PROPAGATION SYSTEM FOR THE PRODUCTION OF ROOTED CUTTINGS FROM PHYSIOLOGICALLY MATURE *PINUS RADIATA* WITHIN 2 YEARS OF FIELD COLLECTION

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ABSTRACT

Scions from selected *Pinus radiata* D. Don trees were grafted on to open-bed-grown seedlings. The resultant first-year grafts produced the material to be used as cuttings. The technique for rooting such material is based on a pre-treatment system developed since the 1960s at the Forest Research Institute nursery. Suspected early graft incompatibility affected the quality of the cutting material produced so that strike rates of cuttings taken from 1-year-old grafts were generally about half to two-thirds of those derived from repropagation hedges originally established with rooted cuttings. All but one of the 24 clones tested in this investigation produced rooted cuttings.

The method described offers opportunities for establishing and updating of clonal repropagation and breeding archives as well as seed orchards with rooted cuttings within 2 years of field ortet selection. This is 1 year longer than if grafts were used but only half the present 4-year period required to produce rooted cuttings, and avoids the long-term problems associated with graft incompatibility.

Keywords: vegetative propagation; grafting; cuttings; incompatibility; *Pinus radiata*.

INTRODUCTION

During the early years of the *Pinus radiata* breeding programme in New Zealand, seed orchards were established using grafts. After a few years of orchard planting it became apparent that delayed graft incompatibility was causing ill health and deaths among some grafted propagules. Graft incompatibility manifested itself to a greater extent in the North Island seed orchards than it did in the South Island orchard at Amberley.

Although tree form ramets suffered visible graft incompatibility to a lesser degree than hedged ramets, roguing in grafted seed orchards often had to take the form of removal of dead and dying trees rather than the extraction of genetically inferior individuals.

Trees suffering from visible graft incompatibility produce small and underdeveloped cones and, as a consequence, small seed. Repropagation hedges established with grafts

produce cutting material of lower rootability than those established with cutting-grown ramets. It is therefore desirable to propagate all clones destined for both seed orchards and clonal hedges from cuttings.

Research into the necessary techniques to propagate physiologically mature cutting material of *P. radiata* started in the 1960s. These techniques, involving the pretreatment of the cuttings by topping and ringbarking 4 to 6 weeks prior to their removal from the donor tree, and then rooting the material in tunnel houses, are now well established and routinely used at the Forest Research Institute (Faulds 1981).

Prior to the development of the method described in this paper, the system of producing rooted cuttings from physiologically mature field ortets involved the following steps:

(1) Grafting buds from field ortets on to open-bed-grown seedlings

(2) Planting of grafts in clonal repropagation hedges

(3) Pruning grafts as "hedges" to produce suitable cutting material

(4) Pre-treatment and setting of cuttings at 2.5 years from grafting.

The time from ortet selection and grafting to the availability of rooted cuttings for planting was therefore 4 years.

In 1986 we proposed that by using 8- or 9-month-old grafts in nursery beds, rather than those present in repropagation hedges, as a source of cutting material it might be possible to shorten this period to 2 years.

By grafting a large number of buds from the selected ortet, large numbers of potential cuttings would be available. These, when rooted, would provide planting stock for the establishment of clonal repropagation hedges and seed orchards, without the complications of long-term graft incompatibility. In addition, new genotypes would be able to be introduced into the breeding programme with a lead time of only 2 years, and "on their own roots".

The objectives of the present study were (1) to determine what size buds should be used for grafting in order to produce shoots suitable for topping and ringbarking, (2) to assess the effect of late season fertiliser applications to the grafts on the rooting success of the cuttings, (3) to compare the rooting percentages of cuttings from 9-month-old grafts with those of cuttings from cutting ramets, and (4) to assess the potential of the graft stubs as short-term cutting supply ramets until cutting ramets become available for this purpose.

METHODS

Donor Ramets

A total of 24 clones were randomly selected from those currently in the *P. radiata* breeding programme—11 from the "268" series, one from the "850" series, and 12 from the "875" series. Donor ramets of the "268" and "850" series were present in 7-year-old repropagation hedges established with cuttings in the Long Mile area in Rotorua. The "268" field ortets were 13 years of age in 1968, and the "850" field ortet was approximately 25 years old in 1950. The donor ramets of the "875" series were available as tree form ramets in the Kaingaroa seed orchard, also established with rooted cuttings, and these ortets were 8 years

old in 1975. The "875" ramets supplied buds for grafting in July 1987 while the "268" and "850" ramets supplied buds for grafting in July 1987 as well as the "cuttings from cuttings" (*see below*) in April 1988.

Cuttings from Grafts

In July 1987, 52 scions of each clone covering the size range of small, medium, and large (*see* Fig. 1) in proportions appropriate for each clone were grafted on to 9-month-old field-grown *P. radiata* seedlings using the tip cleft method.

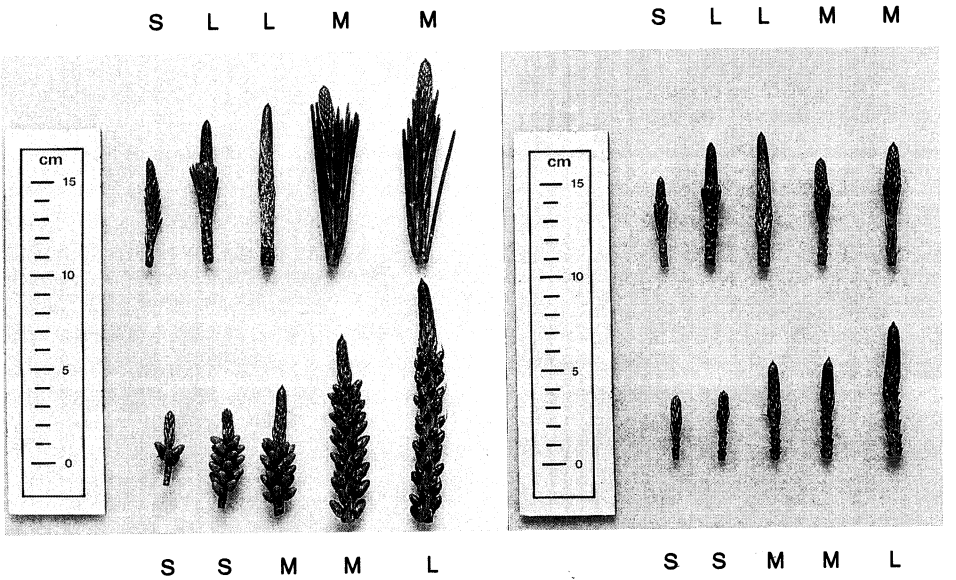

FIG. 1–Size range and type of buds used, after collection and immediately prior to grafting
S = small, M = medium, L = large

Because there were two different ramet types in the Clone 268.065 row in the Long Mile area, in this trial the cuttings from grafts were of mixed origin. Those from cuttings were confirmed to originate from Clone 268.065.

All grafts received standard treatments. When the needles of the scions had elongated fully, half of the grafts of each clone were given additional fertiliser (N:P:K:Mg @ 12:5:14:1.2 + trace elements, at 200 kg/ha on 18 January 1988; foliar applications of 2% urea + 2% sulphate of magnesium, at 5000 *l*/ha on 1 February and 1 March 1988). These applications were timed to avoid excessive elongation of the shoots to be used as cuttings. Care was taken to ensure that approximately 50% of the seedling root-stock foliage remained when topping and ringbarking took place in March 1988. Diseased, damaged, and unthrifty grafts were avoided.

Cuttings from Cuttings

During August 1987 and again in December 1987 clonal hedges were pruned according to each clone's growth habit in order to direct the ramet's growth potential into cutting

production. In March 1988 cutting material was pretreated by topping and ringbarking the 8-month-old shoots.

No suitable material was available from Clones 268.531 and 850.101 because of needle disease problems, while a shortage of material in Clones 268.062 (23 shoots) and 268.109 (25 shoots) meant that only 20 cuttings of each were set.

Setting of Cuttings

In April 1988 cuttings from the Long Mile ramets as well as the nursery grafts were set in polythene tubes and placed in a polythene tunnel house. Temperature was managed within the range 0–25°C while relative humidity was maintained at a minimum of 75% by automatic misting.

Graft Stubs

Open-bed-grown *P. radiata* grafts are normally conditioned by undercutting, wrenching, and lateral root pruning, as described for *P. radiata* seedlings by van Dorsser & Rook (1972). In this trial the start of conditioning was delayed and graft stubs were not undercut until immediately after removal of the cuttings. By July 1988 the graft stubs were adequately conditioned and the remaining root-stock foliage was removed. By this time buds had developed in the uppermost fascicles and root systems were adequate despite the late conditioning (Fig. 2).

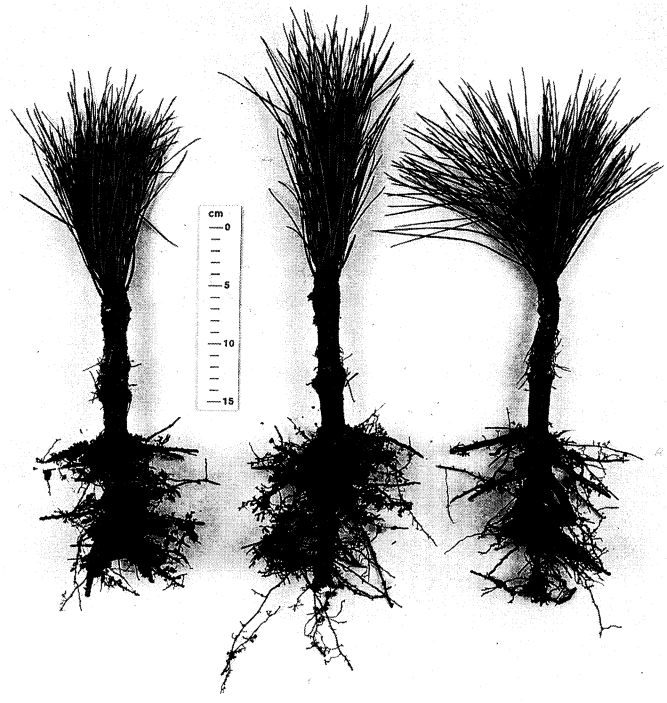

FIG. 2–Graft stubs ready for planting

Ten graft stubs of each of five clones of the "268" series and five graft stubs of each of 10 clones of the "875" series not required for other plantings were planted in the Long Mile area at the FRI, Rotorua.

RESULTS AND DISCUSSION

Graft Performance and Bud Size

Graft survival was high (Table 1) regardless of size of bud grafted but only about half of the small buds developed into shoots suitable for ringbarking. The grafts from small buds also produced a low number of plantable stubs in comparison with those derived from medium and large buds.

TABLE 1–Graft survival, cutting production, and usable graft stubs produced in relation to size of buds grafted

	Clone series	Buds			All buds
		Small	Medium	Large	
Graft survival (%)	268	98.8	99.7	100	99.5
	875	96.5	99.7	98.1	98.7
	All clones	97.7	99.7	99.1	99.1
Grafts suitable for ringbarking (%)	268	44.6	88.1	89.8	77.3
	875	64.5	92.0	84.8	84.6
	All clones	53.9	90.1	87.5	80.9
Topped and ringbarked shoots suitable for collection (%)	268	87.3	96.9	98.2	95.8
	875	94.4	99.1	100.0	98.5
	All clones	91.2	98.1	99.0	97.2
Plantable graft stubs after removal of cuttings (%)	268	45.2	80.4	99.1	80.2
	875	71.4	90.9	98.9	89.1
	All clones	60.2	86.1	99.0	84.9

Cutting Performance

Grafting success, number of grafts pre-treated by topping and ringbarking, percentage of cuttings from both graft and cutting origin that rooted, and number of graft stubs produced are presented for individual clones in Tables 2 and 3.

The poorer performance of the cuttings from grafts was probably due to their observed inferior health as a consequence of suspected early graft incompatibility. The superiority in health of the rooted cuttings from cutting hedges compared with that of the rooted cuttings from grafts is illustrated in Fig. 3.

One exception was Clone 268.405. In this clone the rooted cuttings from grafts appeared just as healthy as the rooted cuttings from cuttings and yet their strike rates suggest that some effect of the grafting was present. The cuttings from grafts of one clone (268.062) out of the 25 clones tested in this study did not form roots. The propagation of such clones by cuttings will have to continue by the old method with field-planted grafts supplying the initial propagation material. In this context graft stubs as the source of future cutting material are a useful part of the new method. With Clone 268.062, for instance, 24 graft stubs suitable for field planting were available.

TABLE 2–Series "268" and "850" clones: Grafting, cutting pretreatment by topping and ringbarking, percentage rooting success, and numbers of graft stubs produced

Clone	Donor plants	No. of growing scions out of 26 grafted	Shoots topped and ring-barked	Ringbarked cuttings collected	Cuttings set	Cuttings rooted (No.)	(%)	Usable graft stubs
268.002	G	26	25	24	20	6	30	22
	C		22	22	20	18	90	
	G +F	26	24	23	20	4	20	18
	C		22	22	20	15	75	
268.041	G	26	22	22	20	8	40	16
	C		22	21	20	18	90	
	G +F	26	22	22	20	9	45	16
	C		22	22	20	17	85	
268.062	G	26	18	18	18	0	0	14
	C		23	23	20	8	40	
	G +F	26	15	14	14	0	0	10
268.065	G	26*	20	20	19	4	21	17
	C		25	25	20	11	55	
	G +F	25*	20	19	19	5	26	14
	C		25	25	20	12	60	
268.109	G	26	23	23	20	5	25	21
	C		25	25	20	13	65	
	G +F	26	24	23	20	6	30	21
268.228	G	26	18	18	18	12	67	17
	C		25	25	20	20	100	
	G +F	26	22	22	20	15	75	20
	C		25	25	20	20	100	
268.308	G	26	22	22	20	7	35	16
	C		25	25	20	15	75	
	G +F	26	21	17	17	9	53	15
	C		25	25	20	16	80	
268.350	G	26	17	16	16	4	25	16
	C		18	18	18	14	78	
	G +F	26	16	13	13	3	23	12
	C		20	20	20	12	60	
268.405	G	25	20	20	18	14	78	17
	C		23	23	20	18	90	
	G +F	26	20	20	20	12	60	14
	C		22	22	20	18	90	
268.494	G	26	14	14	14	2	14	6
	C		25	25	20	8	40	
	G +F	26	22	22	20	2	10	7
	C		25	25	20	9	45	
268.531	G	26	18	17	17	11	65	16
	G +F	25	20	16	16	7	44	16
	No cuttings from cutting ramets available							
850.101	G	26	21	21	20	8	40	17
	G +F	26	16	14	14	8	57	11
	No cuttings from cutting ramets available							

* Scions from mixed identity ramets

Note: Both scions and ringbarked cuttings originated from the same ramets, established as cuttings in the Long Mile area

G = nursery grafts

+F = additional fertilisers

C = hedged cutting ramets

TABLE 3–Series "875" clones: Grafting, cutting pretreatment by topping and ringbarking, percentage rooting success, and numbers of graft stubs produced

Clone	Donor plants	No. of growing scions out of 26 grafted	Shoots topped and ring-barked	Ringbarked cuttings collected	Cuttings set	Cuttings rooted (No.)	(%)	Usable graft stubs
875.054	G	26	21	21	20	4	20	20
	G +F	26	22	22	20	5	25	21
	C						80*	
875.072	G	26	20	20	20	6	30	17
	G +F	26	20	20	20	9	45	20
	C						75*	
875.075	G	26	25	25	20	16	80	24
	G +F	26	23	22	20	12	60	23
	C						85*	
875.098	G	26	21	21	20	9	45	20
	G +F	26	21	20	20	9	45	18
	C						75*	
875.099	G	26	18	17	17	9	53	17
	G +F	26	22	21	20	13	65	21
	C						80*	
875.206	G	25	21	21	20	12	60	12
	G +F	26	16	12	12	6	50	12
	C						60*	
875.218	G	26	24	20	20	9	45	23
	G +F	26	24	20	20	11	55	21
	C						80*	
875.220	G	26	21	21	20	10	50	15
	G +F	26	22	22	20	12	60	15
	C						30*	
875.250	G	22	20	20	20	6	30	19
	G +F	25	21	21	20	8	40	18
	C						50*	
875.251	G	26	24	24	20	8	40	21
	G +F	25	19	19	19	6	32	15
	C						70*	
875.276	G	26	23	23	20	9	45	23
	G +F	25	25	25	20	8	40	22
	C						90*	
875.289	G	26	24	24	20	10	50	22
	G +F	26	24	24	20	13	65	18
	C						95*	

* Average rooting percentage over 5 years based on the use of healthy cutting material from cutting ramets
Note: Scions (buds) collected from 9-year-old cutting ramets in Kaingaroa Seed Orchard
G = nursery grafts
+F = additional fertilisers
C = hedged cutting ramets

Over-all, the rooting percentage of cuttings from 9-month-old grafts of the "268" series was about half that of cuttings taken from well-maintained and "clonally pruned" cutting hedges (Table 4). In the "875" series clones the strike rate of cuttings from grafts was approximately two-thirds that of cuttings from hedged cutting ramets.

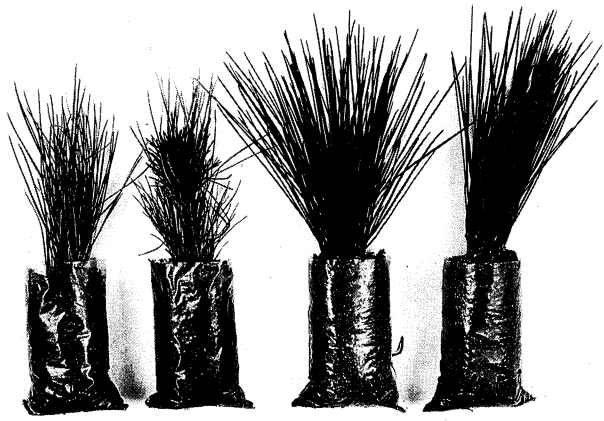

FIG. 3–Rooted cuttings (left) originating from grafts, and (right) cuttings of the same clone from cutting ramets.

TABLE 4–Percentage rooting success of cuttings from grafts and cuttings from cuttings

Clone series	Cuttings from grafts	Cuttings from grafts with fertiliser	Cuttings from cuttings
268	36.7	36.9	73.2
875	45.7	48.5	72.5*

* Average rooting percentage over 5 years, based on the use of healthy cutting material from cutting ramets

Graft Stubs

Graft stubs become available a year before there is certainty that the cuttings will produce plants. It is therefore prudent to establish these stubs as temporary ramets should they be required to produce cutting material according to the traditional method, as would be necessary for Clone 268.062 in this study. They could also be used in areas where the risk of incompatibility is known to be low. Graft stubs treated with standard plant-handling care survived well and grew vigorously (Table 5).

TABLE 5–Survival of planted graft stubs

Clone series	No. planted July 1989	No. growing vigorously January 1990
268	50	49
875	50	50

Other Pines

The results of limited work on the propagation of physiologically mature cutting material of other pine species, viz *P. pinaster* Ait., *P. taeda* L., *P. elliottii* Engelm., *P. patula* Schl.

et Cham., *P. contorta* Loudon, and *P. muricata* D. Don (T. Faulds unpubl. data), encourage us to postulate that the method described for mature *P. radiata* may well be applicable to other pine species troubled by graft incompatibility.

CONCLUSIONS AND RECOMMENDATIONS

By using 9-month-old nursery grafts as donor plants, rooted cuttings of *P. radiata* can be available for planting at 2 years after field ortet selection and grafting, in contrast to the 4-year period required by the traditional method where field-planted grafts supply the initial cutting material.

In order to obtain a sufficient number of rooted cuttings, three to four times as many medium- to large-sized buds as the number of rooted cuttings required should be grafted. Further work is required to clarify the need for or the possible benefits to be obtained from late-season fertiliser applications to the grafts.

For reasons of long-term incompatibility, it is not advisable to plant the graft stubs in repropagation areas or permanent orchards unless the areas in question have been shown to have a low incidence of graft incompatibility. They should be planted on a temporary basis to ensure that for the few clones which do not produce rooted cuttings from nursery grafts a source of traditionally produced cutting material is available.

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