REALISED GENETIC GAIN IN *PINUS RADIATA* FROM "850" SEED-ORCHARD SEEDLOTS GROWN COMMERCIALLY IN THE CENTRAL NORTH ISLAND, NEW ZEALAND. PART 2: STEM QUALITY

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ABSTRACT

Realised genetic gain in diameter, multinodality, stem straightness, malformation occurrence, and stem cone whorl incidence was assessed using field plots in 20-year-old stands planted with Kaingaroa bulk, Kaingaroa climbing-select, and "850" seed-orchard seedlots. The "850" seed-orchard seedlot stands had a significantly greater $\bar{d}$ than Kaingaroa bulk, resulting in 4.2% gain in $\bar{d}$; however, there was no difference in $\bar{d}$ between "850" seed-orchard material and Kaingaroa climbing-select. For tree mean internode length (MIL), incidence of malformation, and degree of stem sinuosity, "850" seed-orchard seedlots showed no significant improvement over Kaingaroa climbing-select or Kaingaroa bulk. The incidence of stem cones was significantly lower for "850" seed-orchard material than for the other two seedlots. The results of this study may partly differ from those of large-plot genetic gain and progeny trials for several reasons. Firstly, the first 8 to 10 years of seed production from the "850" seed orchards contained seed of poorer quality than later seed production. Secondly, superior "850" seed-orchard seedlots may have been better than those planted in commercial stands.

Keywords: "850" seed orchard; genetic gain; Kaingaroa bulk seed; mean internode length; stem sinuosity; malformation; stem cones; *Pinus radiata*.

INTRODUCTION

Review of Studies of Stem Quality Performance of "850" Seed-Orchard Material

The ultimate success of a seed orchard is rated on the performance of seed collected from it. Large-plot genetic gain trials (Shelbourne *et al.* 1986; Sorensson & Shelbourne in prep.) are used to quantify realised gains (the difference in a measured characteristic between the average of the improved progenies and the unimproved seedlot, expressed as a percentage of the unimproved seedlot mean) in genetically improved material over non-seed-orchard or unimproved seed, and progeny trials (Shelbourne 1970) rank material at different levels of improvement. As expected, the results of these trials indicate that "850" seed-orchard material has improved stem straightness, greater freedom from leader malformation, and less stem cone incidence on the lower stem than unimproved and non-seed-orchard *P. radiata* (Shelbourne 1970; Wilcox 1983; Shelbourne *et al.* 1986). The "850" seedlots also tend to have a higher branching frequency than non-seed-orchard *P. radiata* (Shelbourne 1970; Shelbourne *et al.* 1986; Sorensson & Shelbourne in prep.).

Sorensson & Shelbourne (in prep.) have detailed the realised genetic gains from long-term large-plot and row-plot genetic gain trials planted in 1978 (Table 1) in which an open-pollinated (OP) "850" seed-orchard seedlot from 21 clones selected in the central North Island (Gwavas) in 1976 was compared with Kaingaroa bulk unimproved material. The trees in these trials were silviculturally tended to produce a sawlog crop.

Branch cluster frequency gains

One of the criteria for "850" series selection was "light, multinodal branching" because this feature is associated with improved form, and is genetically correlated with good basal area growth (Carson & Inglis 1988; Burdon 1992). Branch cluster depth and branch cluster frequency influence *P. radiata*'s average internode length, and thus the availability of clear cuttings (Carson 1988). Branch cluster frequency in *P. radiata* is under strong genetic control with an estimated narrow sense heritability* of 0.45 (Bannister 1969; Burdon 1992). Site fertility and latitude also influence branch cluster frequency (Carson & Inglis 1988; Tombleson *et al.* 1990; Grace & Carson 1993), with higher branch cluster frequencies where site fertility is limiting (Carson & Inglis 1988; Burdon 1992), while at more southern latitudes *P. radiata* tends to have longer internode lengths. The influence of stocking on internode length is not significant on forest sites (Siemon *et al.* 1976; Beets & Madgwick 1988; Tombleson *et al.* 1990; Grace & Carson 1993).

There is an increase in the number of branch clusters in "850" seed-orchard material compared with non-seed-orchard material. Shelbourne *et al.* (1986) measured a 20% increase in branch cluster frequency score (where 1 = extremely uninodal, 9 = extremely multinodal—Carson 1991) of seed-orchard material over bulk unimproved material in progeny trials at age 5. An age 12 assessment of the 1978 genetic gain trials (Table 1) found a 26% gain in branch cluster frequency score for "850" seed-orchard *P. radiata* grown in Kaingaroa Forest (Sorensson & Shelbourne in prep.) over felling select.

The difference in internode lengths between improved and unimproved seedlots resulting from gains in branch cluster frequency influences the percentage outturn of different timber grades (Carson 1988). This influence of internode length on the profitability of *P. radiata* and the lack of influence of stocking on internode length suggest that the *P. radiata* breeding programme has had, and will have, an extremely important role in selecting for different levels of internode length in *P. radiata.*

Stem straightness (sinuosity) gains

A decrease in the incidence of stem sinuosity in a stand will increase the utilisable volume (Cown *et al.* 1984). Stem straightness is affected by site fertility, with high fertility sites having a greater occurrence of stem sinuosity (Will & Hodgkiss 1977; Birk 1990; Birk *et al.*

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* Narrow sense heritability expresses the extent to which phenotypes are determined by the genes transmitted from the parents (Falconer 1989).

1993). Stem straightness is moderately heritable (Bail & Pederick 1989; Burdon 1992). Open-pollinated progeny tests in 1955 and 1968 comparing commercial "850" seed-orchard seedlots with a bulk unimproved seedlot found an 18% gain in bole straightness score (Shelbourne *et al.* 1986). An age 5 assessment of the 1978 large-plot genetic gain trial in which an open-pollinated commercial "850" seedlot was compared with a bulk unimproved seedlot indicated a 19% gain in stem straightness (Shelbourne *et al.* 1986). The same trial provided similar results at age 12 (Table 1) (Sorensson & Shelbourne in prep.).

TABLE 1–National average percentage genetic gain at age 12 for stem quality characteristics selected for improvement in "850" seed-orchard material, compared with a Kaingaroa bulk seedlot. Gains are given for the national average of the 1978 genetic gain large-plot trial series on a sawlog regime (from Sorensson & Shelbourne in prep.).

Characteristic	Genetic gain (%)
Branch frequency	25.5
Stem straightness	19.0
Malformation	8.0

Leader malformation gains

The considerable reduction in leader malformation from the use of "850" seed-orchard material has been expected to result in large gains in merchantable volume from *P. radiata* (Cleland 1986). Shelbourne *et al.* (1986) found a 6% improvement in malformation score for "850" seed-orchard material over bulk collections. An age 12 assessment of the 1978 genetic gain trial (Sorensson & Shelbourne in prep.) indicated an 8% gain in malformation score (Table 1).

Stem cone incidence gains

Stem cones create serious defects in sawn timber and hence are an undesirable characteristic. The number of stem cones on a tree is moderately heritable (Bannister 1959; Shelbourne 1970). In a sample of 100, 14-year-old trees, the number of stem cones varied from 0 to 110 per tree (Bannister 1959). Stem cones are rarely found in the first log (0.3 to 5.8 m) as *P. radiata* does not begin flowering until age 5 or later in most climates. Cleland (1986) in a study of a commercial stand found no significant difference in the incidence of stem cones in the second log (5.8 to 11.3 m) in seed-orchard and non-seed-orchard material.

Summary

The results of progeny trials (Shelbourne 1970; Shelbourne *et al.* 1986) and genetic gain trials (Shelbourne *et al.* 1986; Sorensson & Shelbourne in prep.) have indicated quantitative and qualitative gains in "850" seed-orchard material over non-seed-orchard seedlots. "850" seed-orchard material provided increases as predicted in branching frequency, improved stem straightness, freedom from malformation, and less occurrence of stem cones in the lower stem.

Current Study

This study was set up to complement these genetic gain and silvicultural trials by identifying realised genetic gain in the commercial planting of "850" seed-orchard seedlots in the central North Island. The aim was to quantify realised genetic gain in multinodality, stem straightness, the occurrence of leader malformation, and stem cone cluster incidence. Data gathered from field measurements of 20-year-old stands were used to determine differences in diameter, internode length, degree of stem sinuosity, incidence of stem cone clusters, and occurrence of leader malformations among three levels of genetic improvement.

METHODS

Data Collection

Plot data were collected from 96 plots, in 12 20-year-old stands (eight plots per stand), at locations in the central North Island, forming four blocks. The four blocks each contained three stands in close proximity—one each of:

- Kaingaroa bulk seedlot;
- Kaingaroa climbing-select seedlot;
- Kaingaroa "850" seed-orchard seedlot.

Site and regime details, derived from SRS data used in Part 1 (Turner 1997), are given in Appendix 1 for each of the stands. The size of the sample set was chosen on the basis of time available and on what was considered to be appropriate for the desired precision in measurement of internode lengths (M.Kimberley pers. comm.). Stands for measurement were selected on the basis of proximity and similarity in management practices. All stands except one (with a stocking of 356 stems/ha) had undergone a production thinning to approximately 250 stems/ha.

Plots were located using the "structured walk" method (Maclaren & Goulding 1993) as this ensured an adequate coverage of the whole stand without biasing results. The "structured walk" method involves locating plots on a stand map in the office by measuring a set distance between plots on a preplanned course which provides adequate coverage of a stand and returns to the starting point.This approach avoids the difficulties of locating random plots in a stand and saves walking time. The plots were circular with a plot area of 0.05 ha to achieve a 12-tree sample.

The trees were measured for the following characteristics:

- height (m) to the base of each branch cluster up to the first cluster at or above 12.0 m in the branched section of the stem
- pruned height (m)
- stem straightness (five sweep classes)
- stem cone clusters (height of occurrence)
- malformations (type and height of occurrence);
    - (i) ramicorns
    - (ii) forks
    - (iii) kinks
    - (iv) wobble
- diameter at breast height (cm).

The pruned height measured was the height to the first branch cluster. Sweep was measured over a 6.0-m log length using a height pole at right angles to the plane of maximum sweep. The five sweep classes were:

0 = no sweep
1 = < diameter / 8
2 = < diameter / 4
3 = < diameter / 2
4 = > diameter / 2.

Analysis

Differences between seedlots for all characteristics measured were tested using a randomised complete block analysis of variance (ANOVA). Means and associated standard errors for each characteristic by seedlot were also calculated and tested for significant differences between them using the LSD multiple comparison procedure.

Diameter

The stand average tree diameter ($\bar{d}$) data for each seedlot were analysed to enable validation of the findings of Part 1 (Turner 1997) of this study.

Internode length

In this study a direct measure of internode length was not used. To calculate internode length a 0.2-m branch cluster depth was subtracted from the measured internode length. This was used for all seedlots in all study locations. Studies of the variation in branch cluster depth between sites and seedlots (Inglis & Cleland 1982; Carson & Inglis 1988; Tombleson *et al.* 1990; Grace & Carson 1993) indicated that branch cluster depth in this study should not vary within the degree of accuracy of measurement used.

Mean internode length* (MIL) for stem height 6.0 to 12.0 m was calculated for a log cut at the first branch cluster above 6.0 m and the last measured branch cluster (Fig. 1). MIL was calculated from 6.0 m to allow comparison of trees pruned to different heights. From the tree statistics the stand MIL was calculated.

The internode length data were also used to study the internode length habit over the section of stem measured. This was done by plotting seedlot average internode length calculated for each 1-m height zone against height from 0 to 11 m (Grace & Carson 1993). This plot gives an indication of how the distribution of internode lengths up the stem differs between seedlots.

Stem straightness (sinuosity)

The sweep class data for each seedlot were analysed in terms of the frequency distribution of sweep classes. The frequency distribution gives an indication of how stem straightness varies within seedlots.

Malformation

The malformation data from each stand were analysed by calculating the percentage occurrence of each malformation for the seedlots by block. Malformation was measured as the total number of malformations in a stand, so trees with two malformations were counted

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$$* \text{ Mean internode length} = \frac{\sum \text{length (m) of internodes in branched section of log}}{\text{number of internode lengths in branched section of log}}$$

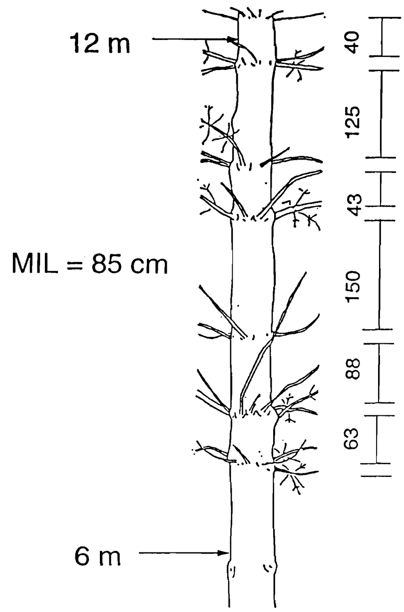

FIG. 1–The position of theoretical cuts used in the calculation of tree MIL over 6.0 to 12.0 m.

twice. An indication of the likelihood of malformation occurrence enables an estimation of the possible gains in harvestable volume resulting from less waste material due to malformation.

Stem cone clusters

The stem cone data for each seedlot were analysed in terms of the percentage occurrence of stem cone whorls. Stem cone cluster incidence was measured as the number of trees with stem cone clusters. As "850" seed-orchard material was selected for a low occurrence of stem cones on the lower stem (Shelbourne *et al.* 1986), the distribution of stem cones up the stem was plotted for each seedlot.

RESULTS AND DISCUSSION

Diameter

The results of the ANOVA showed a significant (p=0.01) difference in $\bar{d}$ among seedlots and blocks, with the rankings of the seedlots in each of the blocks being the same. Both Kaingaroa climbing-select and "850" seed-orchard seedlots had significantly (p=0.01) different $\bar{d}$ from Kaingaroa bulk (Table 2). The estimates of realised genetic gain for

TABLE 2–The adjusted stand average tree diameter ($\bar{d}$), associated standard error of the mean, and realised genetic gain over Kaingaroa bulk for each seedlot at age 20.

Seedlot	GF	Adjusted $\bar{d}$ (cm)	Standard error	Genetic gain (%)	95% confidence intervals		
Kaingaroa climbing-select	7	38.3	0.356	7.3	9.9	4.7	a
"850" seed-orchard	13–14	37.2	0.348	4.2	6.8	1.6	a
Kaingaroa bulk	1–3	35.7	0.345	–	–	–	b

Kaingaroa climbing-select and "850" seed-orchard material over Kaingaroa bulk were larger than those estimated in Part 1 (Turner 1997) of this study, being 4.9% and 2.6% respectively.

Internode Length

The results of the ANOVA showed a significant (p=0.01) difference in MIL among seedlots and blocks, with the rankings of the seedlots in each of the blocks being the same. All three seedlots had significantly different MIL (Table 3), with Kaingaroa bulk material having the shortest internodes and Kaingaroa climbing-select the longest.

TABLE 3–Adjusted mean internode length (MIL) (6.0 to 12.0 m) and associated standard error of the mean for each seedlot.

Seedlot	Adjusted MIL (m)	Standard error (m)	
Kaingaroa bulk	0.48	0.010	a
"850" seed-orchard	0.51	0.010	b
Kaingaroa climbing-select	0.54	0.010	c

Internode length v. *stem height*

The comparison of average internode length along the stem and MIL among the seedlots was influenced by differences in pruned height for the three seedlots. (Fig. 2). The inclusion of a stand of Kaingaroa climbing-select material which had not received its final thinning was apparent in the higher frequency of medium-pruned (pruned height approximately 4.0 m) trees of this seedlot group, compared with the Kaingaroa bulk and "850" seed-orchard seedlot groups. These differences in pruned height frequency distribution among the seedlot groups provided an indication of the precision with which mean internode length was estimated for each 1-m zone for each seedlot.

All three seedlot groups had similar distributions of internode length along the stem (Fig. 3), with Kaingaroa bulk having shorter internode lengths than Kaingaroa climbing-select and the "850" seed-orchard seedlot. The longest internode length for Kaingaroa bulk also occurred slightly higher than for Kaingaroa climbing-select, and "850" seed-orchard seedlot had shorter internode lengths in the lower stem but a longer maximum internode length. No statistical tests of significance were performed on these data, therefore these differences may not be significantly different.

Stem Straightness (Sinuosity)

"850" seed-orchard material and Kaingaroa bulk material had similar sweep class distributions (Fig. 4). Kaingaroa climbing-select material had a greater occurrence of trees with sweep in classes three and four, suggesting that trees from Kaingaroa climbing-select are more likely to have poor stem straightness in the 0- to 6-m section of the stem (Table 4) than those from "850" seed-orchard and Kaingaroa bulk seedlots.

The ANOVA supported this evidence with significant differences in stem straightness for the first log (0 to 6 m) among seedlot groups (p=0.01) and blocks (p=0.05), and a significant seedlot × block interaction (p=0.01). The higher mean stem sinuosity for Kaingaroa

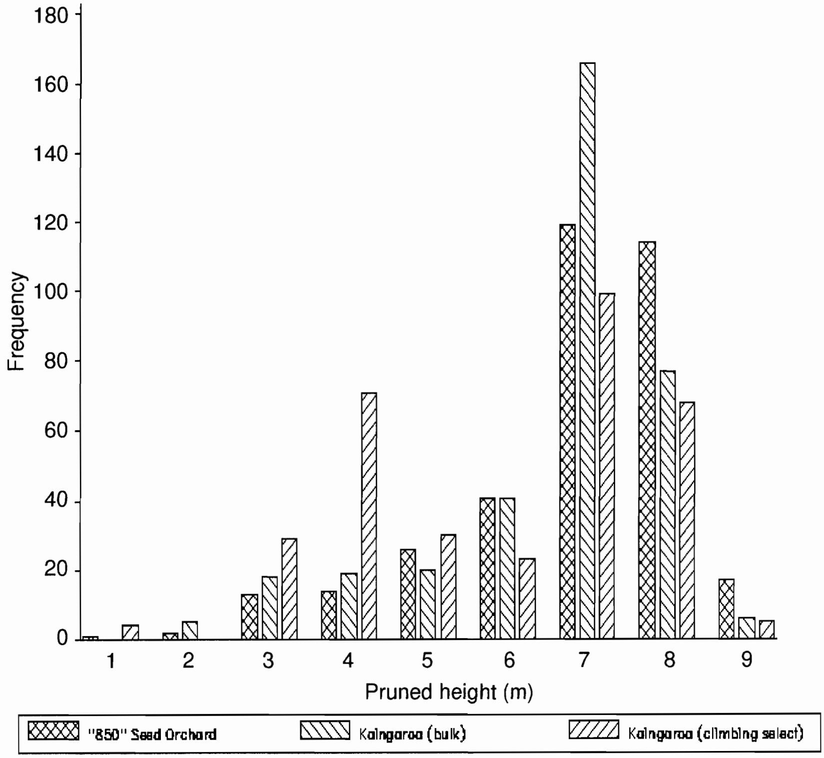

FIG. 2–Frequency plot of pruned heights (m) by seedlot group.

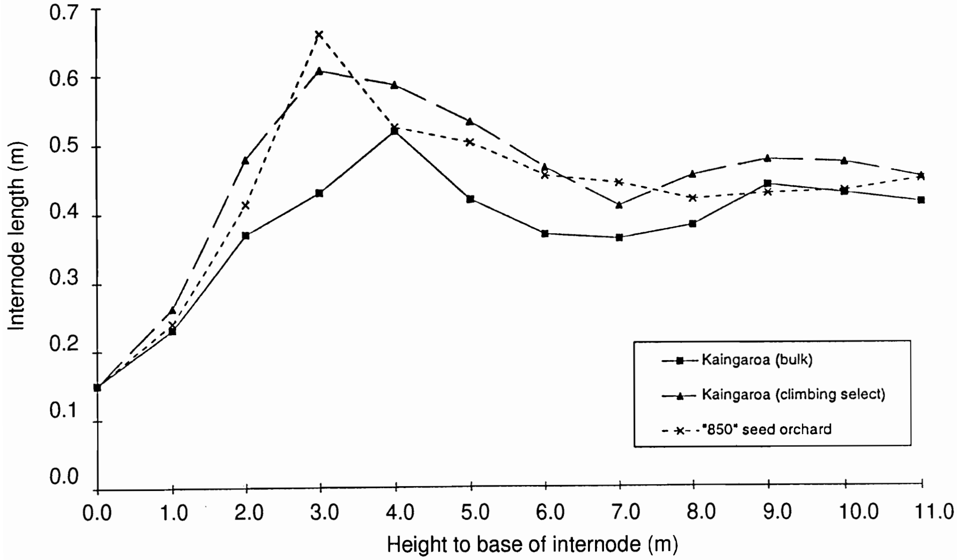

FIG. 3–Average internode length (m) occurring in 1-m height classes against height to the base of internode for "850" seed-orchard seedlot, Kaingaroa climbing-select, and Kaingaroa bulk material.

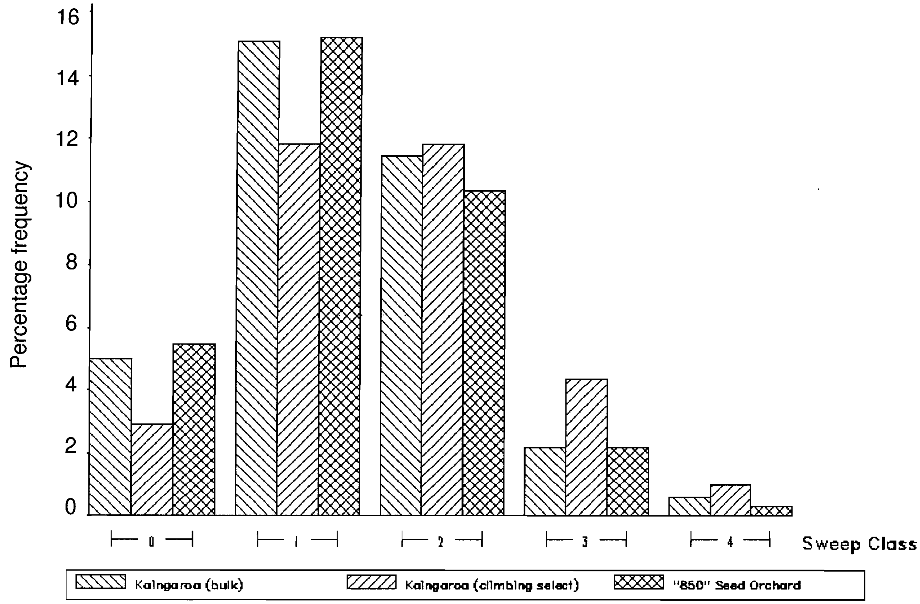

FIG. 4—Sweep class frequency distribution for bulk, climbing-select, and seed-orchard seedlot data. 0 = no sweep, to 4 = >50% sweep.

climbing-select was largely attributable to its higher level of sweep in Block 1 than the Kaingaroa bulk and "850" seed-orchard material (Table 5). For the other three blocks, the three seedlot groups had similar levels of stem sinuosity. The high variability in stem straightness between seedlots in Block 1 may be attributed to a pattern of wind disturbance which resulted in toppling and hence increased stem sinuosity in the compartment containing Kaingaroa climbing-select material (Mason 1985). Kaingaroa bulk and "850" seed-orchard material in Block 1 were planted in another compartment.

TABLE 4—Adjusted means and associated standard error of the mean for each seedlot group, calculated for stem straightness.

Seedlot	Adjusted mean sweep class	Standard error	
"850" seed orchard	2.31	0.047	a
Kaingaroa (bulk)	2.38	0.046	a
Kaingaroa (climbing select)	2.63	0.048	b

TABLE 5—Unadjusted mean sweep for seedlot group by block.

Seedlot	Block			
	1	2	3	4
Kaingaroa climbing-select	3.0	2.6	2.4	2.5
Kaingaroa bulk	2.1	2.6	2.5	2.3
"850" seed-orchard	2.0	2.5	2.4	2.4

Malformation

The results of the ANOVA indicated that for each of the individual types of malformation measured and for the total incidence of malformation there was no significant difference between the seedlots or blocks (p=0.05). Ranking of the seedlots for malformation incidence (Tables 6 and 7) showed that "850" seed-orchard material had a lower percentage occurrence of forking than Kaingaroa bulk and Kaingaroa climbing-select, ramicorn occurrence similar to that of bulk, and a higher occurrence of kinks than the other seedlots. The low occurrence of ramicorns for Kaingaroa bulk was unexpected, particularly considering the high occurrence of forking in this seedlot. Kaingaroa climbing-select had the highest occurrence of malformation.

TABLE 6—Mean percentage occurrence of different malformation types, by seedlot group.

Seedlot	Mean malformation (%)			
	Ramicorns	Forking	Kinks	Stem wobble
"850" seed-orchard	7.6	6.3	2.6	1.8
Kaingaroa climbing-select	13.9	10.3	1.5	1.7
Kaingaroa bulk	9.2	11.5	1.2	1.2

TABLE 7—Mean percentage occurrence of malformation and associated mean standard error, by seedlot group.

Seedlot	Mean malformation (%)	Standard error (%)	
Kaingaroa climbing-select	27.4	4.14	a
Kaingaroa bulk	23.1	4.14	a
"850" seed-orchard	18.3	4.14	a

The lack of a clear breeding effect on malformation occurrence in material measured in this study could be due to malformations arising from many different causes (Bannister 1980) such as storm damage, insect attack, fungal disease, drought, frost, and nutritional disorders. These factors operate independently of genetic disposition, making the identification of the genetic factor as an influence on malformation occurrence difficult. A lack of statistical difference (p=0.05) between seedlots, despite a 30% difference in percentage occurrence of malformations between Kaingaroa climbing-select and "850" seed-orchard material (Table 7) also suggests the sample size chosen was too small to accurately identify genetic differences in malformation occurrence.

Differences in incidence of malformation and degree of stem sinuosity among the seedlots and blocks will be influenced by the selection intensity of thinning; however, there were no large differences in the selection intensity for the stands measured (Table 8).

Stem Cone Clusters

The results of the ANOVA indicated that there was a significant difference in percentage occurrence of stem cones between seedlots (p=0.01) and blocks (p=0.05). The difference in stem cone occurrence between blocks appeared to relate to altitude and therefore to

TABLE 8–Percentage selection intensity for stands measured for stem straightness, malformation, stem cones, and internode length.

Seedlot	Block			
	1	2	3	4
"850" seed-orchard	15	15	10	20
Kaingaroa climbing-select	15	15	21	15
Kaingaroa bulk	14	17	15	15

temperature, with a higher stem cone occurrence at lower altitudes. The comparison of means (Table 9) showed that "850" seed-orchard material had a significantly lower occurrence of stem cones than Kaingaroa bulk and Kaingaroa climbing-select material. The plot of stem cone occurrence with stem height (Fig. 5) indicated that in "850" seed-orchard material most stem cone clusters were higher on the stem than in Kaingaroa bulk and Kaingaroa climbing-select seedlots.

TABLE 9–Means and associated mean standard error for each seedlots' percentage occurrence of stem cones.

Seedlot	Mean stem cone occurrence (%)	Standard error (%)	
Kaingaroa bulk	27.9	2.96	a
Kaingaroa climbing-select	23.4	2.96	a
"850" seed-orchard	13.1	2.96	b

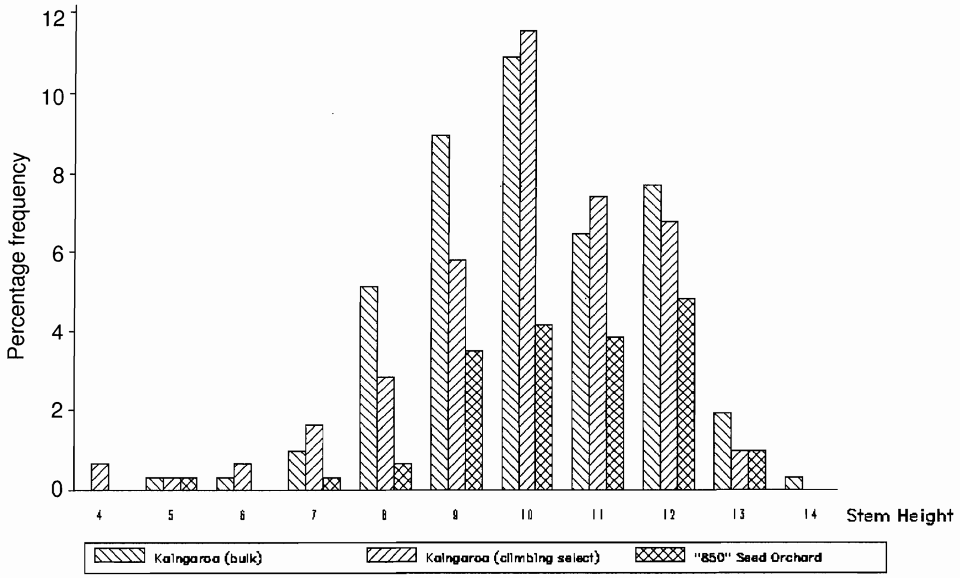

FIG. 5–Stem cone cluster occurrence (%) occurring in 1-m height classes against stem height for bulk, climbing-select, and "850" seed-orchard seedlots.

These results indicate that selection for fewer stem cones on the lower stem resulted in a reduction in stem cone incidence over the whole stem measured. The lower percentage occurrence of stem cones below 6 m was, however, due partly to a large number of trees in the sample being high pruned (Fig. 2).

CONCLUSIONS

This study focused on the realised genetic gain of *P. radiata* grown in a central North Island commercial forest and should, therefore, be viewed as a survey only of the "850" seed-orchard resource, in this region. This study of the stem quality performance of "850" seed-orchard material has led to results which differ from those based on the analysis of large-plot genetic gain and progeny trials. For stand mean tree diameter ($\bar{d}$) at age 20, "850" seed-orchard seedlots showed a significant 4.2% gain in $\bar{d}$ over Kaingaroa bulk. There remained, however, no significant difference from Kaingaroa climbing-select. For degree of multinodality, degree of stem sinuosity, and incidence of malformation, "850" seed-orchard material showed no significant improvement over Kaingaroa climbing-select or Kaingaroa bulk. These results relating to levels of malformation and sweep must be treated with some caution because of the strong influence of factors other than genotype on these characteristics.

In the first 8 to 10 years of open-pollinated seed-orchard seed production there was a high incidence of pollen contamination from *P. radiata* stands outside the seed orchard (M.J.Carson pers. comm.). The first "850" series seed orchard was planted in Kaingaroa Forest in 1957 and began producing seed in 1968 (Shelbourne *et al.* 1986). The "850" seed-orchard seedlots planted into the stands in this study were from seed collections made in 1970 to 1978. These "850" seed-orchard seedlots would have contained seed fertilised by pollen from outside the seed orchard. The same situation applies to seed from the Gwavas seed orchard planted in 1958. For this reason, results of this study are likely to provide lower estimates of genetic gain than for "850" seed-orchard material planted after 1978.

A further explanation for the disparity in results between this study and genetic gain trials is that the "850" seed-orchard seedlots used in genetic gain and progeny trials differ from those used in commercial plantings. Use of superior seed from "850" seed orchards in genetic gain trials would result in gains greater than those found in commercial plantings of "850" seed-orchard material which has been open-pollinated and has contamination from inferior and "wild" pollen.

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APPENDIX I

BLOCK DETAILS

Block 1: Matea

Seedlot	Bulk (R72/927)	Climbing-select (R69/856)	"850" seed-orchard (R73/A1)
Date planted	1975	1972	1974
Initial stocking (stems/ha)	1667	1667	1667
MTH @ 13 yr (m)	16.7	18.1	18.6
BA @ 13 yr (m^2/ha)	25.9	29.1	23.3
Final thin. age (yr)*	16.5	16.5	16.5
Final thin. stems	233	250	250
Final prune age (yr)†	10	10	10
Final prune stems	263	268	275
Final prune ht (m)	5.8	5.8	5.8
Site Index	25.3	26.2	25.3
Altitude (m)	720	700	720
Aspect	NW	NW	NW

Block 2: Central Kaingaroa

Seedlot	Bulk (R72/927)	Climbing-select (R71/902)	"850" seed-orchard (R73/A1)
Date planted	1975	1974	1974
Initial stocking (stems/ha)	1454	1666	1667
MTH @ 13 yr (m)	17.6	20.1	18.2
BA @ 13 yr (m^2/ha)	25.0	27.7	22.1
Final thin. age (yr)	17.5	18.5	18.5
Final thin. stems	250	251	250
Final prune age (yr)	10	10	9.5
Final prune stems	225	250	243
Final prune ht (m)	5.8	5.8	5.8
Site Index	27.3	27.3	27.1
Altitude (m)	580	580	600
Aspect	NW	N	SE

Block 3: Waipaaka

Seedlot	Bulk (R72/927)	Climbing-select (R71/902)	"850" seed-orchard (WN71/A2)
Date planted	1975	1973	1975
Initial stocking (stems/ha)	1666	1666	2500
MTH @ 13 yr (m)	21.4	19.0	21.2
BA @ 13 yr (m^2/ha)	30.8	24.2	31.8
Final thin. age (yr)	17.0	9	16.5
Final thin. stems	250	356‡	250
Final prune age (yr)	9	10	8.5
Final prune stems	224	315	322
Final prune ht (m)	5.8	5.8	5.8
Site Index	31.7	31.5	30.7
Altitude (m)	420	500	380
Aspect	N	SE	SE

Block 4: Northern Boundary

Seedlot	Bulk (R72/927)	Climbing-select (R73/954)	"850" seed-orchard (WN74/A2)
Date planted	1975	1975	1976
Initial stocking (stems/ha)	1667	1666	1250
MTH @ 13 yr (m)	20.2	21.3	22.6
BA @ 13 yr (m^2/ha)	32.3	23.4	28.9
Final thin. age (yr)	17.5	19.5	18.5
Final thin. stems	250	250	250
Final prune age (yr)	9	7.5	8.5
Final prune stems	307	371	273
Final prune ht (m)	5.8	4	5.8
Site Index	29.8	31.7	31.7
Altitude (m)	500	460	440
Aspect	SW	NE	NE

* Thinning details are derived from a post-thinning inventory

† Pruning details are derived from the age-13 pre-thinning inventory

‡ At the time of measurement this stand had not yet received a final thinning