241

Note: 1. Treatments annotated with the same letter were not significantly different at the $p = 0.05$ level of probability.
2. **P** denotes painted pot.

On the sandy site (site 1) at six and eleven months of age, trees raised in the large WG7 container were significantly larger than all the others, the nearest rival at age 11 months being the 102 ml jiffy peat pot (treatment 4) with an average t.v.i. 38% smaller than the WG7 trees.

Over the next fourteen months the trend changed as the site exerted some influence over tree growth. At 25 months of age (table 5) the two best treatments were the small jiffy peat pot and the open rooted stock, both significantly different to the Smith 48 cell painted pot but not significantly different from the others. These treatments also had poorer initial survival (table 3). The site factors contributing to this reversal of position for the WG7 container could include both water and nutrient availability. Nutrition was clearly limiting as signs of deficiency were observed.

On site 2, the lateritic gravel, the early dominance gained by trees in the 215 ml WG7 container was maintained through to 25 months of age.

At each measurement the WG7 trees have been significantly larger than all the others (except for the Smith 48 container at 25 months), as illustrated below:

Age (months)	Mean T.V.I. (cm^3) WG7	Others
6	38	14
11	680	365
25	11230	8843

Note: Others is the mean t.v.i. of the other five treatments.

In this case the trees appear to be healthy (pooled mean height growth of 5.75 m over the 26 month period) suggesting that site factors have not become limiting, possibly resulting in early growth advantages being maintained.

The growing, handling and planting of seedlings in the WG7 container is probably impractical for large scale operations. A more practical container is required.

The remaining containers in this experiment indicate no significant difference in t.v.i. after 11 and 26 months. It can be concluded that on this site there is no benefit in terms of growth rate in raising seedlings in anything other than the smallest container.

In the 1989 experiments seedlings planted on sites 3 and 4 were measured at the time of planting to give an indication of relative differences in seedling height and tree volume index (based on stem diameter at ground level) at that time.

Growth trends to date are similar in each of the four experiments. By way of illustration tree height and tree volume index (t.v.i.) results from site 3 (the lateritic gravel north west of Manjimup) are presented in Tables 6 and 7 respectively.

Table 6:

Mean tree height (m) of *E. globulus* planted on site 3 in 1989 pot experiments, according to container type and tree age.

Treatment Number	Container Type	Volume (ml)	Tree Age (months) 0	7	15
1	NAP Jiffy	22.5	0.08^{f}	0.49^{c}	1.24^{d}
2	T T Jiffy	22.5	0.22^{a}	0.71^{ab}	1.55^{ab}
3	64 kwik **P**	45.0	0.14^{e}	0.72^{ab}	1.53^{ab}
4	42 kwik **P**	92.0	0.21^{ab}	0.67^{b}	1.48^{b}
5	42 kwik **UP**	92.0	0.18^{c}	0.55^{c}	1.29^{cd}
6	Ropak 6 **P**	98.0	0.17^{cd}	0.66^{b}	1.48^{b}
7	Ropak 6 **UP**	98.0	0.20^{b}	0.67^{b}	1.40^{bc}
8	149 Ecopot	103.0	0.21^{ab}	0.70^{ab}	1.40^{bc}
9	QFD	170.0	0.16^{d}	0.77^{a}	1.66^{a}

Note: 1. Treatments annotated with the same letter were not significantly different at the p = 0.05 level of probability.

2. **P** denotes painted pot, **UP** denotes unpainted pot.

Table 7

Mean tree volume index (T.V.I.in cm^3) of *E. globulus* planted on site 3 in 1989 pot experiments according to container type and tree age.

Treatment Number	Container Type	Volume (ml)	Tree Age (months) 0	15
1	NAP Jiffy	22.5	0.06^{g}	315^{e}
2	T T Jiffy	22.5	0.46^{a}	556^{ab}
3	64 kwik **P**	45.0	0.20^{f}	517^{ab}
4	42 kwik **P**	92.0	0.35^{cd}	481^{bc}
5	42 kwik **UP**	92.0	0.28^{e}	338^{de}
6	Ropak 6 **P**	98.0	0.31^{de}	469^{bc}
7	Ropak 6 **UP**	98.0	0.38^{bc}	363^{cde}
8	149 Ecopot	103.0	0.41^{ab}	442^{bcd}
9	QFD	170.0	0.35^{cd}	636^{a}

Note: 1. Treatments annotated with the same letter were not significantly different at the p = 0.05 level of probability.

2. **P** denotes painted pot. **UP** denotes unpainted pot.

3. T.V.I. for seedlings at planting was based on the stem diameter at ground level as opposed to stem diameter at ten cm above the ground for the 15 month data.

At age 15 months the three best treatments (which were not significantly different at p = 0.05) were the QFD Tube (treatment 9), the "control jiffy" (treatment 2) and the 64 cell painted kwikpot (treatment 3). The worst performers were the "NAP jiffy" (treatment 1), the unpainted 42 cell kwikpot (treatment 5) and the Ropak 6 unpainted multipot (treatment 7).

Based on the results from each experiment the following trends are apparent:

1. The size of the seedlings (or the way they were grown) in the small jiffy peat pot has affected performance after planting. On the more favourable gravel sites (3 and 4) the "control jiffy" has performed best (on site 3 the "control jiffy" was seven times the t.v.i. of the "NAP jiffy" at the time of planting). However, on sites 1 and 2 (the deep sands) the "NAP jiffy" has performed better, suggesting that small seedlings may be better off on harsher sites than larger ones.

2. In all cases the unpainted 42 cell kwikpot performed worse than the painted pot. This may be due to root coiling which occurred in the unpainted pot or possibly that the painted root systems initiate more roots from the fibrous root system after planting.

3. The QFD tube was consistently the best performer on all sites. Root growth potential testing at the nursery (in controlled temperature aquaria) showed good root initiation from seedlings raised in the QFD tube.

4. The 64 cell painted kwikpot has performed at least as well as all other containers except for the QFD tube.

In comparison to the small jiffy pot, 64 kwikpot seedlings are cheaper to produce, nutrients are less readily leached and seedling quality is better. The 64 kwikpot also has advantages in the field since it readily fits the smaller potti-putki and does not require intensive plant separation prior to planting (a potential saving of up to fifteen dollars per hectare).

On the basis of these results the CALM nursery switched to the 64 painted kwikpot for eucalypt seedling production.

In the 1989 experiments tree identities were retained to enable analysis of individual tree growth over time. Correlation between seedling growth after planting and seedling size at the time of planting was very weak ($r^2 < 0.2$). However, when tree size (i.e. height, diameter, t.v.i.) at some time after establishment is regressed against subsequent growth, a trend is evident.

For example, the rate of height growth from age 8 months to 13 months on site 2 increased according to tree height at 8 months i.e. the bigger trees grew at a faster rate than smaller ones, although the relative percentage increase was similar, at around 82% ($r^2 = 0.58$, based on 742 trees). On site (4) the increase in tree volume index between nine and fourteen months was closely correlated with the tree volume index at nine months ($r^2 = 0.75$, based on 911 trees), again with a similar relative increase per tree of approximately 300%. This trend is likely to be true in other cases, providing all other factors (weed competition, nutrition) remain equal.

This suggests one of two things. Either the better start the trees have, the better off they will be in the future, and/or (2) the trend evident is due to genetic variation i.e. the superior trees grew best to start with and have maintained their superiority. Whatever the cause, it will be interesting to see just how long such a trend is maintained and how much, in wood production and dollar terms, it will be worth at the end of the rotation.

4.2 Site Preparation

Treatments tested included ripping (at various levels of intensity to a depth of 2m), scalping using the Chatfield Tree Planter, disc ploughing, and mounding with two offset discs.

The objective was to test the effect on yield. \Most of the trials have not been measured to date as they were designed to provide longer term information. One that has been measured was a comparison of mounding and scalping on sands on the Swan Coastal Plain.

Eight months after planting the mean survival of *E. globulus* was 98% on mounds and 87% on the scalped lines (significant at $p = 0.05$). The mean height of trees on mounds after eight months was 1.76m compared with 0.96m on the scalped lines (significant at $p = 0.0001$)

and after fourteen months the trees on the mounds had a mean height of 3.1m versus 1.8m on scalps. The mean tree volume index of trees on mounds after fourteen months was 3355 cm^3 versus 1110 cm^3 on scalps.

The benefit of mounding over scalping on nutritionally poor sands is probably due to the concentration of the organic A horizon within the mound, increasing mineralization and the availability of nutrients in the rooting zone. Rooting conditions within the mound are likely to be more favourable due to greater aeration and reduced soil compaction.

Perceived problems of non wetting sands and drying of exposed mounds on dry sites have not been evident to date, however they are probably very dependent on site characteristics and weather conditions following planting.

The most critical component in mounding is to ensure that live weeds are not buried within the mound since they can be protected from the knockdown and residual herbicides which are in currently use and can emerge vigorously later in the season. This problem is overcome by mounding before germination takes place or by spraying with a knockdown herbicide prior to mounding.

Further site preparation results came from multi-factor experiments. A "dry" sand dune on the Swan Coastal Plain was prepared in each of three ways i.e. disk plough only, scalp and mound. After eight months the trees on the mounds were 19% taller than those in the scalps and 25% taller than those planted into disced site. In two other trials mounding resulted in 16% taller trees after seven months on one site (compared with bulldozer ripping to 70 - 80cm), and 10% taller trees on another (compared with ploughing and ripping).

Another important factor is the need to at least shallow rip sands (to 40 - 50cm) prior to planting to increase the exploitable soil volume in the first six months before the onset of summer. It is possible that shallow ripping may improve soil moisture within the planting line and help overcome any non-wetting problems.

4.3 Weed Control

Several experiments designed to test particular weed control situations and chemicals were undertaken. These experiments addressed the following factors:

(1) the value of standard weed control measures

(2) the use of various combinations of knockdown and residual herbicides for pre-plant weed control

(3) the value of total weed control in the first year

(4) the value of second year weed control

(5) post-plant weed control using herbicides applied through a side delivery nozzle.

Factor (1) was investigated by comparing a knockdown/residual mix of 4l/ha Roundup (1.44 kg/ha glyphosate) and 10l/ha Gesatop (5 kg/ha simazine) against no weed control at all. The experiment was established on a weak, unimproved pasture dominated by flatweed (Hypochoeris sp.). After nine months the mean survival and mean tree height on the sprayed area was 98% and 1.14m respectively and that on the unsprayed area was 84% and 0.62m respectively. In this situation weed control resulted in an average increase in tree height of almost eighty five percent in the first nine months.

Factor (2) involved the comparison of various combinations of Roundup with Atrazine, Simazine and Oust. The standard mix currently used by CALM is 1-4 l/ha Roundup (depending on weed species and size) and 10 l/ha Gesatop. In most cases this rate proved to be best, resulting in 36% taller trees after six months compared with Gesatop at 3 l/ha and 6 l/ha on a lateritic gravelly loam east of Brunswick, and marginally better growth in comparison with 16 l/ha Gesatop and 16 l/ha Gesaprim on mounded, poorly drained sands in the Scott River country south of Nannup.

Encouraging results have also been obtained from Roundup/Oust mixtures. In two experiments established on a gravelly sandy loam and a gravelly loam in 1989, 2 l/ha Roundup with 50 g/ha Oust (750 g/kg sulfometuron methyl) produced results comparable to the standard Roundup/Gesatop mix, with a chemical cost saving of fifty five percent per hectare sprayed ($38/ha versus $86/ha).

The experiments showed that Oust checked the growth of *E. globulus* seedlings for at least the first six months after planting at rates of 100 g/ha and higher (i.e. on the gravelly sandy loam and gravelly loam sites assessed to date, the response on sands is not known). On one site the height of the trees planted in the 100 g/ha and 200 g/ha strips were thirty percent shorter than those in the 50 g/ha strips after eleven months (i.e. 116 cm versus 165 cm), and on the other site the trees in the 100 g/ha, 200 g/ha and 400 g/ha strips were 7%, 19% and 50% shorter respectively after ten months (i.e. 1.64m, 1.43m and 0.88m versus 1.76m). Further experiments were established on a broad range of sites in 1990.

A total weed control experiment was established in 1989 (factor 3). Blocks of standard herbicide treatment were compared against blocks in which weeds were controlled post-planting with Roundup which was applied manually with a shrouded hand lance. The standard treatment gave good control through the first spring. However, after nine months trees in the 100% blocks had a mean height twelve percent taller than the standard (i.e. 1.33m versus 1.18m, significant at p = 0.01) and after 14 months the height difference was thirteen percent (2.59m versus 2.29m) and the difference in tree volume index was seventy two percent (552 cm^3 versus 320 cm^3 based on stem diameter at 1.3m).

Second year weed control experiments were established in 1989 and 1990 (factor 4). The 1989 experiment was established in a stand which had very poor weed control in the first year and was overrun with kikuyu, sorrel and wild radish. Pairs of rows were selected for treatment ten months after planting and weeds were controlled with manually applied Roundup. Weed control was maintained and after a further ten months the trees in the weeded strips had increased their mean height by 244% compared with 157% in the unweeded strips (i.e. trees in the weeded strips grew from 0.94m to 3.23m and those in the unweeded strips grew from 1.04m to 2.67m). In this case ten months of weed control resulted in a 21% difference in mean height, a 31% difference in mean stem diameter at 1.3m and a 95% difference in tree volume index.

The benefits of post-planting weed control flowing into the second year are obviously large, especially if pre-planting weed control allows invasion of a more highly competitive weed spectrum. For example, wild radish, sorrel and dock will readily invade planting strips after the removal of other grass and weed competition. A technique to control such weeds was pursued in 1990 (factor 5) and involved the application of knockdown and residual herbicides through a side delivery nozzle. The aim was to develop an economic technique which can be safely used to improve poor weed control in the first year and to allow weed control in the second year if required.

Experimental results and field observations have shown that the most critical aspect of weed control is to ensure that herbicides are correctly mixed and applied according to recommended practice. It is especially important to have equipment which works properly, with adequate bypass or agitation for the application of highly viscous herbicides such as Simazine. Poor mixing and insufficient agitation will cause problems, with higher than expected rates output initially followed by lower than prescribed rates for the remainder of the tank mix. This results in very good weed control and poor survival in the early rows and poor weed control in the others (noted in at least five plantations established in 1989).

4.4 Nutrition

A number of fertilizer experiments were established in 1989 and 1990 to test various establishment fertilization options. Some early results are presented.

- Nitrogen + phosphorus Timing Experiment: This experiment looked at 2 types of fertilizer (50g DAP or 100g Agras Cu Zn Mo), applied in two forms (granules or tablet), at two different times (at the time of planting or three months after planting), plus a Langley Slow Release Tree Tablet applied at planting, plus a control (ie. 2x2x2 + 2 treatments).

A "karri loam" site south of Northcliffe was planted in June 1989 and received the second fertilizer application in September. Weed control was maintained using Roundup applied with a hand lance and the experiment was measured in January 1990.

There was no significant difference between fertilizer type or form seven months after planting. The only significant difference was due to the time of application. Trees fertilized at the time of planting were on average 34% taller than those fertilized three months after (i.e. 1.03m versus 0.77m). There was no difference between the late fertilized trees and the unfertilized trees.

A poorly drained loamy sand south of Nannup was mounded in April 1989, planted in July and received the second fertilizer application in October. Measurements in February 1990 showed that those fertilized in October were twelve percent taller than those fertilized at the time of planting (significant at $p = 0.05$), which in turn were not significantly different to the control.

The interesting exception was the slow release Langley Tree Tablet (applied at the time of planting), which resulted in the tallest trees; 23% taller than the control, 21% taller than the others fertilized at planting and 8% taller (though not significantly) than those fertilized in October. In an NxP factorial experiment on mounded sands on the Swan Coastal Plain (fertilized at planting), the slow release tablet again proved superior with trees 26% taller than the control and 23% taller than the mean of all other treatments after six months. Other than this, the results showed no significant differences between fertilizer type or form.

These results show that the timing of fertilization and the type of fertilizer applied in relation to site is critical. The drier loamier site responded best to fertilization at planting whereas the wet sandy site responded to fertilizer applied in Spring and to the slow release Langley Tree Tablet applied at planting. It may be that nutrients applied to wet sandy sites with poor nutrient holding capacity are lost before the seedlings are capable of exploiting them, hence the performance of the slow release tablet and spring fertilizer application. Further experiments were established in 1990 to clarify this situation.

- NxP Factorial Experiment: five experiments were established in 1989, mostly on sands, and four had the treatments 50g DAP, 100g Agras Cu Zn Mo and 60g Langley Tree Tablet included for comparison. Nitrogen was applied at 0, 10g, 20g and 30g per seedling and phosphorus at 0, 5g, 10g and 15g. All fertilizer was applied at the time of planting. A few trends are evident in measurements to date:

1. Tree seedlings responded positively to nitrogen, even in the absence of phosphorus, with an optimum rate of around 10g per seedling.

2. Tree seedlings responded more positively to phosphorus with an optimum rate of around 10g per seedling.

3. The best combination was 10g of phosphorus and 10 - 20g of nitrogen per seedling.

4. The combination of nitrogen and phosphorus at high rates (i.e. P10 + N30 and P15 + N20 or N30) was detrimental to growth on the wet sandy site. (Note that all fertilizer was applied in a single hole approximately 200mm from the seedling).

5. The only positive response from fertilization on the wet sand at planting was from the slow release tree tablet, mentioned previously. On "dry" sands (dunes) this was less obvious.

- DAP Rates Experiment: three sites were fertilized with 0g, 25g, 50g, 100g, and 200g of DAP per seedling. A deep white sand fertilized at planting showed a marginal but insignificant response to fertilizer, with an optimum rate of around 100g.

On the other two sites (gravelly sands) fertilizer was applied a month after planting. There was no significant difference between rates of DAP although the optimum rate was around 50g per seedling (based on seven month old trees) which represented a mean increase in height growth compared to the unfertilized trees of 18% on one site and 25% on the other. In both cases the 200g rate resulted in marginally smaller trees than the 50g rate.

In general terms, fertilizer experiments are very difficult to manage and interpret if weed control is inadequate. Weeds may invade an experiment in non-random patterns, confounding results. It is probably not worth fertilizing at planting if weed control is poor. Improvement in growth of young trees is probably best pursued through effective weed control as a first step, followed by fertilization.

4.5 Interaction between treatments

Multi-factor experiments combined all or some of the previous factors together. Four experiments were established in 1989 and 1990.

Results from seven and eight month old trees in the 1989 experiments showed the following:

1. The most important factor in establishing eucalypts on ex-pasture is site preparation in conjunction with weed control. The next most important factor is seedling container type (particularly on sands) followed by fertilizer (probably due to nutrient build up from previous pasture production), although both result in marginal benefits relative to site preparation and weed control.

   On recently cleared sites and sites which are depleted of nutrients as the trees develop, fertilizer is likely to be very much more important. Field examples comparing early growth on ex-pasture with that on "ex-bush" sites have been outstanding. On one property inspected in July 1990, twelve month old trees on ex-pasture were estimated to be at least four times the height of those on ex-bush.

2. There was no significant interaction between factors and it appears that the benefits of each are additive, although more work is required to confirm this.

5. Silvicultural Management

5.1 Planting density

Density experiments were established to investigate the effect of initial stocking density and planting spacing on the long term productivity of *E. globulus* plantations established on a range of sites in the south west.

Particular regard will be paid to:

1. Time taken to reach crown closure and full site occupancy. This will impact on shading of weeds and grasses and reduce competition for water and nutrients.

2. The influence of stocking density on biomass allocation over time. For example, growth of branchwood as opposed to bole wood.

3. Total bole wood production in relation to commercial bole wood production (incorporating piece size).

4. Total (commercial) bole wood production in relation to stocking density, spacing and site.

Four experiments based on the Plaid design (Chuang-Sheng and Morse, 1975) were established on a range of sites in 1989.

The stocking densities considered were based on the following combinations of row and tree spacing:

STOCKING DENSITY

		Row Spacing			
		1m	2m	3m	4m
Tree Spacing	1m	10 000	5 000	3 333	2 500
	2m	5 000	2 500	1 667	1 250
	3m	3 333	1 667	1 111	833
	4m	2 500	1 250	833	625

Blocks of each density were laid out systematically, each represented four times (ie. four replicates) by a plot of 25 trees (i.e. 5 x 5) buffered by a single row around the edge.

Coupled with the relationship between stocking density, spacing, bole wood production and site quality is an uncertainty of the capacity of plantations to survive in the low rainfall areas (i.e. below 700 mm mean annual rainfall).

Deaths ranging from individual trees to groups of trees have been noted in the Wellington catchment planting over the past few years. *E. globulus* plantations are currently established at 830 stems per hectare (4m x 3m) in this area.

Block density experiments (from 500 sph to 1250 sph) have been established to investigate whether this density is adequate for the production of pulpwood and whether higher densities will predispose plantations to drought on some sites.

6.2 Species and Provenance Selection

Over the past two years, nine formal species/provenance trials have been established on a range of sites. The species planted are as follows:

E. botryoides - 4 provenances
E. botryoides x E. saligna
E. brookerana
E. globulus ssp. bicostata
E. globulus ssp. globulus
E. grandis
E. saligna - 4 provenances
E. viminalis - 4 provenances

Informal additions to this list have also been planted as an integral part of the project's demonstration commitment.
Major ones include:

Agonis flexuosa
E. calophylla - 2 provenances
E. camaldulensis (includes clonal material)
E. cladocalyx
E. diversicolor
E. maculata
E. marginata
E. patens
E. talyuberlup

All plantings will be monitored over time to provide the following information:

1. Relative growth performance (yield) of different species and provenances on a range of sites.

2. Relative tolerance to drought, waterlogging, salt, insect grazing and pathogens. The effectiveness of tree species to impact on ground water levels to reduce waterlogging and salinity may also be determined.

3. Relative value in terms of wood quality (for example, basic density, pulp yields, sawn timber quality etc).

4. The value of the species in terms of wind break suitability, wind firmness, amenity planting, honey production, branch shedding etc.

Species mixtures in demonstration planting have been actively pursued throughout the project. Some plantings combined eucalypts with acacias, targeting nitrogen fixation benefits, particularly on sands. Other areas were planted with eucalypts only, targetting mutual benefits from species mixtures.

The most substantial area of mixed species planting is a fifteen hectare plantation of *E. diversicolor* (karri) and *E. globulus* (Tasmanian bluegum) in the "karri belt" south of Manjimup.

The idea is to put karri under strong competition from the faster growing bluegum. The aim is to force the growth of a long, clean, branch free bole to maximize the production of high quality sawlogs from the karri, whilst gaining interim yields of pulpwood from bluegum and karri thinnings.

Karri and bluegum were planted together to create three levels of competition for karri (at 3m x 2m spacing):

1. Two rows of karri followed by a row of bluegum ie. competition on one side only.

2. A row of karri and then a row of bluegum ie. competition on two sides.

3. A row of bluegum followed by a row of mixed (one bluegum and then two karri), followed by another row of bluegum ie. competition on three sides.

A pure stand of karri was planted to allow comparison with the above three mixtures.

6. Future Research

6.1 Existing Experiments

Five experiments were established in 1988, followed by fifty nine in 1989 and forty in 1990 (see appendix 1). Many of the 1990 experiments were logical progressions based on preliminary results from the 1988 and 1989 experiments.

The results from these will not come on stream until 1991 and many have been designed to provide long term yield data. This information will, for the first time, provide managers (and investors) with some cold, hard facts about the return on their establishment and management dollar.

These experiments will be monitored over time and results will be disseminated to the "industry" as they become available.

6.2 Continuing Research

The work undertaken to date lays a small foundation for the future of eucalypt plantation silviculture on farmland. Continued research is essential and will be guided by the results obtained to date and by problems arising in established plantations.

As shown above, there are very big gains in getting trees off to a good start. A important component of this is weed control in the first two years up to crown closure. More research into weed control at planting and post-planting is required. Due to the vast range of sites being planted, weed control must be tailored to suit the site and the target weed species.

Improved establishment techniques are also required on the "dry" sands which are frequently offered for planting and are a prime source of nutrient leaching, causing eutrophication problems in nearby estuaries and wetlands. The growth of trees which do survive on such sites can also be very poor.

Management of established plantations is now also becoming a priority, with many stands showing nutritional deficiencies six to eight months after planting. Although plantations are programmed for fertilization, the types and amounts of fertilizer which should be applied when and for what benefit is unknown. A research programme addressing these issues must be initiated quickly.

The NAP project team has been active in making collections of insect species causing damage to eucalypts. Sixteen insect species which have been observed causing some degree of damage in Western Australia to date. Eleven of these are considered to cause damage of economic importance and their prevalence appears to be increasing each year.

Insect pests have great potential to adversely affect the economic viability of eucalypt plantations on farmland. This is especially so for tree species planted outside their natural range, where the stresses of the adopted environment, may predispose trees to insect attack.

Greater understanding of the limits of tree species in relation to site and their predisposition to insect attack is required, along with an appreciation of the impact of insects on the productivity of plantations. Insect control through silvicultural, managerial and chemical methods is also required if the long term viability of eucalypts as a crop is to be sustained.

Another agent causing recent concern is a root rot fungus (Fusarium sp. and Verticillium sp.) which has resulted in scattered deaths in one year old trees over a three hundred hectare property in the south west. Although not confirmed, it is possibly in other plantations as well. Again, investigation into causal factors and the control of such agents is required.

The tree planting momentum on farmland must be maintained and will only prosper with continued strong research support into establishment and on-going management and additional work into disease and pest control.

7. Specifications For Operations

The NAP Project team contributed to a comprehensive review of plantation establishment by CALM during 1988/89. The NAP team prepared a formal silviculture prescription for the establishment of eucalypt plantations on farmland (appendix 3). This prescription incorporated the results of NAP research.

Quality control standards by which to evaluate establishment performance were also specified (appendix 4)

Appendix 1 - EXPERIMENTS ESTABLISHED UNDER NAP FUNDING

.0 Multi Factor
lanted 1989
- **1.1 Lindberg (Augusta)**
- **1.2 Eckersley (Brunswick)**
- **1.3 Green (Margaret River)**
- **1.4 Odea (Albany)**

lanted 1990
- **1.5 Metcalf (Albany)**
- 1.6 Bombara (Yarloop)
  - **1.6.1 Fert x Prep**
  - **1.6.2 Pot x Fert x Timing**
- **1.7 Johnson (Unicup)**

.0 Spacing/Density Trials
- 2.1 Plaid Density
  Planted 1989
  - **2.1.1 Bombara (Yarloop)**
  - **2.1.2 Bamess (Pemberton)**
  - **2.1.3 Hartridge (Scott River)**
- 2.2 Block Density
  Planted 1989
  - **2.2.1 Wunnunberg (Darkan)**
  - **2.2.2 Gardner (Mumballup)**
  - **2.2.3 WAWA - Mulcahy (Rocky Gully)**
  - **2.2.4 Howard (Albany)**

  Planted 1990
  - **2.2.5 Metcalf (Albany)**
  - **2.2.6 Johnson (Unicup)**
  - **2.2.7 WAWA - Rajander Rd (Darkan)**
  - **2.2.8 Black (Coolup)**

0 Species Mixtures
- 3.1 Species/Provenance
  Planted 1989
  - **3.1.1 WAWA - Wunnunberg (Rocky Gully)**
  - **3.1.2 Hartridge (Scott River)**
  - **3.1.3 Jenkins (Denbarker)**

  Planted 1990
  - **3.1.4 Russell (Albany)**
  - **3.1.5 Campbell (Narrikup)**
  - **3.1.6 Metcalf (Albany)**
  - **3.1.7 Nancarron (Coolup)**
  - **3.1.8 Boobyer (Coolup)**
  - **3.1.9 Madden (Albany)**
- 3.2 Acacia Trial
  Planted 1988
  - **3.2.1 Ayers (Greenbushes)**
  - **3.2.2 Fitzpatrick (Mundijong)**

  Planted 1990
  - **3.2.3 Turnball (Darkan)**
  - **3.2.4 WAWA - Rajander Rd (Wellington)**
- 3.3 Acacia/Globulus
  Planted 1990
  - **3.3.1 Boobyer (Peel)**
  - **3.3.2 Turnball (Darkan)**

3.4 Karri/Globulus
Planted 1989
3.4.1 Ex Ag. Dept (Middlesex)
3.5 Camaldulensis Clones
Planted 1990
3.5.1 Lubcke (Darkan)
3.5.2 Forbes (Bowelling)
3.5.3 Jefferies and Pritchard (Darkan)
3.5.4 Stapleton (Mobrup)
3.5.5 Morgan (Dingup)
3.6 Species/Water Use
Planted 1989
3.6.1 WAWA - Wunnerbergs (Wellington)
3.6.2 Treasure/Henning (Harvey)
3.6.3 Ex Ag. Dept. (Middlesex)

4.0 Pot and Paint Trials
4.1 Planted 1988
4.1.1 Eckersley (Harvey)
4.1.2 Ayers (Greenbushes)
4.2 Planted 1989
4.2.1 Bombara (Yarloop)
4.2.2 Bamess (Pemberton)
4.2.3 Johnson (Unicup)
4.2.4 Dinnis (Manjimup)
4.2.5 Howard (Albany)

5.0 Herbicide Trials (Weed Control)
5.1 Pre Plant Knockdown/Residual
5.1.1 Simazine and Atrazine Rates
Planted 1989
5.1.1.1 Hartridge (Scott River)
5.1.1.2 Ian Eckersley (Brunswick)
5.1.2 Cooch Control
Planted 1989
5.1.2.1 Kentish (Jarrahdale)
5.1.3 Dock Control
Planted 1989
5.1.3.1 Lindberg (Augusta)
5.1.3.2 Jenkins (Denbarker)
5.1.4 Roundup/Oust Trials
5.1.4.1 Planted 1989
5.1.4.1.1 Dinnis (Manjimup)
5.1.4.1.2 Bamess (Pemberton)
5.1.4.1.3 Bombara (Harvey)
5.1.4.2 Planted 1990
5.1.4.2.1 Madden (Albany)
5.1.4.2.2 Campbell (Narrikup)
5.1.4.2.3 Metcalf (Albany)
5.1.4.2.4 Johnson (Unicup)
5.1.4.2.4.1 Unicup 1 - riplines
5.1.4.2.4.2 Unicup 1 - mound
5.1.4.2.4.3 Unicup 2 - riplines
5.1.4.2.4.4 Unicup 2 - mound
5.1.4.2.5 Bombara (Harvey)
5.1.4.2.6 Bamess (Pemberton) - mounds
5.1.4.2.7 Lindberg (Augusta) - mounds

5.1.5 Spray vs No Spray
Planted 1989
5.1.5.1 Dinnis (Manjimup)

5.2 Post Plant Weed Control

5.2.1 Manual Control
Planted 1989
5.2.1.1 Peos (Manjimup)
5.2.1.2 Graham (Pemberton)
5.2.1.3 Johnson (Unicup)

5.2.2 Side Delivery - Bike
Planted 1989
5.2.2.1 Dinnis (Manjimup)
5.2.2.2 Lindberg (Augusta)
5.2.2.3 Bombara (Harvey)
5.2.2.4 Bamess (Pemberton)
5.2.2.5 Johnson (Unicup)

5.3 Lead Times and Rates
Planted 1989
5.3.1 Dinnis (Manjimup)

.0 Site Preparation Trials
Planted 1989
6.1 Eckersley (Brunswick)
6.2 Johnson (Manjimup)
6.3 WAWA Wunnunbergs (Wellington Catchment)
6.4 Treasure/Henning (Harvey)
6.5 Kentish (Serpentine)
Planted 1990
6.5 Campbell (Narrikup)
6.6 Lubcke (Darkan)

0 Fertiliser Trials

7.1 N P Factorials + DAP, Agras & Tree Tablet
Planted 1989
7.1.1 Bombara (Harvey)
7.1.1.1 Gavin sand
7.1.1.2 Joel sand
7.1.2 Nazaroff (Augusta)
7.1.3 Sepkus (Northcliffe)

7.2 Straight N P Factorial
Planted 1989
7.2.1 Dinis (Manjimup)

7.3 Liming on Acid Sands
Planted 1989
7.3.1 Lindberg (Augusta)
7.3.2 Bombara (Harvey)

7.4 DAP, Agras, Tree Tablet, Timing Trial
Planted 1989
7.4.1 Flanagans (Northcliffe)
7.4.1.1 Karri Loam
7.4.1.2 Grey Sand.
7.4.2 Hartridge (Augusta)

- 7.5 DAP, Agras, NPK Rates
  - Planted 1989
    - **7.5.1 Howard (Albany)**
    - 7.5.2 Ball (Albany)
      - **7.5.2.1 Front Plot**
      - **7.5.2.2 Back Plot**
    - **7.5.3 Holmes a Court (Rocky Gully)**
    - **7.5.4 WAWA Mulcahy (Rocky Gully)**
  - Planted 1990
    - 7.5.5 Campbell (Narrikup)
      - **7.5.5.1 Riplines**
      - **7.5.5.2 Mounds**
    - **7.5.6 Metcalf (Albany)**
    - **7.5.7 Johnson (Unicup)**
    - **7.5.8 Madden (Albany)**
- 7.6 Special
  - Planted 1989
    - **7.6.1 Placement - Bombara (Harvey)**

8.0 Miscellaneous

- Planted 1988
  - **8.1 Reference Seedling Trial**
  - **8.2 Ayres - Grazing Trial (Greenbushes)**
  - 8.3 Peel Hardpan Investigation
    - **8.3.1 Blasting**
    - **8.3.2 Trench Digging**
- Planted 1989
  - **8.4 Davies - Black Beetle Control**
  - **8.5 Dinis - Double Density Pots**
  - **8.6 Peos - Simagranz for Weed Control**
- Planted 1990
  - **8.7 Bombara Seedling Topping Trial**
  - **8.8 Johnson QFD Root Damage Trial**

Appendix 2: Discussion of Initial Nursery Results

Observations and measurements in1988/89 by Gordon Baird and Gavin Ellis, October 1989.

ROOT INHIBITING PAINT

Paint was applied to the pots by dipping them into a large tub until all of the cavities filled.

Gaydec paint resulted in good inhibition at levels of 200g and 240g of Cu CO_3. Copper carbonate levels of 120g and 160g were not successful in inhibiting roots and further investigation of levels around 180g would probably be of academic interest only.

Raffles paint was found to be unsuitable as a root inhibiting paint. Even at the highest levels of $CuCO_3$, the root systems appeared the same as the unpainted control.

Successful painting prevented root coiling by terminating roots at the side of the container. Painted pots result in a high density of short roots compared to the unpainted pots, as seen in the washed out root systems.

Root inhibiting paint had no uniform effect on the shoot:root ratio, suggesting that the paint affects the shape of the root system without a reduction in the weight of the roots.

However, the paint appeared to have some effect on seedling vigour in at least the *E. diversicolor* seedlings raised in 42 cell kwikpots. The higher rates of $CuCO_3$ in the root inhibiting paint produced taller seedlings.

Half painting of pots was attempted to try and speed up the dipping process for the production of operational seedlings. Root coiling and balling normally occurs at the base of unpainted kwikpots and half dipping was a good compromise.
Half dipped seedlings were tested in tanks and in field trials.

SOIL MIXTURE PROBLEMS

In April and early May, 1989 seedlings appeared to be very uneven. Some trays were consistently taller than others which suggested a problem with the soil mixing. An investigation was carried out to find the source of this variation.

Two trays were selected from the Kwikpot 42 painted and liquid fed treatment, one with a large average seedling height and one with a small average seedling height (see table 1). The number of Osmocote capsules in each cavity in the small tray was counted by separating the soil from the roots. This was compared to the height of the seedling from that cavity. For each tray the total number of Osmocote capsules was compared.

An adjustment was made for the size of the Osmocote capsule. Larger capsules were given a value of two, or counted twice. This scale is referred to as the "osmorating", and was calculated for each tray (table 1).

Table 1 The effect of Osmocote on the evenness of *E. globulus* seedling growth in trays.

Seedling Size	MEAN HEIGHT (mm)	TOTAL # OSMOCOTE CAPSULES	OSMORATING
small	60.71	75	101
large	102.36	78	96

Correlation between the number of capsules and the size of the seedling was poor (data not presented). However, it was concluded that the number of Osmocote capsules was not responsible for the unevenness found between the trays. Osmocote capsules appeared to be evenly distributed throughout the mixture.

In addition to the Osmocote capsules, three types of granular fertiliser are added to the soil mixture before loading the trays. They are; Superphosphate, Isobutylidene diurea, and Magamp-Plus K. They are not crushed up, and any of them could be responsible for the variation in size between the trays. Trace elements are also added to the soil in an unknown form. Soil moisture content at the time of mixing may bind trace elements before they have been evenly mixed.

It is possible that the mixing process is not sufficient for the variety of components added to the soil mixture. Further investigation is required.

LIQUID FEEDING TRIALS

Liquid feeding of *E. globulus* and *E. diversicolor* was carried out according to the procedure recommended by Day (1989). The mixture was applied daily through a small boom spray on the nursery tractor.

Liquid feeding was stopped after forty days due to severe burning and deformation of leaves, probably from a build up of salts in the peat/vermiculite growing medium.

This problem may have been caused by a variety of factors. The Ropak-6 pots do not absorb water very freely due to the surface area of the cavity top. The peat/vermiculite medium does not wet up easily, creating a situation where the pot does not drain. When the solution is lost to evapotranspiration, salts may be left behind, resulting in an increase in the concentration of the solution with further liquid feeding. When using the liquid feed regime it is important that excess salts are leached through the pot. A better draining medium may be required.

The mixture also resulted in burning of *E. diversicolor* grown in the 42 cell kwikpot with the standard soil mix suggesting that the problem with the procedure may be the feeding regime itself. Greater fine tuning of the concentrations of nutrients for eucalypts is necessary.

MEASUREMENT OF POT AND PAINT SEEDLINGS

Seedlings raised in the nursery for the pot and paint experiments were measured over time to monitor their development in relation to their container and cultural treatment. At each measurement seedling height and shoot and root dry weights were measured.

Method

The shoots of between 8 and 14 average sized seedlings were cut at soil level and dried in an oven at 105 ^{o}C overnight. The roots were carefully washed from the potting mixture and dried also. The Jiffy 72 pots required special care to remove roots from the walls of the peat pot. Samples were then weighed and the ratio between the shoot and root calculated for each treatment. These are presented in the tables on the following pages.

Ratio of shoot : root

Shoot:root ratio trends apparent after the first measurement became less obvious as time went on. By the third measurement the trends had reversed in many cases, although some general trends were apparent. At the third measurement the 72 cell jiffy peat pot resulted in shoot root ratios favouring the tops by around .5 : 1 - 4.5 : 1. The 64 cell painted kwikpot had the next highest ratio at around 2.7 : 1 probably due to a reduction in root weight. All other pots had ratios of 2:1 or similar.

Measurement 1 - 27th April 1989.

POT TYPE	TREATMENT VARIABLE	AGE days	MEAN HEIGHT (mm) n=100	C.V. %	MEAN TOTAL WEIGHT (g)	SHOOT WEIGHT (g)	ROOT WEIGHT (g)	SHOOT ROOT RATIO n=8
72 Jiffy	Mainline	103	215	-	1.49	0.73	0.76	0.96
72 Jiffy	No Top Dress	65	67	29	-	-	-	-
72 Jiffy	Top Dress IBDU	65	62	37	-	-	-	-
64 Kwik	Unfed 240g $CuCO_3$	64	121	20	0.73	0.40	0.33	1.21
64 Kwik	Liquid Fed 240g $CuCO_3$	64	126	21	0.79	0.34	0.45	0.76
42 Kwik	Unpainted	57	108	19	0.50	0.33	0.17	1.94
42 Kwik	200g $CuCO_3$	57	114	17	0.57	0.37	0.20	1.85
Ropak 6	Unpainted	50	92	31	0.39	0.24	0.15	1.60
Ropak 6	200g $CuCO_3$	50	84	39	0.31	0.20	0.11	1.82
Ropak 6	P/V Liq Fed	42	33	36	-	-	-	-
Q.F.D	Stand Mix	44	42	36	0.07	0.05	0.02	2.50

MEASUREMENT 2 - 16th May 1989.

POT TYPE	TREATMENT VARIABLE	AGE days	MEAN HEIGHT (mm) n=100	C.V. %	MEAN TOTAL WEIGHT (g)	SHOOT WEIGHT (g)	ROOT WEIGHT (g)	SHOOT ROOT RATIO n=8
72 Jiffy	Mainline	122	296*	17	1.61	1.32	0.29	4.55
72 Jiffy	No Top Dress	84	80	28	0.40	0.32	0.08	4.00
72 Jiffy	Top Dress IBDU	84	115	38	0.60	0.49	0.11	4.45
64 Kwik	Unfed 240g $CuCO_3$	83	145	22	-	-	-	-
64 Kwik	Liquid Fed 240g $CuCO_3$	83	131	21	0.61	0.42	0.19	2.16
42 Kwik	Unpainted	76	146	23	1.15	0.70	0.45	1.50
42 Kwik	200g $CuCO_3$	76	146	16	1.15	0.70	0.45	1.56
Ropak 6	Unpainted	69	115	35	0.72	0.46	0.26	1.71
Ropak 6	200g $CuCO_3$	69	135	27	0.83	0.56	0.27	2.10
Ropak 6	P/V Liq Fed	61	58	33	0.14	0.09	0.05	1.70
Q.F.D	Stand Mix	63	86	33	0.50	0.31	0.19	1.59

* n=8

MEASUREMENT 3 - 17th June 1989.

POT TYPE	TREATMENT VARIABLE	AGE days	MEAN HEIGHT (mm) n=50-139	C.V. %	MEAN TOTAL WEIGHT (g)	SHOOT WEIGHT (g)	ROOT WEIGHT (g)	SHOOT ROOT RATIO n=8-14
72 Jiffy	Mainline	154	205	30	1.02	0.81	0.21	3.86
72 Jiffy	Top Dress NPK Late	116	123	26	0.61	0.50	0.11	4.55
72 Jiffy	Top Dress IBDU	116	232	26	1.03	0.80	0.23	3.48
64 Kwik	Unfed 240g $CuCO_3$	115	184	26	1.67	1.22	0.45	2.71
42 Kwik	Unpainted	108	227	24	1.54	0.95	0.59	1.61
42 Kwik	200g $CuCO_3$	108	228	20	1.65	1.11	0.54	2.06
42 Kwik	P/V Liq Fed	93	140	24	0.89	0.65	0.24	2.71
42 Kwik	P/V Liq Fed + IBDU	93	160	24	1.80	1.16	0.64	1.81
Ropak 6	Unpainted	101	164	28	1.74	1.14	0.60	1.90
Ropak 6	200g $CuCO_3$	101	230	20	2.48	1.46	1.02	1.43
Ropak 6	P/V Liq Fed	93	122	22	1.05	0.69	0.36	1.92
Ropak 6	P/V Liq Fed + IBDU	93	125	27	1.53	1.00	0.53	1.89
149 Eco	Stand Mix	87	288	20	2.99	1.96	1.03	1.90
[illegible].F.D	Stand Mix	95	125	23	2.06	1.36	0.70	1.94

ROOT SYSTEMS and MANAGEABILITY
The root systems of the various pots will be discussed individually below. A set of photographs of washed out root systems was taken as a permanent record of the root systems developed in each container.

Jiffy 72:
Largest number of seedlings per unit area.
Heavy root binding within trays, especially around the edges.
Extraction and separation of jiffy pots is a slow and cumbersome task, one which must be done prior to machine planting and costing up to fifteen dollars per hectare more to plant than the 64 kwikpot. In some cases, jiffy potted stock may be separated and exposed for a number of hours before being planted, resulting in unnecessary stress.
It is thought that there is a possible wick effect under dry conditions where the peat dries and shrinks, restricting the development of roots. Evidence of this was seen in a number of excavated samples.

64 Cell Kwikpot
Occasional teasing required in painted pots where roots had grown out of the drain hole at the bottom. In some cases there the paint from the bottom of the pot came away with the base of the roots.
Seedlings are lightweight, very easy to plug and are the easiest of all the types tested to handle and plant. The kwikpot insert fits into the black holding tray tightly, resulting in fewer losses during rough transport.

42 Cell Kwikpot
Pots are removed from trays easily. In unpainted pots root coiling was strong, and base of pot needed to be teased prior to planting.
The rim around the base of the pot attracted a coil of roots, even in some of the painted pots - this is potentially the biggest problem with unpainted pots of this sort.
The Kwikpot 42 only just fitted down the standard potti-putki and in some cases the root ball required a gentle squeeze to allow it to fit.

Ropak 6 Multipot
Good root training and air pruning. Pot is a good depth for the age of seedling grown in it in this case.
Seedlings are difficult to extract from the tray and a special extraction board was made to make the job easier. Seedlings were the second most difficult to hand plant (compared to the QFD) due to the size shape and weight of the root system.
The small area at top of the cavity seems to reduce their ability to absorb water.

149 cell Ecopot
The tray is too heavy for safe handling when full.
Good root inhibition from the paper dividers. Root shape appeared good with the corners of the paper pot acting as root trainers. The wide opening at the bottom of the container did not direct roots inwards to a single smaller hole as is the case with the QFD tube and, to a lesser extent, the Ropak 6 multipot.
Seedlings were too close together, making them susceptible to *Botrytis* fungus.

Queensland Forest's Department Tubes

Root trainers work well, with air pruning of the roots at the base of the pot. There was some evidence of roots growing around the container wall (to a small degree) past the root training lines which are rounded, as opposed to the sharp edged ones in the Ropak 6 container.

The pot was too deep for the seedlings after the growing time allowed in this case. After plugging the seedling it tends to break in two as the tap root loses dominance halfway down the pot and when planting, it tends to fold up at the bottom of the potti-putki. After a further period of time the seedling's roots grew into and filled the container nicely.

The foam trays are heavy and difficult to handle and the seedlings are difficult to plug (requiring squeezing of the tube and tapping upside down to get them out). Planting is also cumbersome and slow with the QFD seedlings.

SEEDLING HEIGHT

The tallest seedlings were the glasshouse boosted Ecopots. The larger pots and lines boosted early with IBDU were also tall. All lines were found to be acceptable for hand or machine planting. The smallest seedlings were those in the 72 cell jiffy peat pot which were not top dressed until very late with NPK Red (ie. NAP Jiffy).

SEEDLING HARDNESS

Seedling hardness was important as rough treatment and frosts caused deaths at some sites. Late top-dressing with IBDU or NPK was responsible for soft seedlings, but was necessary to boost seedling size before planting due to late sowing times. *Botrytis* was more common in the soft seedlings.

ROOT TANK TESTING

Root tank testing was initiated by Gordon Baird in September 1989. Tank testing was designed to provide some early data on the root development in each of the containers tested, complementing field plantings of similar seedlings.

SPECIES PROVENANCE MEASUREMENTS

The heights of the seedlings grown for species/provenance experiments in 1989 were measured prior to despatch. Heights are presented below, along with seedling ages and coefficients of variation (c.v.).

POT TYPE	SPECIES	AGE (days)	MEAN HEIGHT (mm) (n)	c.v. (%)
Ropak-6	*saligna* 15261	113	310 (75)	21
Ropak-6	*saligna* 15232	113	245 (75)	25
Ropak-6	*saligna* 13336	113	235 (75)	26
Ropak-6	*saligna* 13522	113	110 (75)	44
Ropak-6	*botryoides* 15529	110	325 (75)	22
Ropak-6	*botryoides* 16027	110	320 (75)	27
Ropak-6	*botryoides* 15303	110	316 (75)	21
Ropak-6	*botryoides x saligna* 15948	110	318 (75)	24
Ropak-6	*viminalis* 17217	110	264 (75)	23
Ropak-6	*viminalis* 16346	110	193 (74)	32
Ropak-6	*viminalis* 12885	110	163 (75)	30
Ropak-6	*viminalis* 17357	no data available		
Ropak-6	*grandis* D1198	109	145 (75)	38
Ropak-6	*brookerana* 15014	109	250 (75)	22
Ropak-6	*bicostata* K88	109	165 (74)	23
Ropak-6	*maculata* K78	109	81 (75)	34
Ropak-6	*calophylla*	109	192 (76)	23
Ropak-6	*diversicolor* K15	109	163 (50)	28
Kwik 42	*diversicolor* K17	114	188 (103)	31
Kwik 42	*globulus* K159	102	226 (99)	20

Appendix 3: Prescription for Operations

DEPARTMENT OF CONSERVATION
AND LAND MANAGEMENT

SILVICULTURE SPECIFICATION 4/90

ESTABLISHMENT OF EUCALYPT PLANTATIONS

CONTENTS

1.0 SITE ASSESSMENT

In order to determine the appropriate level of site preparation and weed control required for the establishment of eucalypt plantations, the following features of a site need to be noted during the reconnaissance:

- soil texture and colour;

- depth of soil to rock, hardpan or clay;

- areas prone to inundation (e.g. flats, low-lying depressions, mid-slope seeps) requiring mounding;

- predominant weeds and grasses to be controlled.

The reconnaissance is best done with the farmer or other persons who have a detailed knowledge of the land.

In cases where major soil textural changes are evident (e.g. grey sandy pockets running into karri loams), or where soil depth is variable around 50 cm, a detailed soil survey is required.

The decision to soil-survey all or part of a property rests with the plantation establishment officer in charge of the planting. Soil surveys are to follow the same procedures as those for softwood establishment, with the addition of noting major weeds and grasses at each sample point.

Properties are to be soil-surveyed in the period from October to December, when soils are moist enough to be penetrated by a soil auger. This also allows sufficient lead time for site preparation and weed control.

The details of the soil survey and classification of its results will be the subject of a separate specification.

2.0 SITES TO AVOID

The following areas should not be broadscale planted:

- steep land where slopes are greater than 10 degrees;

- Gavin sand dunes on the Swan Coastal Plain, especially former bush sites;

- swamps and lakes on the Swan Coastal Plain and the Southern Coastal Plain, which should not be drained for wildlife conservation reasons;

- areas of native vegetation which are not degraded. These are defined as being at least 4 hectares in size and where at least 50% of the plant species that would occur in the natural condition are still present.

Clearing of such native vegetation on private land will also need to conform to guidelines currently being prepared by the Commissioner of Soil Conservation.

On gazetted water catchments, a licence to remove any trees must be obtained from the Water Authority before clearing can take place.

3.0 SPACING/STOCKING DENSITY FOR *E.GLOBULUS* PLANTATIONS

Annual Rainfall	Stocking spha	Spacing (m)
<750mm	830	4x3
750-1000mm	1000	4x2.5
>1000mm	1250	4x2
>1000mm (karri loams)	1666	3x2

For areas to be mounded with the Savannah Bedding Plough the spacing between rows may be varied alternately from 3 m apart to 5 m apart to allow machinery access. Spacing between seedlings should remain as listed in the table above.

4.0 SITE PREPARATION

4.1 Ex-Pasture

Deep Ripping (80 cm)

The aim is to fracture clay or hardpan in the dry summer months to allow root penetration and infiltration of water to depth and to increase the exploitable soil volume.

Deep ripping should be carried out on sites where clay or hardpan layer is within 50 cm of the surface of the soil. A winged tyne is required for this operation.

Boulders brought to the surface during this operation are to be pushed into heaps to improve access for subsequent operations.

Shallow Ripping (30-40 cm)

The aim is to break up compacted topsoil in preparation for planting. Shallow ripping is to be carried out on *all* ex-pasture sites except those to be cultivated and mounded or deep ripped.

Rip lines will also mark out planting lines to be sprayed with herbicide.

Shallow ripping prior to planting is not required on sites to be planted with the Chatfield tree planter, which rips and plants in a single pass. However, these sites will require line marking in conjunction with, or prior to, the knockdown/residual (K/R) spray operation (see section 5.5).

Ripping On Slopes

Slopes greater than 3 degrees are to be contour-ripped with a dozer. The first lines are to be pegged at the base of the slope and then repegged at abrupt changes of contour or as often as necessary to keep the machine on the contour.

Dozer operators must be experienced with contour ripping and preference will be given to machines fitted with levelling meters.

For details regarding the standards and procedure to be adopted refer to *Soil Conservation Manual* (in preparation - Environmental Protection Branch).

Mounding and Drainage

Pre-Mound Cultivation or Ripping

All mounding operations are to be preceded by some form of cultivation or ripping to allow roots to grow unimpeded into the subsurface soil. This should be carried out following total spraying of perennial weeds and grasses (see section 5.1).

Cultivation helps to break down the size of the soil clods before mounding and improves the quality and the profile of the mound formed.

Pre-mound deep ripping (where required) should be carried out after cultivation so that the mounder may follow the wheel tracks of the ripping machine.

Total Cultivation

Total cultivation in the form of disc and/or chisel ploughing is required on sites where soil clods are firm and difficult to break up, causing problems with machine planting, mounding and soil wettability. Sites included in this category are the organic podsols common in swampy, low-lying country and kikuyu-dominant pastures in the heavier country (see section 5.4).

Large Mound - Savannah Bedding Plough

To be carried out on poorly drained and low-lying sites where waterlogging and seasonal inundation occur. The aim is to lift the mounded soil out of the water to enhance the effectiveness of the herbicide and to ensure that seedlings are planted into a drained medium to eliminate waterlogging and encourage early growth.

Large mounds are to be used in preference to standard mounds on sites where the primary objective is to overcome waterlogging and drainage problems.

Standard Mound

To be carried out on sites where waterlogging may be a problem in unusual circumstances. For example, standard mounds are to be used on susceptible sites as an insurance against exceptionally wet seasons. Large mounds are to be used where waterlogging is the norm rather than the exception.

Standard mounds may also be used where cultivation and concentration of topsoil into the planting line are desired, especially on light dry sands common on the Swan Coastal Plain and east of Albany.

Drainage and Alignment

Mounded areas will require drainage and careful alignment to run water off the site to avoid waterlogging and erosion problems.

For details regarding standards and procedures refer to *Soil Conservation Manual* (in preparation - Environmental Protection Branch).

It is probable that small areas of localised depression and soaks cannot be drained. These areas should be identified in winter if possible and left unplanted (see section 2.0).

4.2 Ex-forested Sites

To achieve best results, clear at least 18 months before planting. Allow debris to stand 10-12 months in windrows and burn in late spring. Allow 3-4 months for eucalypt to develop, then foliar-spray (see Herbicide Manual, Technical Instruction Sheet No B8).

Plough the site in late summer/early autumn under dry soil conditions. Areas may then be prepared for planting (see section 4.1). Spray with knockdown/residual herbicide where invader weeds are likely to be a problem (see section 5.5). Interrow-cultivate in the summer following planting.

) WEED CONTROL

The sheet number used throughout this section refers to the Herbicide Manual Technical Instructions.

5.1 Pre-Mounding Total Spray

The aim of pre-mound total spraying is to kill problem weeds (e.g. sorrel and dock) prior to mounding, and in particular to ensure that live weeds and grasses are not buried in the mound.

Perennial Weeds

Proposed mounded areas are to be total-sprayed prior to cultivation with a knockdown herbicide as follows:

Grass-Dominant: Spray Roundup at 4l/ha (Sheet B3), at least 1 week prior to cultivation.

Sorrell and Dock-Dominant: Spray Brushoff at 15-20 g/ha (Sheet B19) at least 2 weeks prior to cultivation. Use a Roundup/Brushoff mix at similar rates on mixed pasture species.

Annual Grasses: Pre-mounding total spray is not required on annual-based pastures if cultivation is carried out prior to the break of the season (before any germinants are evident). Mounding must follow cultivation closely to avoid mounding up post-cultivation germinants.

If the season has broken before cultivation has begun, and if cultivation might not control the early germinants, then strip-spray or total-spray with Roundup at 2-3 l/ha (Sheet B3).

5.2 Sorrel and Dock Control

Total spray with Brushoff at 15-20 g/ha (Sheet B19) except on fine light dry sands where wind erosion may be a problem. Sorrell and dock on these sites to be controlled using Brushoff at similar rates, in the K/R strip spray operation (see section 5.5)

5.3 Bracken Control

For best results, slash bracken in August/September and follow by burning. Then spray with Brush-Off at 50 g/ha (Sheet B9) in Spring when the fronds are fully expanded and growing vigorously.

If slashing and burning is not possible uneven-aged bracken can be sprayed successfully provided the water volume is high.

Follow bracken control with appropriate site preparation (see section 4.0).

5.4 Kikuyu Grass

Total-spray Roundup at 4l/ha (Sheet B3) in summer when grass is actively growing. Burn at the break of season if lead time permits.

Cultivate to break up soil clods and then mound (see section 3.1). Strip-spray with K/R mix at least 1 month prior to planting (Sheet B20).

5.5 Knockdown/Residual (K/R) Spray Prior To Planting

NOTE - Gesatop is extremely viscous and requires thorough mixing and then continual agitation during spraying. Poor mixing and agitation will produce high concentrations at first, followed by lower than prescribed concentrations from then on.

Light dry soils (white leached sand) with very low organic content

Spray Roundup at 1-4 l/ha plus Gesatop at 10 l/ha (Sheet B20). Use lower rate of Roundup where capeweed predominates and/or weeds are newly emerged (2 leaf stage). The rate of Roundup should be increased as weeds mature or when clover predominates. Add "Boost" to the tank mix at 2% v/v or w/v.

Loamy sand and heavier soils

Spray Roundup at 1-4 l/ha (as per 4.5 Light dry soils) plus Gesatop 10 l/ha. (Sheet B20).

Soils with very high organic content (organic podzols)

As most soils fitting this description will be waterlogged for a period during winter and spring, mounding is essential. Allow at least one month for mounds to settle before spraying with a mixture of Roundup at 1-4 l/ha (see 5.5 Light dry soils) and Gesatop at 16 l/ha (Sheet B20).

5.6 Timing of Application

Lead Time Between Mounding and Spraying

Allow one month between mounding and spraying to enable the mound to settle, and to allow any buried weeds to emerge prior to the K/R spray if spraying was not done before mounding.

For Best Weed Control

For prolonged residual activity, residual herbicides are best sprayed onto as bare a soil as possible. Consequently it is desirable to graze paddocks heavily before spraying.

Herbicides must not be sprayed onto inundated soils, as they are subject to cross-surface flow of water.

Knockdown herbicides should not be applied when plants are stressed.

Lead Time Between Spraying and Planting

Planting must not commence within the following periods after herbicide application:

Brush Off - 28 days @ 20g/ha

- 56 days @ 50g/ha

Roundup/Gesatop mixtures - 28 days and at least 50mm of rainfall.

Roundup - 7 days

6.0 FERTILISER

There is little or no benefit in fertilising seedlings if weed control is not successful.

If successful weed control is assured, then seedlings should be fertilised at the time of planting or within 4 weeks of planting. Poor pastures, where residual P is below 15 ppm, should be fertilised with 50 g of diammonium phosphate (D.A.P.); better pastures, where residual P is above 15 ppm, should be fertilised with 50 g Agras Number 1.

Fertiliser should be buried 15-20cm from the base of seedlings with a planting spear or potti-putki.

7.0 PRIORITY OF PREPARATION AND PLANTING

Ideally, all seedlings should be planted as early in the season as possible. However, planting operations should be prioritised in the following order:

1. Southern Coastal Plain (Black Point) - plant early in the season before waterlogging makes access a problem.

2. Sandy dunes in the Swan Coastal Plain and Albany area - plant early to ensure roots have maximum possible opportunity to develop at depth before summer. Planting must be completed by July 31.

3. Sandy lateritic ridges in Central Hills and Wellington Catchment - plant early to ensure maximum growth before summer drying. Planting must be completed by July 31.

4. Low-rainfall cells ahead of high-rainfall cells.

5. Light-textured sands ahead of heavy-textured loams.

8.0 PEST CONTROL

Refer to Plantation Pest Manual (in preparation).

Rabbits

APB control in Jan, Feb, March using oats 1080 baited oats

Black Beetle

The best control against black beetle is to retain unsprayed grass strips between planting lines to give them something else to eat.

Cutworm/Grubs

Control with Sumiciden 75 (75g/l Fenvalerate). Follow the label instructions.

Grasshoppers

Nymphs: spray with Malathion ULV Concentrate as the label directs (500ml/ha). Spray must be applied with a ground mister.

Adults: spray as for nymphs and/or bait with a combination of 1 kg Carbaryl 80 + 40 kg chick starter pellets + 2l water + 4g methocel mixed together in concrete mixer. Spread at 3 kg/ha in a 50-100 m wide barrier zone around plantation.

Other Insects

Contact CALM entomologists Ian Abbott (Como Research) or Janet Farr (Manjimup Research).

Another avenue of advice is via the Agriculture Department entomologists who may be familiar with local insect problems and the control mechanisms. They include Mike Grimm (Albany) and Stewart Learmonth (Manjimup).

All recommended insecticides must be approved for CALM use via Safety Branch, who will arrange permission from the Dept. of Health and prepare a CLM 729.

The Manager of Silviculture Branch should be informed of all broadscale applications of insecticide. In addition, insect problems in plantations should be fully documented (with the date, insect type, damage, area affected, tree species affected, weather conditions, insecticide used, rate used, method of application, degree of success and any other useful information) and forwarded, along with samples of insects, to Forest Entomology in Como.

9.0 SURVIVAL COUNTS and RE-ESTABLISHMENT

Reconnaissances of all properties should be carried out in late Spring/early Summer to enable estimates to be made of infill numbers required for the following season. Seedling orders for re-establishment are required at the nursery no later than 15th December of each year.

Re-establishment should be carried out in:

- broadscale failed areas of 1 ha or greater;

- areas of 1 ha or greater where survival/stocking density is less than 50% of the nominal stocking. Surviving stems should be discarded and areas should be totally replanted. Chemical rates for re-establishment should be as in section 5.0.

Treated areas should be accurately mapped and documented.

F.J. Bradshaw
Manager, Silviculture Branch

Appendix 4: Quality control standards

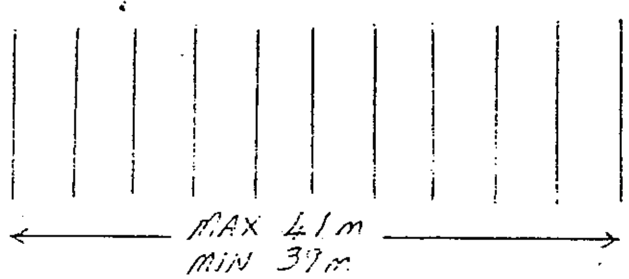
SPECIFICATIONS FOR PLANTATION ESTABLISHMENT WORKS

RIPPING and MOUNDING - GENERAL

- Space bars to be fitted to the front of all machinery to ensure accuracy and consistency of spacing.

- Space bars to comprise an adjustable pipe with a trailing chain approved by CALM supervisor.

- A tolerance of 0.30m either side of the specified spacing is allowable between any two rows. The maximum allowable average tolerance for a run of eleven rows is 0.10m.



- Oil and fuel filters, drums, grease cartridges and general rubbish is to be cleaned up and removed at the completion of the job to the satisfaction of CALM supervisor.

- When using CALM equipment, no down time will be paid during breakdowns.

- Quotations to be on the basis of :
  - $ per hectare, plus
  - $ per hour for small and difficult areas, plus
  - cents per kilometre for transport between properties.

- Contractors to arrange their own transport of machinery (including CALM machinery) between properties.

RIPPING

- Ripping depth to be a minimum of 0.80m deep.

- A winged tyne or approved equivalent is required.

- Ripper to be trailed by a large chain or approved equivalent (offset discs) to ensure rip channels are infilled with soil.

- Machine to be minimum of 200 H.P at the fly wheel.

- Large boulders (>0.5m diam) and debris (>0.15m diam, 1m long) to be heaped if machine is fitted with blade. Contractor to quote an hourly rate for this operation.

- Operator to lift the ripping tyne up out of the ground every 50m to clear any debris which results in channelling of the ripline. Tyne to be lifted any other time that channelling is evident.

- Ground disturbance at the end of riplines to be minimised by reducing machine speed and 3-point turning into the next line.

LOW RIPPING

- Minimum power requirement 85 H.P 4 W.D. or front wheel assist or 100 H.P. 2 W.D. or an approved equivalent.

- Ripper to be coupled to 3 point linkage with double acting hydraulics for downward exertion of tyne.

- Minimum tyne length of at least 0.50m to obtain minimum ripped depth of 0.30m.

- A minimum of 95 % of riplines to be to 0.30m deep before payment is approved.

ARD MOUNDING

- Mounders to be supplied by the contractor wherever possible and must meet the approval of CALM supervisor. A cotton reel roller must be fitted behind the discs to ensure mound is formed and compacted in a single pass.

- If using CALM mounder, maintenance to be carried out by the contractor. Mounder to be returned to CALM in an "as received" condition.

- The optimal mounding speed to be determined and agreed to by the contractor and the CALM supervisor upon construction of mounds of an acceptable standard. Maximum speed not to exceed 5 km/hr.

SPRAYING

- Spray operators must be licensed as a pesticide operator by the Commissioner of Public Health.

- Spray operators must be licensed to use the pesticides specified by CALM in the manner specified.

- Spray operator's license to be viewed by CALM supervisor before commencement of works.

- Spray operator to abide by CALM 729 and technical instructions including product label. Safety regulations (including the wearing of protective equipment) to be abided by.

- Spray operator is to calibrate equipment and then mix and apply chemical at the commencement of the job to the satisfaction of CALM supervisor.

- Spray operator is to record daily calibration figures, chemical useage and weather conditions on the appropriate form.

- Spray operator/contractor to provide own supply of clean water. Water quality to be monitored by CALM supervisor - water must be crystal clear and free from impurities to the satisfaction of CALM supervisor. Dam water is not acceptable.

- Spray equipment to have:
  - booms which are shrouded at the back and sides with a plastic curtain.
  - booms which spray a swathe width of 2.0m.
  - gauges of an appropriate fineness of scale to allow small pressure fluctuations to be monitored, visible to the operator.
  - On/Off switch accessable to the operator in the cab.
  - 100m long hand leads for spraying difficult/inaccessable areas.
  - an efficient agitation mechanism approved by CALM supervisor.
  - flexibility to adjust boom height and spacing for spraying on mounds.

- Spraying to be done with 4W.D. utes or with tractors. The machine to be used will be specified for certain areas according to terrain.

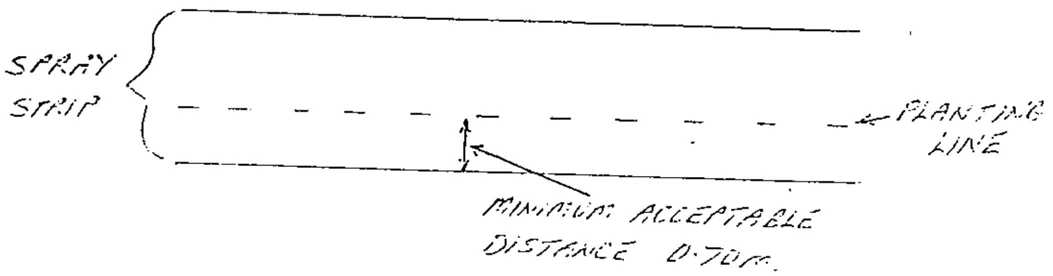
- Spraying will be done on large and small mounds and on riplines. In some cases, spraying may be necessary on unmarked lines which must be pegged at the correct spacing by the contractor before spraying.

- Spray strips must extend to within 2m of piles of rocks, debris and other impediments to ensure full stocking at planting.

- Maximum speed when spraying, no greater than 7 km/hr.

- Spray nozzles to be switched off at the end of each spray line to avoid unnecessary coverage of herbicide.

- The edge of the spray strip is to be no closer than 0.70m from the planting line ie. a tolerance of 0.3m either side of centre is acceptable.



- Spray operators/contractors must ensure that empty chemical containers are double rinsed (Roundup) or triple rinsed (Gesatop) and then holed and disposed of as required by the local authorities on a daily basis.

- Payment will be on a per hectare sprayed basis. 50% of monies will be paid at the completion of spraying and the remainder after the grasses/weeds have gone off and the spray lines have shown up. The penalty on areas missed and those which fall outside the specified tolerances will be on a hectare equivalent basis or remaining monies will be paid on the successful completion of the job.

- Quotations to be on the basis of :
  - $ per hectare sprayed with single boom and double boom, plus
  - $ per hour for small and difficult areas or areas requiring hand spraying or unmarked areas requiring pegging and spraying.
  - cents per kilometre for transport between properties.

PLANTING

- When using jiffy pots, seedlings to be prepared no earlier than 3 hours prior to planting to avoid roots drying out.

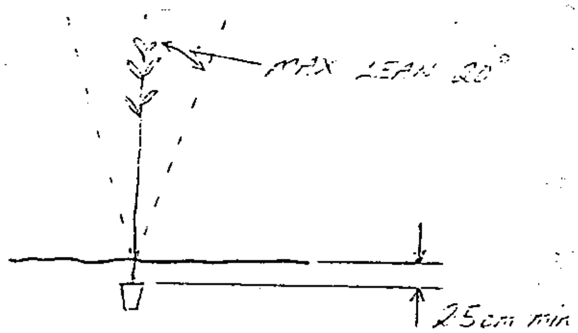
- Prepared seedlings must be sheltered out of the wind and the sun prior to planting.

- Contractors are to ensure that seedlings are watered daily at the seedling dump once planting has commenced

- Seedlings must be planted deep enough to ensure that the top of the pot/root system is at least 5 cm below the soil surface.

- Seedlings must be firmly healed in or pressed in so they are firm in the ground. As a rule of thumb, the top leaves should be able to be pulled off without the seedling coming out of the ground.

- Seedlings must be planted upright and at an angle of no greater than 20 degrees either side of vertical.



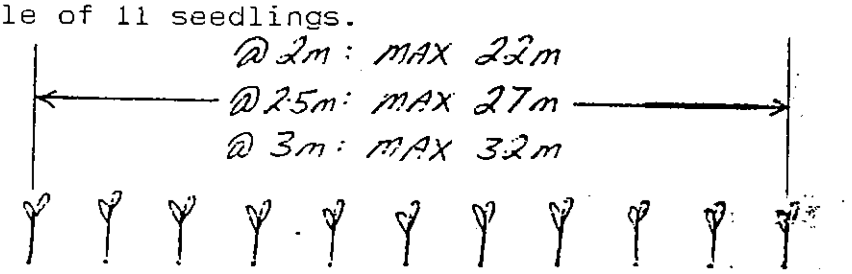
- Planting machines are to be supplied by contractors.

- Coulter wheels are preferred on planting machines.

- It is preferable that the planting machine faces the operator backwards when planting.

- Spacing between seedlings to be governed by a suitable length of trailing chain or rope

- Average spacing between seedlings not to exceed 0.20m over a sample of 11 seedlings.



- When planting on mounds, seedlings must be planted on top of the mound, out of the water. If mounds are being damaged by the planting machine, then hand planting must be employed.

- Contractors are responsible for the return of all trays to a specified dump for subsequent return to the nursery. A levy of $1.00 will be imposed on the contractor for every tray not receipted at the dump at the end of planting.

- Contractors are responsible for the delivery of plants to their planting machines and hand planters within a reasonable distance of the specified seedling dump.

- Press wheels on planting machines are to be set at an angle of 10 - 15 degrees off vertical to ensure the soil around the roots is pressed firmly and deeply. Press wheels must meet with the approval of CALM supervisor.

- Contractor is responsible for the disposal of plastic seedling trays (ie. kwikpots) if used.

- Each property is to be inspected by the CALM supervisor and the contractor and certified as complete before the contractor may move to another property. This certification process forms the basis for payment.

- The planting area is to be fully stocked. Particular attention must be paid to stocking adjacent to piles of debris, rocks, trees and wet areas where machine planting is difficult. Plants should not be planted into unsprayed strips.

- Quotations to be on the basis of :

  - $ per hectare machine planted and $ per hectare hand planted for planting 72 cell jiffy pot seedlings and 64 cell kwikpot seedlings at a spacing between seedlings of 2m and 2.5m and 3m (at standard row spacing of 4m).

  - $ per hour for machine and hand planting small, difficult and dispersed areas, plus

  - cents per kilometre for transport between properties.

FERTILISING

- Fertiliser to be transported around properties from a central dump by the contractor.

- Fertiliser tablet(s) (to make up 50g) must be buried 6" - 8" (150mm - 200mm) from the base of the seedling to a depth of at least 50mm.

- Contractor is responsible for disposing of empty boxes, plastic liners and fertiliser bags.