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RAISING AND PLANTING FLOODED GUM

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SUMMARY

Preliminary studies into the nursery and planting technique for Flooded Gum (*Eucalyptus grandis* (Hill), Maiden) suggested that a satisfactory survival of seedlings in the field could be obtained using open-root seedlings which had previously been transplanted in the nursery. Open-root seedlings which had been top-pruned or root-wrenched, but not transplanted, showed less satisfactory survival after summer planting. Seedlings raised in containers all showed high survival, though growth was retarded when the seedlings were planted in veneer tubes. Small pots made from pulp and sphagnum appeared preferable both to the metal tubes used at present and to seedlings raised in trays.

Nursery establishment was improved by sowing the seed under partial shade and keeping it covered by hessian sheeting until germination occurred. It was shown that seedlings of relatively large size could be successfully transplanted into open metal tubes.

Unhealthy plants and heavy tubing losses appeared to be associated with an essential factor present in soil from under established Flooded Gum, but absent from the rainforest soil normally used at the nursery. It is felt that this factor may be a mycorrhiza.

INTRODUCTION

The fast growth rate and useful timber properties of Flooded Gum (*Eucalyptus grandis* (Hill), Maiden) combine to make it one of the most important forest species in northern N.S.W., and approximately 500 acres of fertile alluvial gully sites are being regenerated with this species each year by the Forestry Commission on North Coast forests. Rainforest tends to be the climax vegetation of the gullies where Flooded Gum occurs naturally, and stands of the eucalypt at an early age provide shelter for a host of rainforest species which will ultimately replace it and prevent its regeneration. Its seedlings are markedly light-demanding, and consequently a clear-felling silvicultural system is needed for its regeneration.

Clear-felling with seed trees has not proved very satisfactory in the past and indeed is impracticable in areas where succession has reached the rainforest stage and no trees of Flooded Gum remain. As a result artificial regeneration is practised. Early regeneration work favoured planting, using seedlings raised in metal tubes, but subsequently this was replaced by the sowing of seed, first broadcast over the regeneration area and more recently spot sown. Considerable research has been carried out on the techniques of sowing Flooded Gum since 1956 and many improvements have been introduced to avoid oversowing, ensure adequate stocking and reduce subsequent thinning costs (Floyd, in print).

However the need for planting still arises under certain circumstances, and if the initial establishment costs were sufficiently reduced planting could receive widespread favour.

PRESENT NURSERY TECHNIQUE

The present nursery technique, which has remained virtually unaltered since Flooded Gum planting was first carried out 20 years ago, involves the broadcast sowing of seed on to prepared seed beds under a shade frame which is adjusted to allow about 50 per cent. sunlight to reach the beds. Sowing is carried out during the spring, and immediately after sowing the seed is either covered by a fine layer of soil or by a sheet of hessian which is removed once germination starts. The beds are kept moist.

Germination usually occurs in about a fortnight. When a seedling reaches the stage of having two pairs of juvenile leaves present and a third pair forming it is lifted and dibbled into the top of a metal tube (8 inches long and about 2 inches diameter) filled with soil. The seedlings are then lined out under shade which is progressively reduced until the seedlings are in complete sunlight. Planting takes place when the seedlings average 5-6 inches in height, after the onset of the wet season in mid-summer. A hole must be prepared as deep as the cylinder of soil within the tube (i.e. 7 to 8 inches). The tubed seedling is placed in this, the metal tube is unclipped and slid away from the seedling and the cylinder of soil, and soil then replaced in the hole.

PRELIMINARY INVESTIGATIONS AND SITE DETAILS

With a view to obtaining information about improved methods of raising Flooded Gum seedlings in the nursery and of planting them in the regeneration area, a number of preliminary studies were carried out during the 1958-59 season. It must be emphasised that all the studies were in the nature of leader trails and were not statistically designed: the interpretation of the results must be viewed cautiously. At the same time a number of the results are of some interest, and for this reason it has been suggested that they should be made the subject of a research note.

The studies covered five separate topics:—

- (1) Initial establishment of seedling crop.
- (2) Size of plants at tubing.
- (3) Tubing medium.
- (4) Open-root planting technique.
- (5) Alternative transplant methods.

Seed used in the work had been collected from a local forest in the summer of 1957-58 and stored. All nursery work was carried out at the Woolgoolga forest nursery, situated about 20 miles north of Coff's Harbour. Seed was sown during the first week of October, 1958. Tubing and other forms of transplanting were carried out in mid-December. Seedlings were lifted and taken to the regeneration area on 16th February, 1959, but owing to cyclonic weather planting was delayed till 19th February.

The regeneration area, a broad, gently sloping gully bottom which had carried Flooded Gum with a rainforest understorey, was located on Lower Bucca State Forest, about 10 miles north-north-west of Coff's Harbour at an altitude of about 400 feet. The area had been clear-felled in the latter part of 1958 and all debris had been burnt in mid-January, 1959.

INITIAL ESTABLISHMENT OF SEEDLING CROP

During the summer before the present studies were undertaken an attempt had been made to line-sow Flooded Gum in an open nursery (i.e. without any shading). Seedlings were to have been root-wrenched and used for an open-root planting trail. However on two occasions the sowing was a complete failure. A third attempt was made and this time the drills were covered with hessian: germination occurred and a number of seedlings became established in the bed, though too late to be used in the proposed planting experiment.

To check these rather unsatisfactory results a simple experiment with three treatments was carried out in 1958-59.

A. Drill sown under low shade.

B. Drill sown in open, drills kept uncovered.

C. Drill sown in open, drills shaded by hessian until seedlings appeared. $\frac{1}{2}$ -oz. of seed was used for each treatment, and the results were assessed on 16th January, 1959 :—

<i>Treatment</i>	<i>No. Seedlings</i>	<i>Av. Height</i> inches	<i>Best Height</i> inches	<i>Appearance</i>
A	181	4 $\frac{1}{2}$	12	Mostly green and healthy.
B	3	2 $\frac{1}{2}$	3	Reddish tints, stunted
C	214	2 $\frac{1}{2}$	5	Reddish tints, stunted

These results suggest that initial protection of sown seed is essential if satisfactory germination and establishment is to be obtained. This is in keeping with the experience of the previous summer and also with field sowing observations: the majority of young seedlings usually occur in the shelter of logs and other protecting debris.

In this particular study, slightly higher establishment was obtained in the open sown, but protected, bed than in the shaded bed. This was unexpected and may have been due to local variations in certain soil factors, plus an unusually good (moist and cloudy) season. Normally far better establishment would be expected under shade. Growth in the shaded bed was generally superior to that in the open, but it is probable that the open-grown seedlings would have been hardier for subsequent planting: none of these seedlings were used.

SIZE OF PLANTS AT TUBING

With a large-scale sowing of Flooded Gum it frequently becomes a sheer impossibility to tube all the seedlings when they are at the requisite size. Their rapid growth causes many to be considerably larger than the "two pairs of leaves" stage before they can be tubed. To see whether these larger seedlings could be satisfactorily tubed, or whether it would be preferable to stagger the sowing time and so have correct sized seedlings available for tubing over a longer period, another study was carried out with two treatments—

A. Seedlings dibbled into top of closed tubes when at the two pairs of leaves stage.

B. Seedlings transplanted into the side of open tubes when larger (4 inches +).

Treatment B was similar to the method used with Hoop Pine and other larger seedlings. Results were assessed in the nursery on 16th January—

<i>Treatment</i>	<i>Alive</i>	<i>Dead</i>	<i>Total</i>	<i>% Alive</i>
A	94	64	158	59%
B	141	9	150	94%

About 50 living seedlings from both batches were planted in the field. Assessed and measured on 8th June, the following results were obtained—

<i>Treatment</i>	<i>Alive</i>	<i>Dead</i>	<i>Total</i>	<i>% Alive</i>	<i>Mean Height</i>
A	48	2	50	96	1.66 ft.
B	42	3	45	93	1.73

The nursery assessment results were rather unexpected, showing a considerably higher survival rate for the larger seedlings than for those tubed in the orthodox manner. The low survival for the smaller seedling is however not altogether reliable as an indication of what might be expected under optimum conditions. Many of the smaller seedlings were in fact somewhat larger than the desideratum and would thus tolerate dibble tubing less successfully.

The results did however indicate what had been sought, that the larger seedlings can be successfully tubed. Results after planting suggest that there is no appreciable difference in either survival or growth dependent upon the size at tubing.

TUBING MEDIUM

During the raising of Flooded Gum seedlings at Woolgoolga in 1957 certain difficulties were experienced which culminated in heavy tubing losses. Many of the seedlings before tubing appeared healthy, strong and green, but there were also many that were unhealthy looking, stunted, and with reddish tints in the foliage. Whilst the healthy seedlings tubed well, a high mortality rate and poor development followed the tubing of the others.

The soil being used for tubing had been collected from the head of Woolgoolga Creek in an area of rainforest, where no eucalypts now grow. This rainforest soil is regarded as being particularly fertile.

The nurseryman, convinced that his tubing technique was not at fault, tubed a small batch of unhealthy seedlings in soil from a Flooded Gum stand adjoining the nursery. The comparison was spectacular, with high survival and healthy plants in the Gum soil against the heavy losses and unthrifty plants in the rainforest soil. This suggested that either the microflora or the fertility status of the two soils was sufficiently different to affect appreciably the tubing results.

To test this suggestion further, an experiment involving four different tubing soil mixtures was carried out—

- A. Rainforest soil.
- B. Flooded Gum soil.
- C. Mixture of 1 part Gum, 3 parts Rainforest soil.
- D. Mixture of 1 part Gum, 1 part Rainforest soil.

Survival was assessed and heights measured on 16th February, 1959—

<i>Treatment</i>	<i>Alive</i>	<i>Dead</i>	<i>Total</i>	<i>% Alive</i>	<i>Mean Height</i> inches
A	76	23	99	77	4.8
B	97	2	99	98	3.3
C	91	6	97	94	5.8
D	93	7	100	93	5.6

A number of seedlings from each treatment were then planted in the field, and further growth and mortality assessed in June—

<i>Treatment</i>	<i>Alive</i>	<i>Dead</i>	<i>Total</i>	<i>% Alive</i>	<i>Mean Height</i> ft.
A	35	2	37	95	1.46
B	48	2	50	96	1.34
C	27	9	36	75	1.59
D	40	0	40	100	1.59

The results of the first assessment confirmed the trends shown the previous year, though not quite so markedly since on this occasion a routine batch of seedlings, both thrifty and unthrifty, were used. Tubed into pure rainforest soil, survival was below 80%, with the height growth of the survivors only moderate. The presence of Gum soil, even as only a quarter of the total bulk, lifted survival to over 90 %, though the subsequent growth of the seedlings was improved by the presence of rainforest soil.

These results can be explained by assuming two factors to be operating—

- (1) A mycorrhiza-type organism, plentiful in Gum soil but scarce in rainforest soil.
- (2) A fertility factor, high in rainforest soil but lower in Gum soil.

Seedlings with negligible mycorrhiza show up as stunted, reddish-hued plants. Transplanted into mycorrhiza-impoverished soil such seedlings have only a doubtful chance of survival, whereas healthy (i.e. mycorrhiza—infected) seedlings can be satisfactorily transplanted. Sickly plants will similarly recover if transplanted into a mycorrhiza-rich substrate. This would also explain the indifferent results which have been obtained when Flooded Gum seed has been sown directly on certain sites which formerly carried pure rainforest without eucalypt relicts.

Mycorrhiza has recently been recorded as being necessary for the growth of certain eucalypts (Pryor, 1956), though the *Macrantherae*, of which Flooded Gum is a member, has not shown the same need as the *Renantherae*. However what appear to be fungal hyphae have been noticed associated with the roots of Flooded Gum seedlings, and this whole question deserves early study.

The Flooded Gum soil used in the experiment was apparently less fertile than the rainforest soil, and consequently mycorrhiza-infected seedlings transplanted into primarily rainforest soil showed better growth than those in pure Gum soil. The conclusion is that both factors, and locally at least both types of soil in mixture, are needed to produce the best seedlings.

The assessment of planted stock showed that subsequent growth had been equal in all treatments, with the initially larger plants still showing the same slight advantage (2 inches) over the smaller. The relatively heavy losses in treatment C after planting are inexplicable, but it is thought that in a replicated experiment they would not be significant.

OPEN-ROOT PLANTING TECHNIQUE

Planting of tubed stock is considerably more expensive to carry out than the planting of open-root stock. Whilst eucalypt planting in Australia has been almost exclusively from tubes, pioneering work on the planting of eucalypts open-rooted has been carried out overseas and more recently successfully applied in the southern, winter-rainfall areas of Australia (e.g. Raeder-Roitzsch, 1958). In the summer-rainfall areas, including the North Coast of N.S.W., its application is more difficult: in summer and early autumn, when moisture conditions are most favourable, the seedlings are at the height of their growth period and are consequently very tender to handle, whereas in the winter, when growth is at its minimum, the seedlings are being planted into the approaching dry season in which even hardy species like *Pinus elliottii* Engelman are liable to suffer heavy mortality.

The economic advantages of being able to plant open-root stock are however sufficient to warrant an investigation of its possibilities and a leader trial was consequently carried out as part of the series of studies, trying 6 treatments:

- A. Open-root stock; no further treatment.
- B. Open-root stock; top-pruned before planting.
- C. Open-root stock; root-wrenched twice in nursery.
- D. Open-root stock; top-pruned and root-wrenched.
- E. Open-root stock; transplanted in nursery at 10 weeks.
- F. Routine tubed stock.

Seed for treatments A—D was sown in drills, whilst treatments E and F were taken from a broadcast nursery sowing of the same age. Root wrenching of C and D was carried out on 15th December and 12th January (i.e. at 10 weeks and 14 weeks); E was transplanted on 15th December into rows 8 inches apart, with 12 to 14 seedlings per foot; and F was tubed in mid-December also. Some thinning of treatments A and B was also carried out at the same time. Transplanting was carried out without loss and few seedlings died as a result of root-wrenching.

Seedlings were lifted on 16th February (19 weeks), individual batches being wrapped in hessian with some moist soil packed around the roots. Treatments B and D were top-pruned to about 6 inches at this stage. Owing to the cyclone, plants were left in the open (though still wrapped up) at the planting site for two days before planting. Pit planting was used for treatments A—E.

Survival was first assessed on 16th March. Whilst there were many obvious deaths, some plants in all batches seemed quite healthy, and many more were leafless but maintained a green stem and showed signs of

producing adventitious shoots. These last seedlings were provisionally classed as alive. However a subsequent assessment in June, 1959 showed that all these had died, while the seedlings which appeared healthy after 1 month still survived after 4 months—

<i>Treatment</i>	<i>1 month</i>		<i>4 months</i>		<i>Total</i>	<i>%</i>	<i>Mean Height</i> <i>ft.</i>
	<i>Healthy</i>	<i>Leafless</i>	<i>Alive</i>	<i>Dead</i>			
A	10	12	10	37	47	21	1.51
B	3	10	1	54	55	2	0.30
C	9	12	10	44	54	19	1.14
D	16	9	15	64	79	19	1.05
E	56	13	56	35	91	62	1.10
F	Not assessed		80	5	85	94	1.16

It is apparent that open-root stock generally is very difficult to plant during the summer. Top-pruning without root-wrenching appears to have reduced survival considerably, but root-wrenching itself does not appear to have conferred any advantages over the untreated control (A). However the small plantings and unreplicated layout must be borne in mind here.

The results obtained with the transplants on the other hand are considered rather satisfactory. These were small, sturdy plants with a good fibrous root system. Their survival of over 60% (equivalent to 400 per acre at 8 x 8 spacing) would provide more stems than could be merchantably disposed of at present, while the heavy weed growth that is a feature of the Flooded Gum gullies would ensure that form was not adversely affected by the apparent light stocking. The delay between lifting and planting would probably have lowered survival in this as in all open-root plantings, even though it provided a moist soil bed for planting. The use of transplants certainly warrants further investigation.

ALTERNATIVE TRANSPLANT METHODS

It was realised at the outset that open-root planting might not be successful, but that possibly some other form of container than the metal tubes might be just as satisfactory as the metal tubes and at the same time allow for cheaper and faster establishment.

Consequently an experiment involving alternative types of containers was carried out—

- A. Tubed in routine metal tubes.
- B. Tubed in veneer tubes (to be planted with tube attached).
- C. Transplanted into trays.
- D. Transplanted into Jiffy pots.

Seed for all batches was broadcast sown in the nursery in early October and the seedlings tubed or transplanted in mid-December except for treatment B, which, owing to late supply of the veneer tubes, was not tubed until early January.

The veneer tubes measured 8 x 8 inches when flat and were of about $\frac{1}{16}$ -inch thickness. They were of a non-durable rainforest species (possibly *Sloanea woollsi* F. Muell) and were held tubular by an elastic band. The tray method (treatment C) was that recommended for use in the Union of South Africa by the Department of Forestry (1950), the seedlings being pricked into tins or boxes of soil about 4 inches deep, and spaced about 2 x 2 inches apart. The whole box is taken to the field and the seedlings there planted out by trowel.

The Jiffy pots (trade name) were small porous pots of the texture of cardboard, manufactured in Norway from a mixture of wood pulp, sphagnum and added fertiliser. Three sizes were available, and that used was $2\frac{1}{4}$ x $2\frac{1}{4}$ inches, costing 1d. per pot. In this experiment the seedlings were dibbled into the pots as for tubing, but it would probably be more convenient to sow the seed directly into the pots and then thin out the resultant plants to one per pot where necessary.

Planting occurred on 23rd February. Originally all veneer tubes were to have been planted with the enclosed seedling, but by accident twenty-one seedlings in this treatment were planted after the veneer tube had been removed. The metal tubes (treatment A) were all removed, as is routine practice, and the Jiffy pots (treatment D) were planted into rudimentary holes with the pot attached: in practically all cases rootlets of the Flooded Gum could be seen growing out of the porous pot.

Planting times were kept for each batch, but these can only be regarded as an indication of comparative planting rates as the labour used was untrained and the batches planted were very small. Results were assessed in June, 1959—

Treatment	Planting Rate (Seedlings/man day)	Alive	Dead	Total	%	Mean Height ft.
A	420	80	5	85	94	1.16
B—tube removed	470	19	2	21	90	1.44
B—tube planted						
C	600	105	14	119	88	1.30
D	680	94	5	99	95	1.46

The various types of container do not appear to have given appreciably different survival rates, except possibly in the case of the veneer tubes (B) when these are left attached to the soil cylinder. Generally however all methods gave a survival rate of about 90% or better. Since in all cases the seedlings' roots are subject to a minimum of disturbance in planting this good survival was expected.

The veneer tubes appear to have produced a definite retarding of growth, presumably due to the slow rotting away of the attached wooden tube: with those plants where the tube was accidentally removed the improvement in growth is marked.

All new methods allowed considerably faster (and therefore cheaper) planting than is the case with metal tubes (A). The planting rate for veneer tubes would have been increased had not time been lost in removing a quarter of the tubes. The Jiffy pots (D) gave a most attractive rate of

planting : in the trial, an acre per man per day at 8 x 8ft. spacing, and this rate should be increased by using experienced labour and adopting a wider spacing. The problem of rotting, which occurs with veneer tubes, does not arise with these, while their small bulk requires a much less substantial hole than earlier metal or veneer tubes. In the field Jiffy pots were satisfactorily transported in the metal carrier tins normally used for tubed stock.

The tray planting (C) had much the same advantages as Jiffy pots but the need to trowel out each seedling individually made for somewhat slower planting. The trays used were bulky and awkward to handle amidst the debris of the regeneration area, and this also reduced the planting rate.

To summarise, it appears that veneer tubes have definite disadvantages which make their use unwise. Metal tubes are slower to plant and have no advantages over the other two methods of which the Jiffy pots seem particularly suitable for use on a routine scale. Certain modifications in the nursery would be needed if Jiffy pots were to be widely used, since they have to rest on a solid (timber or concrete) base, not on soil. However the alterations would not be costly, while the cost of the pots roughly equals the the present depreciation on metal tubes.

GENERAL DISCUSSION

It must be stressed again that all results should be regarded with caution because of the small and unreplicated nature of the trials. Despite this, there are strong indications that present nursery and planting techniques with Flooded Gum can be modified both to increase efficiency and the recovery of seedlings, and to reduce costs.

It appears that open-root nursery transplants can be used to give a satisfactory stocking with summer planting, and probably an even better recovery would follow a late autumn planting when growth is waning and tail-end rains from the wet season can still be expected. However until further work is carried out, wisdom suggests the continued use of seedlings raised in containers when planting is to be performed. Of the various containers tried the Jiffy pots appear to have most in their favour and should allow a considerable reduction in costs over the use of the routine metal tubes or the other containers tried. Veneer tubes (and probably, for the same reason, bamboo and tarred paper tubes) cannot be regarded as satisfactory. Soil blocks have not been tried with Flooded Gum though they are used overseas for raising eucalypts (Thirgood, 1956), but demonstrations by the Department of Agriculture suggest that the cost of manufacture would be no less than the cost of Jiffy pots, while their bulk would render them less acceptable.

In the nursery it appears that seedlings can be raised far more successfully under partial shade than in the open, even though covering the seeds with hessian prior to germination will appreciably increase the establishment rate in the open. The nature of the nursery soil appears to be of considerable importance : some apparently essential factor, possibly a mycorrhiza, occurs in soil from under existing Flooded Gum, but may be lacking in other soils, even those of otherwise high fertility. It would seem desirable to ensure that the soil used in nursery beds and in any containers always has a proportion of Gum soil mixed with it.

Large seedlings can be tubed successfully into the side of open tubes, but where dibbling has to be employed, as with Jiffy pots, only small seedlings (up to two pairs of leaves stage) should be used. Minimum size does not appear to matter: Edwards (1956) reports successful dibbling into tubes as the cotyledons escape from the seed testa with *E. urnigera* Hook. f. However with large scale plantings it could be impossible to pot all seedlings within the limited time available before size became too great, and the sowing of seed directly in the pots and then thinning the resultant seedlings to the best one in each pot would seem preferable.

CONCLUSION

The results suggest that planting costs can be reduced to a more acceptable figure than prevails at present, and at the same time they make further study along certain lines obligatory.

Replicated trials using both Jiffy pots and open-root transplants are clearly needed to determine the best methods of nursery treatment in both cases and the best time to plant with the transplants. Large scale trials are also needed in both cases to obtain trustworthy operation costs.

The possible mycorrhiza needs close study to determine what the necessary factor in Gum soil is, and how great is its significance. Its absence from certain rainforest areas intended for conversion to Flooded Gum could make the planting of infected Gum essential even though all other factors favoured the sowing of seed.

Whether the large scale planting of Flooded Gum will ever be resumed on the North Coast is doubtful, as recent research on sowing has enabled a desirable stocking of Flooded Gum stems to be obtained at a cost below that possible with planting. However in certain areas, such as steep sided gullies, extensive alluvial flats where flooding immediately after sowing could disperse or even carry away much seed, or the rainforest areas mentioned above, planting may still have much to commend it, and it is not unlikely that both establishment techniques will prove complementary in the management of the Flooded Gum working circles in North Coast forests.

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