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ARTIFICIAL REGENERATION
OF
KARRI
(*Eucalyptus diversicolor* F.v.M.)

by

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FORESTS DEPARTMENT

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WESTERN AUSTRALIA

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ARTIFICIAL REGENERATION OF KARRI

O.W. Loneragan

SUMMARY

Artificial regeneration is required to restore the logged areas to full productivity every year when the seed trees are in bud or blossom or have insufficient seed for natural regeneration. Natural seed supply is restricted to one year in three, the prime crops for collection being produced once every 4 - 12 years. Most use should be made of the best seed sources as these are limited and costly to collect.

The percentages of successful establishment of seedlings by the methods tested are broadcast seeding of untreated seeds about 1½ percent and of pelletted seeds five percent; spot seeding 25 p.c., openrooted plantings 75 p.c. and plantings from containers 95 percent. Total costs in comparing methods are found to be very closely the same with one exception. The feasibility of halving the planting costs is demonstrated by raising open-rooted woody plants in the nursery, and planting out with up to six ounces of N+P fertiliser into an adjacent hole about three inches from the seedling roots. Reliability in transplanting depends also upon keeping the roots of the transplants wet at all times until planted.

The necessity to encourage rapid growth of the trees with the minimum of competition is emphasised. Machines, fire and chemicals are used to assist establishment and growth because the time taken to raise land use to full productivity is an important function of cost.

Direct seeding is successful only on the clean fertile sites and is expensive, because the seed is very sensitive to site influence and large amounts are necessary to ensure success. Broadcast seeding may require from between 5 and 10 times as much seed as for spot seeding and from 40 to 60 times as much seed as for the raising of open-rooted seedlings or seedlings in containers in the nursery. The main advantage of plants raised in containers or compressed peat pots is that most rapid possession of the site is possible because the root systems remain intact and undamaged when planted. This advantage becomes a very important factor in unfavourable sites.

INTRODUCTION

Artificial regeneration may be required two years in every three, when the seed trees are in bud or blossom, or have insufficient seed for natural regeneration (Loneragan 1971). A condition of seeding or planting with thorough cultivation of the site may be provided from one of the following sources:

A. Natural regeneration from -

1. Natural seeding when the seedbed has been freshly prepared for germination during the autumn and winter.
2. Advance growth of regeneration, established without being damaged or destroyed by burning or logging in advance of final felling.

B. Artificial regeneration from collected seeds -

1. Direct seeding:
    - 1.1 Broadcast seeding
    - 1.2 Spot seeding
    - 1.3 Pelletted seeding.
2. Planting seedlings:
    - 2.1 Wildling transplants from the forest
    - 2.2 Open-rooted transplants from a nursery
    - 2.3 Container plants from a nursery.

Planning of the cultural operations involves delineation of the cutting areas for protection prior to felling and regeneration. Severe fires are prevented through the judicious use of prescribed burning in a rotational programme, initially, making clean barriers from half to one mile wide in the heath flats and jarrah forest surrounding the karri forest and subsequently, reducing the fuel hazard in the forest areas by the technique of aerial controlled burning using incendiary bombs dropped from aircraft (McArthur, 1966; Watkins, 1966).

The nett area of karri forest being cut in trade operations is about 3,500 acres annually. These areas when regenerated are protected completely from burning during the tender years of development. The desirable time under complete protection depends upon the time required to grow bark sufficiently thick (from 0.4 inches thick for stems with diameters over three inches) to the height of the bole required for the cambium to be able to remain protectedfrom prescribed burning rapidly and economically without damage. Probably ten percent of the forest area (or of the length of the rotation) may be protected completely from burning at any particular time. The total time and the total costs of this protection in any particular area may be reduced greatly through amalgamating the logging areas for regeneration and continuing treatments, which will provide rapid growth of the crop trees during stand development immediately from the time of seedling establishment.

Site preparation, fertility and density of the regeneration will have a marked effect on growth rates, and therefore on the length of the rotation required to produce the marketable crop trees. The importance of fire moreover in aiding the regeneration of the dominant species in temperate forests of eucalypts has been widely acknowledged because of both the removal of the competition and the availability of nutrients for establishment and rapid growth. The feasibility of these current methods of propagation of karri annually in the logged areas is being examined. The location of the sites for these present and earlier investigations are shown in the figure 1.

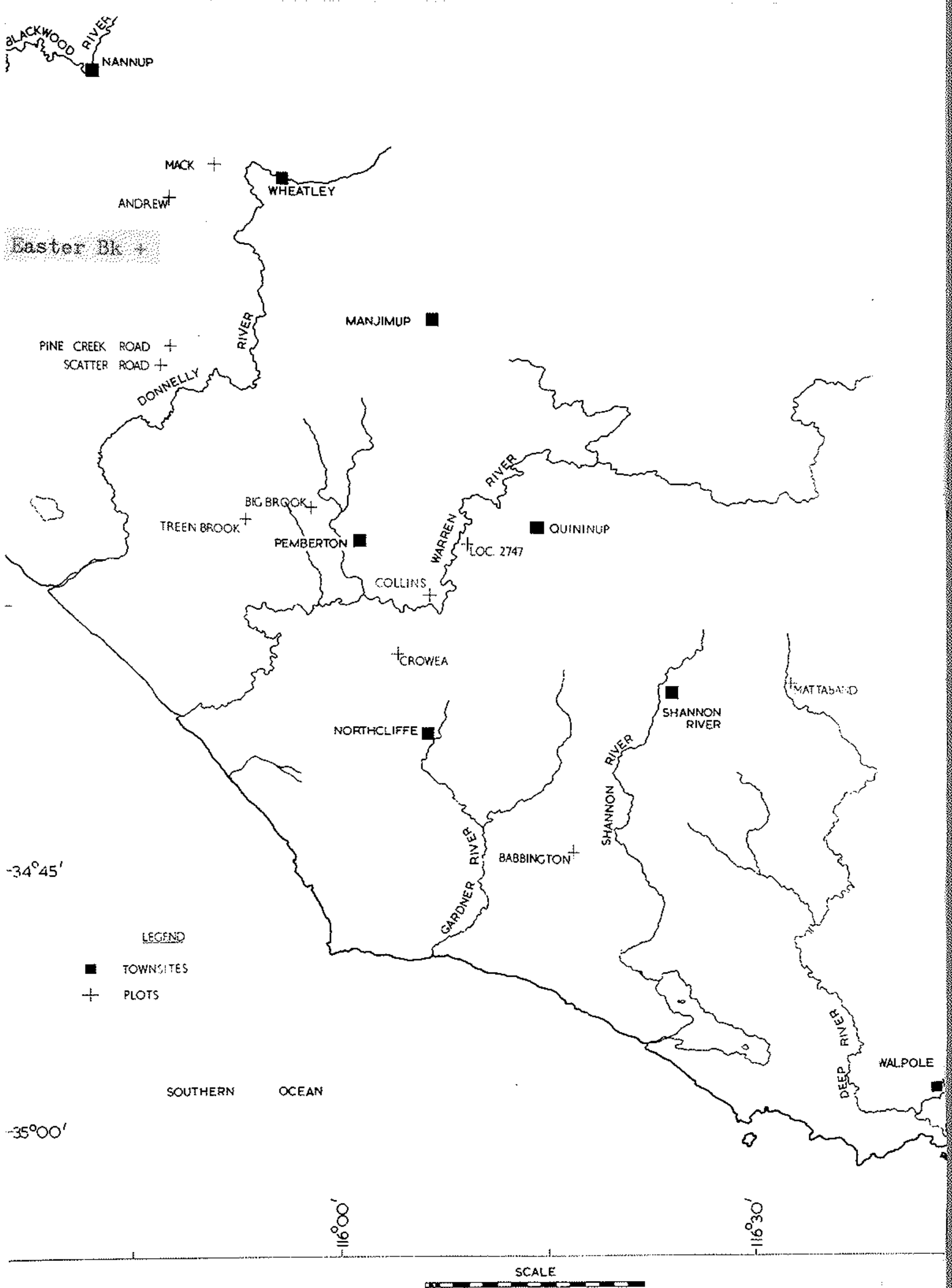

Figure 1 - Location of regeneration experiments in karri forest

1. DIRECT SEEDING.

1.1 BROADCAST SEEDING.

METHODS.

a. Treen Brook (D.W.R. Stewart 1936 Experiment).

An area of heavily cut forest at Treen Brook (Pemberton) in which natural seed fall had occurred during 1934 and 1935, was burnt in March 1936 and seeded artificially in the following month. Sowings were made with commercial seed (70,000 per lb.) as follows:

1. Broadcast sowing at 1.25 lb. per acre.
2. Broadcast sowing at 2.5 lb. per acre.
3. Broadcast sowing at 5.0 lb. per acre.
4. Broadcast sowing at 10.0 lb. per acre.
5. Spot sowing with a small pinch of seed in plots with 25 spots at a spacing of 6 x 6 feet without cultivation, the soil being firmed by foot before application of the seed at 0.5 lb. per acre.
6. Spot sowing as for treatment (5), but with the spots cultivated by mattock and firmed by foot before and after application of the seed.

The six treatments were replicated four times in randomly located plots of 0.025 acres. Two replications of each treatment were fenced, the others were unfenced.

b. Big Brook (D.W.R. Stewart 1937 Experiment)

An area burnt in 1931 some years after logging and lacking karri regeneration was seeded in October,

1937. The seed was broadcast sown in small amounts on plots of 0.025 acre so that bare patches amongst the regenerated undergrowth would be seeded without cultivation. Three treatments, with four replications, were used:

1. Broadcast sowing at 2.5 lb. per acre
2. Broadcast sowing at 5 lb. per acre
3. Untreated control.

c. Quininup Location 2747 (J.C. Meachem 1957 Experiment).

Seven acres of an abandoned farm carrying bracken and weeds was burnt and broadcast sown under control of the writer with 2.5 lb. karri seed per acre in April 1957. Most of the area was classed as non ashbed with small patches of ashbed around fallen logs.

RESULTS.

a. Treen Brook (compartment 65).

An enumeration of one-year old survivors present on August 5th, 1937 is given in Table 1.

TABLE 1.

SEEDLING SURVIVAL AT AUGUST 5, 1937, FIFTEEN MONTHS AFTER SOWING. TREEN BROOK, PEMBERTON.

		TREATMENTS (Text 1.1)					
		No. of Surviving Plants from Broadcast Seed				No. of Sown Spots Surviving	
		1	2	3	4	5	6
Fenced	A	23	14	49	81	6	2
Fenced	B	11	29	73	83	9	6
Unfenced	C	21	23	32	102	11	5
Unfenced	D	49	42	41	165	2	3
Total		104	108	195	431	28	16
Mean per Plot		26	27	49	108	7	3
Mean per Acre		1040	1080	1950	4310	280	160
Tree %		1.19	0.62	0.56	0.62		
Spot %						28	16

The average number of seedlings per 100 seeds for all broadcast sowings is 0.5 per cent. One pound of this seed may secure the establishment of 500 plants per acre. The high tree per cent of the lowest seeding intensity is considered to be due to an unusually favourable site. The mean value is similar to that reported for small eucalypt seeds (Jacobs, 1955). The highest mean recorded by the present writer for karri is 2.8 percent in 1957 (Loneragan, 1961; 1971).

b. Big Brook

Dense bracken growth prevented a detailed assessment of this experiment, but the following observations were made. Up to 30 seedlings per plot were found on the eight seeded plots, but no relationship between seeding intensity and number of survivors was resolved. Only one seedling was found in the four unseeded plots, indicating that natural seeding was insignificant. All survivors were small, being from 2 to 4 inches high at an age of 11 months, with small leaves and an unhealthy appearance.

c. Quininup (abandoned farm Loc. 2747).

An inspection in July 1957 showed that all the ashbeds were occupied by germinants with a density of up to 6,600 per acre. Non ashbed sites were from 30 to 60 per cent occupied by germinants with the densities ranging from 900 to 1,300 per acre. A further enumeration was carried out in July 1964, about seven years after sowing. The stocking in 17 plots each 0.025 acres was 790 ± 260 stems per acre. Local gaps ranged up to one square chain in area, and the height of the regeneration varied from three to 30 feet.

DISCUSSION.

Very little difference was observed between the success of fenced and unfenced treatments at Treen Brook. This area was located some distance from the nearest cleared pasture, and rabbits which inhabited the farmland in large numbers did not apparently travel very far into the forest in search of food.

An assessment of costs in 1936 showed that broadcast seeding, although using five times as much seed as spot sowing, cost half as much due to the high cost of labour for clearing and cultivation of the spots seeded. The percentage of spots surviving fifteen months after sowing was considered to be unsatisfactory, and broadcast seeding was regarded as superior to spot seeding.

It was evident from the Big Brook seeding trial that broadcast sowing six years after a fire is unsuccessful, due probably to shading and root competition from the established bracken and weed species.

Abandoned farmland was unsuitable as a site for broadcast seeding unless an ashbed was created. Without a satisfactory burn, competition from bracken and pasture species prevented the establishment of karri.

Although broadcast seeding appeared to be cheaper and more effective than spot seeding, it lost favour in later work because of the large amounts of seed required to regenerate an area and the high cost of seed collection. Seeding intensities have been defined as occasional, frequent and abundant for 120,000, 240,000 and 480,000 seeds per acre, respectively. A direct seeding rate of 2½ lb. equivalent to 180,000 seeds per acre cannot be expected to produce the same density of regeneration as occurs during years of abundant natural seeding. The advantage of broadcast sowing is that seed should reach all sites in an area, and make use of the best seedbeds. Spot sowing, in which the sites are selected manually and especially where spacing is systematic, may neglect niches where seedlings could establish and flourish.

1.2 SPOT SEEDING.

METHODS.

a. Big Brook (D.W.R. Stewart 1935 Experiment)

Natural seeding occurred at Big Brook, Pemberton, between 1928 and 1930 and none in 1931 when Compartment 37, surrounded by fire protected forest, was burnt.

Experimental plots were established using lines five feet wide and ten feet apart in which the scrub was cleared, stacked and burnt. Sowing lines, where they were used, were 3 to 4 feet apart on the cleared strips.

The treatments were -

1. Spot sown at two feet intervals with about six seeds per spot, the spots cultivated by mattock.

2. Sown in lines with 20 seeds per foot on ploughed strips in the cleared areas.
3. Broadcast sown in ploughed strips five feet wide.
4. As for treatment (1) but the scrub unburnt.
5. As for treatment (1) but without clearing or burning.

Four replications of each treatment were applied, two being fenced with rabbit proof netting, the others unfenced. Sowings were carried out in October 1935. The experiment was repeated in Compartment 37 in April 1936.

A similar trial was established in Compartment 18 in April 1936. This area was burnt in an uncontrolled fire in March 1934 and the undergrowth was cleared from the planting lines but not burnt.

b. Mattaband (B.J. White 1960 Experiment).

Spot seeding was carried out in August 1960 on eight acres of previously cut over forest burnt in January, which had failed to regenerate. Four plots were established, two on and two off ashbed, each with 25 spots at a spacing of 6 x 6 feet. An area of 15 inches square was mattocked at each spot, firmed by foot and sown with a pinch of about six seeds.

c. Babbington and Crowea (A.J. Hart 1962 Experiment).

Part of Babbington Block (Northcliffe) burnt for regeneration in January 1962 and Crowea Block (Pemberton) burnt in an uncontrolled fire in March 1961 were selected for spot seeding trials in July 1962. Eight seeds per spot were sown in plots with 24 spots cultivated (as below) at a spacing of 6 x 4 feet. Three plots were located on ashbed and three off ashbed at both Babbington and Crowea.

Further sowings were carried out at Babbington in early October 1962 in plots with 25 spots at 3 x 3 feet spacing. Eight, 16, 32, 64 and 128 seeds were sown in separate spots and each seeding intensity in separate plots. Replicates were established on and off ashbed.

Sowing was carried out by cultivating a small spot with a harden hoe, firming the soil by foot and sprinkling a previously weighed portion of seed on the cultivated area. Monthly inspections were made from November 1962 into June 1963.

d. Andrew (1963 Experiment).

A series of latin squares was used to study the germination and survival of karri seed at different intensities of seeding, on and off ashbed, on new and old burn areas, on north, west and south aspects, with two dates of sowing. Five treatments were applied, 8, 16, 32, 64 and 128 seeds being sown per spot with a total of 25 spots in each square. The centre row of the latin square was unfertilized, the other four being treated with NPK fertilizer (Nitrophoska Red). The old burn area was burnt for regeneration in December 1961, and the fresh burn in March 1963. Sowings were carried out in May and July 1963.

A similar experiment was conducted with 16 seeds per spot in square plots with 25 spots at 6 by 6 feet spacing, also dusting and not dusting the seed with dieldrin.

For each set of site conditions the constant and variable seed density plots were located close together.

RESULTS.

a. Big Brook

Large numbers of seedlings were present on cleared and burnt planting lines within the exclosure of the spring sowing, 1935. No survivors were found on the unburnt or uncultivated treatments of the fenced area, or on any treatments outside the fence. Fewer survivors were found within the exclosure of the autumn seeding experiment, 1936, than for the sowings of the previous spring. No seedlings survived outside the fence. The trial in Compartment 18 was inconclusive. Falling limbs broke down the netting exclosure, providing access to rabbits which consumed all available germinants. Abundant natural seeding in the surrounding 150 acres in 1934 resulted in dense germination but both natural and artificial seeding failed due to foraging by rabbits, and to a lesser extent by quokkas.

The outstanding results initially obtained from the fencing of Big Brook plots compared with those at Treen Brook (Table 1) appear to have been due to the proximity of Big Brook to cleared pasture. Rabbits apparently lived in the cleared areas and travelled only a short distance into the forest. Native animals appeared to have little effect on the success of direct seeding.

b. Mattaband

Survivors from the spot seeding were counted in December 1960, the results being shown in Table 2. Survival values were highly variable, the differences within seedbed classes exceeding the differences between the means for the two seedbeds by a considerable margin. The plots were located on a gravelly site which may be considered marginal for karri regeneration. Site differences within the plots could therefore account for the variable success of establishment, from 20 to 60 per cent of the spots.

TABLE 2.

SEEDLINGS SURVIVING AT DECEMBER 8, 1960, FOUR MONTHS AFTER SPOT SEEDING IN COMPARTMENT 1, MATTABARD, SHANNON RIVER (Text 1.2).

Plot No.	Seedbed	No. of Spots		Survivors Per Plot	Percent of Spots	
		Germin.	Surviv.		Germin.	Surviv.
1	Non ash	18	15	20	72	60
2	Non ash	9	7	10	36	28
3	Ash	11	5	9	44	20
4	Ash	15	14	32	60	56
Mean	Ash	13.0	9.5	20.5	52	38
Mean	Non Ash	13.5	11	15	54	44

c. Babbington and Crowea

(i). Germinants: The means and standard errors of the number of germinants per spot at Babbington are shown in Fig. 2 and the percentage of successful spots in Fig. 3. The results for eight seeds per spot were obtained from 96 spots, the remainder from 25 spots each. The differences between numbers of germinants per spot are significant in only a few cases, all of which are associated with a high percentage of successful spots. Seedbed had little influence on the intensity of germination.

The percentage of spots with germinants varied widely and with no relation to the number of seeds sown per spot. Sowings with eight seeds per spot were as successful as those with 128 per spot. Non ashbed sites carried more successful spots generally than ashbeds.

Delayed germination occurred on most ashbed plots between the April and May inspections in 1963. This phenomenon was almost absent from non ashbed sites.

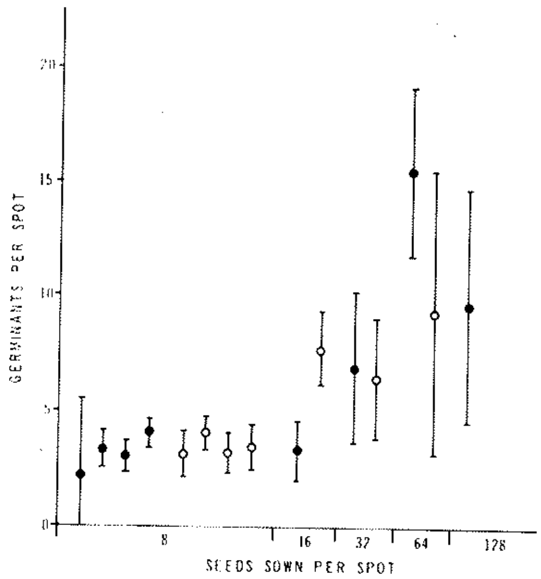

Fig 2. Means and standard errors of number of germinants per spot for ashbed and non ashbed sites and different seeding intensities, Babbington, 1962.

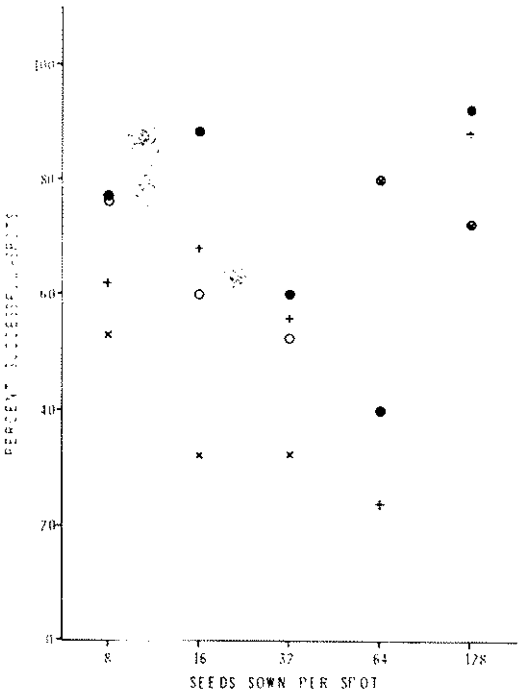

Fig 3. Percentage of successful spots at germination (November 1962) and survival (June 1963) from direct seeding, Babbington.

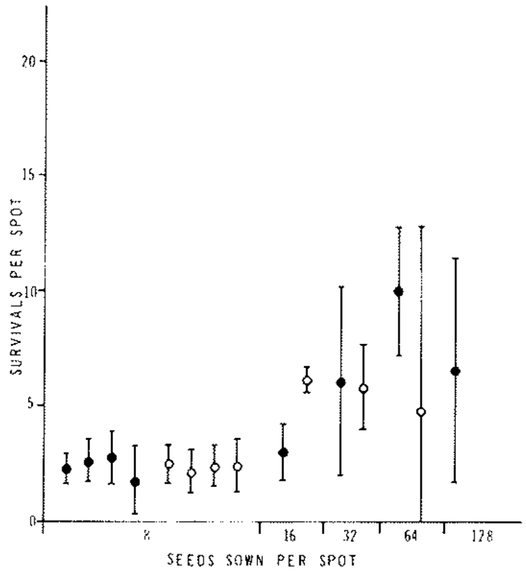

Fig 4. Means and standard errors of number of survivors per spot for ashbed● and non ashbed○ sites and different seeding intensities, Babbington, 1962.

(ii). Survivals: Fig. 4 illustrates the range in values for the number of survivors per spot. The standard errors of means for high seeding intensities are large, and differences between means are not significant in most cases. Very high germination and survival values were obtained for 128 seeds per spot off ashbed, and they are not shown in Figs. 2 and 4.

Fewer spots failed between germination and the final inspection at high seeding intensities than where eight or 16 seeds were sown per spot. This applied particularly to ashbed sites though there was a less prominent, similar trend off ashbed.

(iii). Seeding at Crowea was a failure. Very few germinants appeared, and these died quickly, so that observations were discontinued after September 1962. The high proportion of failed spots appeared to be associated with a fine textured clay soil, one year old weed growth and native animal activity.

d. Andrew

Aspect had no consistent influence on any phase of germination or establishment of karri, as can be seen from Fig. 5 and 6. North, West and South aspects were combined for consideration of other factors affecting establishment. The application of fertilizer to the seeding site did not improve either germination or survival, and dusting the seed with dieldrin had no beneficial effect. Although germination showed little difference between ashbed and non ashbed sites, survival as a percentage of the seed sown, and of the

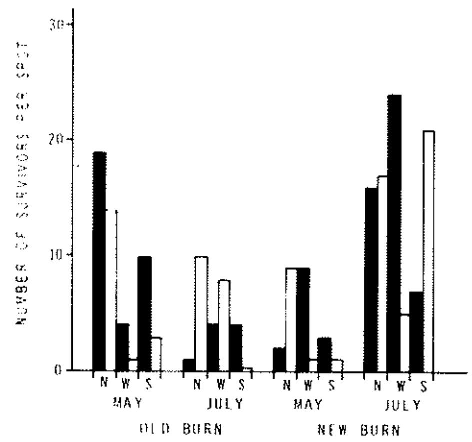

Fig 5. Influence of seedbed, aspect, date of sowing and age of burn on the mean number of survivors per plot from direct seeding, Andrew. Solid columns, ashbed: open columns, non ashbed.

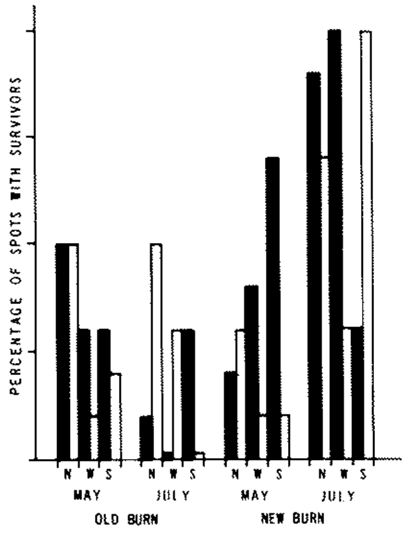

Fig 6. Influence of seedbed, aspect date of sowing and age of burn on the percentage of surviving spots per plot from direct seeding, Andrew. Solid columns, ashbed: open columns non ashbed.

successful spots, was higher on than off ashbed.

RESULT OF METHOD OF ASSESSMENT OF BABBINGTON AND ANDREW TRIALS.

The direct seeding trials for Babbington and Andrew were compared using the method of Finlay and Wilkinson (1963). Regressions were calculated to determine the effect of site on the mean number of seeds per spot (including failed spots) and on the proportion of successful spots. The following numbers were used to identify the sites:

I Babbington, new burn, October sowing.
II Andrew, new burn, May sowing.
III Andrew, new burn, July sowing.
IV Andrew, old burn, May sowing.
V Andrew, old burn, July sowing.

Analyses were made separately for ashbed and non ashbed locations. The responses for five seeding intensities obtained at each site were plotted against the mean for all seeding intensities at the respective sites. For example, a regression line was calculated relating the number of germinants for a given seeding intensity to the site means for all seeding intensities. The values of the regression coefficients indicated the sensitivity of the factor under study to site variations. Regressions with coefficients less than 1.0 indicate relatively conservative responses to improvement in site. Those with coefficients greater than 1.0 show relatively sensitive responses to site improvement.

(i). Germination: The response to site improvement of seed number treatments determined by germinants per spot, increased with the number of seeds sown per spot. This is illustrated in Fig. 7 and 8 for ashbed and non ashbed locations. Spots sown with eight seeds were almost equally successful on poor and good sites. Sowing rates of 128 seeds per spot were no more successful than eight seeds on poor sites, but resulted on good sites in about six times as many germinants, the relative successes on good sites being approximately proportional to the seeding intensity.

Between 70 and 90 per cent of spots carried germinants at all seeding rates. No relationship was found between the number of seeds sown per spot and the percentage of successful spots, or between the successful spot percentage and site improvement. Fig. 9 and 10 show a close cluster of values around the overall mean for both ashbed and non ashbed.

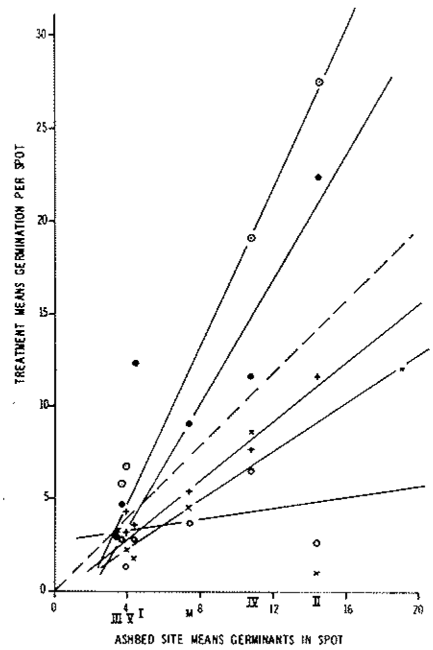

Fig 7. Response of number of germinants per spot to site for different seeding intensities on asnbed. Symbols: O 8 seeds per spot, X 16 seeds per spot, + 32 seeds per spot, ● 64 seeds per spot, ⊙ 128 seeds per spot: I Babbington; II Andrew, new burn, May sowing; III Andrew, new burn, July sowing; IV Andrew, old burn, May sowing; V Andrew old burn, July sowing: M mean of all sites.

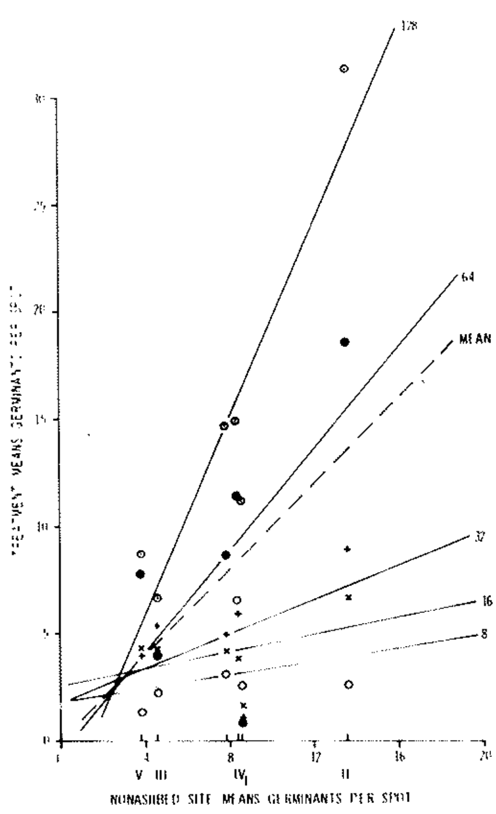

Fig 8. Response of number of germinants per spot to site for different seeding intensities off ashbed, Symobls as for Fig. 7.

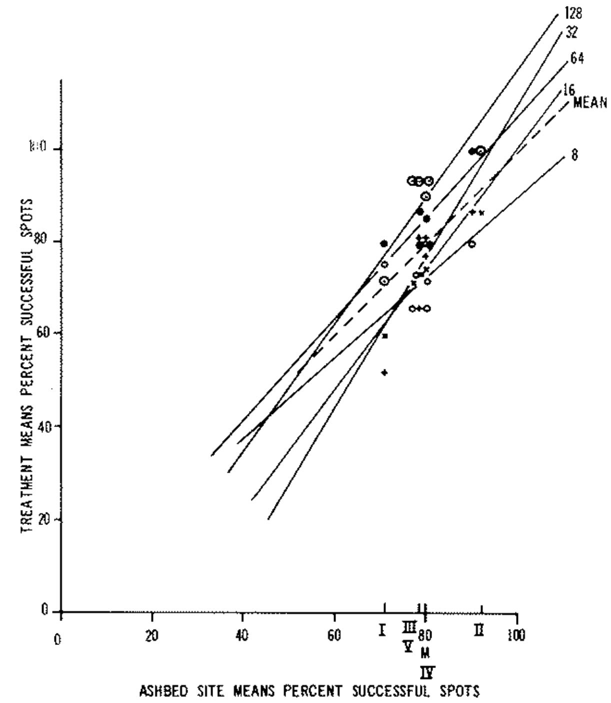

Fig 9. Response of percentage of spots with germinants to site for different seeding intensities on ashbed. Symbols as for Fig. 7.

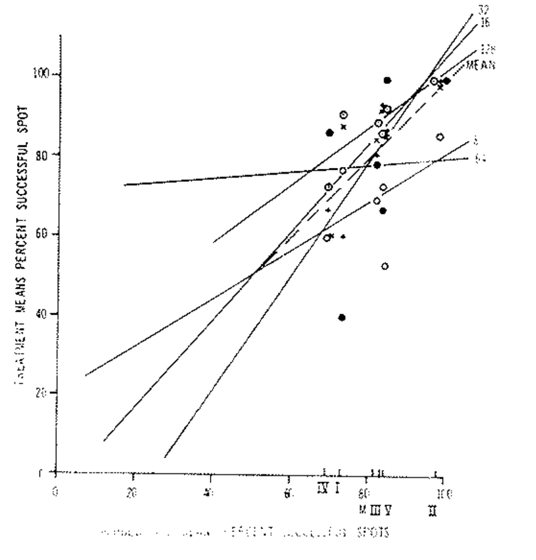

Fig 10. Response of percentage of spots with germinants to site for different seeding intensities off ashbed. Symbols as for Fig. 7.

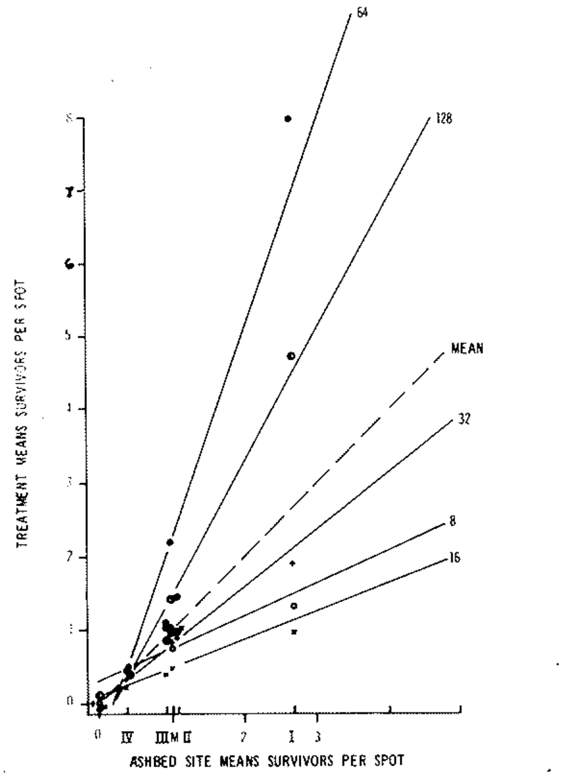

Fig 11. Response of number of surviving seedlings per spot to site for different seeding intensities on ashbed. Symbols as for Fig. 7.

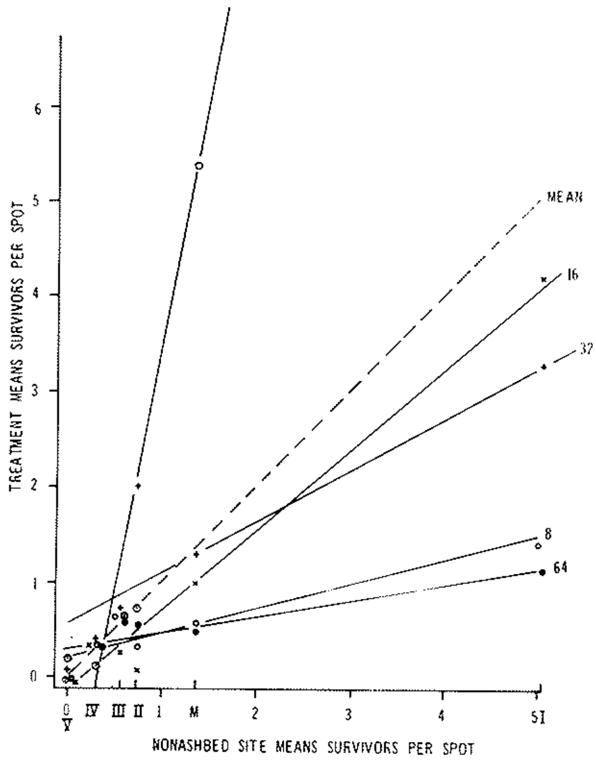

Fig 12. Response of number of surviving seedlings per spot to site for different seeding intensities off ashbed. Symbols as for Fig. 7.

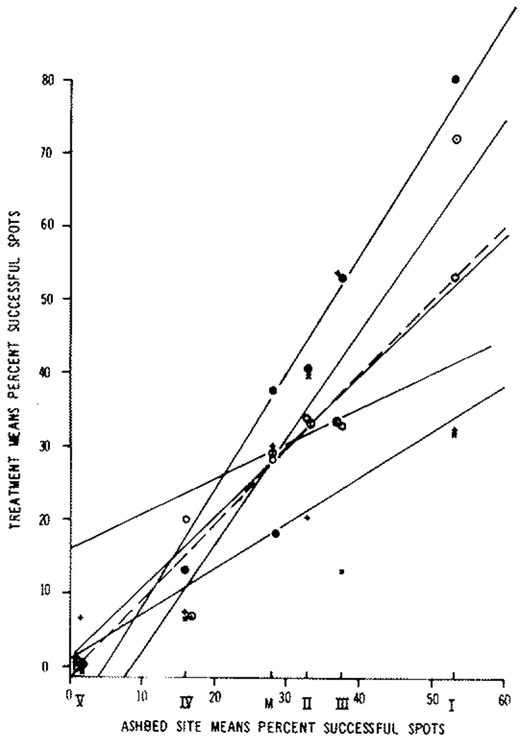

Fig 13. Response of percentage of spots with survivors to site for different seeding intensities on ashbed. Symbols as for Fig. 7.

Fig 14. Response of percentage of spots with survivors to site for different seeding intensities off ash-bed. Symbols as for Fig. 7.

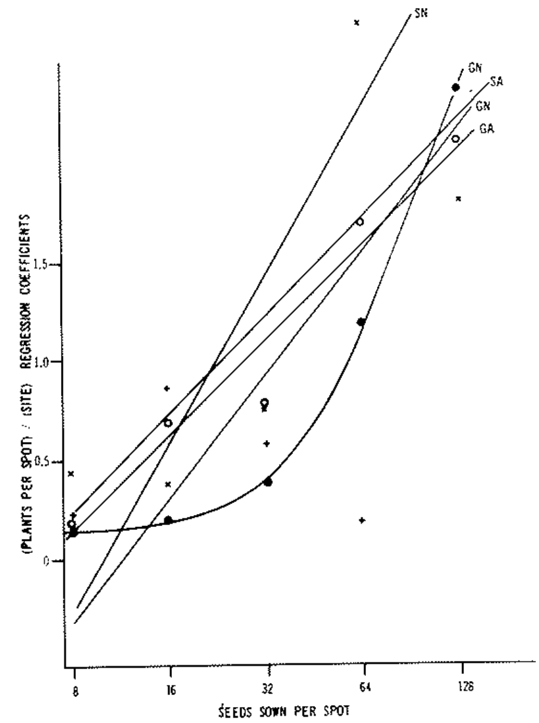

Fig. 15 Influence of seeding intensity on response to site as expressed by number of germinants and survivors per spot. Symbols: O Germinants, ashbed: ● Germinants non ashbed: + Survivors, ashbed: X Survivors, non ashbed.

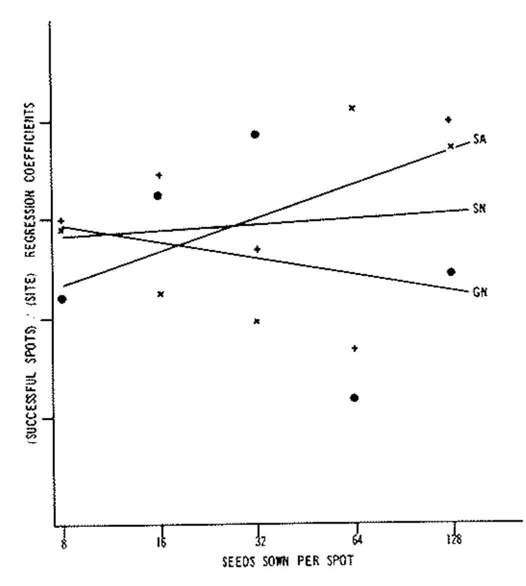

Fig. 16. Influence of seedin intensity on response to site as expressed by percentage of spots with germinants and with survivors. Symbols as for Fig. 15.

(ii). Survivals: The relationship between survivors per spot and the range of seed number treatments for the site resembles that for germinants on ashbed and non ashbed (Figs. 11 and 12). Babbington was the most successful site for both seedbed classes followed by Andrew-May sown, and Andrew-July sown. High seeding intensities were the most sensitive to site quality, though responses were not strictly in proportion to seeding intensity. The variation of individual values about the regression lines was very high.

Babbington-October sowings produced an average of 58 percent successful spots at the time of assessment of survivors. Andrew-May sowings resulted in 30 percent success, while July sowings yielded eight per-cent of spots with survivors. These values apply to ashbed and non ashbed, the differences between seed-beds being only slight. No seeding intensities was more strikingly successful than the others, partly due to a wide variation in success within each site.

This is illustrated by Figures 13 and 14.

DISCUSSION.

It may be seen from Figures 15 and 16 that a marked difference in response to site occurs between the number of plants per spot and the number of success-ful spots. These relationships suggest that, regard-less of the general site quality and seeding intensity, there is sufficient vigorous seed in a sample of from eight to 128 seeds to occupy any suitable niche on which they are planted. Tetrazolium chloride viabili-ty tests indicated 68 per cent strong and 93 per cent viable seed in the parcel used, providing approximately five vigorous seeds in the lowest seeding intensity.

The constancy of the successful spot percentage indicates a relatively uniform proportion of spots, both on and off ashbed, on the five planting sites which were favourable for germination. The variation between the sites may therefore be explained by the physiological response of the seeds. Sites II and IV, Andrew-May sowings, were the most successful from the point of view of germinants per spot. Andrew-July sowings and Babbington-October sowings were about equally successful, but much less so than the May sowings.

Minimum air temperatures are approximately equal in May and October at Manjimup and Pemberton, while the July minimum is 2 to 3 degrees-F lower. This may be sufficient to explain the differences in germination between May and July sowings, as the July temperature is about 42 degrees, close to the minimum for plant growth.

Although the spring and early summer of 1962-63 was three times as wet as normal in the karri forest, delayed germination was recorded at Babbington during April 1963. Some of the seed may have dormancy induced by high temperatures or may have remained sufficiently dry during the spring to delay its germination until the following autumn.

The comparative success of the Babbington-October sowings must be attributed to the high spring and summer rainfall of 1962. The Andrew plots were exposed to a long dry summer in 1963/64 which caused a large number of deaths between January and April. Mortalities in the dry season at Babbington were confined to February 1963.

It is evident that under normal conditions May sowings are more likely to succeed than July or October sowings, either on or off ashbed. A summer sufficiently wet to sustain small karri seedlings cannot be relied upon, even near the south coast. July sowings do not appear to provide sufficient opportunity for seedling establishment before the commencement of the summer drought under normal conditions.

1.3 PELLETTED SEEDING.

SUMMARY.

Clay pelletted seeds have shown three times as many germinants as unpelletted seeds; but requirements for direct seeding nevertheless are very high. The potential for better use of the available seed by direct seeding has not been improved using these methods here with fertilisers.

INTRODUCTION.

Hall and Richmond (1961) reported on the potential of pelletted eucalypt seed for artificial regeneration. One pound of karri seed was pelletted subsequently in 1963 by Australian Paper Manufacturers Ltd. at Traralgon, Victoria. The ingredients for a batch of pellets containing 1 lb. of karri seed were:

6 lb. peat

3 lb. pulp waste

2 lb. vermiculite

12 lz. dieldrin dust

1 oz. sodium alginate (1 oz. = 0.45 p.c. of mix)

8 oz. urea formaldehyde

9 oz. "Agro Plus" NPK fertiliser.

Four seed applications were used: 8, 16, 32 and 64 seeds per pellet. Half the pellets were sprayed with 3 percent diethylene glycol, the remainder were left unsprayed. Planting sites in Andrew Block included new and old burn, ashbed and non ashbed, and heaped mineral soil. The plots on old burn were sprayed with 0.5 percent 2,4,5-T to remove competition from _Acacia pulchella_ and _Bossiaea aquifolium_.

Glycol-sprayed and unsprayed pellets in May 1963 were planted at spacings of 9 by 3 feet in each plot, the four seed densities being distributed throughout each treatment. An area of one square foot was cultivated by hoe, and the pellet pressed into the ground by foot until level with or slightly below the surface.

Germination was extremely variable within the classes of seed number per pellet, pellet spray treatment, seedbed, and aspect. In most cases the results were disappointing and all plots were total failures by October 1963, when the experiment was terminated.

Although pelletted seeds gave very promising results in glass house trials (Hall and Richmond 1961), field trials resulted in established seedlings from only 17 percent of the pellets sown. Similar experience at Andrew resulted in the discontinuance of this method until new techniques could be established along the lines of those developed by the Victorian Forests Commission (1967). These present techniques are described.

METHODS.

a. Laboratory Techniques.

1. Leader trials - The preliminary investigations have shown no large differences in the capacity of germination by the acceptable technique of pelletting karri seed without pretreatments in kaolin clay with thin cellofas sticker (Appendix I). These standard treatments have been screened out from a number of trials in the laboratory testing -

three pretreatments - control seed;
seed soaked in water, one day;
seed soaked in liquid fertiliser, one day:

five stickers containing standard concentrations of insecticide, fungicide and bird repellant
cellofas 'A' (or methocel) thick and thin;
latex, thick and thin;
Victorian mucillage (gum arabic):

three coating substances -
peatmoss and clay;
Kaolin clay;
bentonite clay:

2. Preliminary requirements - Pelletting an adequate number of viable seeds, grading the pellets, sampling, testing and resolving the average number of viable seeds per pellet and the total numbers per parcel are essential procedures before the required numbers may be sown in the field. Preparations have been made in the laboratory along the following lines of investigation -

2.1 Seed quantities have been calculated initially allowing for the numbers required in the designed experiment, in testing the quality of the pelletted seeds, and in providing a safety factor of 2 or 3 to account for unforeseen interaction of factors in handling seed in the laboratory and in the field.

2.2 Pelletting - Standard procedures and ingredients for pelletting and re-pelletting of karri seed are listed in Appendix I.

2.3 Grading - In addition to defining weight and number of seeds in each parcel, the grade is defined by two sieve sizes, the one through which it is passed and the other on which it is retained. Small seeds have been made up in two grades, singles and multiples for karri.

2.4 Sampling - A leader sample in each grade has been taken by weight and number of sound seed in a squash test, under magnification as is necessary for small seed. This defines a suitable sample size for either 50 pellets or 50 sound seed per replicate for testing the quality of the pellets and the seed.

Subsamples of each parcel after thoroughly mixing are taken in the desired size either by repeated halving and quartering (Grose and Zimmer, 1958) or in a tube pushed to the bottom of the parcel at an angle perpendicular to the surface.

2.5 <u>Squash tests</u> - The quality of the pellets is defined initially by the quantity of sound seeds in the weights of six replicates of 50 and in the average number per pellet obtained in the standard squash test. Any required quantity of seed may be calculated then by proportion from the numbers in the sample weights.

2.6 <u>Viability tests</u> - Six replicates of 50 pellets of each grade have been tested for number of germinants obtained on moist vermiculite in dishes in incubators at 25°C for seed of karri. <u>Percentage viability</u> for each set of tests is calculated, multiplying by 100 and dividing by the number of whole seeds in the pellets in these and in the squash tests. The true number of viable seeds for weights sown in experiments, demonstration trials or other use also may be calculated directly by proportion - from the numbers of viable seeds in the sample weights tested.

b. <u>Field Techniques</u>

1. <u>Experimental area, materials and methods</u>

Two blocks of treatments were designed in a factorial experiment to test surface sowing methods in pelletted and unpelletted seeds -

Block 1. Factors: Sowing methods x 2

Pelletting x 3

Months x 3

Replicates x 2

Broadcast-sowing three grams per replicate in ½ chain squares = 18 plots in Block 1. A filler in sago at 20 x weight of seed was mixed and broadcast from a cyclone spreader at a pre-calibrated setting for each test.

Spotsowing of 50 seeds per replicate in spots, two seeds per foot within lines ½ chain long, 11 feet between lines (3 per ½ chain square) = 18 lines in Block 2 without fertiliser.

Block 2. Factors: Fertiliser levels x 3

Pelletting x 3

Months x 3

Replicates x 2

Spotsowing as above in 54 lines by random numbers for treatment.

Fertiliser (1) nil; and (2) 0.9 grams ($\pm$ 0.3) per gelatin capsule of blood and bone (5,11,5) or (3) magamp 12 (7,40,6); placed one match-length (5cm) from seed on cellotape.

Pelletting (1) nil; (2) single; (3) double.

Months (1) April; (2) May; (3) June.

Germinants were counted in October (27th) 1970.

2. Demonstration area, materials and methods

Broadcast-sowing was extended to another site using surplus pellets to indicate possible interaction of time of preparation and storage of pellets on the viability of the seed in the laboratory, and of site conditions and weather at the time of sowing in the field.

Seed pelletted in June 1968 and stored at ambient temperature for two years was sown in six trials over 1.5 acres in June 1970.

Seed pelletted in February 1970 was stored at ambient temperature until sown in this area in four trials over 2.0 acres in July, and in the experimental area as above.

Germinants were counted late in November and early December, in a four percent assessment covering a 66-chain strip two links wide (132 mil. acres.)

3. Preparation of Site

The experimental area off Pine Creek Road was located on an exposed steep slope and stony soil bed varying from tractor track to ashbed, following logging and burning.

The demonstration area off Scatter Road was located on gently undulating karri soil type (RBfSL). Logging and burning provided a range of seedbeds - 16 percent good (well charred soil surface or ashbed); 52 p.c. moderate (cultivated surface soil, cleaned by burning and disturbed by tractor); and 32 p.c. poorbed (undisturbed, compacted surface, or subsoil).

RESULTS.

1. <u>Experimental</u> - Germination of pelletted karri seed was three times better than unpelletted seed, no difference being established in any other treatments, sowing in May, June and July.

I. Spot and broadcast seeding -

Germination of multiple seed in pellets = 27%) P.01
" " single seed in pellets = 20%) **
" " unpelletted seed = 8%

II. Spot seeding with and without fertilisers -

Germination of multiple seed in pellets = 14%) P.05
" " single seed in pellets = 12%) *
" " unpelletted seed = 4%

2. <u>Demonstration</u> - Karri seed pelletted in winter 1968 was equally as good as seed of the same source pelletted in summer 1970 -

1970 Germination from 1968 pellets
= 25 p.c. in 995 seeds assessed in six trials.

1970 Germination from 1970 pellets
= 22 p.c. in 3,430 seeds assessed in four trials.

CONCLUSION

Seed requirements are very high for direct seeding. Clay pelletted seeds increased the number of germinants threefold, indicating that the mean plant percent may be raised to about five percent, (from 1.7 p.c. unpelletted), and reduce seed requirements per thousand acres for example from 1,000 lb. to 330 lb. This benefit is removed partly by seeding with fertilisers here in parallel trials.

The potential for direct seeding requires that further improvements will be needed in the use of fertilisers before better use of the available seed may be made by these methods. Thorough preparation of acceptable sites is a desirable requirement.

2. PLANTING TRIALS.

In an attempt to increase the certainty of establishment of artificial regeneration, the use of transplanted wildings and nursery raised stock was investigated. These plants should be able to establish themselves more quickly than germinants from seed, so competing more effectively with weed growth. Other trials in artificial and natural regeneration also were tested with chemicals to remove competition by spraying and with N.P. fertilisers to assist establishment and rates of growth of karri seedlings.

MATERIALS.

A. PLANTING SITES.

1. Babbington

The experimental site was located in an area burnt in January 1962. Weed seedlings, chiefly *Acacia pentadenia* were about four months old and very small when planting was carried out in early August 1962. No preparation was made on this karri site.

2. Crowea

A karri-marri stand was selected which had been burnt in an uncontrolled fire in March 1961. Ashbed plots carried regenerating *Acacia decipiens* which had reached a height of four feet by the time of planting in late July 1962. Planting lines two chains long and nine feet apart were sprayed with a 2.5 percent solution of "Weedone 80" to clear a strip four feet wide along each line, one week before planting.

3. Mack

A recently disturbed mineral soil surface of light brown lateritic fine sandy loam in a medium quality karri stand was selected in two areas for planting after logging.

4. Andrew

An area burnt for regeneration in December 1961 and carrying an inadequate stocking of karri seedlings was selected. Planting blocks about 10 chains long and one chain wide were located on north, west and south aspects. Rows were spaced nine feet apart, half being sprayed with 1.0 percent 2,4,5-T to kill vegetation on a strip four feet wide one week before planting.

Planting lines about three chains long were prepared on an area burnt in April 1963 in a similar manner to that described for the old burn. Two plots were used, one on a large ashbed and the other mainly free of ashbed.

B. PLANTING STOCK.

Plates (1-5) show range in size of nursery stock raised by different methods. Size for age is similar for wildlings available in selected ashbed in the logging areas (Plate 6).

Plate 1 - Seedlings at six months raised in jiffy compressed peat pots in trays at Manjimup nursery by P. Gnuske.

Plate 2 - Karri at six months in jiffy peat pot (2¼ in/5½ cm square), and in plastic tube.

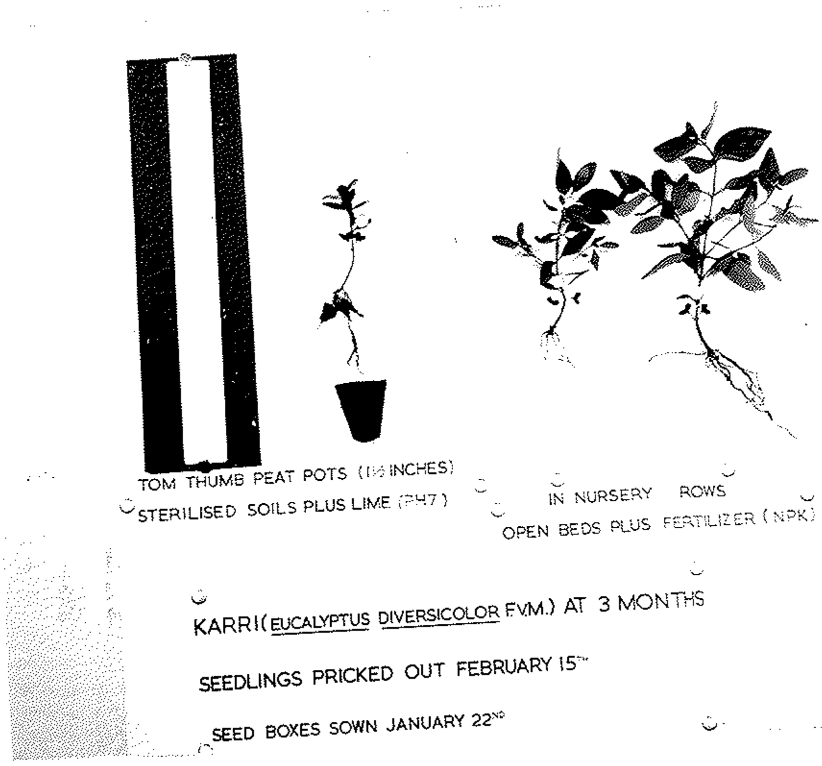

Plate 3 - Karri at three months raised in thumb peat pot L.H.S.
And in open beds in nursery as openrooted seedlings, R.H.S.

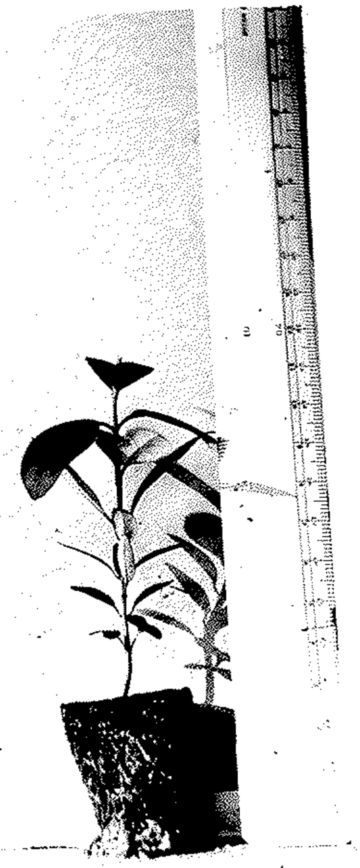

Plate 4 - Karri at three months in round thumb peat pot (1½ in/3½ cm).

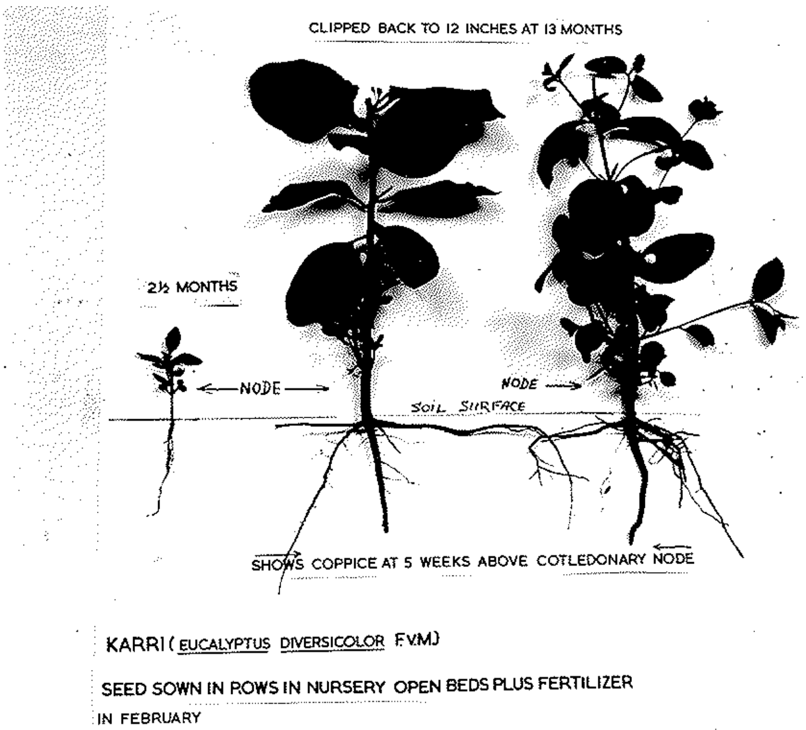

Plate 5 - Openrooted karri at $2\frac{1}{2}$ months; and at 13 months, clipped back to 12 inches five weeks before lifting, and showing coppice shoots and root development without root-wrenching.

Plate 5A - Root wrenching on seedlings over 12 months, showing strong growth too unwieldy for convenient handling.

Plate 5B - Close view of callus growth after root wrenching (Plate 5A).

Plate 6 - Wildling nursery of karri at 17 months, at July, 1963 in Court Block after a summer fire in 1962.

1. Babbington and Crowea

a. Seventeen month old wildlings were obtained from an area in Carey Block, burnt in an uncontrolled fire in January 1961, which supported dense regeneration. Three methods were used to lift 140 seedlings required for planting:

1. pulled up by hand without pre-treatment,
2. spade lifted, the roots being cut at a depth of 8 to 9 inches and shaken free of soil before bundling,
3. spade lifted, with soil packed around the roots before their removal from the ground, referred to as root balled.

The seedlings were wrapped in plastic sheeting so the shoot tips protruded from the top of the bundle. They were transported about 40 miles to the planting site in a covered utility, "heeled in" with one side of bundles unwrapped, and planted two days after lifting.

b. Three month old wildlings resulting from a fire in Giblett Block in April 1962, were treated in a similar fashion to those from Carey, except that a knife was used instead of a spade for lifting, and these 140 required for planting were transported in a plastic box.

2. Mack

Six month old open-rooted seedlings from seed sown in February in open nursery beds with blood and bone fertiliser, were lifted in August 1964. Two

TABLE 3.

DETAILS OF TREATMENTS APPLIED TO KARRI WILDLINGS BEFORE PLANTING IN JULY 1963 AT ANDREW (TEXT 2B3).

Stock No.	Pretreatment	Lifting Method	Wrapping for Transport in Plastic Sheet.
1	None	Spade	Complete
2	None	Spade	Open at top
3	None	Pulled	Complete
4	None	Pulled	Open at top
5	(Shoot clipped	(Spade	Complete
6	(to 12-15 in.	(Spade	Open at top
7	(Root pruned	(Pulled	Complete
8	(to 8-9 in.	(Pulled	Open at top

hundred were wrapped in plastic sheeting and transported to the planting site.

3. Andrew

a. Wildlings.

Three areas of dense one year old karri regeneration in Court Block were selected as wildling nurseries. Some seedlings were pre-treated by clipping the shoots in half to a length of 12 to 15 inches and root pruning by spade about one month before transplanting. The remainder of the seedlings were left in their natural condition.

Table 3 indicates the treatments applied to the planting stock. Lifting of 1,300 wildlings for the planting trials was either by spade or by hand, as described for the Babbington experiment. Some bundles of plants were completely enclosed in plastic sheeting for transport to the planting site, while the remainder were wrapped so the shoot tips protruded beyond the sheet.

b. Potted Nursery Stock.

The use of compressed peat "jiffy" pots for the raising of planting stock was investigated with a view to increasing the certainty of establishment of desirable plants in the field.

The soil mixture used was prepared from one part of red brown karri forest loam, two parts of black sand and three percent by weight of "Nitrophosa Red" NPK fertiliser.

The mixture was fumigated with methyl bromide and placed in jiffy pots at the rate of one cubic foot of soil to 300 pots.

Six to seven seeds were sown directly into each pot and covered with a quarter of an inch of sand or vermiculite. Sowing was carried out from January 22 to March 19, 1963, the pots being kept under complete shade until germination was complete. At this stage the pots were transferred to a shade-house giving 50 percent shade for a period of 8 to 15 weeks.

The seedlings were thinned to one or two per pot when shifted from the shadehouse out to hardening frames, where 900 were retained until required for the planting trials. When planted in July 1963, shoot length ranged from 2.5 to 17 inches, height being proportional to the time between sowing and planting.

The most favourable size was considered to be from 8 to 10 inches, resulting from sowings in mid February. These plants were easier to handle and suffered much less damage during transport in trucks and trays than did taller stock.

PLANTING METHODS.

1. <u>Babbington and Crowea.</u>

A small area was cultivated by mattock at each planting spot, and a hole dug about eight inches deep. No fertiliser was applied to the wildlings which were planted in July 1962. Quarterly inspections were made to count survivors and six monthly height measurements were made up to April 1964.

2. Mack

Planting in the first week of August 1964 happened to be a little late in the season. A hole to nine inches deep with a planting spade was dug and the seedling was planted about one inch below the root collar. The spade was re-inserted about 2 or 3 inches along the side of the planting hole and pressed sideways to close any air pockets and to hold the seedling firm in the planting hole. Half were planted in separate plots without fertiliser and the other half with fertiliser. In this instance a handful of fertiliser (2-3 ozs. nutrifert 5:11:5) was added in the second spade hole. This hole was closed with the foot before moving on to the next one.

3. Andrew

Planting was carried out in July 1963 at a nominal spacing of 9 by 9 feet. Lines about five chains long were planted with seedlings of the one stock, the fertiliser and stock number sometimes being altered for the remainder of the 10 chain planting line.

Fertiliser was applied to plants in some rows in the following manner. A nitrogen and phosphorus fertiliser comprising equal parts of "Nitrogreen" and super-ammonia (N-P compound 13:7:0) was applied at the rate of 2½ ounces per plant. A hole about nine inches deep was dug with a mattock and a handful of fertiliser was placed in the bottom. This was covered by two inches of soil and the seedling planted so its root collar was just below the soil surface when the soil had been firmed around it. Jiffy pots were planted in the same manner as wildlings, the pot being just covered by soil. A 10 percent dieldrin dust mixed with four times its weight of agricultural lime, was applied in the same manner as the nitrogen and phosphorus fertiliser. All plants were identified by a yellow painted wire marker.

The following treatments were applied, fertiliser as above at the time of planting and spraying (see planting sites) one week earlier -

1. F & S. N+P: Fertilised with one handful of "Nitrogreen" and super-ammonia mixture per plant, and the planting line sprayed with 1 p.c. 2,4,5-T. at 2½ lb./ac.
2. F & S D: Fertilised with one handful of dieldrin dust and lime, the planting line sprayed with 2,4,5-T.
3. F/only N+P: Nitrogen and phosphorus fertiliser as for (1) the planting line unsprayed.
4. F/only D: Dieldrin and lime applied as in (2) the planting line unsprayed.
5. S/only: Planting line sprayed with 2,4,5-T one week before planting, no addition of fertiliser.
6. U/S U/F: Unsprayed and untreated control.

Monthly inspections were made from August 1963 to January 1964 to enumerate survivors. Height measurements were made at a final inspection in April 1964.

RESULTS OF PLANTINGS.

Plate 7 - Openrooted karri, eight months after trans-
plantating (from open nursery beds at the
age of six months Plate 3) into the field
with and without fertiliser in Mack Block
(Plate 8).

Plate 8 - Close view of transplanted seedling without
fertiliser (front) and with 2½ ounces of
blood and bone (rear) in Mack Block (Plate 7).

TABLE 4.

KARRI WILDLING TRANSPLANTS 1962 AND SURVIVALS 1963-64

A. 17 MONTH OLD STOCK. BABBINGTON (See Figure 17).

Treatment	Seedbed	Number Planted	Survivors (% of Planted)					
			1962		1963			1964
			31.10	11.12	16.1	12.6	24.9	29.4
Pulled Up	Ash	24	100	100	100	95.8	95.8	95.8
	Non Ash	23	95.7	95.7	95.7	91.3	91.3	87.0
Spade Lifted	Ash	23	100	100	100	100	100	95.7
	Non Ash	22	100	100	100	100	100	100
Roots Balled	Ash	24	100	100	100	100	95.7	91.3
	Non Ash	22	100	100	100	100	100	86.4

B. 3 MONTH OLD STOCK. BABBINGTON.

Treatment	Seedbed	Number Planted	31.10	11.12	16.1	12.6	24.9	29.4
Pulled Up	Ash	24	79.2	79.2	75.0	66.5		
	Non Ash	22	72.7	72.7	63.6	54.0		
Spade Lifted	Ash	24	79.1	79.1	75.0	70.0		
	Non Ash	22	86.5	86.5	81.8	77.3		
Roots Balled	Ash	23	91.0	82.6	78.3	69.5		
	Non Ash	24	87.5	87.5	79.2	66.6		

TABLE 5. PERCENTAGE SURVIVAL OF 1300 WILDLINGS APRIL 1964, NINE MONTHS AFTER TRANSPLANTING IN WINTER 1963 AT ANDREW.

Abbreviations for stock numbers in Table 3, fertiliser, and spray treatments explained in text methods. (See Figures 18, 19 and 20).

Burn	Stock No.	Seed Bed	Fertiliser & Spray Treatments						Mean
			F&S N+P	F Only N+P	F&S D	F Only D	S Only	U/S U/F	
New	1	Ash	85.7						85.7
		N/A	71.5			91.0			81.4
	3	Ash		66.7					66.7
		N/A		61.9					61.9
	4	Ash				100			100.0
		N/A				75.0			75.0
	5	Ash					95.0		95.0
		N/A					89.5		89.5
	6	Ash						77.8	77.8
		N/A						95.0	95.0
	7	Ash						83.4	83.4
		F/A						90.5	90.5
	8	Ash						100.	100.0
		N/A						90.0	90.0
	Mean		78.6	64.3		88.6	92.3	89.4	

(Continued next page)

TABLE 5. continued

Burn	Stock No.	Seed Bed	Fertiliser & Spray Treat.						Mean
			F&S N+P	F Only N+P	F&S D	F Only D	S Only	U/S U/F	
Old	1	N/A	58.0	81.8	38.2	62.0	61.9	69.4	62.2
	2	N/A	81.8	73.5	82.0	82.0	64.2	73.5	76.1
	3	N/A		68.2					68.2
	4	N/A					42.3		42.3
	5	N/A			85.2				85.2
	6	N/A					80.0		80.0
	7	N/A			66.7				66.7
	8	N/A					70.9		70.9
	Mean		69.9	74.3	68.0	72.0	63.8	71.5	

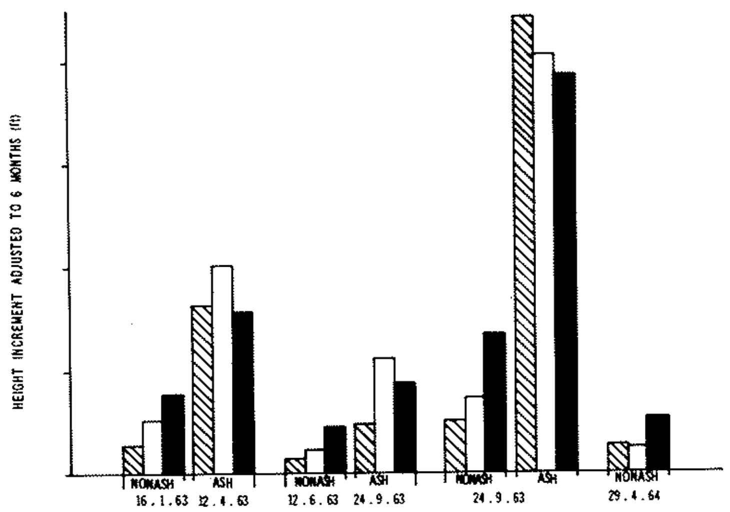

Fig. 17. Influence of lifting method and planting site on growth rates of karri wildling transplants at Babbington and Crowea between September 1963 and April 1964. Solid columns, root balled; open columns, spade lifted; hatched columns, pulled up. (see also Table 4).

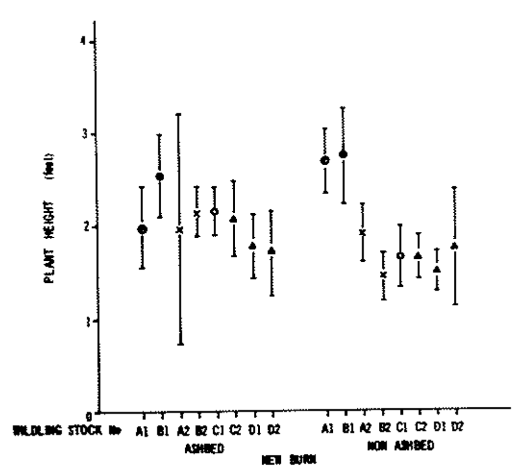

Fig. 18. Mean heights and standard errors, of karri wildlings on recently burnt area April 1964, nine months after transplanting in Andrew.
Symbols : ⊕ N & P fertilizer, 2.4.5-T spray; ● N & P fertilizer only: + Dieldrin and lime, 2.4.5-T spray; X Dieldrin and lime only; O 2.4.5-T spray only: △ untreated control.
Stock numbers as in Tables 3 and 5.

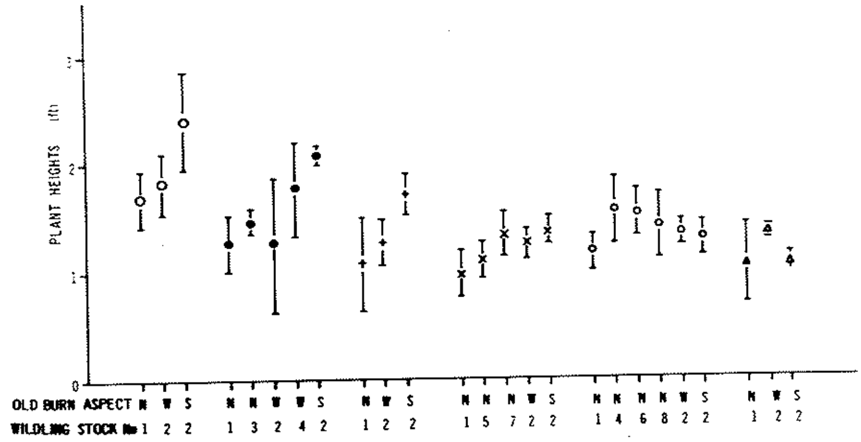

Fig. 19. Mean heights and standard errors of karri wildlings on old burnt non ashbed. Showing influence of aspect April 1964, nine months after transplanting in Andrew. Symbols as for Fig. 18.

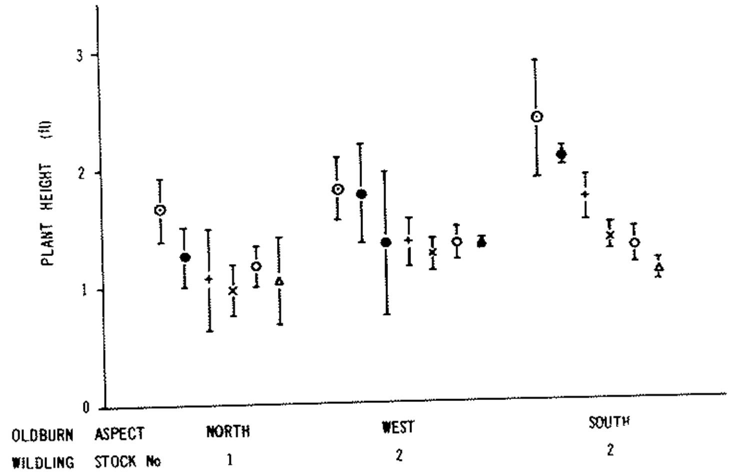

Fig. 20. Mean heights and standard errors of karri wildlings on old burnt non ashbed showing influence of treatments, April 1964, nine months after transplanting in Andrew. Symbols as for Fig. 18.

1. <u>Crowea: Wildlings.</u>

The ashbed plot was completely spoiled by the activities of native animals during 1963 preventing a comparison with other plots. The non ashbed plot was extensively overgrown by <u>Acacia pulchella</u>. The only reliable information collected from Crowea was the height growth of wildlings off ashbed between September 1963 and April 1964, and this is included in Fig. 17.

2. <u>Babbington: Wildlings.</u>

a. <u>Survival</u>

Survival percentages for 3 and 17 month old stock are shown in Table 4. The suppression of the younger planting stock by naturally established karri and weed species resulted in numerous deaths throughout the summer and led to the suspension of this portion of the study in June 1963.

Prior to the second summer after planting, survival percentages for 17 month old stock were very high, with the exception of those which were pulled up by hand. Several fatalities occurred during the second summer, the plants concerned having been suppressed by the natural regeneration which developed after the time of planting.

b. <u>Height Growth</u>

Fig. 17 illustrates the height growth of surviving 17 month old planting stock for three periods of measurement, the values being adjusted to a six month interval for comparison. About 20 plants contributed to each value in the figure. For any lifting method, growth on ashbed was approximately twice that off ashbed during both summer and winter. The difference was most marked in the second summer after planting.

Root balled plants showed consistently greater height growth off ashbed than either spade lifted or pulled up stock. Where the wildlings were planted on ashbed, however, no particular method of lifting gave clearly superior results. The variation about the mean values was large, and differences between treatments within seedbed classes were not significant.

3. Mack Block: Open rooted nursery plants -

Rapid height growth and vigour provided by 2½ ounces of blood and bone fertiliser is well demonstrated in the field plantings (Plates 7 and 8; Harris, 1966 Plate 21, page 56). Survivals also as shown compare well here with those in the other trials, in spite of planting out of season early in August.

4. Andrew: Wildlings.

a. Survival

Survivals on recently burnt ashbed were about three per cent higher than off ashbed. No consistent trend in survival percentages could be detected in the fertiliser and spray treatments applied. Comparisons of the survival of different stock numbers was difficult because only two were planted over the whole range of conditions, as may be seen from Table 5. The average survivals for the various site treatments on old burn were four percent lower than for new burnt areas.

Deaths of seedlings occurred from the time of planting to the final inspection. Many of these were recorded in the first month after planting, few additional deaths being observed between August and December.

b. Height Growth

The seedlings were between 24 and 30 inches in height at the time of planting, except for those in which the shoots had been clipped to 12 to 15 inches.

Figures 19, 20 and plates 9-12 demonstrate responses to fertiliser and plant treatments on both new and old burnt areas. The plant heights in the nitrogen and phosphorus treatments only are significantly greater than the remainder on new burn non-ashbed and old burn south aspect sites. From Fig. 19 it can be seen that plant height on the southern aspect is significantly greater than on the northern aspect for nitrogen and phosphorus treatments, with or without spray and for lime-dieldrin and spray treatments.

Lime-dieldrin without spray resulted in a consistent, but not significantly greater height growth on southern as compared with northern aspects.

Plates 9 - 12. - Karri wildings transplanted from the field nursery at the age of 17 months (Plate 6), 15 months after transplanting in July 1963 - without fertiliser (growth stagnated, Plates 9 and 10); with 2-3 ounces of N + P fertiliser covered with soil in the planting hole (stimulated vigorous growth in the new leaders from the side shoots (Plates 11 and 12): subsequent growth completely occluded the dead tips that had died back following planting. Andrew Block, October 1964 (see pp 78a. 78b).

Plate 9 - Shoots not clipped before planting without fertiliser.

Plate 10 - Shoots clipped back to 15 in. before planting without fertiliser.

Plate 11 - Shoots not clipped back before planting with fertiliser, shows dead tip and leader from the side shoot with an axillary ring on the stem.

Plate 12 - Shoots clipped back to 15 in. (about 40 cm) before planting with fertiliser.

The addition of nitrogen and phosphorus without spraying produced smaller plants than when spray was used; although the differences are not statistically significant, they are consistently better from 0.1 to 0.5 feet.

c. Plant form

Most plants died back at the tips initially, the extent of the damage varying considerably within each treatment class. Pruned seedlings appeared to suffer no more set back than most of the unpruned plants. (Plates 9 and 10 without fertiliser; and 11 and 12 with fertiliser).
Bifurcation of the leading shoot was common, particularly in plants where the shoot had been clipped. This deformation was most prominent where the shoot was over 0.15 inches thick at the point of cutting. Subsequent observations have shown these deformations have been occluded in the rapidly grown plants when fertiliser has been applied. Other than the axillary ring where the tip has died back (Plates 11 and 12) there is now no other visible evidence of deformation at all in these trees.

5. Andrew: Peat Pot (Jiffy) Stock

a. Survival

There were practically no deaths before January 1964, and Table 6 summarizes the survival values at the final inspection. Old burn ashbed and non ashbed figures were combined due to a lack of plants on old ashbed.

TABLE 6.

PERCENTAGE SURVIVAL OF 370 JIFFY PEAT POT STOCK APRIL 1964, NINE MONTHS AFTER PLANTING IN JULY 1963; ANDREW.

Fertiliser and Spray Treatments Explained in Text Methods. (See Figures 21, 22 and 23).

Treatment	New Burn		Old Burn*	Mean
	Ashbed	Non Ashbed		
F & S N+P	100	100	97.5	99.2
F Only N+P	100	95.5	91.9	95.8
F & S D			89.7	89.7
F Only D	97.8	95.0	87.5	93.4
S Only	86.0	95.5	87.7	89.4
U/S U/P	83.0	90.5	81.3	84.9
Mean	93.2	95.1	88.9	

* Old ashbed and non ashbed figures were combined because of an insufficient number of plants on old ashbed.

TABLE 7.

SUMMARY OF MEAN HEIGHT INCREMENTS OF JIFFY POT STOCK FOR SEEDBEDS AND TREATMENTS, 40 (± 20) PLANTS PER MEAN.

(Figures 21, 22, 23 and TABLE 6)

Increment in feet and cm between July 1963 and April 1964. All plants were 12"-15" (35cm) at time of planting.

Treatment	New Burn				Old Burn			
	Ashbed		Non Ashbed		Ashbed		Non Ashbed	
	(ft)	(cm)	(ft)	(cm)	(ft)	(cm)	(ft)	(cm)
F & S N+P	1.7	52	1.9	58	1.05	32	.7	21
F Only N+P	1.5	46	1.65	50	1.05	32	.5	15
F & S D					.3	9	.15	5
F Only D	.65	20	1.1	34	.15	5	.2	6
S Only	.4	12	.5	15	.25	8	.1	3
U/S U/F	.5	15	.5	15	.4	12	.15	5

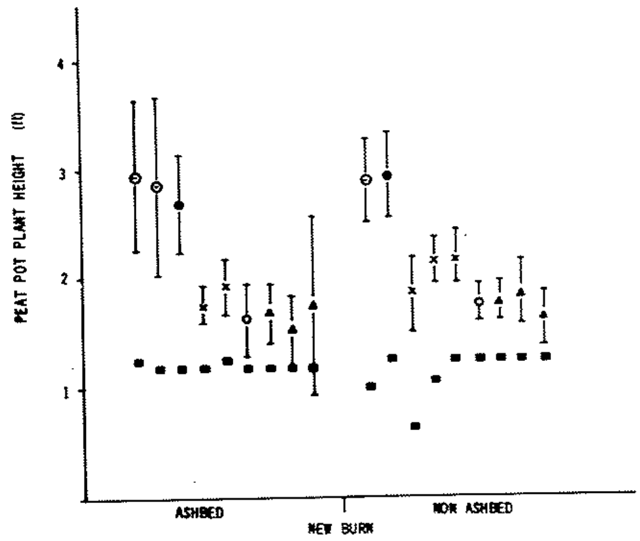

Fig. 21. Mean heights and standard errors of karri jiffy pot stock on new burnt area, April, 1964, nine months after planting out in Andrew. Symbols

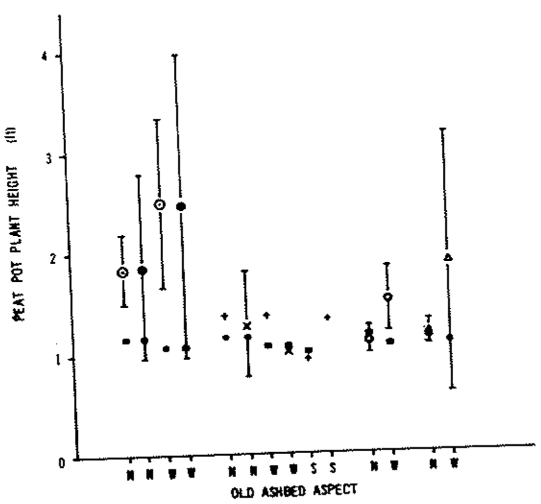

Fig. 22. Mean heights and standard errors for karri jiffy pot stock on old ashbed, for aspect and stock classes April 1964, nine months after planting out in Andrew. Symbols as for Fig. 18, 21.

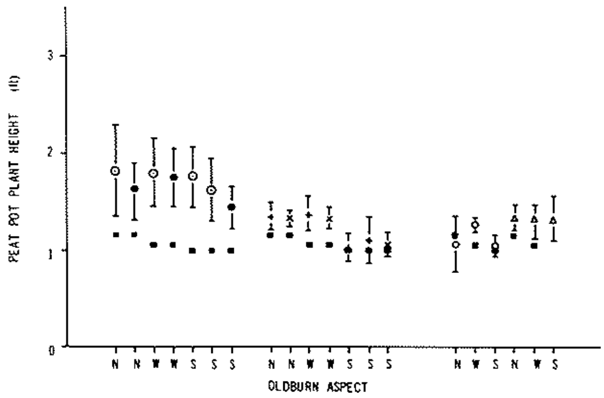

Fig. 23. Mean heights and standard errors for Harri jiffy pot stock on old nonashbed, for aspect and stock classes April 1964, nine months after planting out in Andrew. Symbols as for Figs. 18, 21.

Most successful establishment was obtained by the removal of competition and addition of fertiliser, even on ashbed. Untreated and sprayed only areas showed survival values 10 percent lower on non-ashbed than on ashbed. The cause of the difference was not ascertained. No difference occurred between the survival for unsprayed but fertilised, and sprayed only treatments on the new non ashbed sites. This indicates that the stimulus resulting from the addition of fertiliser here was equal to that produced by the removal of competition, though the competing plants were only small.

On old burnt areas the addition of nitrogen and phosphorus fertiliser alone gave better establishment than spraying, or the application of dieldrin alone. Best results were obtained with removal of competition and the addition of nitrogen and phosphorus fertiliser. Untreated plantings showed six per cent fewer survivals than any of the other treatments.

b. <u>Height Growth</u>

The mean heights of the various seedling stocks at the time of planting were between 1.0 and 1.25 ft., as indicated in Fig. 21, 22 and 23. Plant height may therefore be used as an expression of height growth and the success of establishment of the seedlings.

On new burnt areas, plants fertilised with nitrogen and phosphorus, with or without spraying, were approximately one foot taller than those with any other treatment (~~[illegible]~~), the differences being significant at the 95 per cent probability level

(Fig. 21). The standard error of plant height was generally greater on than off ashbed, probably due to a larger site variation in the ashbed areas. The standard errors were also greater for nitrogen and phosphorus treatments than for others on ashbed. This may be the result of a more pronounced interaction between site and treatment for nitrogen and phosphorus applications than for the other treatments.

In this experiment jiffy pot seedlings lacking nitrogen and phosphorus treatments resulted in no greater growth on than off ashbed, (Table 7). The addition of lime-dieldrin stimulated growth to a small extent.

A low number of plants on old ashbed prevented the demonstration of statistically significant differences between the heights of plants for the various treatments. In Fig. 22 where less than four plants occurred in any class standard errors were not calculated.

Height differences (Fig. 23) were less striking on this old ashbed site than on those previously described. The growth of plants treated with nitrogen and phosphorus varied from 0.5 to 0.8 feet, while other treatments resulted in height increments of 0 to 0.3 feet. The differences between treatment means despite small standard errors were not significant in many cases.

DISCUSSION OF PLANTINGS.

1. Effect of Planting Stock.

The height growth of root-balled wildlings at Babbington was consistently greater than for spade lifted or pulled up stock when planted off ashbed. This is considered to be due to the retention of a greater number of small feeding roots in the root balled stock, permitting quicker control of the planting site than in the other planting stock types. No advantage was gained by root balled stock on ash-bed. A ready supply of nutrients would be available to even the most restricted root system, enabling vigorous growth to occur.

Protection of the plants from desiccation at the time of lifting and during transportation was provided by wrapping the plants well in plastic sheeting. Enclosing them completely during transport did not appear to have added any beneficial effect on establishment, neither did root pruning before lifting.

Most wildling shoots appeared to have died back after planting, regardless of their preliminary treatment. It is suggested that this may be due to the tender nature of eucalypt shoots, especially when rapidly grown as crowded wildlings on ashbeds, and when little hardening off occurs before lifting, they become unduly long and succulent. Rapid growth of hardy plants in the early years after planting however rapidly occludes the dead tips. Since wildlings nurseries with desirable planting stock may not always be readily available or accessible, openrooted seedlings may be raised more easily and at less cost also than potted plants in the managed nursery.

Planting stock raised in the nursery are more amenable to growth regulation than other types of seedlings. By suitable fertiliser and watering treatments, their condition, size and time of planting can be adjusted to suit planting requirements. For example, tall plants may be required in a moist site where weed growth is established at the time of planting, while small, hardy plants would be more satisfactory on an exposed or marginal site.

Jiffy pot plants, where they have been fertilised with nitrogen and phosphorus, are much more likely to become established especially in harsh sites than are transplanted seedlings. Because they possess an undisturbed dense root system, potted seedlings can withstand adverse planting conditions better than open rooted stock, and quickly develop an adequate root system. This will be discussed further in the following section.

2. Site Treatments

Transplanted wildlings demonstrated responses of height growth, though not of survival, to ashbed and to the addition of nitrogen and phosphorus fertiliser. Considerable variation in survival percentages within all treatments indicated that opportune site and weather conditions were more important to survival than the treatments themselves.

Jiffy pot stock showed on new burnt areas, a response of survival to fertiliser approximately equal to the spraying response, while on old burnt sites the nitrogen and phosphorus response was greater than that for spraying. This indicates that spraying in strips 18 months after burning is not effective in elimination of root competition from a planting strip four feet wide. Plants outside this strip could easily extend their root systems into the sprayed area and compete with karri seedlings just as effectively as weeds in an untreated area. Mortalities among jiffy pot stock without nitrogen and phosphorus increased after January, while fertilised plants maintained a high survival percentage. It appears that an effective root system must be established quickly by the seedling, and this is assisted more by improving its immediate nutrient supply and competitive ability than by temporarily enlarging the uncontested root space.

Ashbed effect was only detected on old burn areas in the nitrogen and phosphorus treatments. Leaching and competing species would have removed some of the nutrients. Competing species had the advantage of one year's growth before the karri seedlings were planted, and would be in command of all sites.

Growth responses in the nitrogen and phosphorus treatments were much more variable on new ashbed than in similar treatments off ashbed. This suggests that an application of 2 or 3 ounces of this type of fertiliser at the time of planting may not produce maximum growth, and also that in small patches of a large ashbed a concentration of minerals from the burnt debris may enhance the fertiliser response. This is in agreement with the results of the pot trials of Loneragan and Loneragan (1964).

3. DEMONSTRATION PLOTS

Combinations of early thinning and fertiliser trials have been established in natural regeneration and in planting trials, demonstrating and contrasting selected treatments for saleable growth in stand development in a number of areas. Three here are recorded.

a. Mattaband KA Site : natural regeneration 1960 -

A pilot trial of two acres in 28 plots with and without thinning to 360 stems per acre, thinned at 2 and 4 years of age on selected ashbed and off ashbed on the best disturbed mineral soil; with and without broadcasting fertiliser up to 8,000 lb per acre, was established in the autumn 1962.

b. Easter Brook KC Site : natural regeneration 1961 -

A pilot trial of two acres in 28 plots with and without thinning to 360 s.p.a. at the age of one year on selected ashbed and off ashbed on the best disturbed applications of fertiliser up to 700 lb per acre, was established in the autumn 1962.

Measurements 5½ years later in 1967 show high responses to the ashbed, to the spot applications of fertiliser, and to the thinning treatments. The increment on 360 stems per acre has been analysed for response to the treatments in the 26 plots on the ashbed in these two stands,
(Appendix II for details in ranking treatments and responses) pooled as follows -

Factor 1- For thinning at two levels :

(1.1) Thinned either at 1 or 2 years of age

(1.2) Thinned either at 4 years or unthinned

Factor 2- For application of fertiliser at three levels

(2.1) Nil

(2.2) Moderate (light to heavy)

(2.3) Heavy (to very heavy)

Treatments and Responses on Ashbed:	Factor (1) Thinning - (1.1) Either at 1 or 2 yrs. Factor (2) Fertiliser -		(1.2) At 4 years or Unthinned.	
Diameter Growth (ins/an)	(1.1) 0.67 ***		(1.2)	0.48
Fertiliser Heavy		(2.3) 0.65 *		
Moderate		(2.2) 0.59		
Light		(2.1) 0.50		
Volume Growth (c.ft/ac/an)	(1.1) 78 **		(1.2)	44
Fertiliser Heavy		(2.3) 80 *		
Moderate		(2.2) 57		
Light		(2.1) 47		

Top Height:

36' - 48' on ashbed and 5' - 36' off ashbed.

Off Ashbed, with and without fertiliser, with and without thinning -

Diameter growth under 0.35 in./an.

Volume growth from 1 to 18 c.ft/ac/an.

c. Collins KMA site : woody wildlings with fertiliser in adjacent hole 1966 -

This stand of karri was logged in 1959, the final felling of marri was followed up in 1965, and the surplus logs, crowns and stumps were stacked and burnt in May, 1966. Five acres were planted with about 3,000 woody wildlings, without fertiliser and with six ounces of blood and bone, eight inches deep four inches from the transplanted wildlings at 9 x 9 feet spacing in July 1966.

Survival is 90 percent and the annual growth is about six feet with the fertiliser (Plate 13). Without fertiliser the annual increment is about two feet and survival is 70 percent.

Future treatments and measurements also may be made to compare these growth rates with those of the natural regeneration two years earlier (1964) in a similar contiguous site well burnt over in the spring 1963 after clear felling and logging in a 16 chain by 4 chain strip within the stand as above in 1959. The one year old regeneration here was sprayed with 2-4-5-T acid equivalent at 1.25 lb per acre in the winter of 1965, only to provide access and to remove competition from the fireweeds, mainly Acacia pulchella.

(Take in Plate 13 near here)

Plate 13 - Karri wildings five years after trans-
planting in 1966 without fertiliser (foreground) pp 91A
(6-12 ft) and with 6 oz. nutrifert (30 ft)
Collins plot at June 1971. (background, close view)

Plate 14 - Natural and artificial regeneration seeded in the same month (January, 1963) - Natural regeneration in two years after germination (small in foreground), and peat pot seedlings raised in the nursery for six months, planted out with fertiliser in July 1963 and photographed at twenty-one months in Mack Block, April 1965.

at 9 by 9 feet spacing in July 1966.

Survival is 90 percent and the annual growth is about five feet with the fertiliser (Plate 13). Without fertiliser the annual increment is under two feet and survival is 70 percent.

Measurements in the future may be made also to compare these with the growth rates of 5½ year old natural regeneration (1964) in a similar adjacent area well burnt over in spring 1963 after clear felling and logging a 16 chain by 4 chain strip in 1959. The regeneration area was sprayed with 2,4,5-T acid equivalent at 1.25 lb. per acre only to remove fireweed competition in the winter, 1965. (compare plate 14.)

GENERAL DISCUSSION.

The two main factors contributing to site effects are nutrient supply and competition from other plants. Due to the destruction of the weeds and much of the seed in the soil during burning, ashbeds are sparsely occupied by regeneration, though where these beds are sown with karri seed the germinants have a most favourable opportunity for establishment. The enhanced nutrient supplies in ashbeds permit rapid early growth and control of the site by karri. When competing vegetation is established before the karri seed germinates, the development of karri is retarded. It has been observed repeatedly that artificial seeding carried out to rehabilitate a failed area results in later germination and less vigorous early growth than does natural seeding. This reduces the value of direct seeding in competition with the previously established weeds.

Broadcast seeding results in very variable success, as shown by a comparison between the experiments at Treen Brook and Quininup, Loc. 2747. At Treen Brook a good seedbed was available and broadcasting of 1.25 lb. of seed resulted in over 1,000 seedlings per acre. At Loc. 2747, where the area sown had been under degraded pasture and bracken, the seedbed was leached, compacted and occupied by competing species. As a result, establishment was very poor. Tree percent for broadcast seeding on burnt over mineral soils in those trials ranged from about 0.02 to 1.16 per cent. The main cost in broadcast seeding is that of the seed, especially where aerial spreading is used. If large areas are seeded in this manner, it must be expected that much of the seed will fall on unsuitable sites, lowering the mean tree percent. Reasonable results, although uncertain even with pre-treated pelletted seeds, may be obtained only on the best sites and under favourable conditions.

The minimum number of seed suitable for all average conditions known for broadcasting seed for satisfactory regeneration is 80,000 per acre (Loneragan 1971). It has been estimated that when one man is able to spread seed satisfactorily over a strip 20 feet wide as he walked through the bush, seven acres of gaps could be seeded per day. On the basis of the unit costs, shown in Table 8 the total cost per acre would be about $17.50, most of which is due to the cost of seed.

Spot seeding has been examined in order to reduce the wastage of seed occasioned by broadcasting. The 1963 trials were compared, following the method of Finláy and Wilkinson (1963, A.N.Z.A.A.S. paper 1962). Regressions were calculated to show the effect of site on the main number of seeds per spot including failed spots, and on the proportion of successful spots; co-efficients less than 1.0 indicate less sensitive response than those greater than 1.0. Results demonstrated that sowing wider between spots than six feet achieved an unacceptable distribution in the resultant stand with less than 300 successful spots per acre, and no seeding rate was much more successful than another. The worst sites should be avoided in spot seeding, but the information presented in Figures 13 and 14, and supported by evidence of earlier trials show that only about 25 per cent of spots can be expected to carry survivors. Figure 16 indicates that a seeding intensity of eight seeds per spot is as satisfactory as 128 per spot. From these data, 1,200 spots are required to secure a final spacing of 12 by 12 feet, and one pound of seed will be sufficient for about five acres.

The necessity of cultivating a small area on which the seed is to be sown would restrict the rate of seeding to about 800 spots per day. Although seed is conserved, the planting cost increases to $17 per

TABLE 8

KARRI ESTABLISHMENT COSTS PER ACRE USING VARIOUS METHODS

The following unit costs apply to the table:

Seed	:	$16 per 100,000 karri seeds; equivalent to price of *E. pilularis* seed from N.S.W. in 1962-63.
Plants	:	Wildlings - lifting rate of 1,000 per man day.
		Open rooted woody stock - sowing and tending costs $3 per 1,000, materials $1 per 1,000.
		Jiffy pots - nursery costs $20 per 1,000.
Fertiliser	:	$60 per ton applied at 4 oz. per plant.
Plantings	:	Broadcasting seed - 7 acres per man day in strips.
		Spot seeding - 800 cultivated spots per man day, 8 seeds per spot.
		Wildlings - 600 plants per man day.
		Open-rooted stock - 600 plants per man day.
		Jiffy pots - 450 plants per man day.
Wages	:	assessed at $7.00 per day.

Process	Broadcast Sowing	Spot Seeding	Wild-lings	*Open-rooted Stock	Jiffy Pot Stock
Percent success		25	75	75	95
No. of spots (To establish 300 Trees)		1200	400	400	320
Seed and Plants	$13.00	$3.00	$3.50	$2.00	$6.50
Fertiliser			1.50	1.50	1.00
Planting	1.00	10.50	5.00	** 5.00	5.00
Operations	14.00	13.00	10.00	8.50	12.50
Overheads	3.50	3.50	2.50	2.50	3.50
Total Cost	$17.50	$17.00	$12.50	$11.00 **	$17.00

(Aerial Seeding - $3.41 for the low cost of seed in Victoria: Grose, Moulds and Douglas, 1964).

* Reliability in transplanting depends upon keeping karri transplants wet in plastic at all times until planted.

** Reduction in technical and managerial costs is feasible.

acre due to the density of spots seeded and the low percentage of surviving spots.

It has been assessed that 1,000 wildlings may be lifted per man day for transplanting. If a wildling nursery is close enough to a road to avoid the construction of an access track, the wildlings can be landed at the planting site for about $8 per 1,000. Alternatively, nursery stock may be raised in open beds at an estimated cost of $4 per 1,000. The average survival percentage of openrooted seedlings is 74 per cent, requiring that 400 be planted (9' x 12') per acre to achieve a final stocking of 300 stems. The addition of nitrogen and phosphorus fertiliser at the rate of four ounces per plant benefits growth. About 87 lb. of fertiliser (costing $60 per ton) may be applied per acre, the cost being $1.50. This results in a total cost per acre for wildlings of $12.50 and $11.00 for openrooted nursery seedlings.

Hall and Richmond (1961) studied the use of open rooted eucalypt stock for artificial regeneration in Victoria. Nursery costs were low except for tending such as weeding and watering which cost about $6 per thousand plants. If these could be eliminated the cost of plants would be about $3 per thousand. The survival percentage in Victoria was about 50 per cent, whereas the current karri trials indicate 75 per cent survival. Under these conditions the planting cost per acre may range between half and full cost of the other methods.

The cost of raising jiffy pot stock has been assessed at $20 per thousand, or $6.50 per acre at a

TABLE 9. ANNUAL REQUIREMENTS FOR REGENERATION USING VARIOUS METHODS.

Method of Regeneration	Regeneration Density Planned			Seeding Rates		Harvest	Seedling Operations (3 500 acs.)		
For known Plant percent or Trees per 100 Seed (p.c.)	Planted		Established	Acres per lb of 50 000 Seed	Seed lbs per 1000 Ac.	Capsules (tons)*	Seed (lb)*	Planted (no.)	Established (no.)
	Spacing	(no/ac)	(no/ac)						
Container seedlings in Nursery	9'x 9'	540	500	30	33	1.4	115	1 890 000	1 750 000
(for 33 Plants per 100 Seed) *	11'x12'	330	310	50	20	0.85	70	1 150 000	1 085 000
Openrooted seedlings from Nursery, or Wildlings of haphazard origin (with 4-6 ozs. fertilisers)	9'x 9'	540	420	30	33	1.4	115	1 890 000	1 470 000
N + P	9'x12'	400	310	40	25	1.05	88	1 400 000	1 085 000
Spot seeding at 8 seed per spot									
a. seed only	6'x 6'	1 210	300	5	200	8.5	700	4 250 000	1 050 000
b. with pelletted seed	7'x 7'	890	300	15	67	2.8	234	3 120 000	1 050 000
Broadcasting									
a. seed (1.7 p.c.)			850	1	1 000	42	3 500	(minimum)	3 000 000
b. with pelletted seed (5 p.c.)			750	3	330	14	1 170	(")	2 620 000
Natural regeneration (0.6-2.8 p.c.)			2 000	0.4	2 500		8 750	(seed trees)	7 000 000

* Average seed harvest of 15 percent purity - 83 lbs of seed with chaff, per ton of capsules.

*·S ha/kg kg/100 ha 15% purity × 7 pure seed.

98.

stocking of 320 per acre. Because of their bulk, the planting rate of jiffy pots is about 450 per man day, costing $5 per acre. Fertiliser is applied in the same manner as for wildlings. Jiffy pots cost a total of $17 per acre at establishment.

Provided a large source of cheap seed is available and seedbed conditions are good, broadcast seeding by hand may be the most rapid method of artificial regeneration. If this is to be used in general practice for karri however, 3,500 lb. of unpelletted seeds or 1,170 lb. of pelletted seeds would be required to regenerate the forest cut over in one year. It has been estimated that one man may collect from between 50,000 and 100,000 karri seeds per day. The work force and facilities required for such large scale collection and treatment during the infrequent years of abundant seed production is important but the amount required for direct sowing is excessive (Table 9) and unwarranted in proportion to the value of the method.

Spot seeding does not appear to be much more practicable. One pound of seed is sufficient for five acres, and the amount of seed required would be 200 lb. per 1,000 acres of regeneration (Table 9). As with broadcast seeding, the limitations of seed supply and collection during favourable seasons apply here, and some reserves must be kept to carry the programme through years in which it is uneconomical to collect seed (Loneragan, 1971).

To be able to support an extensive artificial regeneration programme, it becomes necessary to consider the other alternatives. One pound of karri seed will suffice for 50 acres of jiffy pot stock or ten times the area by spot seeding. Seventy pound of seed would be required to regenerate one year's cutting with 1,150,000 jiffy pot plants; and 115 lb. would be needed for the raising of openrooted seedlings.

Transplanting of openrooted karri seedlings, of sufficient shoot growth from 7 to 14 inches high, and shoot/root ratio of almost 2:1 gave more certain establishment, from 65 to 85 percent survival, than did seeding; but the establishment [illegible] in the field was generally from 15 to 35 percent less reliable and over a longer period than planting out potted plants from the nursery.

Woody seedlings established well; but succulent seedlings, especially seedlings three months old were suppressed by weeds when transplanted and usually failed.

Successful plantings were established on all 13 sites in 1963 with from between 100 and 300 healthy seedlings raised to six months old in the nursery, to 17 months old as wildlings lifted from ashbeds; to 2 and 3 year old wildlings lifted from non-ashbed fields and from ashbeds, but with their shoots clipped to a desirable size at the time of lifting. Keeping the roots and shoots wet, by wrapping in plastic sheeting and wetting when wrapped, even when roughly pulled out of the ground, was an important factor for preventing damage through desiccation during distribution and planting out more than 1,300 transplants in these trials.

Dependence upon field wildlings appears hazardous, as these will occur in local, isolated areas of favourable seedbed and seed supply. They develop consequently in seasons where regeneration is likely to be successful in a number of scattered areas. Control of size and shape of openrooted nursery plants however with careful handling, complete preparation of the site and thorough planting, success will be certain in the field.

When openrooted karri seedlings were transplanted without fertiliser, the shoots died back after planting to about one third of their initial height, and the new leading shoots then were commonly forked and malformed. Unless the growth was stimulated in the first season, development was retarded early and restricted subsequently by weed growth. Placing from 2 to 3 ounces of fertiliser into a hole about two inches from the planting hole stimulated growth twofold - 6.9 feet height growth in 2½ years compared with three feet without fertiliser. The best and most uniform growth rates however were demonstrated when competition was removed, and from 4 to 6 ounces of blood and bone was applied in a hole adjacent to the planting hole. No benefit from broadcasting fertilisers up to 3½ tons per acre has been observed in natural regeneration by comparison, probably due to the competition of the weeds and dense stocking.

Wildlings and jiffy pot transplants are more successful on new than on old burnt sites, reflecting the benefit of establishment on freshly prepared sites before weed competition becomes too severe. Height growth of jiffy pot stock responds more to fertiliser treatment than to the present preparation of the planting site. Wildlings, on the other hand, appear to respond to ashbed as much as to nitrogen and phosphorus fertiliser, with no interaction between ashbed and 2 or 3 ounces of fertiliser, indicating an efficient experimental design for the field trials with openrooted seedlings is required to sort out the species, site and fertiliser requirements.

Survival percentages for jiffy pot stock exceed those for wildlings by 30 per cent in most cases. The improvement is most marked where nitrogen and phosphorus fertiliser is used. Jiffy pot seedlings without spray or fertiliser applications have been no more successful than similarly treated wildlings.

Establishment has been most successful by planting out karri seedlings raised in compressed peat pots (2½"). Survivals, over 95 percent at two years for 860 of these potted plants, were 15-35 percent better than other previous methods tested. This is the best method so far of raising healthy, sturdy seedlings in greater numbers, in shorter periods and more cheaply than any other type of container. Other containers tested have included earthenware pots, metal tubes, softwood veneer and polythene plastic tubes. Raising eucalypts in flat trays or seed boxes and transferring them into the field costs the same as the peat pot plantings; but is not favoured because of the damage to the roots when they are cut out from the tray, and the imbalance of the shoot/root ratio consequently when planted. The compressed peat pot permits root tips to penetrate, develop a desirable shape, and dense root system which is not disturbed at the time of planting.

The potted seedlings showed a greater response of height growth, to the application of fertiliser (N + P compound in equal quantities) than to removal of competition by weedicide spraying or to planting on an ashbed. They branched more freely but retained a distinct leading shoot and much more uniform growth than the natural uneven development on ashbed, (plate 14), they also exhibited exceptional vigour and rapid growth in the second year. At 2½ years, the mean height of seedlings with fertiliser in new burn was 10.3 feet, and in one year old burn with fertiliser 5.9 feet; and without fertiliser 6.1 feet and 3.8 feet respectively; that is an increase in height growth with fertiliser of about 50-70 per cent.

Although the responses of jiffy pot stock to spray and fertiliser treatments were much clearer, differences in height of wildling stock between various site treatments were not significant in most cases (Plates 15 - 17). Each year the actual benefit of the fertiliser as measured by height growth, has accumulated in successive years (Plate 15), and continues to do so. This is indicated by the maximum ashbed effect noted during the life of the young stand

Plates 15 - 17 - Karri wildings (Plates 9,11,12, six months later, 21 months after transplanting in July 1963 Plate 6), without fertiliser (Plate 15), and with fertiliser (Plates 16 and 17). Andrew Block, April 1965.

Plate 15 - Growth for 21 months from 15 inch clipped wilding retarded without fertiliser.

Plate 16 - Healthy growth for 21 months in wilding planted with 2-3 ounces of fertiliser (close view plate 11)

Plate 17 - Healthy growth for 21 months in wilding clipped back to 15 inches and planted with 2-3 ounces of fertiliser and subsequent growth, where the side shoot took over leadership, occluded the clipped tip that had died back (at present indicated by a piece of white chalk, close view plate 12).

Plate 18 - Growth of karri regeneration stimulated throughout the life of the young stand to the present age of 23 years, height growth 115 feet (35m), girth 53 inches (diameter 42 cm) on ashbed made by burning of felled crowns and seeding in 1936; dominated the growth off ashbed-height 50 feet (15m) and girth 14 inches (diameter 11cm), Treen Brook C65, 1959.

(Plate 18), which may be regenerated by any of these methods with adequate fertiliser to supplement soils and ashbed having major elements below optimum. Phosphorus varies for example from 15 to 173 p.p.m. in karri ashbeds of the same and different ages (Hatch, 1960).

CONCLUSION

The plantings of openroot and jiffypot seedlings offer more chance of success than do the other methods discussed here. Because of their price advantage, woody openrooted nursery stock could be used for planting in favourable sites while jiffy pot seedlings may be best suited for marginal sites. The roots of peat potted seedlings appear to be unchecked at the time of planting, and they rapidly take possession of the site, which is an important factor where conditions are unfavourable.

Experiments have shown that seedlings planted on freshly cleared sites are more likely to become established than those planted on areas where competing vegetation is present. This applies especially to the woody openrooted transplants. Although restricted by its small root system, the transplanted seedling establishes well and grows most rapidly when some 3-6 ounces of N and P fertiliser (9-9) has been placed in a hole about three inches distant from the roots in the planting hole. On this basis productivity will be increased at least twofold while refinement in experimental design and new techniques will continue to provide improvement in solutions to problems in tree farming practice.

If artificial regeneration is to be relied upon, it is necessary to ensure that the final product will be of the greatest value to recoup the investment in establishment. Control of the seed source, seedling establishment and early growth therefore are very important. It is desirable therefore to use the best available seed sources, and as these are limited, most effective use must be made of them.

ACKNOWLEDGEMENTS

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APPENDIX I. PELLETTING OF KARRI SEED

Operations and Ingredients	Quantities	Procedures
PREPARATION OF STICKER		*
Sticker Cellofas A or Methocel	20 gm	
+ Water Hot	100 cc	Stir
+ Cold water	1100 cc	Stir with protectants)
+ PROTECTANTS (range from 0.1-1.0 percent)		Use Safety Precautions**)
Fungicide at 0.1 p.c. T.M.T.D. (80%)	1 g/litre	Stir
Insecticide at 0.1 p.c. ALDRIN (40%)	2½ cc/l	Stir
(OR DDT at 1.0 p.c. DDT (50%)	(10 g/l)	
Bird repellant ANTHRAQUINONE (80%)	7 g/l	Stir
		* Stand over-night
PELLETTING FIRST COATING OF SEED		
Seed (Base Weight = 100)	100	Allow up to ¼ vol. of container
+ Sticker	14	Mix
+ Kaolin clay	30	Mix
		+ 5 minutes in shaker
Roll in kaolin clay	60	* Dry over-night

(continues next page).

APPENDIX I continued

Operations and Ingredients	Quantities	Procedures
REPELLETTING FOR STABILISING CLAY COATING OF SEED ± COATING OF FERTILISER		
Coated seed (Base weight = 100)	100	
+ Sticker	27	Mix or spray
+(Kaolin clay or/) Fertiliser Dust	60	Mix
+ Organic dye powder, Hoechst A070 Yellow	1	+ 5 minutes in shaker
Roll in(kaolin clay or/) Fertiliser Dust.	120	* Dry over-night
GRADING WITH SIEVES (mesh openings)		
No. 9 (0.14") - No. 6 (0.09")	Doubles (2 seed/pellet)	
No. 6 (0.09"+) - 1/16" (0.06")	Singles (1 seed/pellet)	

** FOLLOW SAFETY PRECAUTIONS WHEN HANDLING POISON-PROTECTANTS

1. Read labels before use.
2. Avoid contact through mouth, nose, eyes and skin.
3. Handle gently with surgical gloves and masks for dusting.
4. Wash exposed body skin after use, before smoking or eating.
5. Wash out empty containers thoroughly and dispose safely.

APPENDIX II

RANKING OF PLOTS AND TREATMENTS ANALYSED AT P.05 POOLED FOR FIVE YEAR RESPONSE IN REGENERATION AT AGES 6½ and 7½ (7) YEARS

Karri Regeneration: 7½ Years Mattaband Ashbed Site KA; 6½ Years Easter Brook Ashbed Site KC — F.1 Thin	F.2 Ferts.	Plot No.: (F2) Broadcast Over 25; (F2) Spot Only Under 25 — F3 Sets of Four	Mean Increment: Diameter (ins/an) Plot	Diameter (ins/an) Pool	Volume (c.ft/ac/an) Plot	Volume (c.ft/ac/an) Pool	Ranking Significance At P.05 Vol.	Ranking Significance At P.05 Diam.	On Ashbed Interaction of Treatments: (F1) Thinning Age (yrs)	(F2) Fertilisers Spot (lb/ac)	(F2) Fertilisers Bdcst (lb/ac)
1	3	261	0.85		155				2	-	8 000
		21	0.78		100				1	700	-
		2	0.74		92				1	700	-
		251	0.63	0.75	71	105	*		2	-	8 000
	2	5	0.73		90				1	210	-
		4	0.73		82				1	165	-
		20	0.61		48				1	210	-
		12	0.58	0.66	48	67			1	165	-
		11	0.63		54				1	75	RanKing Paired Plots:
		1	0.53		34				1	75	
	1	39	0.74		115				2	0	0
		31	0.73		90				2	0	0
		19	0.55		35				1	0	0
		6	0.53	0.61	34	63			1	0	0
2	3	38	0.63		75				(Note) 4		8 000
		43	0.58		63				4		1 000
		29	0.49		47				Unthinned		8 000
		45	0.49	0.55	40	56			4		1 000
	2	30	0.58		62				Unthinned		1 000
		32	0.49		48				Unthinned		1 000
		37	0.49		39				4		250
		33	0.49	0.51	47	49			Unthinned		250

		11 1	0.63 0.53	54 34			1 1	75 75	RanKing Paired Plots:
	1	39 31 19 6	0.74 0.73 0.55 0.53 0.61	115 90 35 34 63			2 2 1 1	0 0 0 0	0 0 0 0
2	3	38 43 29 45	0.63 0.58 0.49 0.49 0.55	75 63 47 40 56			(Note) 4 4 Unthinned 4		8 000 1 000 8 000 1 000
	2	30 32 37 33	0.58 0.49 0.49 0.49 0.51	62 48 39 47 49			Unthinned Unthinned 4 Unthinned		1 000 1 000 250 250
	1	28 44 3 10	0.50 0.47 0.38 0.15 0.38	48 37 18 8 28			Unthinned 4 Unthinned Unthinned	0 0 0 0	0 0 0 0

(Three years since thinning at age of four years).

Treatment for* Diameter increment in younger <u>thinned</u> stand on ashbed in low quality site is better than delaying thinning two years in high quality site.

APPENDIX III

CAPTIONS FOR FIGURES

Fig. 1 - Map of karri forest in South Western Australia showing location of artificial regeneration experiments.

Fig. 2 - Means and standard errors of number of germinants per spot for ashbed● and non-ashbed○ sites and different seeding intensities, Babbington, 1962.

Fig. 3 - Percentage of successful spots at germination (November 1962) and survival (June 1963) from direct seeding, Babbington. Symbols as for Figure 7.

Fig. 4 - Means and standard errors of number of survivors per spot for ashbed● and non-ashbed○ sites and different seeding intensities, Babbington, 1962.

Fig. 5 - Influence of seedbed, aspect, date of sowing and age of burn on the mean number of survivors per plot from direct seeding, Andrew. Solid columns, ashbed: open columns, non ashbed.

Fig. 6 - Influence of seedbed, aspect date of sowing and age of burn on the percentage of surviving spots per plot from direct seeding, Andrew. Solid columns, ashbed: open columns non ashbed.

Fig. 7 - Response of number of germinants per spot to site for different seeding intensities on ashbed. Symbols: O 8 seeds per spot, X 16 seeds per spot, + 32 seeds per spot, ● 64 seeds per spot, ⊙ 128 seeds per spot: I Babbington; II Andrew, new burn, May Sowing; III Andrew,

new burn, July sowing; IV Andrew, old burn, May sowing; V Andrew old burn, July sowing: M mean of all sites.

Fig. 8 - Response of number of germinants per spot to site for different seeding intensities off ashbed. Symbols as for Fig. 7.

Fig. 9 - Response of percentage of spots with germinants to site for different seeding intensities on ashbed. Symbols as for Fig. 7.

Fig. 10 - Response of percentage of spots with germinants to site for different seeding intensities off ashbed. Symbols as for Fig. 7.

Fig. 11 - Response of number of surviving seedlings per spot to site for different seeding intensities on ashbed. Symbols as for Fig. 7.

Fig. 12 - Response of number of surviving seedlings per spot to site for different seeding intensities off ashbed. Symbols as for Fig. 7.

Fig. 13 - Response of percentage of spots with survivors to site for different seeding intensities on ashbed. Symbols as for Fig. 7.

Fig. 14 - Response of percentage of spots with survivors to site for different seeding intensities off ashbed. Symbols as for Fig. 7.

Fig. 15 - Influence of seeding intensity on response to site as expressed by number of germinants and survivors per spot symbols: O Germinants, ashbed: ● Germinants non ashbed: + Survivors, ashbed: X Survivors, non ashbed.

Fig. 16 - Influence of seeding intensity on response to site as expressed by percentage of spots with germinants and with survivors. Symbols as for Fig. 15.

Fig. 17 - Influence of lifting method and planting site on growth rates of karri wildling transplants at Babbington and Crowea between September 1963 and April 1964. Solid columns, root balled; open columns, spade lifted; hatched columns, pulled up. (see also Table 4).

Fig. 18 - Mean heights and standard errors, of karri wildlings on recently burnt area April 1964, nine months after transplanting in Andrew. Symbols: ⊙ (S) N & P fertiliser (S = 2,4,5-T spray); ● N & P fertiliser only; (S) + Dieldrin and lime fertiliser, 2,4,5-T spray; X Dieldrin and lime only; O 2,4,5-T spray only: △ untreated control. Stock numbers as in Tables 3 and 5.

Fig. 19 - Mean heights and standard errors, of karri wildlings on old burnt non ashbed. Showing influence of aspect April 1964, nine months after transplanting in Andrew. Symbols as for Fig. 18.

Fig. 20 - Mean heights and standard errors, of karri wildlings on old burnt non ashbed showing influence of treatments, April 1964, nine

months after transplanting in Andrew. Symbols as for Fig. 18.

Fig. 21 - Mean heights and standard errors, of karri jiffy pot stock on new burnt area, April, 1964, nine months after planting out in Andrew. Symbols as for Fig. 18, mean height of seedling stock lots at time of planting (see also Tables 6 and 7).

Fig. 22 - Mean heights and standard errors, of karri jiffy pot stock on old ashbed, for aspect and stock classes April 1964, nine months after planting out in Andrew. Symbols as for Fig. 18, 21.

Fig. 23 - Mean heights and standard errors, of karri jiffy pot stock on old non ashbed, for aspect and stock classes April 1964, nine months after planting out in Andrew. Symbols as for Figs. 18, 21.

Not all areas are scrub rolled, only those which contain too much green scrub. In a five year natural regen. period, by the time the first regen. burn in year 4 is contemplated, the areas cut in years one and two contain green scrub and would require rolling. Two years of five would require scrub rolling, i.e. 40% of the area as a whole. $12 per acre actually rolled represents $4.80 (40% of $12.00) per acre overall. As each year's falling is burnt and planted each year in artificial planting, scrub rolling is considered unnecessary.

Though the two systems are distinct, in fact a combination of both is used in practise. A certain percentage (estimated at 10% for this exercise) can be expected to fail in natural regeneration. This can be either stocked artificially or carried through the rotation as it is. Case 2 represents the combination of both systems. Spot refilling is recognised as being more costly per acre than blanket planting. $25 per acre refilled, or $2.50 (0.1 x 25) per acre overall is the cost allowed.

Revenues are estimated at $1.00 per load for pulpwood and $5.00 per load for large material of sawlog and peeler log quality.

The rotation is designated at 100 years. Lefroy Brook at approximately this age contains 160 loads per acre. This stand had been lightly thinned early in the rotation. 100 years is a rotation which has been referred to often in karri. One thinning at age 35, yielding 75 loads per acre of pulpwood is envisaged. In Treen Brook such a thinning leaves about 50 square feet of B.A. in crop trees. It is assumed that these will grow on and produce 150 loads per acre at rotation age of 100 years. Of this 120 loads are of sawlog quality, and 30 of pulpwood quality.

Yield therefore is estimated at -

Yield	at age 35	-	75 loads per acre.
Yield	at age 100	-	150 loads per acre.
	Total		225 loads per acre.

MAI = 2.25 loads per acre.
= 112.5 cu. ft. per acre.

Actual MAI for the unthinned Lefroy Brook stand is 111 cu. ft. per acre per annum.

The naturally regenerated stand, without refilling, is assumed to be 10% unstocked. Yields at age 35 and 100 are therefore assumed to be 10% less than the refilled or fully planted stands.

Interest rates sought are 2%, 3%, 5%, 7% and 10%.

Overheads required are 0%, 50%, 100%, 150%.

Internal rates of return are requested.

B J White

B.J. White
SENIOR SILVICULTURIST

BJW:LH

RAISING SEEDLINGS IN THE NURSERY AT MANJIMUP. (1967)

INTRODUCTION

Two basic methods of propagation of forest trees from seed are:

1. Natural regeneration using the best trees retained by Foresters during trade cutting, for seed.
2. Artificial regeneration using imported seed, or seed collected from desirable trees. The seedlings are raised and planted into unstocked areas.

Two basic methods of preparation of the planting bed to stimulate the growth of the seedlings in the forest are required:

1. Extensive use of fire to provide a clean seedbed, made free of competing growth and covered with ash.
2. Intensive cultivation of the topsoil, and sowing or planting with fertilisers.

The immediate objective here is to raise seedlings in the nursery for experimental propagation of hardwoods, mainly *Eucalyptus* species and of softwoods mainly *Pinus* species. The selected species are being tested in new areas to show their suitability over a long period. The long term objectives are to improve the proportion of light coloured timbers in our native forests, and to increase timber production in poor sites, in areas following wildfires, and in areas close to future wood using industries. The whole range of sites are being tested with new species; and include jarrah sites, treeless flats and karri sites.

PREPARATION IN NURSERY

Materials ~~required~~ for requirements here are:

1. Seed: about 10 lbs, includes 3 lbs of assorted Eucalypt seed raised here and Pines raised at various nurseries.
2. Soil mixture, and seed beds.
3. Containers, and tools.
4. Water, and sprinklers.
5. Covers for shade.
6. Sundry chemicals:
   fertilisers, fungicides, insecticides, and sterilisers (fumigant methyl bromide.)
7. A skilled nurseryman for 20,000 plants in containers

Seed: The seeds of Eucalypts are very small and are mixed with unfertilised ovules (called chaff). They are shed from the capsules when its valves dry out and open. The number of live seeds in a commercial ounce varies widely with species from about 300 to 14,000. Commercial seed for example may be 15 percent in purity of seed only; and in karri, about 3,000 seeds per ounce.

Size of seed however is measured by the number of pure seed only. The average size of seed of Queensland Ironbark (E. crebra) is 100,000 per ounce, of karri is 20,000; and of pines, which very also widely, from only two in the Queensland bunya pine (Araucaria bidwillii), to 500 in the Southern European Pinus Pinaster, and from 600 to 900 in the Californian Pinus Radiata.

NURSERY TECHNIQUES

Seed Treatments: Stratification and pelleting are being investigated for uniform germination rates.

Seedbeds of high fertility and tilth have to be maintained by manuring, green cropping and tillage.

Soil mixtures and seed containers: A crumbly and light textured soil with organic matter mixed and sieved, is prepared for the seed boxes: the mix is usually 1 part of forest loam, 1 part of sand and 1 part of compost. Materials are sterilised with methyl bromide to kill weed seeds, insects, fungi and bacteria. A layer of raw litter (pine needles or straw) is placed in the open spaced bottom of the seed boxes for drainage, and are filled with the soil mixture. The soil surface is moistened best by wetting it from below by placing the filled seed box in a watering tray.

Sowing the seed: Seed is sown progressively from October into January. The slow growing species are sown earlier than the faster growing ones. A small germination test before sowing is of great advantage.

Calibration of a seed shaker is necessary in a germination tests for direct seeding into containers. Subsequently, planting is made directly into the field with 1 or 2 seedlings in each container.

For growing small sized sturdy plants of from 6 to 8 inches, in containers for planting directly into the field, sowing is made from 4 to 6 weeks later than for growing the full sized plants of about 15 inches. These larger plants are raised, either directly in the soil or in containers. When raised in the soil for transplanting they are called 'open rooted' seedlings. Consequently, as indicated by the germination test, the numbers are calculated to raise about 10 sturdy seedlings per foot of nursery seed-bed; ~~or~~ When sown in seed boxes for transplanting into containers, about one or more ounces of Eucalypt seeds are sown per square yard.

The seed is covered over thinly, to its own thickness, with finely sieved sand and kept moist.

<u>Germination and protection</u>: Frequent fine sprays and good ventilation needs to be well controlled. Protection is given from winds, rain and sun; and from fungus with ½% solution of cuprox (or Cheshunt mixture). Germination commences in about one week. At two weeks the germinants are hardened off with less shade. This is necessary prior to transplanting any into conta

<u>Pricking out</u>: From 3 to 4 weeks after germination, when they possess two pairs of true leaves above the cotyledons, the seedlings are pricked out into containers. A seedling is handled only by the tip of a leaf and never by the stem. They are always kept moist; and loosened with and pricked out in a hole with a dibble (similar to a wooden pencil).

<u>Container Methods</u>: Many types of containers are used for raising and transporting trees. Containers may be grouped broadly into non-expendable and expendable. The more durable ones, cement, and earthen flower pots, and metal tubes are non expendable.

Methods preferred are the easiest ones for planting out into the field, usually with the least disturbance to the root system. The main methods include:

1. <u>Open rooted methods</u>, when success in transplanting has been proved (as for the above pines, and as indicated for karri seedlings when over 12-months old). Puddling the roots in clay, and wrapping the plants in plastic sheeting has proved highly successful for karri.
2. <u>Tray Methods</u>: Seedlings raised in trays are transferred directly into the field for planting. A network of roots during growth extends over the bottom of the tray. Control of this network and restriction of root development to the individual soil ball by slicing crosswise frequently to separate each plant in the tray in practice is difficult and may need more thorough testing. In practice so far when transplanting from the trays into the field, the biggest plants receive the greatest root damage

This technique, therefore, is not favoured.

3. Root-ball methods: Trials comparing open-rooted plants with those raised with undistributed roots in peat jiffy pots in a shorter interval~~s~~ have been tested by Australian Paper Manufacturers Co. Ltd. (Victoria). The compressed peat pot permits penetration by the root tips and desirable root shape and development without root coiling is encouraged. A higher take with the jiffy peat pots, ~~however,~~ is possible under adverse conditions in the field. The most favoured expendable tubes in Australia have been softwood veneer, but polythene plastic tubes and also pots of compressed peat have now been introduced into some nurseries. The surface area of tubes of the size normally used (about 1½" diameter) is, however regarded by some authorities as inadequate for the development of sturdy plants. The bottomless earthenware pots now in use by the Forests Department constitute a compromise between tubes and pots. Being 3¾" in outside diameter the surface area is adequate for healthy shoot shape and development

4. Nursery treatments:

1. Protection is provided from winds and undue heat, by windbreaks and covered frames. Protection from fungu is provided by a copper based spray (above); and from insects by spraying desirably, with malathion or DDT weekly.
2. Watering with water of low salt content is carried ou twice daily during the dry season, each morning and afternoon. A fine rose-type nozzle under low pressur is used to give an even hand watering to Eucalypts in containers. For open-rooted seedlings in beds, knocker type sprinklers on movable aluminium pipe-lin are used.
3. Weeding. Fumigation of potting soil prevents weed growth in containers. In open seed beds, the weed growth is reduced between the rows using chemicals, and in the rows by hand weeding. Care in their use, and the long term effects of chemicals need to be controlled.
4. Root pruning is carried out below the containers, onc or twice when needed. The containers are raised abou 3-inches off the ground to reduce the root growth.

5. Liquid fertilisers: These may be used sparingly to stimulate retarded growth.

DISCUSSION

Field Plantings

Thorough preparation of the planting site, and heavy fertiliser applications (5 or 6 oz per plant) have been standardised for field establishment. The stock is usually planted one inch deeper than the nursery level, and never planted shallow. The fertiliser is planted next to the plantir hole.

Nurseries for Public Requirements:

To meet requirements of the people in country areas for planting Eucalypts and other trees, two nurseries have been developed, one at Hamel for the wet area species and one at Dryandra near Narrogin for the dry area species. The public generally prefer large trees; to be satisfactory, a large tree needs a large container. However factors such as packing, handling and rail freight have had to be taken into account and the container size used represents a compromise between what is desired by the buyer and what can be supplied to him at a reasonable price.

Although developed independently, the pots now in use at our nurseries and which have internal dimensions of 3½" top diameter and depth of 4" contain a bulk of soil approximating to that considered by F.A.O. authorities to be minimum desirable for Eucalypt seedings, viz, 300 cubic centimetres (see A. Metro, F.A.O. Eucalypts for Planting 1955).

Under natural conditions in south western Australia Eucalypts germinate in autumn and early winter and thus have cool conditions in which to establish. Plants raised artifical when ~~used~~ seed is sown in autumn must either be planted out in the first winter at an early stage in their development or held over for more than 12 months in the nursery before planting out during the second winter.

These older plants become unduly large and develop severe root coiling particularly if grown in pots having only a small opening in the bottom. Coiled roots after planting strangle the main root development and the trees are subject to windthrow. This condition may be to some extent, relieved by cutting through the root coil before planting.

Sowing in spring under artificial conditions and planting out 8 months later in winter saves half the nursery establishment and space compared with raising plants by sowing in autumn. The spring sown seedlings are tender and need more protection and shade during the summer.

CONCLUSION

When the question of raising Eucalypts for establishment in the lower South West arose, cheaper and smaller plants were necessary. The cheaper plants in small containers such as the ~~small jiffy~~ 2¼ inch peat pots could be raised in greater numbers of smaller size in a shorter period. These plants are being raised for testing new species in experimental field trials. Other improvements in techniques, aiming to raise smaller sized, but sturdy plants, as for example in one inch peat pots, are being tested also.

OWL:LH
14.8.67.

TABLE ~~5~~ Compare Table 9 pp. and Costs Table 8. pp.

ANNUAL REQUIREMENTS FOR REFORESTATION USING VARIOUS METHODS

ethod of Regeneration (or Plant Percent, Known in rees per 100 seed sown)	Crop Density of Regeneration: Planted Spacing	Crop Density: Planted (No./ac)	Crop Density: Established (No./ac)	Acres: Per lb of 50,000 seed	Seeds, lbs: Per 1,000 acres	Harvested: Capsules (tons)	Seedling ~~Planting~~ Operations (1500 acs): Seed (lbs)	Operations: Started (No.)	Operations: Established (No.)
ising seedlings in nursery	9'x9'	540	500	27	37	*	55	810,000	750,000
or 30 plants per 100 seed)	12'x12'	300	280	50	20	0.5	30	450,000	420,000
ldings ~~transplants~~ of hap-hazard origin.	9'x9'	540	420					800,000	630,000
ith fertilizers 6 ozs N, P)	11'x11'	350	310					525,000	465,000
ot seeding (8 seed/spot)	6'x6'	1,210	300	5	200		300	1,815,000	450,000
ith stratified-pelleted seed)	7'x7'	890	300	7	140	3	215	1,335,000	450,000
oadcasting seed (1.7 p.c.)			850	1	1,000	18	1,500		1,275,000
ratified-pelleted (projected 5 p.c.)			750	3	330	6	500		1,125,000
tural regeneration (0.6-2.8 p.c.)			2,000	0.4	2,500		3,750	(seed trees)	3,000,000
* Expected seed harvest (1967), 83 lbs of seed with chaff, per ton of capsules							(purity 15%)		

Original *

SOME FACTORS AFFECTING GERMINATION OF KARRI SEED ON REGENERATION BURNT AREAS

by

P.S. CHRISTENSEN.*

SUMMARY

Karri (Euc. diversicolor, F.V. Muell) seed starts to germinate in autumn at the break of the season after 2" - 3" of rain distributed over a number of days. Ninety to ninety five per cent of the germinants have emerged by mid June and germination is virtually complete by the end of July. Autumn burning in the 5th year of the floral cycle, although seed supply is less, should give better results than spring burns due to the heavy losses incurred by insects if the seed lies on the ground over summer. Germination on mixed Karri/Marri (Euc. callophylla, R. Br.) sites was superior to that on Karri sites. Germination on non - ashbed was found to be significantly better than that on ashbed. Dieldrin significantly improved results both in spring and autumn sowings indicating the importance of insects both at the pre and post emergence stage. Other factors, namely shade and fungicide treatment did not significantly affect germination.

* W.A. Forests Department, Manjimup.

* Withdrawn by writer from publications list
R. 5/12/73

INTRODUCTION

The season of burning is a factor of considerable importance under the present seed tree system of regenerating cut over Karri stands. Opinion is divided on the question of whether spring or autumn burning is best. Germination, although it is not the only factor influencing this problem is nevertheless of great importance. If burning is carried out in spring, because the fire stimulates total seedfall within a few weeks, (Christensen, P.S. 1970) much of the seed may be lost over summer to insects and other agencies, (Loneragan, O. W. 1965). In order to determine the extent of these losses and to obtain more information on germination in the field generally, a series of trial plots were sown in 1969.

METHODS

Experiment No. 1 - Object - to determine the effect of season of sowing on Karri seed germination.

Four 0.9 acre sites burnt in spring 1968/69 were chosen. Two sites were mixed forest, Karri/Marri (K/M) stands; one on Pine Creek 16 miles West of Manjimup and the other on March Road 18 miles S.E. of Manjimup. The other two were Karri (K) stands; one on Grace Road 23 miles S.S.E. of Manjimup, the other on Pine Creek. The seedfall after burning was recorded using 0.0001 acre seed trays. Nine trays were used on each area, two fixed and seven roving, (Wilm, A.G. 1946). Directly after the burn, on 21/1/69 seven 0.0001 acre randomized plots in each area were sown with 100 seed each, (spring sowing). On 10/4/69 seven further plots were sown on each site, (autumn sowing).

Experiment No. 11 - Object - to determine the effect of season of sowing, seedbed type, shade treatment, insecticide treatment and fungicide treatment on germination.

A K/M area with the Karri seed trees removed, burnt in spring 1968/69, was chosen on March Road, forty 0.0001 acre plots were selected on ashbed sites and forty on non - ashbed sites. These were randomized and twenty of each were sown with 100 seed in spring on 21/1/69, the balance were sown in autumn on 10/4/69. Of each of these twenty sites, five were given no treatment (controls), five were dusted with Dieldrin insecticide, five were dusted with Zineb fungicide, and five were shaded with fly wire screens providing light shade.

The seed used in both experiments was of mixed origin containing seed from various localities. The germination on moist filter paper under laboratory conditions was 84.5%. Germination was recorded at various times throughout the winter. Once recorded, seedlings were uprooted to avoid confusion in later counts.

RESULTS

1. Season of Sowing

As can be seen from the figures in Tables 1 and 11 there was a considerable seasonal difference. The mean germination percentage for spring sown seed was 5.4 in experiment No. 1 and 5.5 in experiment No. 11. The figures for autumn sown seed were 7.3 per cent and 14.2 per cent respectively. On analysis the difference between spring and autumn results was shown to be not significant in experiment No. 1 and significant at the .01 level in experiment No. 11. The fact that no significant difference was detected between spring and autumn sowing in experiment No. 1 is thought to be due to the influence of the seed from the seed trees. Although this was measured in the seed trays and a factor was used to allow for it in the calculation it still meant that a certain amount of spring sown seed was present in the autumn sown plots. The results from experiment No. 11 in which no seed trees were present are therefore considered more reliable.

2. Forest Type

The germination percentage on Karri sites was 5.5 and on M/K sites it was 9.2. This difference was significant at the .01 level. In this case the presence of seed from the seed trees in the plots would not affect results since the season of sowing was not considered.

3. Seedbed Type

The percentage germination on ashbed sites was 7.7 as compared with 12.0 on non - ashbed sites. This difference was only significant at the .05 level.

4. Seed Treatment

The only treatment that significantly increased the germination percentage was the insecticide treatment. Using the least significant difference method the insecticide treatments were superior to all other treatments at the .01 level. However, using Duncans multiple range test this was reduced to the .05 level.

The shade treatment appears to have had little or no effect.

The fungicide treatment seems to have had a detrimental effect on germination. Although this effect was not significant it appears to have been very real especially on the ashbeds.

5. Rainfall and Germination

Although it was not planned as part of the experiment a few observations on the amount of rain needed to stimulate germination are presented, (Figure 1). The spring sown seed germinated in autumn at the break of the season i.e. after the first fairly heavy showers of the season, 360 points fell between 6th - 10th April. The autumn sown seed sown on the 16th April germinated between 8th May and 26th May apparently stimulated by the 270 points that fell between these two dates. It will be noticed however that the greater part of the germination of the autumn sown seed occurred after the 26th May when more rain was recorded. It seems that germination is associated with the first definite break in the season and requires approximately 2" - 3" of rain over a period of days. This conclusion is further strengthened by the fact that 169 points of rain which fell between 4th - 7th February 1970 failed to stimulate germination in spring sown seed.

No evidence was found of any delayed germination occurring in spring. Ninety to ninety five per cent of the germinants had appeared by mid June and germination had virtually ceased by the end of July, (Figure 11). This was confirmed by results in another trial also, where germinants were pegged for further observations.

DISCUSSION

Under natural conditions Karri seed germinates in autumn at the break of the season after the first heavy rains. It appears that 2" - 3" of rain spread over a number of days is necessary. However, it is likely that less rain associated with high humidity over a fairly long period would also initiate germination. There was no evidence of any germination occurring in spring.

Observations from another trial (Christensen, P.S. 1970) indicate that germinants grow very little during the winter months. Most seedlings progress little beyond the cotyledon stage till early spring. At this time the warmer conditions cause a dramatic flush of growth resulting in the seedlings becoming much more apparent. Thus unless detailed counts are made it would be easy to assume that more seedlings had germinated in spring. It is thought that this could be the explanation for the popular misconception amongst some W.A. foresters of a spring germination.

The question of whether regeneration burning should be done in spring or in autumn has long been a subject of debate. With regard to germination, probably the most important factor, it has been shown in the past (Loneragan, O.W. 1969) and confirmed in these trials that germination of autumn sown seed is far superior to that of spring sown seed. In general the autumn sown seed showed an improvement of 158 per cent over the spring sown seed. If the results from the untreated control only are used the figure is 180 per cent. However, it should be remembered that in practice, if seed trees are left over summer 45 - 50 per cent seed loss can be expected since the seed that falls over summer will be incinerated in the autumn burn, (Christensen, P.S. 1970). This loss of seed over summer could be compensated for by a 90 - 100 per cent increase in germination of autumn seed. Since the increase in the germination percentage appears to be between 160 - 180 per cent this amply compensates for summer losses and in fact still allows for an improve - ment of 70 to 90 per cent. It would thus seem that autumn burning should give the best results especially in years of medium to poor seed supply. It should be stressed that this refers to the 4th - 5th year of the floral cycle, the normal time for regeneration burning, (see Figure 111). Spring burning is sometimes possible in the 5th - 6th year of a cycle but autumn burning in this year is seldom if ever successful. This is because virtually all remaining seed is shed over this summer of the cycle and would be incinerated in an autumn burn.

It is possible that burning may be successful in the autumn of the 4th year of the floral cycle as most of the seed is usually ripe and will germinate under laboratory conditions at this stage. In the past successful burns appear to have been carried out at this stage, (White, B.J. *). If flowering is early i.e. in spring and summer of the 3rd year instead of autumn - winter, the seed is almost certain to be ripe at this time (Loneragan, O.W. 1969). At present little information is available on the percentage of seed likely to have matured at this stage. Further work on this point seems worth while since if only 50% or more of the seed is ripe this would be the best time of all to burn.

Another interesting fact that emerged from these trials is that germination was significantly better on K/M sites. What this could be due to is not yet known.

The fact that Karri germinates better on non - ashbed sites than ashbed sites has been known for some time. However, figures which have been subjected to proper statistical analysis have up to now not been available. The importance of insects can be guaged from the spectacular increase in germination per cent in the plots treated with Dieldrin. The germination of both spring and autumn sown seed has been improved 200 to 300 per cent by the use of this insecticide. Insects would appear to be responsible not only for removal or destruction of much seed over summer but also for destruction of many of the newly emerged germinants. This latter was confirmed by field observation. Inconsistent results were obtained with shade treatments and it would appear that shade is not a factor of great importance. A peculiar feature is the very high germination per cent of shaded autumn sown seed on non - ashbed sites. Shade has not improved the germination per cent in spring sown seed which would tend to suggest that few seed die from radiant heat during summer.

The fungicide treatments were inconclusive and if anything appear to have had a detrimental effect on germination, especially on ashbed sites! (see Table 11).

This effect was very close to being significant at the .05 level. It is perhaps of interest to record that we have had similar results in some lab trials and that sterilization of soil appears to retard germination of Karri. The reason for this is unknown. It seems unlikely that fungi are a factor of major importance in germination of Karri. However, pot trials indicate that under certain circumstances damping off, caused by a *Pythium* sp., may be of importance. This is likely to be of local importance only.

As these trials were carried out during a particularly dry year the results may be taken to represent the extremes. It is possible that under more favourable condition the germination percentages might be higher. However, it does not seem likely that the basic trends observed would differ much. This assumption is supported by the fact that past work on some of these factors has indicated similar trends.

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CAPTIONS AND SUBSCRIPTS TO FIGURES IN THE TEXT

FIGURE 1

Caption

Germination of Karri seed on March Road plot; plotted with weekly rainfall figures from Manjimup.

Subscript

●—● Spring sown seed (21/1/69)

○—○ Autumn sown seed (10/4/69)

FIGURE 11

Caption

Graph showing germination of Karri seed on Grafe Road plots

Subscript

Germination at each point was calculated as a percentage of total germination

FIGURE 111

Caption

Relative availability of Karri seed for any given crop during regeneration burning periods.

Subscript

⬚ Approximate only

■ Spring burning period

□ Autumn burning period

TABLE 1

Table showing percentage germination experiment No. 1, figures are means of seven plots.

Season / Site	Spring Sown	Autumn Sown
Pine Creek (K)	2.9	5.4
Grace Road, (K)	1.9	3.9
Pine Creek (K/M)	7.9	9.7
March Rd (K/M)	8.8	10.2

TABLE 11

Table showing percentage germination, experiment No. 11, figures are means of five plots.

Season	Spring Sown		Autumn Sown	
Seedbed → treatment ↓	Ashbed	Non Ashbed	Ashbed	Non Ashbed
No treatment	3.2	3.8	11.6	9.2
Shade	4.8	2.0	5.2	20.8
Insecticides	10.8	12.6	24.4	34.2
Fungicides	1.2	5.6	0.6	7.4

Fig. I.

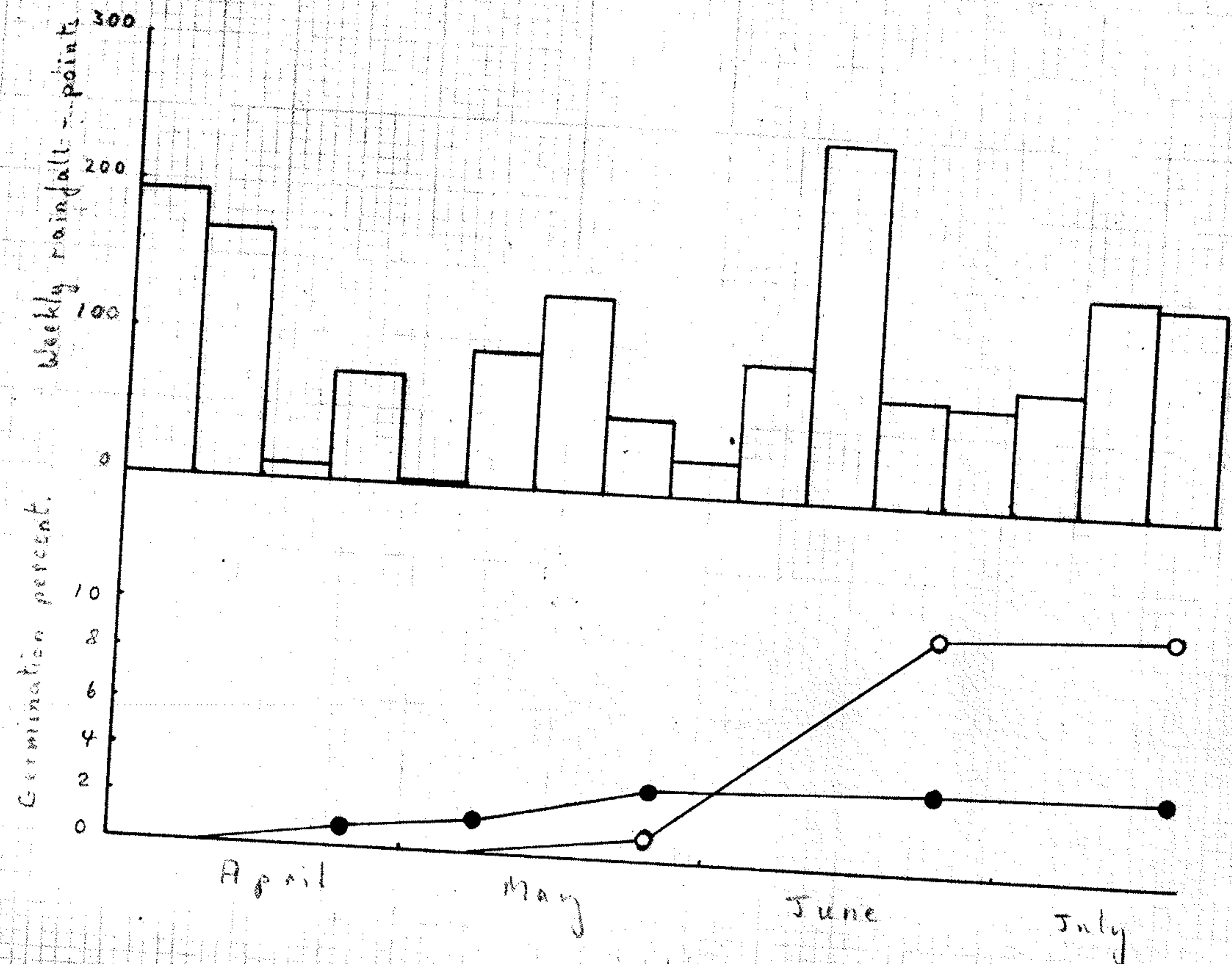
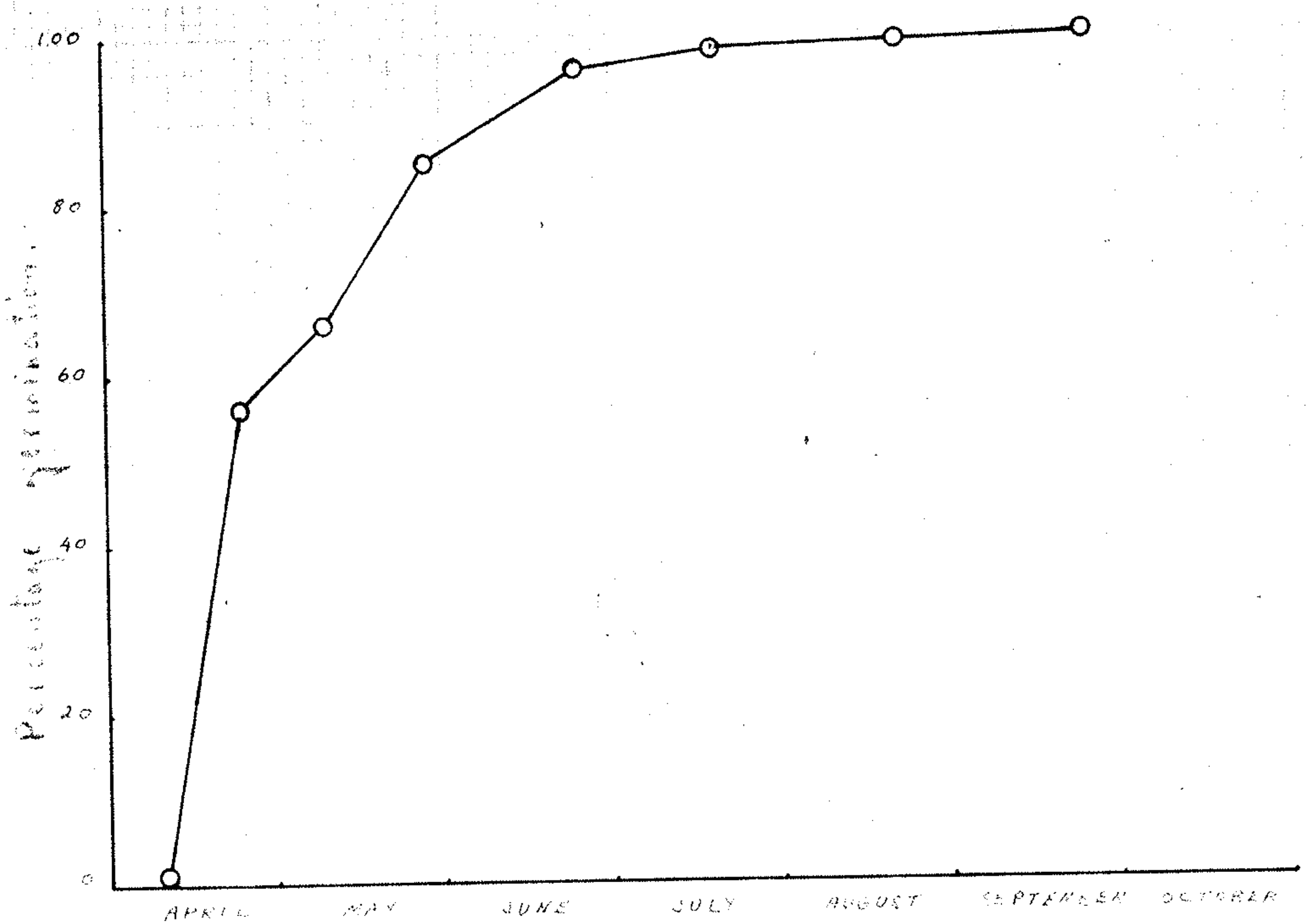

Weekly rainfall - points
300
200
100
0
Germination percent.
10
8
6
4
2
0
April
May
June
July

Fig II



100
80
60
40
20
0
Percentage Germination
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER

Fig III