PACKAGING AND COOL-STORAGE EFFECTS ON GROWTH OF CUPRESSUS MACROCARPA SEEDLINGS

JOHN M. BALNEAVES
Ministry of Forestry, Forest Research Institute,
P.O. Box 31-011, Christchurch, New Zealand

(Received for publication 2 December 1987; revision 14 June 1988)

ABSTRACT

Root growth capacity, shoot height, and diameter growth of **Cupressus macrocarpa** Hartweg seedlings were reduced by 48 hours or more of cool-storage, regardless of type of packaging. However, seedlings packaged horizontally in either a wax-impregnated kraft cardboard box with polythene liner (DL-55 planting box) or a 4-ply gusseted kraft paper bag with polythene liner (Capcote bag) produced greater height growth in the year after planting than those seedlings packaged vertically in the conventional manner.

Correlations between root growth capacity and final height and diameter were significant. However, there was not the same strong relationship with growth increment.

Keywords: cool storage; packaging systems; root growth capacity; **Cupressus macrocarpa.**

INTRODUCTION

The establishment of woodlots of *Cupressus macrocarpa* has attracted considerable interest in recent years in New Zealand. However, establishment has not always been successful because of failure to select suitable sites, poor quality of seedlings supplied by many nurseries, inadequate site preparation and post-planting weed control, and failure to ensure adequate care during the lifting, handling, and planting out of nursery stock.

A small trial, looking at how root exposure after lifting affected seedling water deficit and subsequent root growth capacity (RGC) (Balneaves 1987), suggested that *C. macrocarpa* seedlings were not as sensitive as *Pinus radiata* D. Don to mishandling during lifting and replanting.

This paper reports on another trial set up to evaluate three types of packaging systems and the effects of cool-storage on seedling vigour as measured by RGC and shoot growth after planting.

METHOD

Three packaging systems × four cool-storage periods were evaluated. Packaging systems were:

(1) Conventional package – wax-impregnated kraft cardboard box, 70 × 60 × 30 cm. Seedlings were lifted carefully (some soil and mycorrhizas being left on the roots)

and their roots dipped in water before they were packed on the bed, vertically in plastic bags (50 seedlings/bag; 6 bags/kraft box).

(2) DL-55 planting box* – wax-impregnated kraft cardboard box, 55 × 35 × 22 cm, with the addition of a polythene inner liner. Seedlings were lifted and their roots dipped in water before they were packed on the bed, horizontally (100 seedlings/box). The polythene liner was folded over to envelop the root system and lower portion of the stem.

(3) Capcote bag† – 4-ply gusseted kraft paper bag, 55 × 100 cm, with a polythene film inner lining. Seedlings were lifted and their roots dipped in water before they were packed on the bed, horizontally into the bag (200 seedlings/bag). The bag was folded over at the top and stapled.

Storage treatments consisted of set periods: 0 hours (lift and plant immediately), 48 hours, 1 week, and 2 weeks, in a cool store at +2°C with a relative humidity of 85%. In all, 12 treatments (four storage periods × three packaging systems) were evaluated.

Tree Seedling Material

1/0 seedlings were raised in the FRI Rangiora Nursery at a spacing of 12.5 cm between drills, and then hand-thinned to 10 cm spacing between seedlings within each drill. In late February, seedlings were undercut at a depth of 10 cm and conditioned by a combination of conventional undercutting and wrenching, lateral root pruning, and hand box-pruning. The final nursery bed treatment was box pruning so that root trimming was unnecessary at lifting. Seedling specification was set at a shoot length of 30–35 cm, a root collar diameter of 6 mm or greater, and a root system with a maximum depth of 10 cm and a maximum radial length of 5 cm. Seedlings not reaching these criteria were culled. Most root systems were compact and fibrous, with abundant root initials.

Thirty seedlings/treatment were used for RGC determination and 80 seedlings/treatment were used for field testing. A further 45 seedlings/treatment were destructively sampled and oven dried at 80°C for 48 hours to determine oven dry weight of roots and shoots (ODW).

Root Growth Capacity (RGC)

Root growth capacity is a measure of the ability of a tree seedling to initiate and elongate roots when placed into an environment favourable for root growth, and has proven a reliable predictor of field performance after planting (Ritchie 1985). In this trial, root growth was assessed by the displacement technique (Burdett 1979). Initial root volumes were measured after storage treatments, and seedlings were then placed with their roots in an aerated water bath maintained at 19°C ± 1°C for 3 weeks

* UEB Industries Ltd. DL-55 planting boxes have been superseded by DL-1350 L "Aquapruf" planting boxes (Fibre Container Branch, P.O. Box 59-012, Mangere Bridge, Auckland). Double-skin fluted high-density polythene planting boxes (Addington Engineering (Plastics) Co. Ltd, P.O. Box 4289, Postal Centre, Christchurch) are of the same design as the DL-55 box. Results of this trial would be relevant to both these new products.

† Manufactured by NZ Forest Products Ltd, Private Bag, Penrose.

before root volumes were remeasured. The gain in root volume was used as a measure of RGC.

The water baths were placed in a glasshouse. Air temperature was maintained at 21°C for 16 hours and 12°C for 8 hours in each 24-hour period. Relative humidity was maintained at 60% and incandescent lighting was used to give a controlled photoperiod length of 16 hours.

In addition to the treatments already listed, an extension of cool-storage periods to 4 and 6 weeks was made for those seedlings packaged in the Capcote bags to see what effect, if any, longer cool-storage periods would have on RGC.

Field Trial

Eighty seedlings (five replications of 16 trees) were planted out, direct from the cool store, on a cultivated site adjacent to the nursery. The site was well-sheltered and had heavy loamy soil (Wakanui silt loam) which was very wet during winter/early spring but dried out rapidly during the late spring and remained that way for the duration of the trial.

Planting was at 0.5 × 0.5 m spacing by using spade and the "positive pull up" technique (Trewin & Cullen 1985). The seedlings were kept weed-free for the 12 months of the trial.

Measurements of seedling heights and diameters were made 7 days and 12 months after planting.

Analysis of Data

Two-way analyses of variance, including packaging systems and storage times, were used to test for difference in root growth capacity and field growth, where the variates were diameter increment, final diameter, height increment, and final height. The LSD test was used to compare means and is indicated as a letter on the Figures. Means and 95% confidence limits are also shown.

RESULTS

Root Growth Capacity

Seedling RGC did not vary significantly between the three packaging systems (Fig. 1). Cool storage for longer than 48 hours significantly reduced RGC ($p \leq 0.001$) with a substantial decline after 1 week's storage. However, longer cool-storage periods in Capcote bags caused no further reductions in RGC (Fig. 2).

In an earlier trial with *Pinus radiata* it was noted that seedling root collar diameter was correlated with RGC (Balneaves & Fredric 1983). This study showed that RGC was more strongly correlated with root collar diameter and ODW of both shoots and roots than with stem height (Table 1); seedlings with greater root collar diameters and root/shoot ODW also had greater RGC.

Field Trial

Increased length of cool-storage slightly reduced survival (Table 2), but not significantly. No packaging system was better than any other.

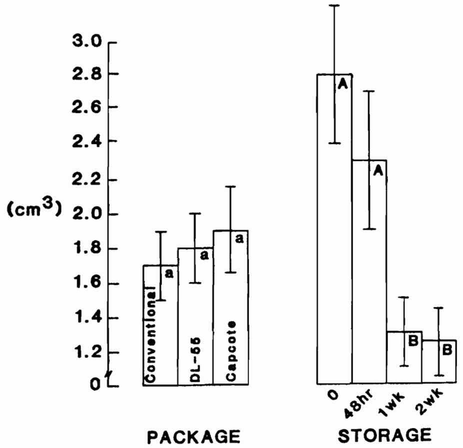

FIG. 1—Mean root growth capacity ($\pm$95% confidence intervals) at 19°C for 3 weeks (cm^3/seedling) after packaging and cool-storage.

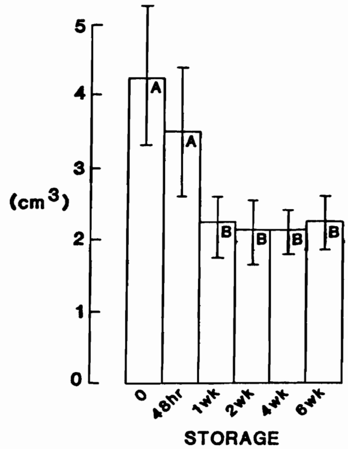

FIG. 2—Mean root growth capacity (cm^3 / 3 weeks / seedling) ($\pm$95% confidence intervals) of **C. macrocarpa** seedlings stored in Capcote bags for 0 and 48 hours, and 1, 2, 4, and 6 weeks.

TABLE 1–Correlations of root growth capacity with root collar diameter, plant height, and oven-dry weight of roots and shoots

Time	Diameter		Height		ODW Roots		ODW Shoots	
0 hour	0.27	**	0.20	NS	0.23	*	0.29	***
48 hours	0.34	***	0.21	*	0.34	**	0.38	***
1 week	0.17	NS	0.28	**	0.18	NS	0.09	NS
2 weeks	0.23	*	–0.02	NS	0.26	*	0.21	*

* significant at 0.05 level
** significant at 0.01 level
*** significant at 0.001 level

TABLE 2–Percentage survival of seedlings by package type and cool-storage period

Package	Cool-storage period			
	0 hours	48 hours	1 week	2 weeks
Conventional	100	100	97	90
DL-55	100	100	100	90
Capcote	100	97	97	93

Conventional packaging yielded the lowest height increment 12 months after planting ($p \leq 0.05$) compared with the DL-55 planting box or the Capcote bag (Fig. 3). This was also reflected in final height ($p \leq 0.05$). Increasing cool-storage period reduced both height increment ($p \leq 0.001$) and final heights ($p \leq 0.001$). A significant loss of growth was noted after 48 hours of cool-storage.

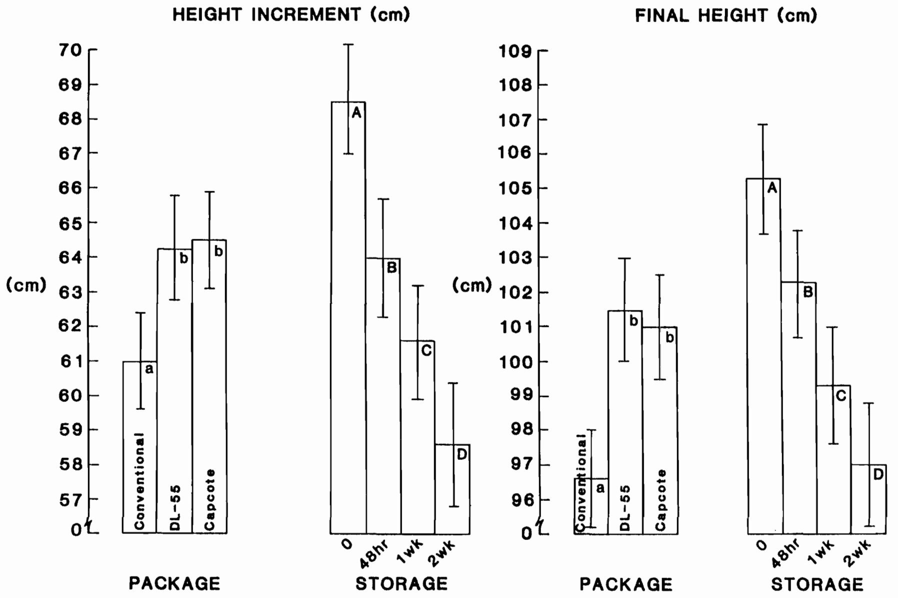

FIG. 3—Effect of packaging and cool-storage on mean seedling height growth (±95% confidence intervals).

Different packaging systems did not affect diameter growth (Fig. 4) but increased duration of cool-storage reduced both final diameter ($p \leq 0.001$) and diameter increment ($p \leq 0.001$).

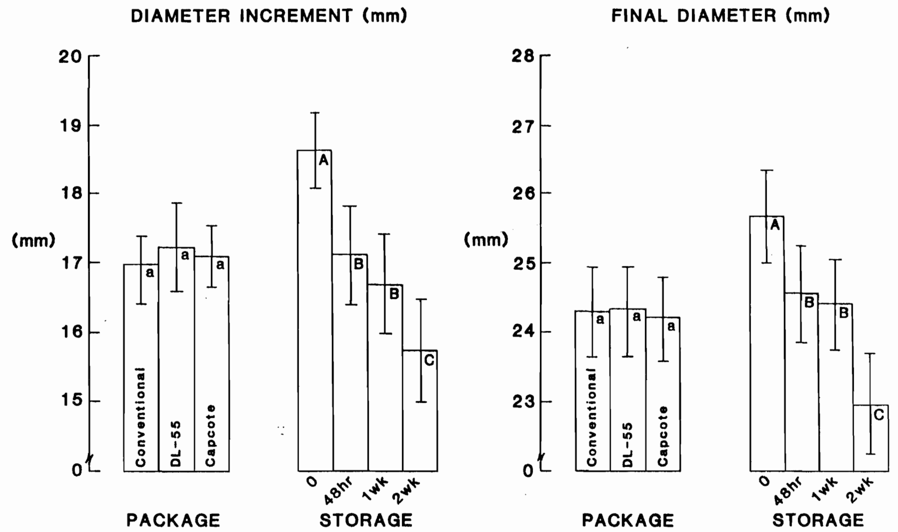

FIG. 4—Effect of packaging and cool-storage on mean seedling diameter growth (±95% confidence intervals).

Correlations with RGC and final height and diameter were significant. However, correlations with RGC and growth increment were not (Table 3). This suggests that RGC may have some value as a parameter for assessment of *C. macrocarpa* planting stock quality. However, more conclusive work needs to be undertaken to demonstrate this.

TABLE 3–Correlations between seedling root growth capacity and measurement of field growth

Mean diameter increment	Mean final diameter	Mean height increment	Mean final height
0.34 NS	0.62 $p \leq 0.05$	0.46 NS	0.61 $p \leq 0.005$

CONCLUSIONS AND DISCUSSION

Earlier experience including a national survey of forestry interests in New Zealand (unpubl. data) indicated that many plantings of *C. macrocarpa* seedlings had either failed completely or were partial failures. In the trial described here, emphasis was placed on producing sturdy tree seedlings and then evaluating packaging and storage effects on them. The planting site was sheltered and consisted of a good loamy soil, total weed control was ensured, and planting quality was of a high standard. Tree handling in the manner described in this paper, although significant, did not have a major impact on growth. Claims by both nursery and forest managers that *C. macrocarpa* seedlings failed as a direct result of poor handling would indicate that packaging and storage treatments, field transport, and handling, were indeed very poor. This trial demonstrated that

(a) Packaging method did not affect RGC or survival, but did affect growth after planting;

(b) Cool-storage time affected RGC and field growth.

On this basis, therefore, it is recommended in future that seedlings be packaged in DL-55 planting boxes or in Capcote bags. Storage must be less than 48 hours for best results.

Other factors such as good stock quality, correct site selection, good planting practices, and good weed control are essential for successful establishment of *C. macrocarpa* woodlots.

ACKNOWLEDGMENTS

The assistance of Des Weston, Rick Denton, and Brian Cosslett is gratefully acknowledged. Brian Fredric analysed the data. Dr Ian McCracken, Dr Ruth Gadgil, Mr Dudley Franklin, and Mrs Joanna Orwin advised on the presentation of this paper.

REFERENCES

BALNEAVES, J. M. 1987: Root growth capacity of **Cupressus macrocarpa** and **Pinus radiata** seedlings. **New Zealand Forestry 32(2):** 24–5.

BALNEAVES, J. M.; FREDRIC, B. J. 1983: Effect of precision sowing on grade output of 1/0 **Pinus radiata** seedlings – Edendale Nursery. **New Zealand Journal of Forestry 29(1):** 100–12.

BURDETT, A. N. 1979: A non-destructive method of measuring the volume of intact plant parts. **Canadian Journal of Forest Research 9:** 120–2.

RITCHIE, G. A. 1985: Root growth potential: principles, procedures and predictive ability. Pp. 93–106 **in** Duryea, M. L. (Ed.) "Proceedings, Evaluating Seedling Quality: Principles, Procedures and Predictive Abilities of Major Tests." Forest Research Laboratory, Oregon State University, Corvallis.

TREWIN, A. R. D.; CULLEN, A. W. J. 1985: A fully integrated system for planting bare-root seedlings of radiata pine in New Zealand. Pp. 524–48 **in** D. B. South (Ed.) "Proceedings of the International Symposium on Nursery Management Practices for the Southern Pines." Montgomery, Alabama, August 1985.