EFFECT OF PRECISION SOWING ON GRADE OUTPUT OF 1/0 *PINUS RADIATA* SEEDLINGS —EDENDALE NURSERY

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ABSTRACT

In evaluating seedlings grown at uniform spacings in the nursery, height:diameter ratio or height alone gave no indication of the ability of a seedling to grow away rapidly after planting, but root collar diameter was a useful indicator.

Investigations of root growth potential patterns showed that, with increasing diameter classes, irrespective of initial spacing, root growth potential increased.

If grading of 1/0 radiata pine tree stocks from Edendale Nursery is necessary it would be best to base it on root collar diameter (trees with smaller diameters (<5mm) going to the more benign sites and trees of larger diameter size (6mm<) going to the harsher planting sites) in the first instance and ideally on ODW of shoots and roots if possible.

INTRODUCTION

An earlier report (Balneaves, 1983), outlined the effects on growth after planting of raising 1/0 radiata pine planting stock at Edendale Nursery at three in-drill spacings.

This paper discusses the use of three grading methods to assess seedlings from this trial and their effect on subsequent field performance following planting out. The three grading methods were: (1) shoot length:root collar diameter ratio (2) shoot length only, and (3) root collar diameter only.

The first method of grading as a measure of seedling quality or sturdiness has been used for several years (Chavasse, 1980, 1981). The significance of grading by shoot length alone in an effort to achieve uniformity of a tree crop was discussed by Chavasse and Weston (1969), Chavasse (1977, 1981), and Trewin (1981). The third method was first discussed by Prior (1969), Wilkinson (1969), Chavasse and Weston (1969) and again by Anstey (1971).

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METHOD

Seed was hand-sown at 4, 6, and 8 cm spacing in drills 15 cm apart and details on the raising of the tree stocks has been discussed previously (Balneaves, 1983).

At lifting, 1000 seedlings per spacing were graded by the three criteria mentioned above.

Evaluation of seedlings from within each grade was carried out first by determining oven dry weights (ODW) of plant roots and shoots, by root growth studies, and finally by growth at 12 months after planting in the field. Numbers of seedlings to determine initial ODW and initial root growth involved 15 seedlings/grade/spacing. Field growth and final ODW was based on a sample of 75 seedlings/grade/spacings planted out in a randomised block. Field growth measurements involved survival, height and root collar diameter measurements.

Analysis of data was confined to chi-square test, Student's *t*-test, analysis of variance, and Duncan's multiple range test at the 0.05 probability level. Correlations were also done for all the initial variables and the final change in height, diameter, and bulk index ($D^2 \times H$) (see Appendix 1).

RESULTS

1. *Shoot Length:Root Collar Diameter Ratio*

The percentage of seedlings that came within each grade are given in Table 1.

TABLE 1: PERCENT SEEDLINGS/GRADE BY SEEDLING SPACING

Spacing (*cm*)	*Grades*		
	<45	*46-60*	*61-80*
4	8a*	64ab	28a
6	21b	68a	11b
8	42c	56b	2c

*Using a chi-square test. Treatments sharing a common letter are not significantly different (0.05 level) [Vertical direction].

With increased seedling spacing, there is a marked decrease in the percentage of seedlings in the lowest grade (61-80) and a marked increase in the percentage in the highest grade (< 45).

A summary of the results of the various growth parameters measured is given in Table 2.

Differences between grade performance within spacing treatments are not very marked. Further investigation of the data

TABLE 2: GROWTH PARAMETERS IN RELATION TO HEIGHT:DIAMETER RATIO AND SEEDLING SPACING

Spacing (cm)	Height Diam. Ratio	Initial ODW (g) Root	Initial ODW (g) Shoot	New Root Growth Mean No./ Plant	New Root Growth Total Length/ Plant (mm)	Field Growth (Final-Initial) Height (cm)	Field Growth (Final-Initial) Diam. (mm)	Field Growth (Final-Initial) Bulk Index (cm^3)	Final ODW (g) Root	Final ODW (g) Shoot
4	<45	0.7b	3.6a	11b	19b	50a	4a	57a	6bc	30a
	46-60	0.6a	3.2a	5a	16b	52b	5ab	56a	4a	25a
	61-80	0.6a	3.3a	5a	9a	50b	4a	49a	5ab	24a
6	<45	1.0b	5.5b	18c	38cd	36a	5b	61a	6bc	38b
	46-60	0.8a	4.5b	21c	30c	38a	6b	58a	5a	37b
	61-80	1.0b	5.2b	17c	48d	39a	6b	63a	4a	42b
8	<45	1.0b	5.3b	10b	50d	49b	7c	107c	9d	59c
	46-60	0.9ab	4.6b	12b	44d	50b	7c	89b	7c	51c

showed clearly that the initial height:diameter ratio is not correlated with change in growth—*e.g.*, bulk index (Appendix 1).

2. *Height Class*

Seedlings were graded into height classes to determine what effect this would have on early growth after planting. The distributions of seedlings within each class are given in Table 3.

TABLE 3: GRADING BY HEIGHT CLASSES (% SEEDLINGS/CLASS)

Spacing (*cm*)	*Height Class* (*cm*)			
	15-20	*21-25*	*26-30*	*31-35*
4	—	30	56	14
6	—	51	49	—
8	18	57	25	—

Fourteen percent of the seedlings raised at 4 cm spacing were greater than 30 cm in height at lifting (but were not used in the analysis) whereas there were no seedlings in this height class in the 6 and 8 cm sowings. Seedlings sown at 8 cm spacing tended to be much shorter and in fact 18% were less than 20 cm. Seedlings sown at 6 cm were intermediate and much more uniform in height.

Results of growth parameters assessed after lifting are given in Table 4 along with the statistical significance of these data within each spacing treatment.

Although there were differences between height classes within any given spacing treatment, the differences between spacings for any given height class were equally as great. A weak correlation existed between initial height class and the change in bulk index ($r = 0.1868$, $df = 336$, $p < 0.001$) but appears to be of little use as an indicator of growth potential (Appendix 1).

3. *Collar Diameter*

The distribution of seedlings within each diameter class is given in Table 5.

Again, spacing had a marked effect on the grade outturn. Previous work in Southland Conservancy (Wilkinson, 1969; Anstey, 1979), recommended that 1/0 radiata pine seedlings produced from Milton Nursery should have a root collar diameter of at least 4 mm. If this is true for stock from Edendale Nursery, then all seedlings sown at 8 cm spacing could be considered

TABLE 4: GROWTH PARAMETERS IN RELATION TO SEEDLING SPACING AND HEIGHT CLASS

Spacing (cm)	Height Class (cm)	Initial ODW (g)		New Root Growth		Field Growth			Final ODW (g)	
		Root	Shoot	Mean No./ Plant	Total Length/ Plant (mm)	Height (cm)	Diam. (mm)	Bulk Index (cm^3)	Root	Shoot
4	21-25	0.6a	3.0a	7a	19a	49a	4a	52b	4a	23a
	26-30	0.9b	4.3c	8a	13a	53a	6b	94d	6ab	33c
6	21-25	0.8ab	4.1a	12b	40c	33b	5ab	53b	5a	25b
	26-30	1.0b	5.4b	14b	33b	34b	6ab	65bc	5a	29b
8	15-20	0.8ab	4.3b	16b	31b	30bc	5ab	43a	6ab	25b
	21-25	0.9b	4.9b	14b	27b	44a	7c	93cd	6ab	29b
	26-30	1.2b	6.6d	12b	41c	34b	6ab	71c	8b	39c

TABLE 5: PERCENTAGE OF SEEDLINGS WITHIN ROOT COLLAR DIAMETER CLASSES

Spacing (cm)	*Root Collar Diameter (mm)* 3	4	5	6	7
4	23a*	39a	31a	7a	—
6	16b	23b	39b	22b	—
8	—	18b	43b	33c	6

*Using a chi-square test. Treatments sharing a common letter are not significantly different (0.05 level) [Vertical direction].

plantable whereas only 84% and 77% of the seedlings sown at 6 and 4 cm spacing, respectively, could be considered plantable.

Investigation of the root growth potential patterns shows that, with increasing diameter classes within individual spacings, root growth potential increases ($r = 0.238$, $df = 336$, $p = <0.001$). Differences between root growth potential for the one diameter class in each of the three seedling spacings are equally important. These data are given in Table 6.

TABLE 6: ROOT GROWTH POTENTIAL IN RELATION TO SEEDLING DIAMETER CLASSES AND SPACING

Diam. Class (mm)	*New Root Growth* — *Mean No./Plant* 4 cm	6 cm	8 cm	*Total Length/Plant* 4 cm	6 cm	8 cm
3	4a[1](a)[2]	10a(a)	—	7a(a)	15a(b)	—
4	8a(a)	13ab(a)	7a(a)	8a(a)	22a(b)	38a(c)
5	9a(a)	13ab(a)	13ab(a)	19b(a)	37b(b)	51a(c)
6	11b(a)	18b(a)	18b(a)	17b(a)	27ab(b)	36a(b)
7	—	—	17b	—	—	42a

[1]Using Duncan's M.R. test. Working down the column, those treatments sharing a common letter are not significantly different (0.05 level).
[2]Using Student's *t*-test and Duncan's M.R. test. Working across the columns, those treatments sharing a common letter are not significantly different (0.05 level).

The other growth factors evaluated are presented in Fig. 1. From this it can be seen that root collar diameter influences growth performance dramatically. The significance of these results is given in Table 7.

With increasing root collar diameter all factors evaluated have increased and furthermore differences between seedling spacing but within a root collar diameter class were marked. An increase in spacing within root collar diameter class resulted in greater performance after planting. The one exception to this

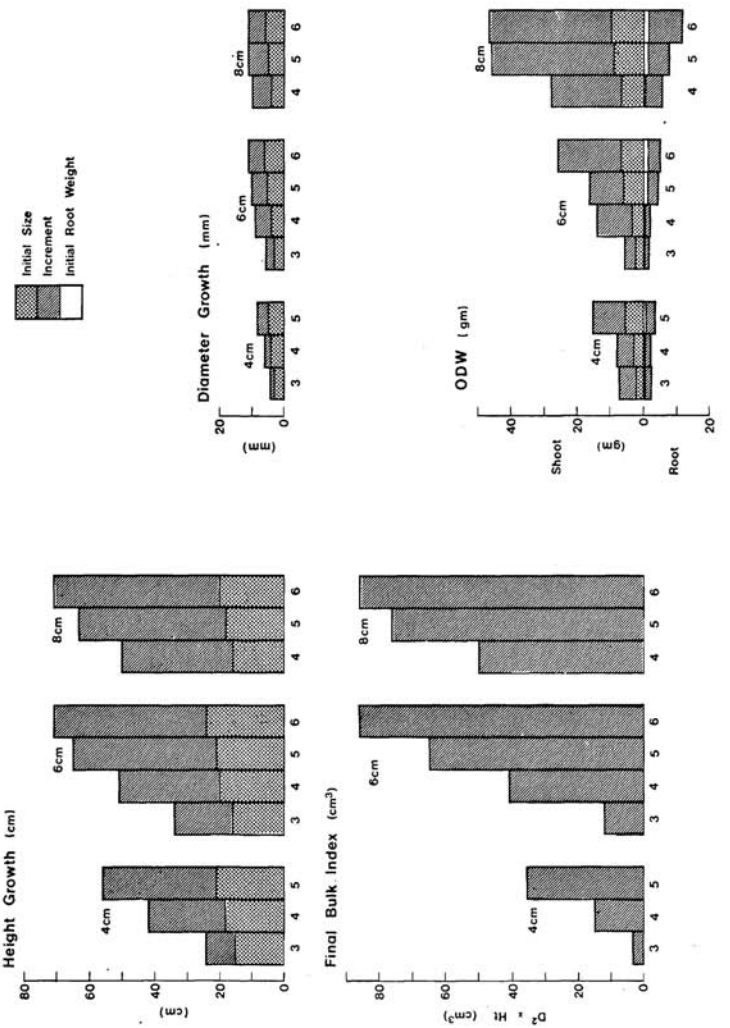

FIG. 1: *Growth of seedlings for 12 months after planting in relation to spacing and initial diameter class.*

TABLE 7: SIGNIFICANT DIFFERENCES (0.05 LEVEL) BETWEEN TREATMENTS USING DUNCAN'S M.R. TEST AND STUDENT'S *t*-TEST

Diam. Class	4 cm				6 cm				8 cm			
	H	*Diam.*	$D^2 \times H$	*ODW*	*H*	*Diam.*	$D^2 \times H$	*ODW*	*H*	*Diam.*	$D^2 \times H$	*ODW*
3	a(a)	a(a)	a(a)	a(a)	a(b)	a(a)	a(b)	a(a)				
4	b(a)	b(a)	b(a)	a(a)	b(b)	b(b)	b(b)	b(b)	a(b)	a(b)	a(c)	a(c)
5	c(a)	c(a)	c(a)	b(a)	c(b)	b(b)	c(b)	b(a)	b(b)	a(b)	b(c)	b(b)
6					c(a)	b(a)	d(a)	c(a)	b(a)	a(a)	b(a)	b(b)

was the non-significant difference between 6 and 8 cm spacing within the 6 mm root collar diameter class.

DISCUSSION

Chavasse (1980) considered that the most useful measure of seedling quality is either the height:diameter ratio, or simply the root collar diameter. Optimum height:diameter ratio for any one species and age class is related to the nursery site, with higher ratios in the north or at lower altitudes and on more favourable soils, and lower ratios in the south or at higher altitudes and in heavier soils. Optimum for 1/0 radiata pine at the FRI Experimental Nursery at Rotorua is 60:1 but for Milton Nursery in Otago the ratio was 45:1 or less.

The results of the trial described in this paper indicate that height:diameter ratio resulted in only small differences, whereas spacing had a more marked effect than grading by this manner. Initial height:diameter ratio was *not* correlated significantly to any of the growth potential parameters. Grading by height alone had an effect on seedling size 1 year after planting out; this was almost entirely a reflection of the initial differences between grades, and height grading had little or no effect on *growth* after planting (Appendix 1 correlations between initial height and bulk index).

Using the easily measured parameter of diameter it can be seen from the correlations (Appendix 1) that a significant relationship exists between initial diameter and the change in bulk index ($r = 0.3291$, $df = 336$, $p < 0.01$). Figure 2 illustrates the effect stem diameter has on growth after planting out. As stated earlier, increasing diameter classes, irrespective of initial spacing, are correlated with increased root growth potential.

Other factors to emerge from this study indicate that if oven drying facilities are available at the nursery it is even better to take initial measurements of oven dry weight of roots and/or shoots as an indication of growth potential. There was a strong relationship between initial shoots and the change in bulk index ($r = 0.7714$, $df = 336$, $p < 0.001$).

The relationship between initial roots and the change in bulk index ($r = 0.6214$, $df = 336$, $p < 0.001$), is not as strong as that for initial shoot ODW but is stronger than that for initial diameter or height. The correlation between initial root:shoot ratio and the change in bulk index is significant ($r = 0.3008$, $df = 336$, $p < 0.001$), but does not appear as useful as initial diameter or root or shoot measurements.

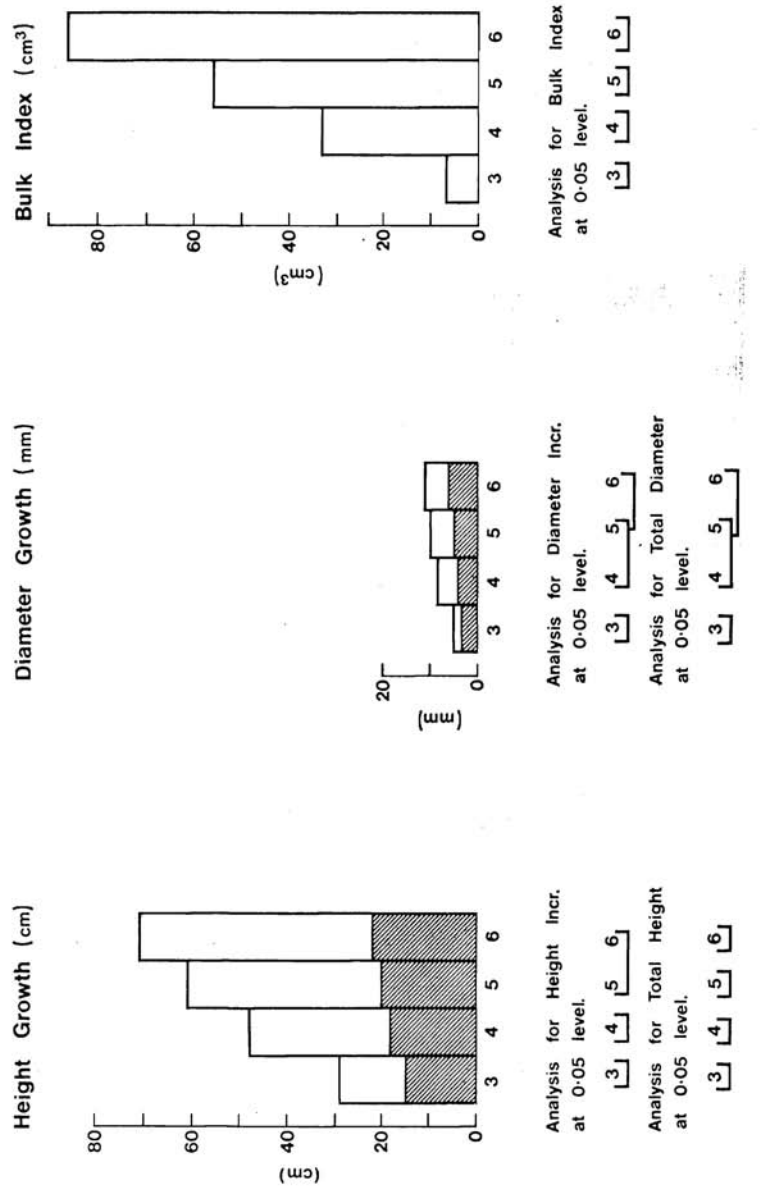

FIG. 2: *Effect of stem diameter on growth after planting (ignoring spacing effects).*

In this trial survivals were high (all were in excess of 95%) and there were no differences between grades, but from past experience, on a harsher site, there could be differences in survival and the difference in growth between grades would almost certainly be more pronounced.

CONCLUSION

(1) Seedling grading by height:diameter ratio and by height class alone did not result in marked growth differences between grades after planting out.
(2) Grading by root collar diameter only resulted in marked growth differences in seedling performance after planting out.
(3) In-drill seedling spacing had a marked influence on growth after planting out irrespective of grading method.
(4) If grading of 1/0 radiata pine tree stocks from Edendale Nursery is necessary, it would be best to base it on root collar diameter (the smaller trees going to more benign sites with the larger seedlings going to the harsher sites), in the first instance and ideally on ODW of shoots and roots if possible.

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APPENDIX 1
Table of Correlations

Initial Paramater		*Change in Diameter*	*Change in Height*	*Change in D^2H*
Initial Diam.	S4	—0.0588	—0.0148	0.3008**
	S6	—0.1484	0.0363	0.2266*
	S8	—0.0326	0.1745	0.2686**
	Overall	0.0925	—0.0661	0.3291**
	%SS	0.8549	0.4367	10.8316
Initial Height	S4	0.1642	—0.0086	0.3473***
	S6	0.1463	—0.1421	0.2577**
	S8	0.0879	—0.0417	0.1804
	Overall	0.0981	—0.1154 *	0.1868***
	%SS	0.9622	1.3320	3.4889
Initial H/Diam. Ratio	S4	0.2337*	0.0144	0.0629
	S6	0.2851**	—0.1765	0.0324
	S8	0.1098	—0.1753	—0.0236
	Overall	0.01135	—0.0261	—0.1129
	%SS	0.0129	0.0682	1.2738
Initial Roots	S4	0.6767***	0.5985***	0.7733***
	S6	0.4778***	0.3679***	0.6220***
	S8	0.4267***	0.2795**	0.4379***
	Overall	0.5595***	0.3038***	0.6214***
	%SS	31.3043	9.2269	38.6156
Initial Shoots	S4	0.6999***	0.5895***	0.8302***
	S6	0.6383***	0.6261***	0.7739***
	S8	0.6321***	0.4766 ***	0.6869***
	Overall	0.6858***	0.3961***	0.7714***
	%SS	47.0291	15.6895	50.5055
Initial Root/ Shoot	S4	—0.3567***	—0.3976 ***	—0.3905***
	S6	—0.3070***	—0.3982 ***	—0.2943**
	S8	—0.2163*	—0.2112 *	—0.2307*
	Overall	—0.3220***	—0.2085 ***	—0.3008***
	%SS	10.3689	4.3486	9.0492

* Significant correlation at 0.05 level
** Significant correlation at 0.005 level
***Significant correlation at 0.001 level

Notes:

(1) Using the easily measured parameters of diameter and height it can be seen from the above correlations that there exists a stronger relationship between initial diameter and the change in bulk index ($r = 0.3291$, $df = 336$, $p < 0.01$), than between initial height and the change in bulk index ($r = 0.1868$, $df = 336$, $p < 0.001$).

(2) The initial height:diameter ratio is not correlated with the change in bulk index.

(3) If oven drying facilities are available it is even better to take initial measurements of shoots and/or roots as an indication of growth potential. There is a strong relationship between initial shoots and the change in bulk index ($r = 0.7714$, $df = 336$, $p < 0.001$).

The relationship between initial roots and the change in bulk index ($r = 0.6214$, $df = 336$, $p < 0.001$) is not as strong as that for initial shoots but is stronger than that for initial diameter or height.

(4) The correlation between initial root shoot ratio and the change in bulk index is significant ($r = -0.3008$, $df = 336$, $p < 0.001$) but does not appear as useful as initial diameter or root or shoot measurements.

Thus it is recommended that initial ODW of shoots and/or roots are taken, if possible, as an indication of growth potential, or, if oven drying facilities are not available, initial diameters are taken as an indication of growth potential.