INSTALLATION REPORT FOR
NZFSMC BORON TRIAL FR358/1,
BALMORAL FOREST, NORTH CANTERBURY.

S.T. Olykan, A.C. Leckie, M.F. Skinner,
& J.D. Graham

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NZ FOREST SITE MANAGEMENT COOPERATIVE

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S.T. OLYKAN[1], A.C. LECKIE[1], M.F. SKINNNER[2],
& J.D. GRAHAM[2]

[1]Christchurch and [2]Rotorua
Forest Research

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EXECUTIVE SUMMARY

This report describes the following aspects of the NZFSMC boron trial FR358/1, which was installed in Balmoral Forest, North Canterbury, in 1998:

- background and objectives for the trial series and this trial,
- site selection criteria, location, associated soils information, historical foliage data and recent environmental data,
- trial design including treatments (fertiliser and weed control), plot details and planting stock
- installation issues and procedures including layout of plots in the trial, allocation of blocking and treatments and fertiliser requirements,
- results from the biomass of plants, initial measurement and survival assessment,
- data storage and analysis
- a schedule for future measurements and assessments.

In brief, the current trial was installed in stand 3 of Cpt. 65 in Balmoral Forest and planted in August 1998. There are 4 replicates of the following 11 treatments:

- B added as ulexite (~10% B) at rates of at 0, 4, 8, 16 and 32 kg B/ha, by
- weed control (plus or minus).

Plus an additional 'optimum' treatment:

- 1 rate of Nitrophoska Blue TE (added at 50 kg P/ha) plus 16 kg B/ha, with weed control.

The fertiliser was applied in October 1997.

Results from the biomass and initial measurement of the trial indicted that:

- total dry weights, and weights of individual components, and the size of the planting material (based on height and root collar diameter measurements) prior to planting varied greatly between the genotypes.
- once planted overall mean plot tree height was 26 cm (individual range of 4 to 52 cm) and mean tree root collar diameter was 6.7 mm (individual range of 2.0 to 17.1 mm). As expected from the variation in the planting material, there were some differences between the genotypes in terms of height and basal diameter.
- between planting and measurement (approximately 8 weeks), survival across the trial was 95% (ranging from 84 to 100%).

An assessment of survival in April 1999 found that:

- across the trial, survival in the inner plots, after the dry 98/99 summer, was 72.5%.
- a number of factors affected mean plot and individual survival including blocking, rate of B addition, and genotype. These are discussed in the report.
- the trial was still statistically robust and could be used for future research purposes.

The trial will be measured this winter and foliage sampled in February 2001.

INTRODUCTION

Background to the FR358 trial series

Boron (B) related research in New Zealand and Australia has provided the forest industry with recommendations on foliar B critical levels and the type and rate of B fertiliser required to prevent B deficiency in radiata pine (e.g., Forest Research Institute 1985, Will 1985). Various studies have also provided a range of results indicating that B may increase tree growth (Hopmans and Flinn 1984, Olykan *et al.* 1995), internal retranslocation of B can occur (Hopmans and Clerehan 1991, Olykan 1993, Olykan and Adams, *in prep.*), there appears to be a relationship between B foliar levels and rainfall (Hopmans and Clerehan 1991, Olykan 1993), B deficiencies in plantations can be exacerbated by water stress (Lambert and Ryan 1990), the addition of B can improve wood cell characteristics (M. Skinner and A. Singh, unpublished data) and added B may reside for a number of years in the surface soil (Olykan *et al.* 1995).

When this trial series was proposed, the only active B trial in New Zealand was FR 24/2 - a New Zealand Forest Site Management Cooperative (NZFSMC) trial installed in Rerewhakaaitu Forest (Cpt. 273) in 1988 in a 2 year-old stand of radiata pine (268 series). The annual rainfall of 1400 mm was probably not a factor limiting the plant availability of B. The trial included a number of B fertiliser types (control, colemanite, ulexite and borax) added at 6 kg B/ha. Half of each plot received weed control. From 1989 to 1994, foliar B was significantly (p<0.05) elevated by the addition of borax, ulexite and colemanite. The latter two fertilisers were able to maintain the highest levels of foliar B over time.

Evidence from Skinner and Singh (unpublished data), based on B fertilised and unfertilised trees on a drought-prone site, indicated that B had a significant affect on radiata pine cellular strength and dimensions. Also within the forest industry there has been unsubstantiated claims associated with B. These have included boron's alleged effect on the behaviour of milled wood; where bowing, twisting and defects such as resin pockets have been associated with wood from B deficient trees; and improved root growth in B fertilised trees. The evidence, both scientific and anecdotal, needed to be investigated further. To provide the opportunity to do this, a standardised trial design incorporating a range of B rates, weed control and genotypes, was proposed and developed (Olykan *et al*. 1998). Four sites across New Zealand were to be selected based on a matrix of high/low total soil B with high/low rainfall[1].

The culmination of the work, both within the NZFSMC and associated PGSF research, will be a comprehensive Boron Decision Support System (B DSS). The development of a B DSS framework has been supported by the NZFSMC.

FR358/1 in Balmoral Forest, North Canterbury.

The Balmoral Forest trial, FR358/1, was originally planted in 1997. However, after a very dry summer, inner plot survival was assessed at 50% in the April 1998. A decision was made to replant the inner plots and blank the outer plots in 1998; the same year that the Taupo trial, FR358/2 was established. All of the data pertaining to the initial measurements and assessments of the 1997 planting of the trial are in **Appendix 1**. This report deals solely with the results from the current 1998 planting.

FR358/1 objectives

To test the following hypotheses on a site where the rainfall is low, soil total B is medium to high and the B nutrition of radiata pine is marginal to low:

- B addition significantly improves wood cell characteristics and wood quality in radiata.

[1] In the workplan (Olykan *et al*. 1998), the original matrix was based on high/low foliar B and high/low rainfall. However, foliar B is a product of the influence of rainfall on soil moisture and soil B. Also the range in foliar B in unfertilised radiata pine stands in NZ is not large and ranges from about 5 to 20 ppm. In addition, stands could function adequately with supposedly 'deficient' foliar B levels because soil B supply was not interrupted (i.e. there was a continuous supply of soil moisture and the risk of drought was very low).

- Weed control improves B availability to trees by a) removing direct competition for B and b) indirectly by increasing soil moisture availability (B is taken up in the transpiration stream).
- A measure of the rainfall in the spring/summer season prior to foliage sampling in March can assist in the diagnosis of foliar B concentrations.
- Internal retranslocation significantly increases the efficiency of B use and prolongs the effect of added B.
- The soil can act as a reservoir of B for a number of years after B addition.

SITE SELECTION AND SOILS

Site selection

Boron nutrition along the east coast of the South Island has been described as marginal with a high probability of some deficiency (Hunter *et al.* 1991). A visit was made to the Carter Holt Harvey Forests (CHH) Ashley Forest headquarters, January 1997, to discuss the potential of siting the first trial in Canterbury. After some discussion, it was proposed that the B trial be installed in Balmoral Forest for two key reasons:

- A number of stands in Balmoral Forest had not received any B fertiliser (this was not the case for Ashley Forest).
- Of CHH's forested areas on drier sites, Balmoral Forest had the lowest rainfall (720 mm per annum) and there were visual B symptoms (e.g., dead tops) displayed in dry summers (especially on the terraces near the Hurunui River). The soils were stony and alluvial so soil moisture was clearly a limitation.

Site and soil details

General forest stand information

An area in the eastern block of stand 3 in Cpt. 65 (**Figure 1**) was available for planting in the winter of 1997. The trial site is flat (less than 8 degrees), at an altitude of 190 m asl, and is located at 685 N and 283 E. The crop site index is 19.8.

The current rotation is the third one of radiata pine on this site. The second rotation was established in 1967. There is no record of fertiliser additions during the second rotation. The second rotation was harvested in 1996. Much of the harvesting debris was left around the skid site. When the stand was selected for this trial it had already been ripped at 4 m spacings (lines running east-west).

Historical foliage data

At the time of locating the site for this trial there was no historical foliage data available from Cpt. 65, Balmoral Forest. A subsequent search of the Forest Research foliage database has identified results from a number of foliage samples taken from Balmoral Forest that were not related to experiments. The results are summarised in **Table 1**. All of the samples were analysed for B, which ranged from 5 to 18 µg/g with a mean of 11.3 µg/g. Seven of the samples had a foliar B concentration less than or equal to 8 µg/g (i.e., a low rating).

Some of the samples were analysed for N and P and there was a large range in the resulting values. Foliar N was low to marginal with no values greater than 1.5%. Foliar P was generally satisfactory but 4 values were below 0.12%.

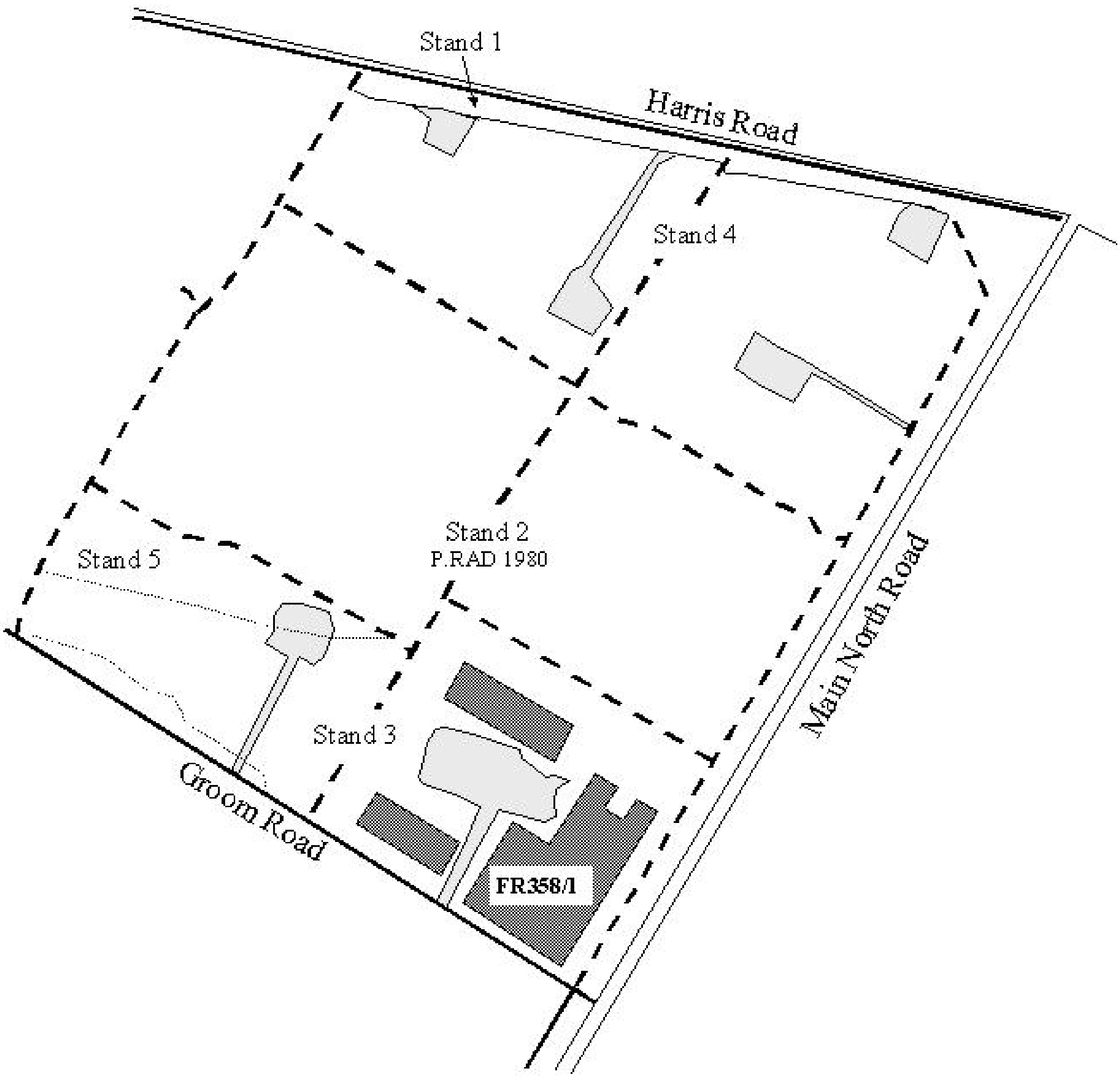


Figure 1: Stand map of compartment 65, Balmoral Forest, and the siting of FR358/1.

Table 1: Summary of historical foliar nutrient data from Balmoral Forest, North Canterbury, from stands recorded as being unfertilised (on Forest Research data base), not part of an experiment and the material collected was 1 year-old foliage.

	N	**P**	**B**
	-------- % --------		**µg/g**
Mean[#]	**1.24**	**0.15**	**11.3**
Rating*	Marginal	Satisfactory	Marginal
Minimum	1.04	0.11	5
Maximum	1.46	0.19	18
No. samples	18	18	28
Std dev	0.119	0.028	3.81

[#] Based on a total of 28 samples taken between 1982 and 1988 from trees ranging in age from 2 to 12 years-old (mean age 2.7 years). * Rating based on the critical values of Will (1985).

Soils

The soils in this area were mapped as part of the Balmoral soil set (New Zealand Soil Bureau 1968). The Balmoral soil is a dry subhygrous yellow-brown shallow and stony soil associated with the yellow-grey earths on terrace lands and fans. These soils are widespread on the older fan surfaces of the Canterbury Plains. The parent material is greywacke alluvium gravels with a very thin loess cover (mostly 20 to 40 cm, but less than 15 cm in some places) and some small patches of shallow sand. These soils are subject to moderate to severe wind erosion in places.

The Balmoral soil set consists mostly of stony silt loams with some sandy loams (New Zealand Soil Bureau 1968). Typically the topsoils are dark greyish brown silt loams with nutty or crumb structure and the subsoils are yellowish brown silt loams with weak nutty or crumb structure, and in many cases stony, overlying sandy gravels.

The Balmoral soil has a low water holding capacity, a low natural fertility (**Table 2**) and is considered marginal for forestry (New Zealand Soil Bureau 1968).

Table 2: Typical chemical characteristics of the Balmoral soil set (New Zealand Soil Bureau 1968).

Depth (cm)	pH	C %	N %	CEC	TEB	Ca me %	Mg	K	P citric mg %
0.5-4	5.9	4.5	0.35	15.3	6.5	4.1	1.8	1.00	7
10-15	5.6		0.20	10.6	2.1	1.1	0.6	0.70	8
25-32	5.8			4.4	0.9	0.5	0.3	0.25	28

Soil sample taken from a flat terrace 5 km east of Culverden at an altitude of 160 m.

Soil boron in Balmoral Forest

Soil samples were collected from the 'true' control plots[2] in July 1999 to confirm the B status of this soil. Five samples were taken from each plot and bulked to give a sample for the 0 to 10 and 10 to 20 cm depths. The samples were analysed for total soil B, using a $HNO_3/HClO_4$ digest and measuring B on an ICP, and 'plant-available' B using a hot-$CaCl_2$-extraction.

Total soil B was 19 ppm in the 0 to 10 cm depth (**Table 3**). This value was considerably higher than expected considering the problems with B nutrition in this forest. However, Wells and Crear (1962) rated this area as 15-20 ppm.

Table 3: Soil boron in Balmoral Forest.

Depth (cm)	Total B ppm	Hot-$CaCl_2$-ext. B ppm	Available B (as % of Total B)
0-10	19 ± 1.4	0.33 ± 0.096	1.7
10-20	21 ± 3.2	0.23 ± 0. 096	1.1

The amount of hot-$CaCl_2$-extractable B was 0.33 ppm in the 0 to 10 cm depth. This value is extremely low and the proportion of the total B that could be termed "available" was only 1.7%. Typically, the expectation is that approximately 10% of the total B could be extracted in a plant available form (e.g., Olykan *et al*. 1995). The low availability of B and the high risk of summer drought may explain why foliar B concentrations can be low in this area when fertiliser has not been applied. It is not certain what impact the movement of harvest debris into large slash heaps around the skid site or the accompanying soil disturbance may have on depleting soil organic matter and B availability.

[2] Treatment 1 (no fertiliser or weed control) consisting of plots 13, 31, 32, and 43.

Environmental conditions

Temperatures during the 2-year period from July 1998 to June 2000 were considerably warmer than the 30-year average from 1960 to 1990, especially during the summer of 1998/99 (**Figure 2**).

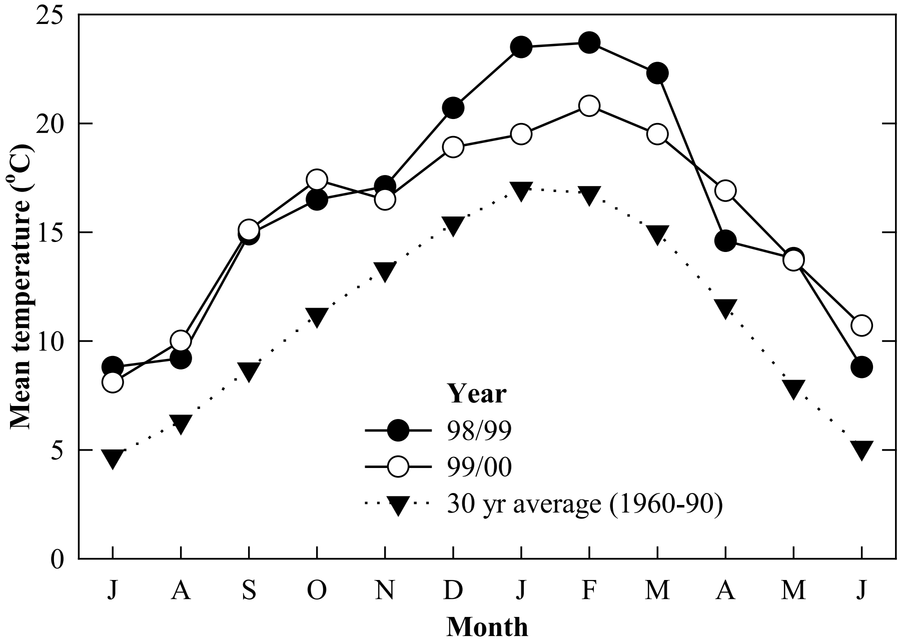
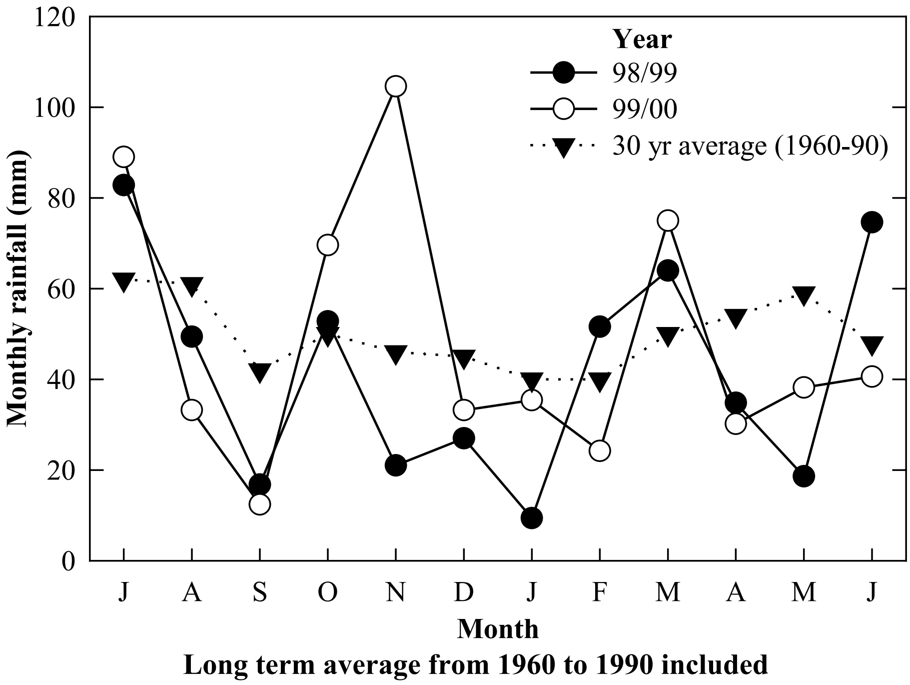


Figure 2: Mean monthly temperatures from July 1998 to June 2000 at Balmoral Forest, North Canterbury. Long term average from 1960 to 1990 included.

The trial is located in a low rainfall area. The 30 year (1960 to 1990) long term average annual rainfall for Balmoral Forest is 597 mm (Grant Pearce, *pers. comm.*). Rainfall since the middle of 1998 has been variable as shown in **Figure 3**. During the 1998/99 year, September, November, January and May were particularly dry with average monthly rainfalls less than half the long term average (40, 46, 24 and 32% respectively). While July 1998 and June 1999 were relatively wet months, the total rainfall for this period was 503 mm and only 84% of the long term average annual rainfall.

Figure 3: Monthly rainfall in Balmoral Forest, North Canterbury, from July 1998 June 2000.



Long term average from 1960 to 1990 included

The total rainfall during the 1999/00 year was 586 mm. While there were a number of months with rainfall less than the long-term average in 1999/00, only September was particularly dry at 30% of the long-term average. November was a wet month where 105 mm of rain fell compared to the long-term average of 46 mm.

The spring and summer of 1998/99 were particularly dry and warm. The high rainfall in November 1999 followed by 3 months of rainfall averaging 75% of the long term average was a welcome relief for the trees in the trial and would have aided their establishment during the second summer.

TRIAL DESIGN

Treatments

The trial design consists of a factorial of the following treatments:

- B added as ulexite (~10% B) at rates of at 0, 4, 8, 16 and 32 kg B/ha, by
- weed control (plus or minus).

plus an additional 'optimum' treatment:

- 1 rate of Nitrophoska Blue TE[3] (added at 50 kg P/ha) plus 16 kg B/ha, with weed control.

There are a total of 11 treatments (**Table 4**), which are replicated 4 times to give a total of 44 plots.

Weed control

It was envisaged that chemical and/or manual methods of weed control would be depending on the weeds present on the site and the standard practices of the forest company and the topography.

Plot size

At Balmoral, the inner plots are 25 m x 25 m and the outer plots are 45 m x 45 m (0.0625 and 0.2025 ha respectively) covering an area of 8.9 ha. It was envisaged that this plot size would provide sufficient measurement trees during the rotation and allow the periodic biomassing of trees.

Table 4: Treatments added in the FR358 trial series.

	Treatments		
Trtmt no.	**Boron kg/ha**	**Weed control (+/-)**	**Optimum**
1	0	- (No)	-
2	4	- (No)	-
3	8	- (No)	-
4	16	- (No)	-
5	32	- (No)	-
6	0	+ (Yes)	-
7	4	+ (Yes)	-
8	8	+ (Yes)	-
9	16	+ (Yes)	-
10	32	+ (Yes)	-
11	16	+ (Yes)	Yes

[3] Nitrophoska Blue TE' contains the following elements: 12% Nitrogen (N), 5% Phosphorus (P), 14% Potassium (K), 6.4% Calcium (Ca), 4% Sulphur (S), 1.2% Magnesium (Mg), 2000 µg/g Iron (Fe), 3 µg/g Copper (Cu), 100 µg/g Zinc (Zn), 200 µg/g Boron (B) and 5 µg/g Molybdenum (Mo). This rate of Nitrophoska would add: N at 120 kg/ha, P at 50 kg/ha, K at 140 kg/ha, Ca at 64 kg/ha, Mg at 12 kg/ha, S at 30 kg/ha and trace elements.

Planting stock

The radiata pine planting stock for the B trials was provided by CHH (3 families) and FCF (5 clones) as an inkind contribution. The same genetic material will be used for installing all of the B trials.

Stocking rate

The site at Balmoral Forest was ripped at 4m intervals. Therefore the planting pattern was 4 m (between rows) x 3 m within rows to give a final stocking of 833 sph (**Appendix 1**).

TRIAL INSTALLATION

Installation of plots

The plots installed in June 1997[4]. Wooden pegs were used to mark the corners of the inner and outer plots. The tops of pegs in the inner plots were painted blue and the outer plot pegs painted yellow.

The layout of the plots is shown in **Figure 4**. The plots are then numbered 1 to 44 and numbered Allflex tags were attached to at least one of the pegs in each inner plot for future identification.

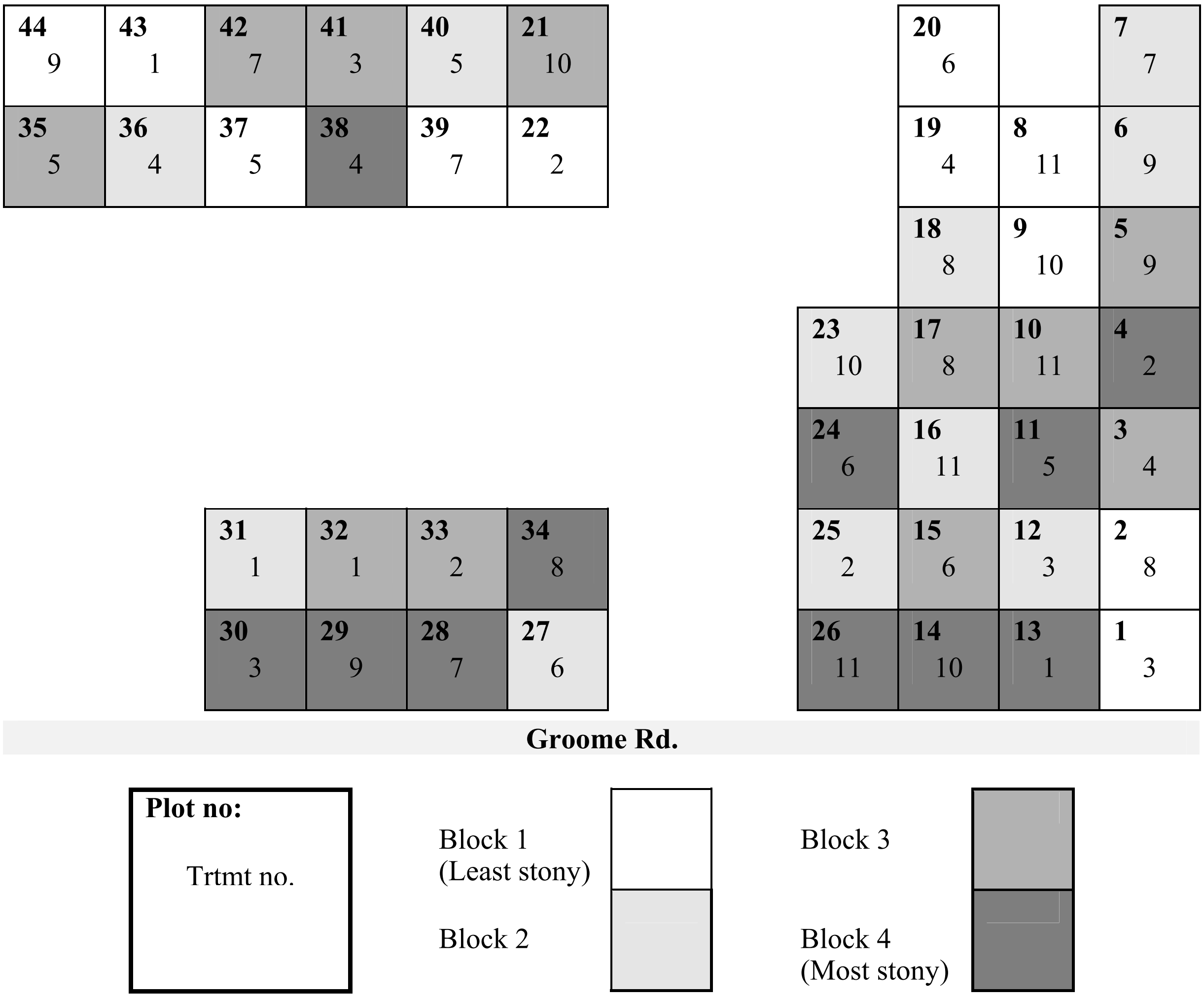


Figure 4: Layout of the plots in the Balmoral Forest Boron trial FR358/1.

[4] Within stand 3 of the compartment some areas could not be used for plot installation (refer to **Figure 1**) including areas used by the ripper to turn, areas with excess slash (there was a large slash dump/skid area in the middle of the stand), compacted areas associated with tracking around the stand (from the aerial photograph this appeared to be worse in the north-eastern areas of the block) and the NE edge of the block where the trees in stand 2 were 17 years old and would shade plots which were close (same applied to the eastern corner as well).

Preparation and planting of stock

Preparation of the planting stock

Each genotype, to be planted in the inner plot, was labelled with a coloured tag to identify its genetic origins (**Table 5**). The tag was attached to the upper part of the seedling so that it was not buried during planting.

Table 5: Genotypes and codes of the planting material planted in the Balmoral Forest B trial, FR358/1, in 1998.

No.	Genotype	Tag
1	Clone 111P	Orange
2	Clone 107P	White+red splash
3	Clone 143P	White
4	Family B	White split
5	Clone 230P	Blue
6	Family A	Yellow
7	Clone 146P	Lime green
8	Family C	Blue split or Blue ink splash

On receiving the planting material from the companies it was kept in a cool store. Preparation of the stock for planting involves recombining the genotypes for planting and repackaging in the planter boxes. As a maximum of 64 individuals[5] was required for planting the inner plot, 8 individuals per genotype were required in the planter box. The outer plots required more material and placed in 2 planter boxes.

Planting

The trial was planted in August 1998. CHH provided contracted personnel to plant the trial inkind. Forest Research transported the planting stock from the cooler to the field, distributed planting stock to the planters (ensuring the inner plots were planted first) and oversaw the planting process. This involved the removal of the old material planted in 1997 and replanting with the new material (as described above) in the inner plots and the removal of dead trees in the outer plots which were replanted with CHH family material.

Blocking and allocation of treatments

Blocking of the plots was based on a visual assessment of stoniness (see **Appendices 3** and **4** and **Figure 3**). Then the treatments were randomly allocated to the plots within each block (**Appendix 5**) which is also shown in **Figure 3**.

Fertiliser requirements and addition

The total amount of fertiliser required for each trial and per plot is shown in **Appendix 7**. Ravensdown supplied the fertiliser in kind. The fertiliser was broadcast by hand on 31st October 1997. There was no rain during the application.

MEASUREMENT, ASSESSMENT AND SAMPLING: METHODS AND RESULTS

Initial biomass

Individuals from each genotype were randomly selected for measurement, dry weights and chemical analysis using the following procedure:

- Random selected 8 individuals from each genotype.
- Measured shoot length and root collar diameter.

[5] Based on inner plot size and stocking rate. In the Balmoral Forest trial, a maximum of 64 seedlings were required for the inner plots and a maximum of 126 were required for the outer plots. Because planting occurred in rip lines, the number of seedlings per inner or outer plot varied depending on the number rips within the plot.

- Washed roots and dried with hand towels, cut at root collar. For each genotype, bulked samples of shoots and roots were placed in paper bags and oven dried (65ºC). The needles were then separated from the stem.
- Measured dry weights of each component (roots, needles and stem). Sent samples to the Forest Nutrition Laboratory at Forest Research for nutrient analysis (total of 24 samples).

The total dry weights, and weights of individual components, varied greatly between the genotypes **(Figure 5)**. The size of the planting material, based on height and root collar diameter measurements, prior to planting also varied (**Figure 6**).

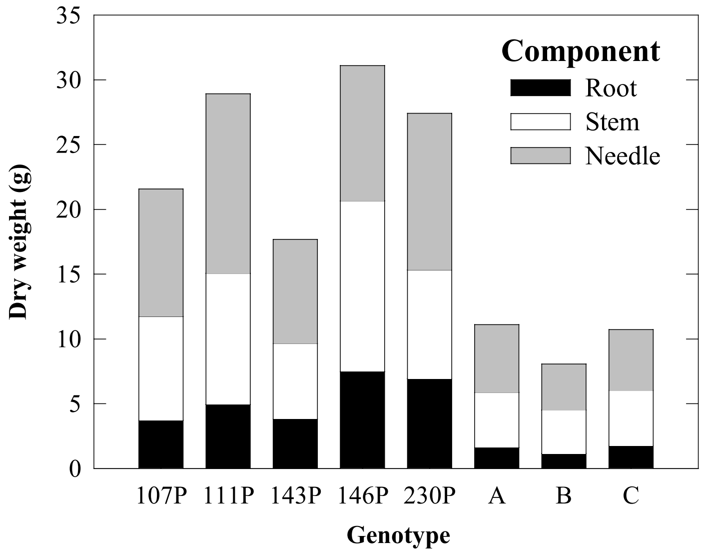


Figure 5: Dry weight of components of radiata genotypes planted in the Balmoral Forest B trial, FR358/1, in 1998.

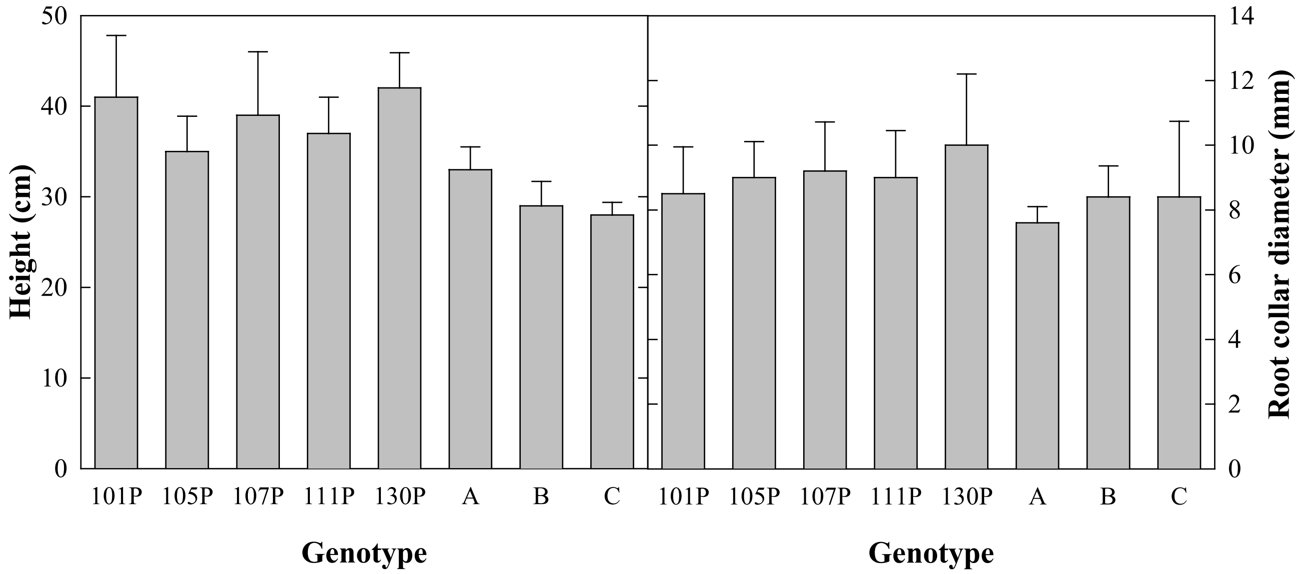


Figure 6: Height and root collar diameter of the biomassed radiata genotypes.

Mapping genotypes and initial measurement

The mapping of genotypes and the initial measurements were carried out simultaneously in October 1998. The procedure for numbering the individuals in the inner plot is shown in **Appendix 3**. The genotype of each individual in the inner plot was recorded (see **Table 5**) and the height and root collar diameter measured and recorded (see **Appendix 4** for plot means).

Between planting and measurement (approximately 8 weeks), survival across the trial was 95% (ranging from 84 to 100%). Overall mean plot tree height was 26 cm (individual range of 4 to 52 cm) and mean tree root collar diameter was 6.7 mm (individual range of 2.0 to 17.1 mm). There were differences between the genotypes in terms of height and basal diameter (**Figure 7**). Genoytpe 146P was the largest particularly in basal diameter. However, once planted, there was less of a difference in size between the radiata genotypes compared to the material that was biomassed (shown in **Figure 6**).

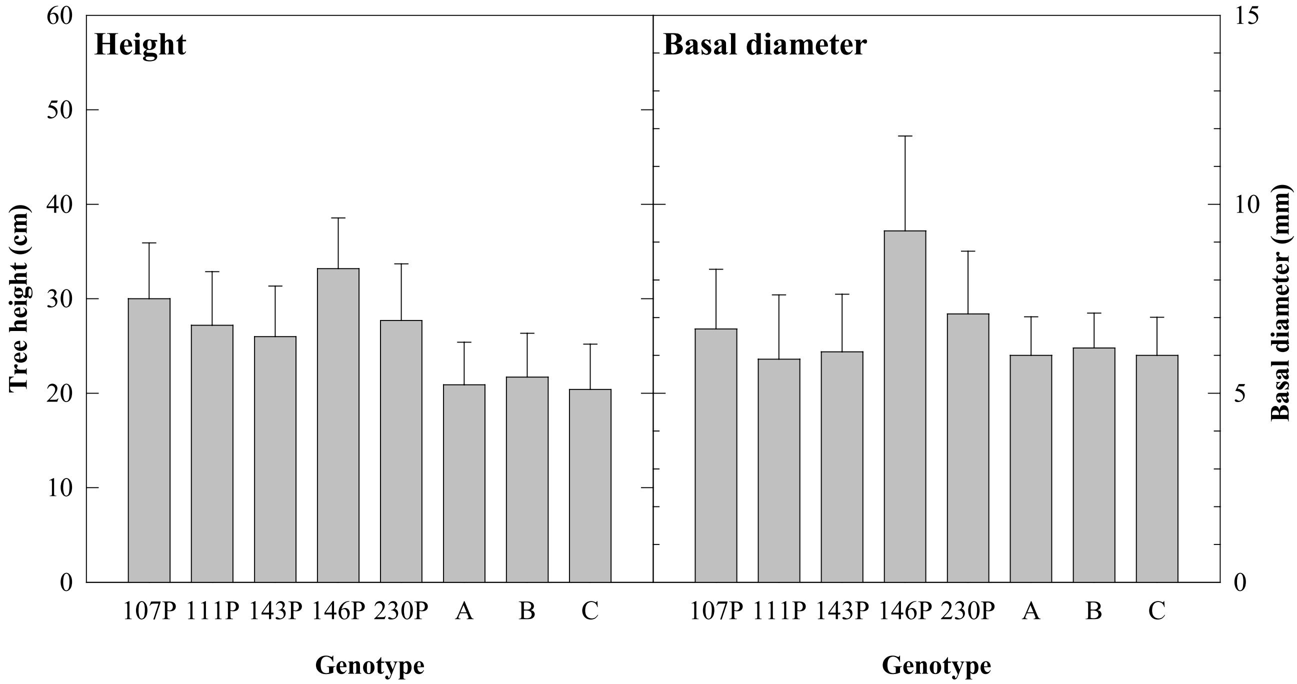


Figure 7: Initial height and basal diameter measurement of the radiata genotypes planted in the Balmoral Forest B trial, FR358/1.

Results of the survival assessment in 1999

In April 1999 the trial was assessed, using the categories described in **Table 6,** to determine survival during the summer. This was carried out in order to determine if the trial was still viable.

Table 6: Scoring categories used to assess survival in April 1999 in FR358/1, Balmoral Forest.

Score	Observation
0	Dead
1	Barely alive – may be a few needles slightly green or yellow
2	Many symptoms of ill health, some have a dead top (DT). Will probably survive.
3	Needle tips browning off, signs of nutrient deficiency (slightly yellow), some DT. Will definitely survive.
4	Few dead needles, no DT, some yellow needle tips.
5	Perfect
The above scores combined: Dead = 0+1, OK = 2+3, Good = 4+5[6]	

[6] The summary of the scores into these 3 categories allowed for comparisons with the assessment of 1997 trial.

The survival data was statistically analysed (SAS GLM procedure) to identify what treatment factors may have influenced survival. Duncan's Multiple range test was used to compare means at $p<0.05$.

General comments about the trial and treatments

While the 98/99 summer was dry in North Canterbury, mean survival in the Balmoral B trial by April 1999 was 72.5% and better than the survival rate of 50.2% of the trial planted in 1997 and assessed in 1998 (**Figure 6**).

The scoring systems to assess survival in 1998 and 1999 were different so it was difficult to make a direct comparison between the data (apart from the % of dead stock). However, recombining the scoring categories (see the bottom of **Table 6**) highlighted that fewer trees had died during the 1998/99 summer although a 45% of the 1998 trees had suffered to some degree being described as 'OK' as opposed to the 30% that were 'Good'.

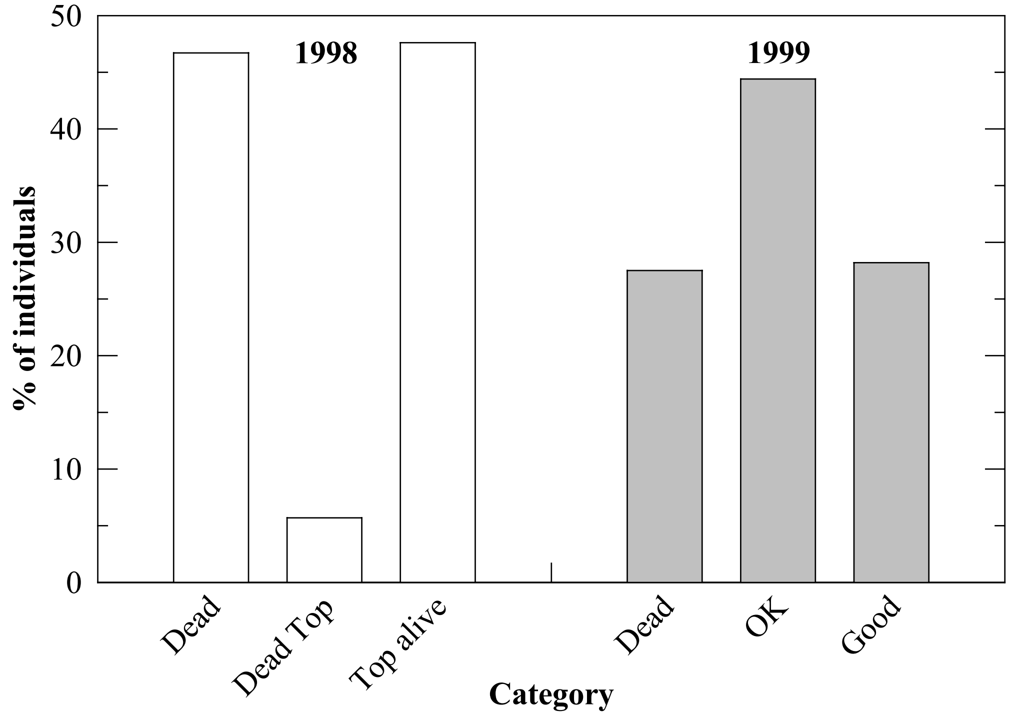


Figure 8: Distribution of survival scores in the Balmoral Forest B trial, FR358/1, in 1998 and 1999 (based on material planted in 1997 and 1998, respectively).

Analysis of plot data

The following results are based on an analysis of plot means of the percentage of planting stock that had survived. The percent survival was based on the sum of the stock that were 'OK' and 'Good' (as shown in **Figure 6**) as a proportion of the total number in each inner plot.

In 1999, blocking did not have a significant effect on percent survival:

Mean	N	Block
74.2% a	11	2
74.2% a	11	3
72.1% a	11	1
69.6% a	11	4

(Means with the same letter were not significantly different at $p<0.05$).

In 1998 the blocking effect had been significant with survival in the stoniest block (4) being significantly lower than in the other blocks (see **Appendix 1**). During the summer of 1998/99, the additional problem of weed invasion caused high mortality in a confined area of the trial. This may have masked the blocking affect at this level of analysis.

Rate of B affected percent survival

Mean	N	B rate (kg/ha)
80.2% a	8	0
79.6% a	8	4
78.8% ab	8	16
69.2% bc	8	8
67.6% c	8	32

(Means with the same letter were not significantly different at $p<0.05$).

Rate of B addition had a weak effect ($p = 0.087$) on percent survival. Highest survivals were in the control, B4 and B16 plots. The addition of B at 8 or 32 kg/ha appeared to reduce survival percentages. However, it should be noted that Plots 1 and 2, which received 8 kg of B/ha, had low survivals of 33 and 54% because of the heavy invasion of weeds (predominantly grasses) in this area of the trial. Mean survival in the other plots receiving 8 kg B/ha was 78% - which was not significantly different from adding 4 or 16 kg B/ha.

The addition of 32 kg B/ha appeared to be detrimental to survival in 7 of the 8 plots where mortality rates ranged from 28 to 41 % (mean of 35%). In plot 40, which also received 32 kg B/ha, mortality was only 13%. Only one of the plots (number 14, mortality of 37%) was in the area that was heavily invaded by weeds.

The weed control (WC) treatment

Survival was 75% for both weed control treatments. This was expected because all of the clones and seedlings had received a spot spray after planting to assist the establishment of the trial.

Nitrophoska addition reduced survival

Mean	N	Nitrophoska
82.6% a	4	Not applied
47.0% b	8	Applied

(Means with the same letter were not significantly different at $p<0.05$).

Nitrophoska (+WC and 16 kg B/ha) was applied to 4 plots in treatment 11. A comparison was made with plots from treatment 9 which had the equivalent WC and B but no Nitrophoska. It was found that the application of Nitrophoska had dramatically reduced survival ($p=0.002$).

<u>Statistical robustness of the trial</u>

The 1999 on-site observations and the survival data confirmed that the trial had survived and could be used for future research purposes. While some plots were badly affected by mortality (**Appendix 5**), it was necessary to ensure that the trial still had sufficient replicates (at least 3 out of 4) in each treatment for future work and analysis of data.

Those treatments that have suffered the worst mortality in a number of replicates were 5 and 10 (B added at 32 kg/ha) and 11 (Nitrophoska added). Other treatments of concern were 2 and 3. Treatment 3 included Plot 1 which had high mortality due to weed invasion. Mortality in the other replicates of these treatments was not greater than a third.

<u>Analysis of individual survival score data</u>

Because the genotype of the individual trees in the inner plots had been identified, it was possible to analyse the individual survival score data to identify any differences between the genotypes and include the other factors - block, boron, and WC - in the analysis of this much larger data set.

The first GLM analysis used all combinations of the following factors: Block, Boron, WC, and Genotype. This model was significant ($p<0.001$) but the r^2 of 0.29 indicated that much of the variation in the data was not explained by the known variables. The coefficient of variation (CV) was 55%.

Block had a significant effect on individual survival

The effect of block was significant ($p=0.004$) and the mean survival score in Block 4 was significantly less than in the other blocks (**Figure 9**). The lower survival of stock in Block 4 (the stoniest) was also identified in the analysis of the 1998 data. There was no difference between the other blocks suggesting that stoniness at this site may have to be fairly extreme to significantly affect the establishment of radiata. It must also be remembered that the heavy weed invasion, which clearly reduced survival, affected a number of plots including 1 and 2 which were in Block 1.

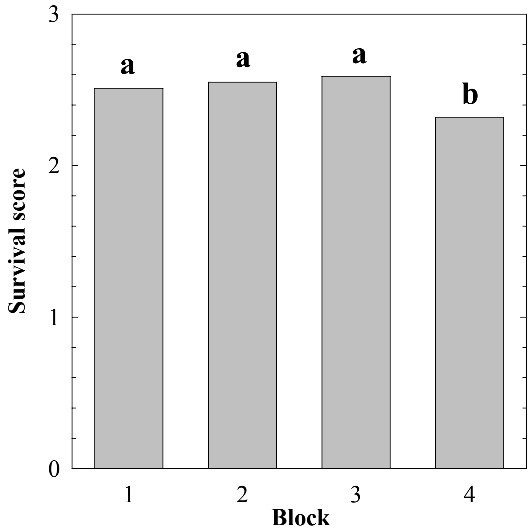


Figure 9: Effect of blocking on 1999 survival scores in the Balmoral Forest B trial, FR358/1.

There were two significant interactions that affected survival scores and included the blocking factor. These were Block*Boron ($p<0.001$) and Block*WC ($p=0.012$).

Rate of B affected survival score

The effect of Boron rate on the survival scores was highly significant ($p<0.001$) and the results confirmed what had been found for the plot means for percent survival:

Mean	N	B rate (kg/ha)
2.7 a	464	4
2.7 a	482	0
2.6 ab	434	16
2.3 bc	485	8
2.2 c	455	32

(Means with the same letter were not significantly different at $p<0.05$).

As was previously mentioned, several plots in the B8 treatment were affected by heavy weed invasion and therefore affected the result. In contrast, the effect of B32 reducing survival appeared to be the result of the high rate of B. There were three significant interactions which included the Boron factor: Block*Boron (as above), Boron*WC ($p<0.001$) and Boron*Genotype ($p=0.040$).

The weed control (WC) treatment

As previously described, WC was not a significant factor in the analysis of survival although there was an interaction between WC and several other factors. Blanket WC had been applied to the plots requiring this treatment as well as a spot spray for all of the planting stock. Without further detailed analysis it is not possible to say what the effect of WC in the interactions has been.

Genotype had a significant effect on survival

Genotype had a significant ($p<0.001$) affect on percent survival, which ranged from 58% (clone 146) to 86% (clone 143) as shown in **Figure 8**. The distribution of survival scores across the different genotypes was very similar and ranged from 1.7 (clone 146) to 3.0 (clone 143).

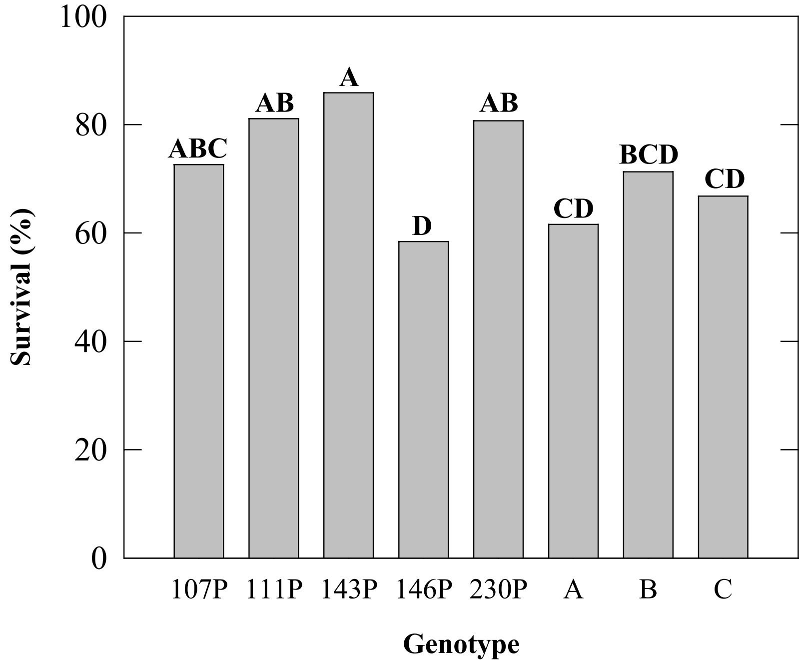


Figure 10: Effect of radiata genotype on % survival in 1999, Balmoral Forest B trial FR358/1.

(Means with the same letter were not significantly different at $p<0.05$).

After the very hot summer in 1998, which contributed to high mortality in the original trial planted in 1997, it was hypothesised that the differences in genotype survival may have been a result of the differences in planting stock size between the genotypes (see **Figures 5** and **6** in **Appendix 1**). Specifically, clones or seedlings with large shoots would find survival more difficult in the hot Nor'west winds due to greater transpiration rates that may not be matched by the uptake of moisture from the soil. No relationships were identified when comparing % survival to a number of biomass and measurement characteristics of the genotype stock. The same relationships were tested with the 1999 survival assessment data from the current trial with similar results.

Weed control measures since 1998

The application of weed control has been the responsibility of CHH in consultation with Forest Research. Initial weed control, consisting of a spot spray, was recommended and carried out for all of the plots to enhance the establishment of the seedlings by reducing weed competition. The application of weed control to plots with treatment numbers 6 to 11 (including buffer area in outer plot) was carried out in November 1999 and will be required periodically to ensure that the +WC remain weed free.

The chemical treatment record for this trial to date is as follows (Alasdair Woore, *pers. comm.*):

11/98 Chemical Tree Release: release (19lts), pulse & Maximiser oil
Broadcast spray: gardoprim (60 lts), pulse (5.5lts), release (40 lts) & roundup (33 lts).

11/99 Broadcast spray: glyphosate 360 (0.7lts), maximiser oil (10.8 ltrs), terbuthylazine 500 (135 lts) & blue dye.

MAINTENANCE OF THE TRIAL

Schedule of future measurements, assessments and sampling in FR358/1

There are a number of growth measurements, foliage and soil sampling, and visual assessments proposed for this trial (see **Table 7**). It is expected that the following will be funded by NZFSMC:

- Regular measurements of tree height, root collar diameter/dbh.
- Regular foliage sampling and chemical analysis of samples.
- Periodic soil sampling and analysis.
- Periodic visual assessment of form with particular emphasis on identifying the presence of B deficiency symptoms.

Table 7: Schedule of general measurements, soil and foliage sampling, assessments and biomassing for the Balmoral Forest B trial, FR358/1, for the first 3 years.

Year†	Month	Measure	Sampling		Assess	Biomass
			Foliage	Soil		
1998	August	✓ Initial				✓ Seedlings
1999	April				✓ Survival	
2000	August	✓			✓ Form	
2001	March		✓	✓		

Shaded tasks have been completed.

Additional boron research projects will also be carried out in this trial using PGSF funding and may include the following pieces of work will be undertaken during the next 6 years:

- Investigation of the role of sugar alcohols in the internal retranslocation of B in radiata pine genotypes.
- Lysimeter studies to investigate B flux in relation to rainfall.

- Regular soil sampling to identify B fractions in the soil and determine the longevity of B in the soil as a result of fertiliser addition.
- Periodic biomass studies (above and below-ground radiata and weeds) to provide information relating to B cycling and tree growth and nutrient content and material for the measurement and assessment of wood cell characteristics (as done by M. Skinner and A. Singh) and wood quality.

Future foliage and soil sampling

These will be carried out as required. The first full foliage sample of this trial is scheduled for March 2001. Soil samples should also be taken at this time.

Weed control

As previously mentioned, the maintenance of the weed control treatment is the responsibility of CHH.

Trial integrity and general management

CHH have erected large yellow posts around the trial to ensure that the trial is clearly visible and will not be compromised in anyway by normal forestry operations which may be carried out in the vicinity of the trial.

Forest Research staff will be regularly visiting the sites and will maintain the plot pegs and tree numbering.

The requirement for, and methods of, future silvicultural management will be discussed with the forest owner.

Reports and papers

Reports summarising the measurements, foliage and soil analysis results, and assessments (as outlined in **Table 7**) from all of the trials in this series will be produced for the NZFSMC periodically.

Data location

All data is being stored on the Forest Research PSP system and held on Excel spreadsheets by Forest Research staff who are team members of this project.

BORON DECISION SUPPORT SYSTEM

In the medium term, a Decision Support System (DSS) will be produced for the management of B nutrition in radiata pine plantations in New Zealand. The development of a framework for a B DSS has been funded by NZFSMC for the 2000/01 financial year.

ACKNOWLEDGMENTS

We wish to acknowledge the assistance and contributions of the following companies and individuals since the installation of the original trial in 1997:

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- CHH for supplying the site and information, planting crew and ongoing maintenance of the weed control treatments (Rob Goldring, John McLanachan, Andy McCord, Raoul Thomas, Peter Thomson, John Webb and Alasdair Woore).
- Ravensdown for supplying the fertiliser inkind (Arthur Duncan).
- John Poynter, Dave Henley, Alan Nordmeyer, Peter Clinton, and Joy Wraight (***Forest Research***).

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APPENDICES

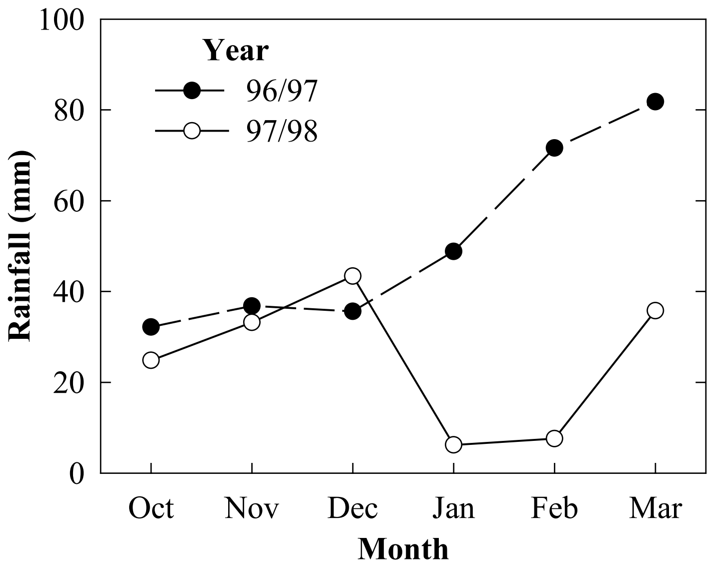
Appendix 1: Survival of planting stock, after the 1997/98 El Nino summer, in the original FR358/1 planted in 1997, Balmoral Forest.

Introduction

A very dry summer was experienced in North Canterbury during the summer of 1997/98 due to the strong El Nino weather patterns (see **Figure A1**). Given the lack of rain, it was decided that the survival of the planting stock in the Balmoral Forest Boron trial (FR358/1) should be assessed before further plans for the trial were made.

A brief visit to the trial on 14 April, suggested that about 50% of the planting stock had survived based on a walk through the inner plots 1, 13 and 14 (between 2 rip lines). It was decided that a full visual assessment was required in order to determine the fate of the trial and what steps could be taken to re-establish the trial if necessary.

Figure A1: Rainfall data for Balmoral Forest during the 1996/97 and 1997/98 summers.



Methodology

Survival assessment

On 28 April 1998, each individual tree in the inner plots of the trial was visually assessed and scored using the following categories:

A or ✓ = Alive (top had to be alive, death of lower needles not critical)
TD or ○ = 'Alive' but growing tip dead (some of these seedlings might not survive)
D or × = ramet/seedling completely dead

For each plot, the number of individuals in each category was counted and the percentage of alive with alive tops, alive with dead tops and total survival (the sum of all alive individuals) was calculated as a percentage of the total number of individuals present in each inner plot. It was assumed that the mortality observed in the inner plots would be reflected in the outer plot areas.

Seedling measurement and biomassing

From the planting stock, 5 individuals from each genotype were selected for measurement and destructive sampling. The shoot length and root collar diameter of each individual was measured and then divided into shoots and roots at the root collar. The roots were thoroughly washed and dried with hand towels. The shoots and roots were bulked by family/clone, put in paper bags and oven dried. The shoot samples were then further divided into stem and needles. The dry weight of each sample was taken and then the samples were sent away for chemical analysis.

Statistics

SAS GLM was used to identify if boron addition, blocking (based on 'stoniness') or genotype had affected dead tops and overall survival. The data tested were:

i) plot means,
ii) plot means for genotype, and
iii) plot means of seedling versus clone.

Duncans Multiple Range Test was used to identify significant differences between means at a confidence level of p=0.05.

Results and Discussion

It was observed that the location of the dead trees was extremely variable within the plots. Dead trees may be spread evenly, particularly in those plots where mortality was lower, but in many cases patches of trees had died including entire rows.

Across the inner plots of the entire trial, total survival (based on all live trees) averaged 50% (**Table A1**). Survival per plot ranged from 20 to 79 %.

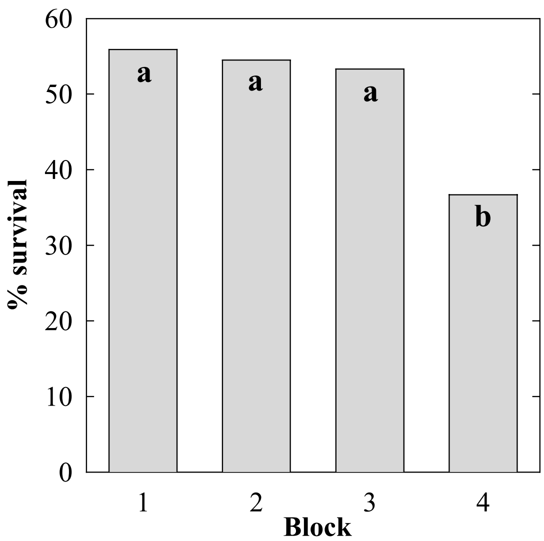
Table A1: Grand means and range of % of alive individuals and total survival after the 1997/98 summer at Balmoral Forest.

	Alive	Alive (tops dead)	Total survival
	---------- % ----------		
Mean	**43.5**	**6.7**	**50.2**
Max	74.1	25.9	79.0
Min	14.8	0.0	20.3

Boron addition did not have a significant effect on survival. This result could be expected given that:

1) the fertiliser was applied in November 1997,
2) the planting material was small and unlikely to have taken up much of the applied B,
3) the dry summer dramatically reduced soil moisture and therefore B supply from the soil, and
4) individual growth rates would have been comparatively low.

Figure A2: % of individuals that survived in each block in 1997 FR358/1 trial, Balmoral



Block had a significant effect on the number of live individuals with tops, (p=0.010) and total survival of the individuals (p=0.011). In both cases, the values were significantly less (p>0.05) in Block 4 as shown in the **Figure A2** for total survival. Block 4 included the stoniest plots in the trial. These plots were likely to be the most freely draining having lower soil moisture content and making plant survival in a drought more difficult. No difference could be picked up between Blocks 1 to 3 in terms of survival.

The type of planting stock had a highly significant effect (p<0.001) on survival (**Figure 3**). The 5 FCF genotypes had survival rates of 29 to 59% while the 3 CHH genotypes had survival rates of 52 to 60%.

The genotypes varied in their size at planting (**Figure A4**). The CHH material was shorter, on average, than the FCF material because it had been topped prior to lifting. There was little difference in the root collar diameters.

There was a large range in total dry weight and the weight of the 3 components (needle, stem and roots) between the genotypes (**Figure A5**). On average, the CHH material was lighter; particularly A and C, while 107 and 130 were the largest of the FCF material mainly due to higher stem weights.

Because of the dry summer and the Nor'west winds it was hypothesised that the larger the planting stock, the lower its chances of survival. While this relationship may have been valid for the CHH genotypes (the heaviest seedling, B, had the poorest survival), it was not for the FCF genotypes (**Figure A6**). It is not known what other factors were affecting the survival of the FCF genotypes particularly 111.

Figure A3: Percentage survival of each genotype, 1997 planting of FR358/1, Balmoral Forest.

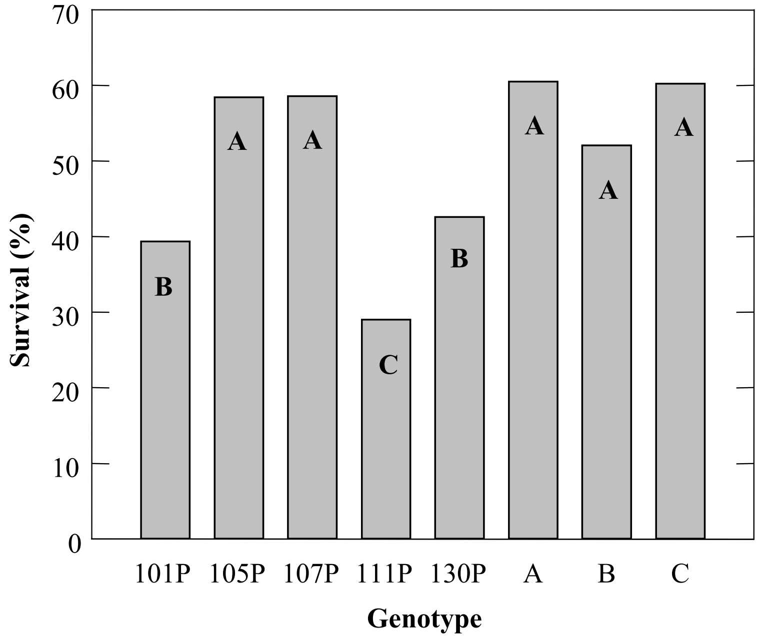


Figure A4: Initial shoot heights and root collar diameters of the genotypes planted in FR358/1, Balmoral Forest, in 1997.

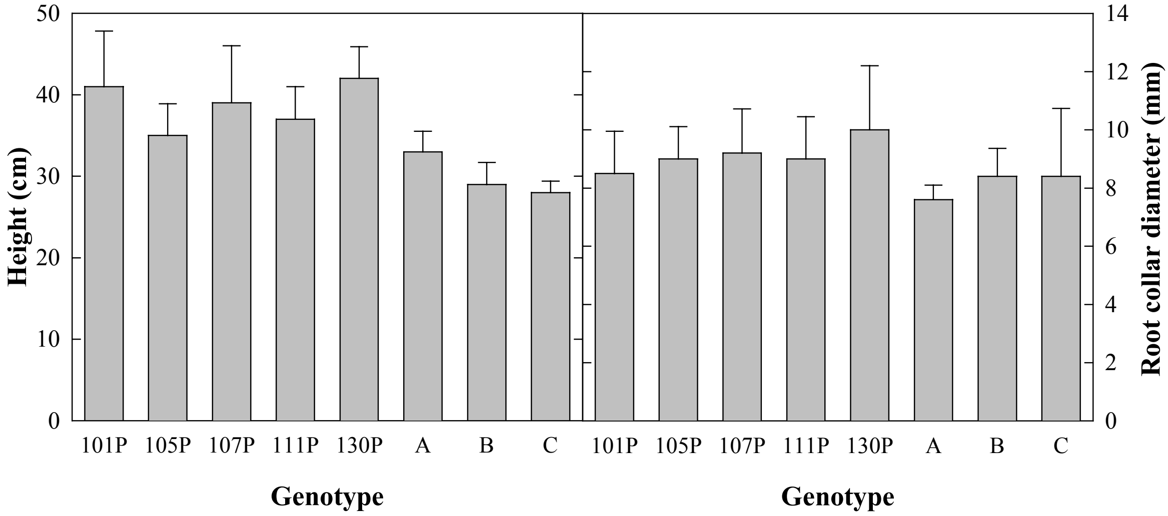


Figure A5: Dry weight of components (root, stem and needles) for each radiata genotype planted in 1997, FR358/1, Balmoral Forest.

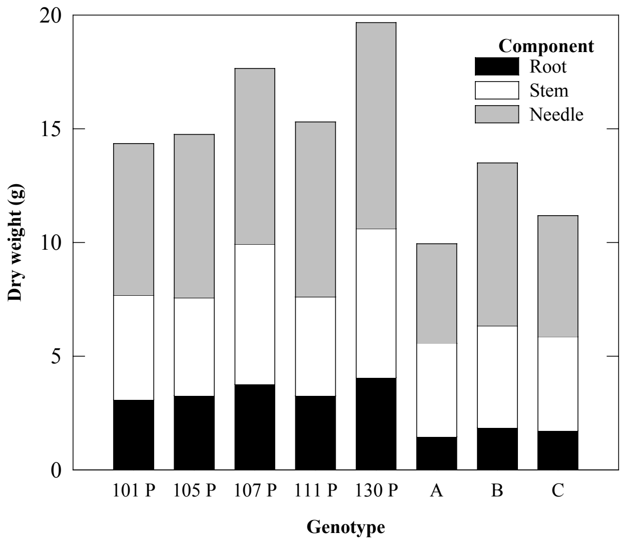
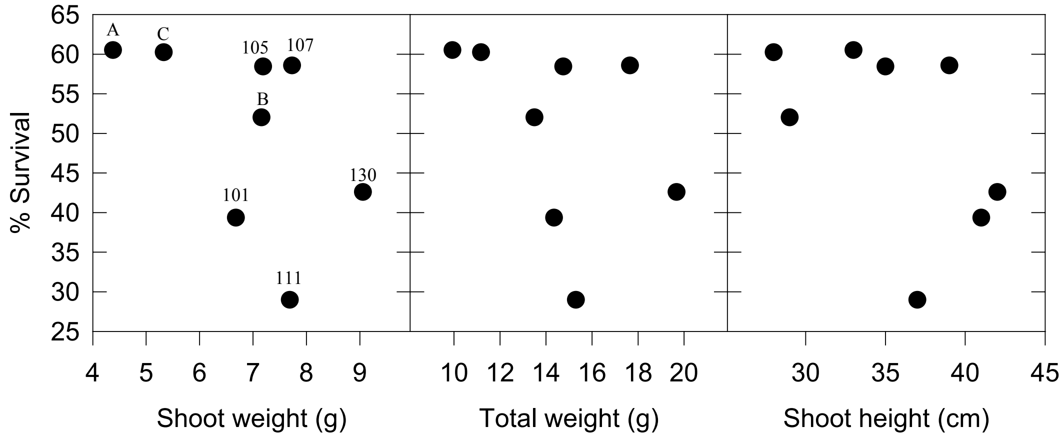


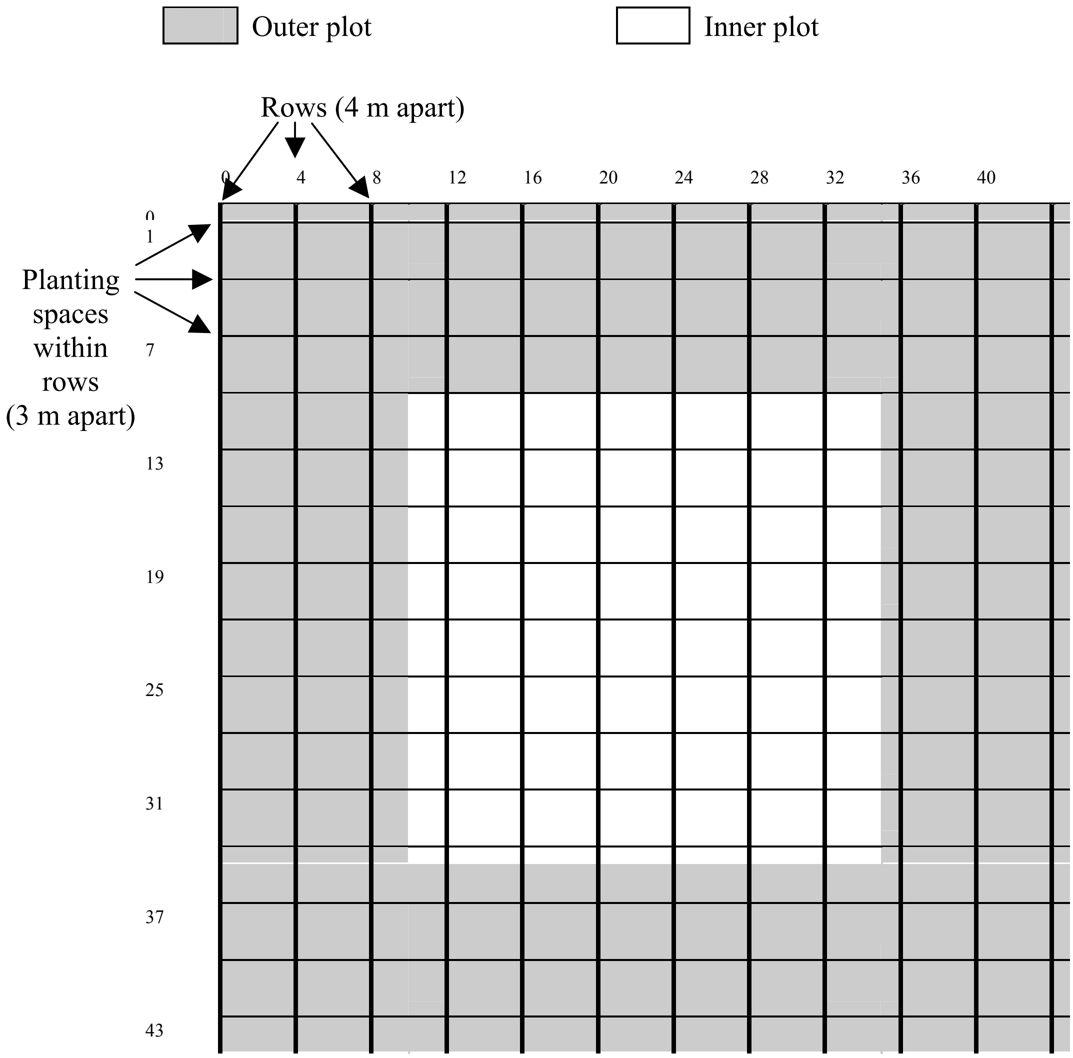
Figure A6: Relationships between survival of the genotypes and a) shoot dry weight, b) total dry weight and c) shoot height.



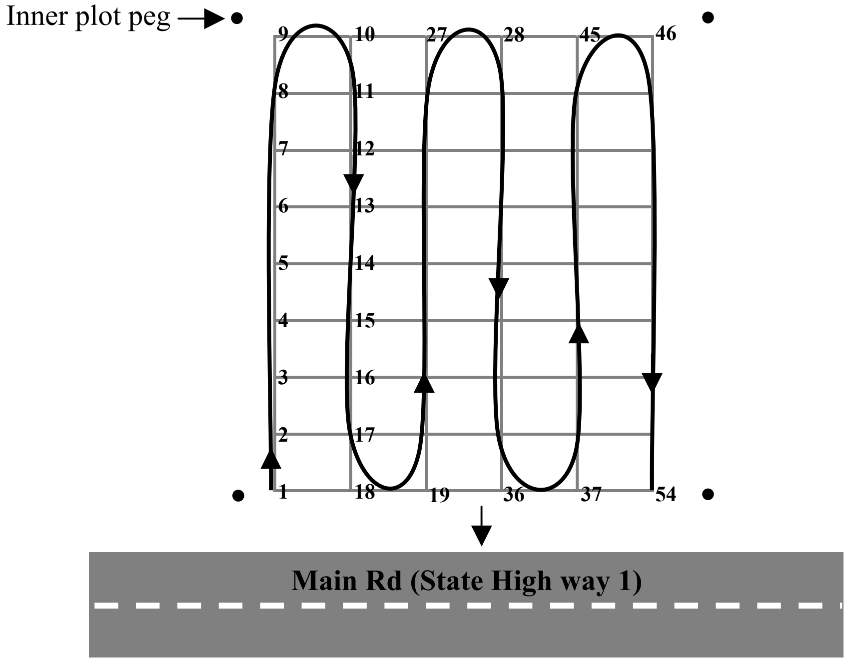
Conclusion

Poor survival in the original planting of this trial was attributed to two factors: late planting and a very dry summer. It is not possible to compare the relative significance of these two factors except that the dry summer was believed to be the most crucial one. As a result of the poor survival of the planting stock, the inner plots of this trial were replanted in 1998 and the outer plots blanked.

Appendix 2: Layout of planting in the inner and outer plots of FR358/1, Balmoral Forest.



Appendix 3: Example of numbering of trees in the inner plot of FR358/1, Balmoral Forest.



Appendix 4: Plot summary initial survival and height and diameter measurements from the 1998 planting of FR358/1, Balmoral Forest.

Plot	Total planted	No. measured	Survival %	Height (cm) Mean	Height (cm) Min	Height (cm) Max	Root Collar Diam. (mm) Mean	Root Collar Diam. (mm) Min	Root Collar Diam. (mm) Max
1	63	55	87	**24**	13	42	**6.8**	4.4	14.5
2	63	53	84	**21**	11	33	**6.3**	3.2	11.7
3	63	60	95	**29**	18	43	**6.3**	3.6	15.5
4	63	58	92	**31**	20	52	**6.6**	3.5	17.1
5	54	50	93	**24**	12	36	**5.8**	3.5	10.6
6	54	52	96	**26**	16	37	**6.9**	4.3	10.7
7	54	50	93	**25**	13	36	**6.8**	4.4	11.7
8	54	50	93	**26**	14	40	**7.0**	3.9	13.2
9	54	52	96	**25**	14	35	**6.5**	3.5	9.8
10	54	49	91	**25**	14	38	**5.9**	3.0	10.8
11	62	56	90	**28**	15	41	**6.7**	3.6	12.9
12	62	60	97	**23**	9	38	**6.5**	4.3	12.9
13	62	62	100	**25**	14	40	**6.3**	2.0	12.0
14	63	63	100	**26**	14	40	**6.5**	4.0	12.0
15	63	62	98	**25**	13	36	**6.5**	4.0	13.0
16	63	60	95	**26**	11	41	**6.0**	3.0	10.0
17	63	59	94	**23**	10	42	**6.2**	3.0	11.0
18	63	61	97	**26**	14	40	**6.5**	4.0	14.0
19	54	52	96	**23**	13	40	**6.3**	4.0	12.0
20	54	53	98	**29**	13	44	**7.1**	4.0	12.0
21	54	47	87	**29**	15	42	**6.6**	4.0	14.0
22	54	51	94	**23**	11	52	**6.4**	3.0	14.0
23	63	57	90	**28**	6	44	**6.8**	4.0	12.0
24	63	60	95	**27**	14	38	**6.3**	3.0	12.0
25	63	60	95	**25**	9	37	**6.4**	4.0	13.0
26	63	61	97	**26**	15	46	**6.9**	5.0	12.5
27	63	61	97	**23**	14	45	**6.8**	3.6	14.0
28	63	62	98	**27**	11	42	**7.6**	3.4	15.0
29	63	62	98	**25**	13	36	**7.0**	3.6	13.6
30	63	57	90	**28**	12	44	**7.8**	4.0	17.0
31	63	61	97	**26**	14	42	**6.6**	4.0	13.0
32	63	60	95	**29**	19	44	**7.1**	4.0	16.0
33	63	63	100	**26**	13	40	**6.4**	3.0	11.0
34	64	62	97	**25**	10	39	**6.3**	4.0	11.0
35	54	51	94	**25**	10	37	**6.3**	4.0	10.0
36	54	50	93	**26**	12	41	**6.6**	4.0	11.0
37	54	53	98	**25**	4	37	**6.4**	3.0	14.0
38	45	43	96	**30**	17	44	**6.9**	4.0	15.0
39	54	51	94	**27**	13	39	**7.3**	4.0	17.0
40	54	54	100	**25**	17	41	**6.6**	3.5	11.5
41	62	59	95	**25**	13	40	**7.1**	4.0	13.5
42	54	53	98	**25**	11	41	**6.3**	4.0	10.0
43	54	54	100	**28**	12	40	**7.6**	4.3	15.6
44	54	52	96	**28**	17	40	**7.5**	4.4	16.3
Mean	**59**	**56**	**95**	**26**	**13**	**41**	**6.7**	**3.8**	**12.9**
Max	64	63	100	31	20	52	7.8	5.0	17.1
Min	45	43	84	21	4	33	5.8	2.0	9.8

Appendix 5: Percentage of inner plot material in each survival category in FR358/1, Balmoral Forest.

Trt	Plot	Blk	B	WC	Nit	Dead	OK	Good	Trt	Plot	Blk	B	WC	Nit	Dead	OK	Good
1	31	2	0	No	No	7.9	55.6	36.5	**7**	42	3	4	Yes	No	9.3	22.2	68.5
1	43	1	0	No	No	11.1	18.5	70.4	**7**	39	1	4	Yes	No	16.7	44.4	38.9
1	32	3	0	No	No	15.9	55.6	28.6	**7**	7	2	4	Yes	No	24.1	44.4	31.5
1	13	4	0	No	No	**33.9**	41.9	24.2	**7**	28	4	4	Yes	No	**25.4**	44.4	30.2
2	33	3	4	No	No	12.7	68.3	19.0	**8**	34	4	8	Yes	No	21.9	56.3	21.9
2	22	1	4	No	No	14.8	16.7	68.5	**8**	18	2	8	Yes	No	22.2	46.0	31.7
2	25	2	4	No	No	**27.0**	52.4	20.6	**8**	17	3	8	Yes	No	**25.4**	55.6	19.0
2	4	4	4	No	No	**33.3**	52.4	14.3	**8**	2	1	8	Yes	No	**46.0**	25.4	28.6
3	41	3	8	No	No	8.1	30.6	61.3	**9**	44	1	16	Yes	No	11.1	31.5	57.4
3	30	4	8	No	No	**27.0**	54.0	19.0	**9**	29	4	16	Yes	No	14.3	60.3	25.4
3	12	2	8	No	No	**29.0**	48.4	22.6	**9**	5	3	16	Yes	No	22.2	72.2	5.6
3	1	1	8	No	No	**66.7**	22.2	11.1	**9**	6	2	16	Yes	No	22.2	57.4	20.4
4	19	1	16	No	No	22.2	63.0	14.8	**10**	9	1	32	Yes	No	**27.8**	61.1	11.1
4	36	2	16	No	No	22.2	35.2	42.6	**10**	14	4	32	Yes	No	**36.5**	58.7	4.8
4	38	4	16	No	No	22.2	24.4	53.3	**10**	23	2	32	Yes	No	**39.7**	52.4	7.9
4	3	3	16	No	No	**33.3**	52.4	14.3	**10**	21	3	32	Yes	No	**40.7**	42.6	16.7
5	40	2	32	No	No	13.0	42.6	44.4	**11**	8	1	16	Yes	Yes	**44.4**	40.7	14.8
5	35	3	32	No	No	**31.5**	37.0	31.5	**11**	26	4	16	Yes	Yes	**52.4**	39.7	7.9
5	37	1	32	No	No	**31.5**	44.4	24.1	**11**	16	2	16	Yes	Yes	**54.0**	27.0	19.0
5	11	4	32	No	No	**38.7**	53.2	8.1	**11**	10	3	16	Yes	Yes	**61.1**	18.5	20.4
6	20	1	0	Yes	No	14.8	40.7	44.4									
6	27	2	0	Yes	No	22.2	49.2	28.6									
6	15	3	0	Yes	No	23.8	41.3	34.9									
6	24	4	0	Yes	No	**28.6**	50.8	20.6									

Mortality rates (i.e. 'Dead') above 25% have been bolded. Those treatments that have been badly affected (i.e., have more than 1 plot with mortality above 25%) have been shaded.

Appendix 6: Results from the assessment of stoniness in the inner plots of FR358/1, Balmoral Forest, and the resulting block number allocation.

Plot	Stoniness rating*				Block
	No	Slightly	Moderately	Very	Number#
1	90	0	10	0	1
2	75	15	10	0	1
3	0	50	25	25	3
4	15	10	65	10	4
5	25	0	65	10	3
6	25	50	15	10	2
7	25	55	10	10	2
8	50	40	10	0	1
9	50	40	10	0	1
10	40	10	40	10	3
11	0	25	50	25	4
12	65	10	25	0	2
13	25	0	50	25	4
14	25	0	65	10	4
15	40	10	25	25	3
16	50	0	50	0	2
17	50	0	40	10	3
18	25	40	25	10	2
19	65	25	10	0	1
20	90	10	0	0	1
21	40	0	50	10	3
22	75	25	0	0	1
23	25	65	10	0	2
24	0	25	50	25	4
25	50	25	15	10	2
26	0	25	50	25	4
27	50	40	10	0	2
28	0	0	75	25	4
29	25	0	50	25	4
30	25	0	50	25	4
31	65	25	0	10	2
32	0	75	0	25	3
33	25	50	0	25	3
34	15	0	75	10	4
35	25	50	0	25	3
36	40	50	0	10	2
37	50	50	0	0	1
38	0	50	0	50	4
39	75	25	0	0	1
40	25	50	25	0	2
41	0	75	0	25	3
42	0	75	0	25	3
43	75	25	0	0	1
44	90	10	0	0	1

* Percentage of each inner plot in each stoniness rating.
# The least stony plots were allocated to Block 1 while the stoniest went to Block 4.

Appendix 7: Fertiliser requirements for FR358/1, Balmoral Forest

Fertiliser required for each treatment in the B trial series.

Fertiliser rate	No. plots	Total area (ha)	Ulexite required†	Nitrophoska required‡
0 kg B/ha	8	1.62	-	-
4 kg B/ha	8	1.62	65	
8 kg B/ha	8	1.62	130	-
16 kg B/ha	8	1.62	261	-
32 kg B/ha	8	1.62	522	
Nitrophoska + 16 kg B/ha	4	0.81	130	810 kg
		Total:	1108 kg	810 kg

† Based on using Boronat which is 9.94% B[7].

‡ Based on using Nitrophoska Blue TE (5% P) and applying at 50 kg P/ha.

Fertiliser requirement per plot in the B trial series.

Fertiliser rate	Trtmt no's	Area (ha)	Element required/plot	Ulexite required	Nitrophoska required
0 kg B/ha	1, 6	0.2025	-	0 kg	-
4 kg B/ha	2, 7	0.2025	0.81 kg B	8.15 kg	
8 kg B/ha	3, 8	0.2025	1.62 kg B	16.30 kg	-
16 kg B/ha	4, 9	0.2025	3.24 kg B	32.60 kg	-
32 kg B/ha	5, 10	0.2025	6.48 kg B	65.21 kg	
Nitrophoska + 16 kg B/ha	11	0.2025	10.13 kg P + 3.24 kg B	- 32.60 kg	202.6 kg

[7] MW of B_2O_3= 69.617 g. %B in B_2O_3 = 0.311. 100 kg of Boronat Ulexite = 32 kg B_2O_3 and 9.94 kg B. Boronat = 9.94 %B.

Appendix 8: Allocation of treatments to plots.

Plot	Block	Trt no.	B	WC	Nitro
1	1	3	8	No	-
2	1	8	8	Yes	-
3	3	4	16	No	-
4	4	2	4	No	-
5	3	9	16	Yes	-
6	2	9	16	Yes	-
7	2	7	4	Yes	-
8	1	11	16	Yes	Yes
9	1	10	32	Yes	-
10	3	11	16	Yes	Yes
11	4	5	32	No	-
12	2	3	8	No	-
13	4	1	0	No	-
14	4	10	32	Yes	-
15	3	6	0	Yes	-
16	2	11	16	Yes	Yes
17	3	8	8	Yes	-
18	2	8	8	Yes	-
19	1	4	16	No	-
20	1	6	0	Yes	-
21	3	10	32	Yes	-
22	1	2	4	No	-
23	2	10	32	Yes	-
24	4	6	0	Yes	-
25	2	2	4	No	-
26	4	11	16	Yes	Yes
27	2	6	0	Yes	-
28	4	7	4	Yes	-
29	4	9	16	Yes	-
30	4	3	8	No	-
31	2	1	0	No	-
32	3	1	0	No	-
33	3	2	4	No	-
34	4	8	8	Yes	-
35	3	5	32	No	-
36	2	4	16	No	-
37	1	5	32	No	-
38	4	4	16	No	-
39	1	7	4	Yes	-
40	2	5	32	No	-
41	3	3	8	No	-
42	3	7	4	Yes	-
43	1	1	0	No	-
44	1	9	16	Yes	-