Root Pruning Can Influence First Order Lateral Root Development of Containerised Plants

Warrick R. Nelson
Transplant Systems Limited, P.O. Box 29074, Christchurch

There is a strong positive correlation between the number of first order lateral roots (FOLR) of a tree seedling and its rate of growth after planting. This number is under genetic control, but can also be optimised or reduced by characteristics of the seedling tray. The choice of container to be used for seedling propagation is, therefore, one means of enhancing the chances of plantation success, in this instance by choosing a container likely to result in seedlings with a higher number of FOLR. Two seedling trays currently used for plantation seedling propagation in Australia were tested and the number of first order lateral roots (FOLR) counted. The number of FOLR was significantly different. The tray with a greater lateral root pruning effect produced the higher number of FOLR. A second trial comparing copper root pruning and no pruning confirmed that lateral root-pruning increases the number of FOLR of containerised seedlings. These trials confirm that FOLR initiation can be influenced by nursery practices and that lateral root pruning, by air or chemical means, is one way of increasing the number of FOLR.

INTRODUCTION

A greater number of first order lateral roots (FOLR) at planting out is positively correlated with improved survival and growth in a wide range of woody perennials (Fig. 1) (Whitcomb, 1988; Schultz and Thompson, 1990; Kormanik et al., 1994; Kormanik et al., 1995). These lateral roots form the basic framework of the developing root system (Nambiar et al., 1979) which is responsible for the plant's mechanical stability (Burdett, 1978).

Control over the number of FOLR developing in a seedling is under strong, but not exclusive, genetic control (Kormanik, 1986, 1988; Kormanik et al., 1989, 1990). Nursery practices, for example reducing seedling density and pruning the tap root at a young stage, can increase the number of FOLR (Barrett, 1981; Whitcomb, 1988; Schultz and Thompson, 1990; Donald, 1992). Auxin treatments can massively increase FOLR numbers (Seaby and Selby, 1990; Simpson, 1990), although these chemically induced lateral roots do not appear to have a similar effect on subsequent plant vigour.

Two trials were conducted to determine the differences in FOLR development of *Pinus radiata* seedlings. Firstly, seedlings were grown in two trays already in use for seedling propagation. The trays differ in side slot exposure and therefore air root-pruning ability. Secondly, the differences between lateral root pruning and nonpruning effects, using copper as the pruning agent, were tested in a smooth-walled tray.

MATERIALS AND METHODS

Two types of trays being used for large-scale plantation tree seedling propagation in Australia were used. These are the Lannen Plantek side slot 121F and the Col-Max model 64. In spite of the substantial differences in cell specifications, these two trays are frequently considered equivalents in the biological plant results obtained from them although no comparison trials have been conducted (Table 1 and Fig. 2).

Pinus radiata seed (Pro Seed, GF10) was direct sown in August 1995 into the cell trays filled with Palm Peat (Horticom, Auckland, New Zealand). After germination, the plants grew in outside conditions in Christchurch, New Zealand. The seedling trays were placed on raised benches to ensure airflow beneath them for good air root pruning. The seedlings were fertilised with Peters Excel 13:5:20 (Grace Sierra, The Netherlands) at 1 g $litre^{-1}$ applied as required until harvesting and assessment in Nov. 1996.

Trial 1. Twenty-four seedlings were harvested from each tray type, chosen at random but excluding the outer rows of each tray. The roots were washed clean of growing medium and then cut back to expose only the taproot and FOLR. These laterals were counted, separated into the group of laterals growing nearest the root collar and tending to grow in a clearly demarcated whorl, and total number of laterals along 20 mm of tap root measured from the topmost lateral (Selby and Seaby, 1982; Seaby and Selby, 1990). Root systems below this 20-mm level tended to become very difficult to separate and distinguish as in many cases this was only just above the air-pruning point at the base of the cells. Data were subjected to analysis of variance and F-test of significance as an exact test (unpaired data).

Trial 2. Seed from the same batch as Trial 1 was sown into a Landmark 512-plug tray. Every alternate row of the tray had been treated with Spin Out™ (Griffin Corporation, Valdosta, USA), a copper-containing paint intended to prune roots as they come in contact with the copper-treated cell walls. Seed was sown in July 1997, then in Jan. 1998 10 seedlings from each treatment were selected at random, excluding the seedlings on the edge rows. Because of the shallow depth of these cells (25 mm), only the first whorl of lateral roots was counted. As before, the data were subjected to analysis of variance and the F-test for significance was applied.

RESULTS AND DISCUSSION

Trial 1. Results from other container systems (Table 2 and Fig. 3) indicate an increased number of FOLR develop at lower plant density, greater container volume, and reduced container depth (Barrett, 1981; Whitcomb, 1988; Donald, 1992). There was clearly a difference between FOLR development in the two trays under study (Fig. 4). These results indicate that some of these factors play a larger role in inducing FOLR development than others. The model 64 tray, in spite of a lower plant density and shallower depth, resulted in fewer FOLR.

Early pruning of the tap root is considered important for increased FOLR initiation (Whitcomb, 1988), while diverting of existing lateral roots downwards by container walls inhibits initiation of further laterals (Halter et al., 1993). It would appear that the degree of lateral root pruning is of greater significance for determining the number of FOLR than earlier tap-root pruning by shallower containers. The amount of flashing covering the slots in the Col-Max container was so great that this trial could almost be regarded as comparing lateral root pruning and no pruning.

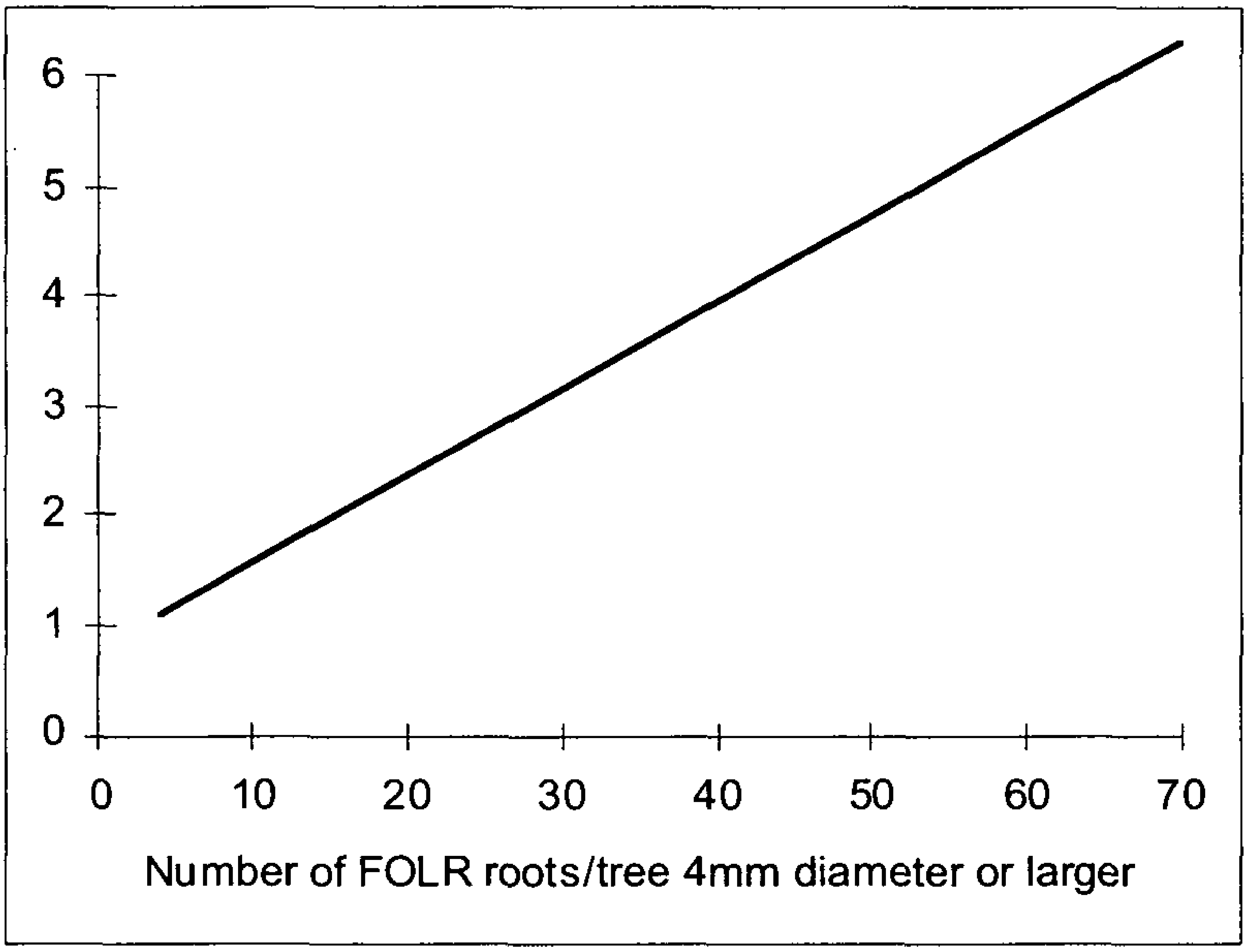

Figure 1. *Stem diameter related to number of FOLRs at time of planting. After* Whitcomb, 1988.

Table 1. Physical dimensions of the seedling trays.

	Lannen 121F	Col-Max 64
Tray dimensions (mm)	385 × 385 × 72	293 × 345 × 55
Cell dimensions (mm)	34 × 34 × 72	34 × 34 × 55
Cells m^{-2}	820	633
Cell volume (ml)	50	63
SA:D ($cm^2\ cm^{-1}$)	1.61	2.10
% of side wall as slot	6.8	1.3 to 5.2*

* Cells varied enormously as to how many and to what degree any of the slots were open. The outer edge of the outer row of each cell has no slots, but many of the internal cells showed no slots either.

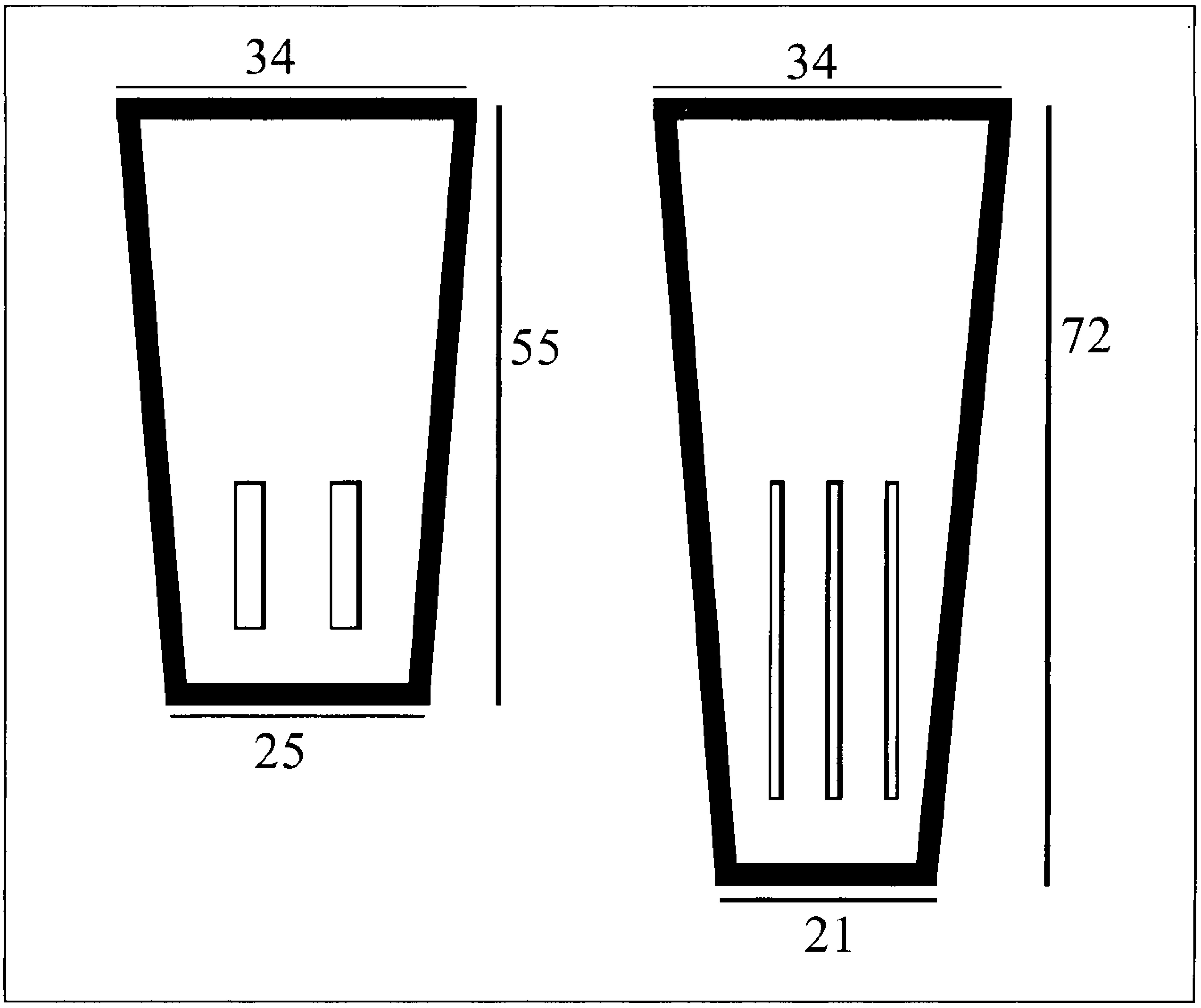

Figure 2. Detail of the sides of the cells showing size and position of the side slots. Measurements in millimetres. Col-Max 64 on the left, Lannen 121f on the right.

Table 2. Summarised results of FOLR numbers reported elsewhere.

Author, species	Cell volume (ml)	Cells/m^2	FOLR
Barrett, 1981 (*Acacia mearnsii*)	36	550	6.35
	22	860	5.50
	35	1280	4.40
Donald, 1992 (*Pinus radiata*)	36	550	5.70
	66	421	6.87
	80	310	6.80

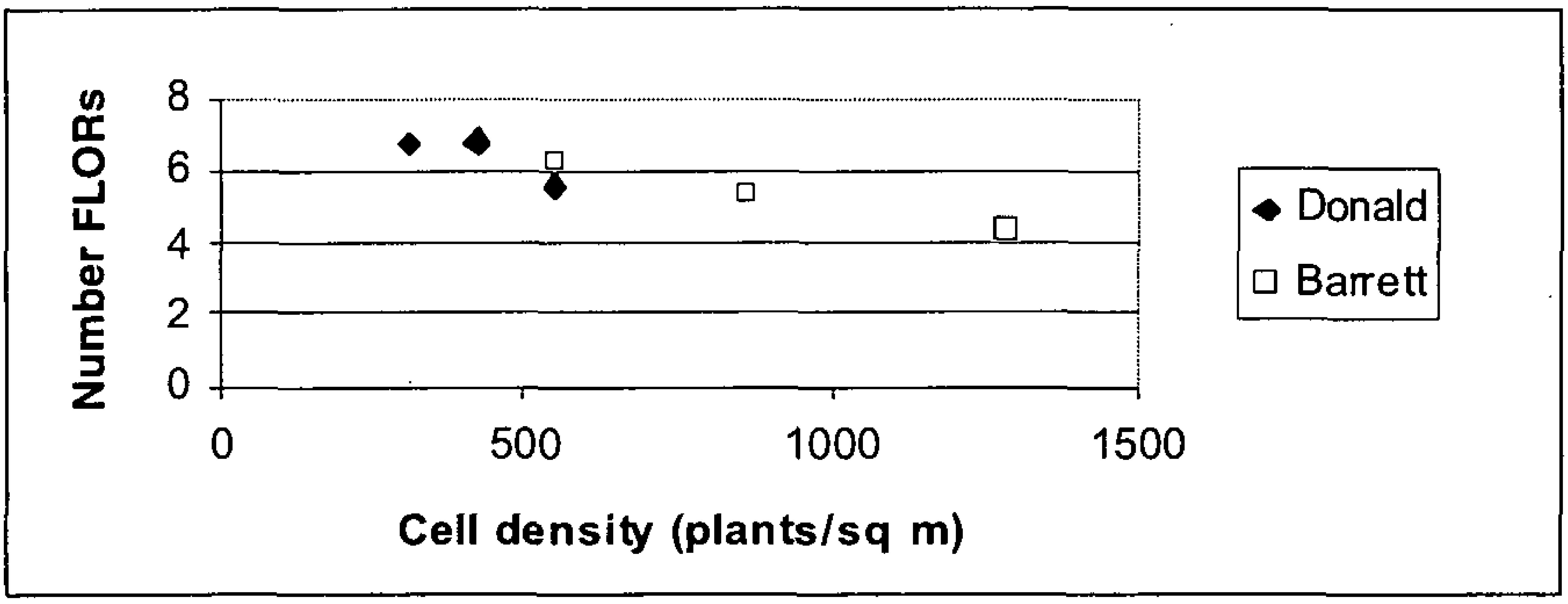

Figure 3. Relationship between cell density and FOLR numbers of containerised seedlings. Figures of Barrett, 1981 and Donald, 1992

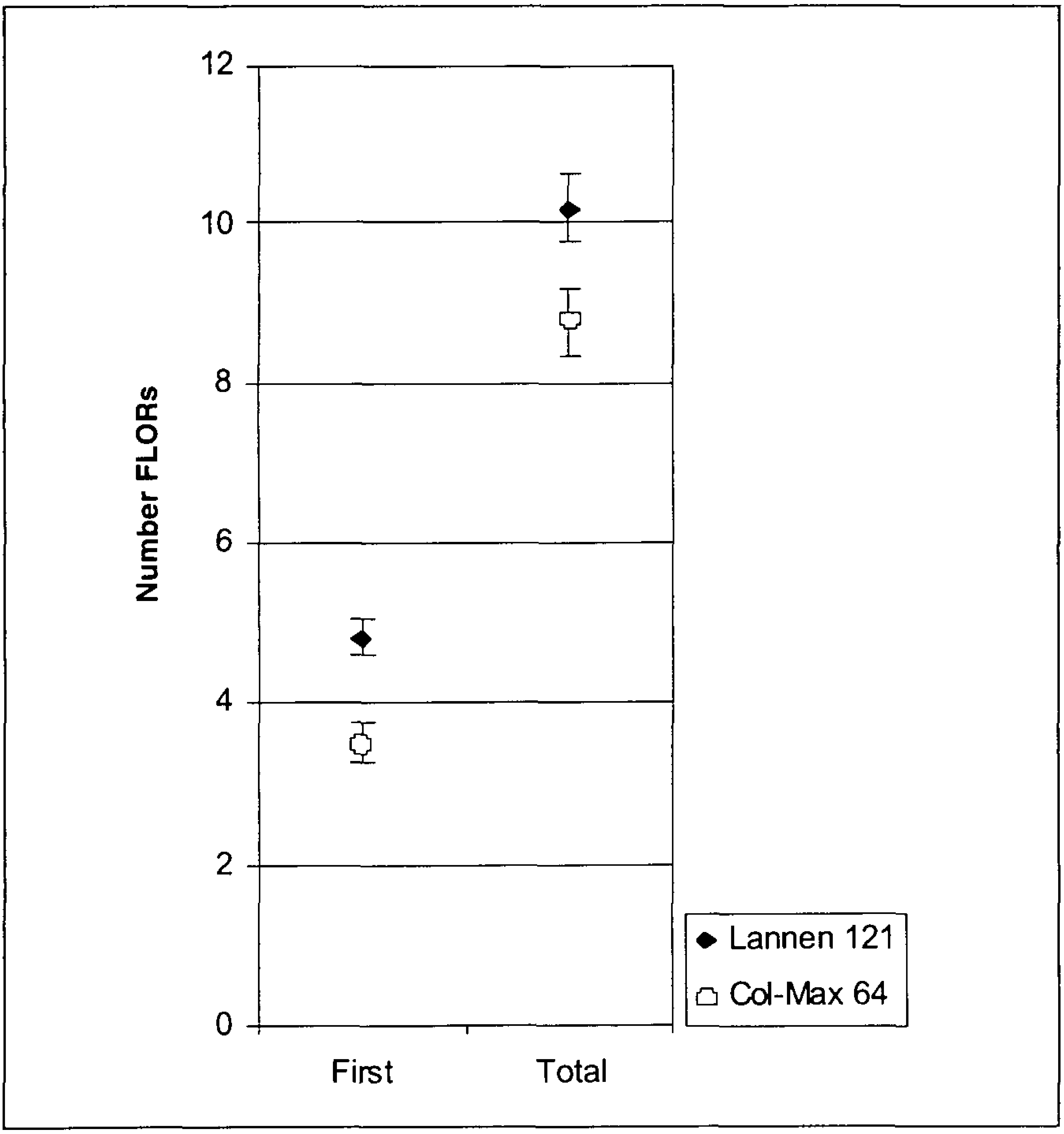

Figure 4. *Pinus radiata* seedlings grown in two tray models (Trial One). The bars indicate L.S.D. (p=0.05).

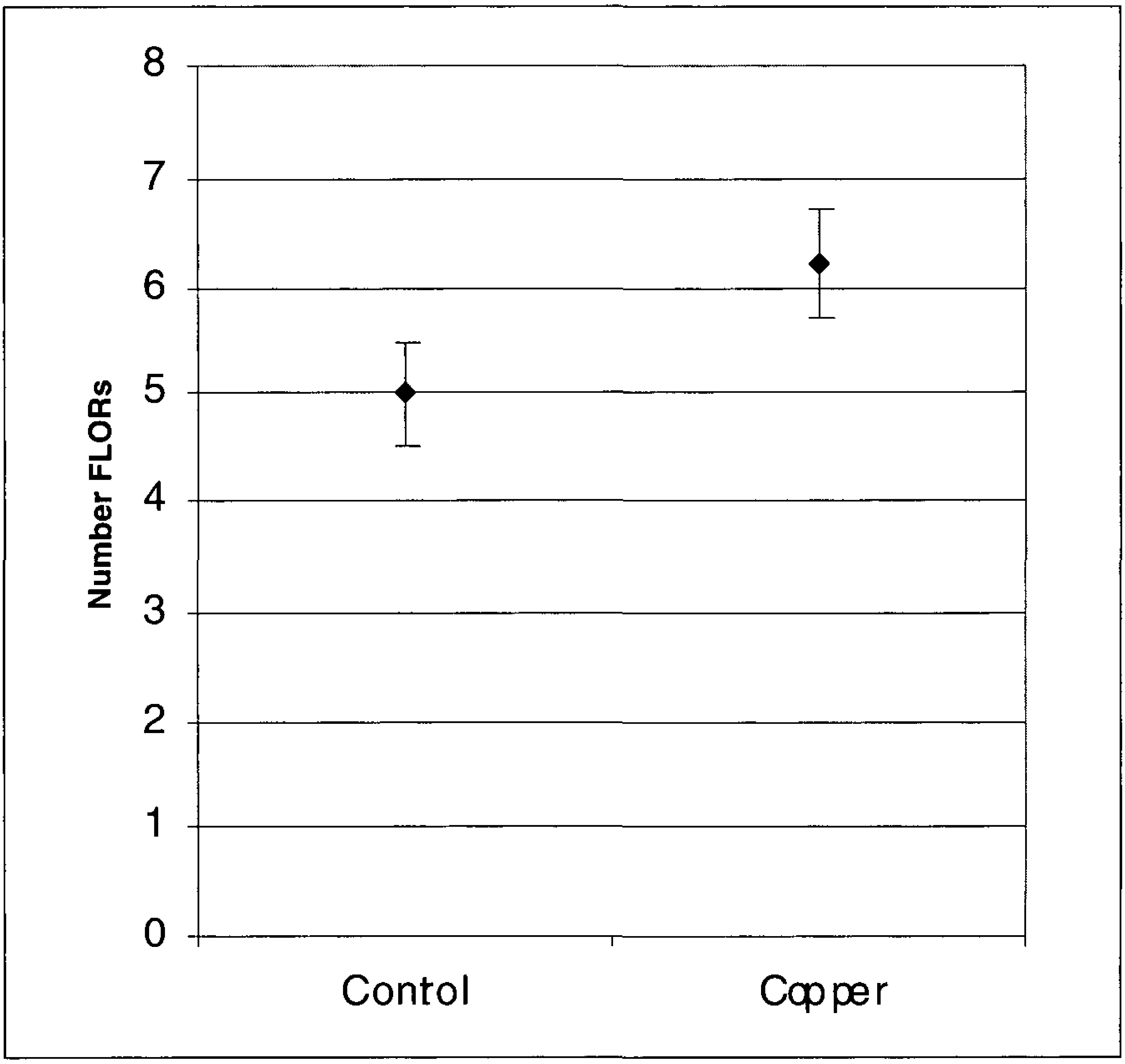

Figure 5. *Pinus radiata* seedlings grown in a 512 plug tray treated with copper for lateral root-pruning (Trial Two). The bars indicate L.S.D. (p=0.05).

The slight differences in overall height growth of seedlings in the two trays was not measured, but is consistent with expectations of growth from cells varying in volume and plant density. Seedling height and collar diameter have not been linked to FOLR development in the nursery stage as the irrigation and fertilisation practices allow even poor seedlings to grow to a normal size, thus masking the effect of increased numbers of FOLR (Kormanik et al., 1994).

Trial 2. The copper-pruning trial confirms that simply having a difference between lateral root-pruning and no pruning can have a significant effect on FOLR numbers (Fig. 5). The only difference between treatments in this trial was the presence or absence of lateral root pruning. Copper-pruning has been demonstrated to increase the number of FOLR previously, for example in cork oak (*Quercus suber*), Jeffrey pine (*Pinus jeffreyi*), roundleaf eucalyptus (*Eucalyptus polyanthemos*) and mesquite (*Prosopis tamarugo*) (Nussbaum, 1969), ponderosa pine (*P. ponderosa*) (McDonald, et al., 1981), and rose gum (*Eucalyptus grandis*) (Smith and McCubbin, 1992).

CONCLUSIONS

These results agree with other observations that seedling tray design features influence the number of FOLR. This is therefore a practical means of at least partially overcoming the genetically controlled component determining the number of FOLR. Choice of containers likely to improve the number of FOLR, and therefore also positive plantation outcomes, is one factor available to plantation managers in their quest to reduce risk factors to the plantation investment.

Key factors in container design apparently affecting the expression of genetic control of FOLR initiation are:

- Preventing lateral roots from being diverted downwards by the container walls (root pruning by air or chemical means).
- Early pruning of the tap root (shallow container).
- Sufficiently low plant density in the nursery.

LITERATURE CITED

Barrett, R.L. 1981. Some observations on root forms of forest trees from planter-flats and other nursery systems. Annual Report, Wattle Research Institute 1980-1981:104-115.

Burdett, A.N. 1978. Control of root morphogenesis for improved mechanical stability in container-grown lodgepole pine. Can. J. For. Res. 8:483-486.

Donald, D.G.M. 1992. The effect of tray volume and spacing on the growth and development of *Pinus radiata* seedlings. South African For. J. 162:27-31.

Halter, M.R., C.P. Chanway, and **G.J. Harper.** 1993. Growth reduction and root deformation of containerized lodgepole pine spalings 11 years after planting. For. Ecol. Mgt. 56:131-146.

Kormanik, P.P. 1986. Lateral root morphology as an expression of sweetgum seedling quality. For. Sci. 32:595-604.

Kormanik, P.P. 1988. Frequency distribution of first-order lateral roots in forest tree seedlings: silvicultural implications. pp. 101-105. In: Proceedings of the Fifth Biennial Southern Silvicultural Research Conference, Memphis, Tennessee, November 1988. USDA Forest Service Gen. Tech. Rpt. SO-74.

Kormanik, P.P., J.L. Ruehle, and **H.D. Muse.** 1989. Frequency distribution of lateral roots of 1-0 bare-root white oak seedlings. Research Note - Southeastern Forest Experiment Station, USDA Forest Service No. SE-353.

Kormanik, P.P., J.L. Ruehle, and **H.D. Muse.** 1990. Frequency distribution and heritability of first-order lateral roots in loblolly pine seedlings. For. Sci. 36:802-814.

Kormanik, P.P., S.S. Sung, and **T.L. Kormanik.** 1994. Irrigating and fertilising to grow better nursery seedlings. pp. 115-121. In: Rocky Mountain Forest and Range Experiment Station, USDA For. Serv., Gen. Tech. Rpt. RM-243.

Kormanik, P.P., S.S. Sung, T.L. Kormanik. and **S.J. Zarnock.** 1995. Oak regeneration — why bigger is better. pp.117-123. In: National Proceedings Forest and Conservation Nursery Associations. USDA For. Serv., Gen. Tech.Rpt. PNW-GTR-365.

Mcdonald, S.T., R.W. Tinus, and **C.P.P. Reid.** 1982. Root development control measures in containers: Rcent findings. pp. 207-214. In: Canadian containerised tree seedling symposium. **City, etc????**

Nambiar, E.K.S., G.D. Bowen, and **R. Sands.** 1979. Root regeneration and plant water status of *Pinus radiata* D. Don seedlings transplanted to different soil temperatures. J. Exp.Bot. 119:1119-1131.

Nussbaum, J.J. 1969. Chemical pinching for roots of container plants. Calif.Agr.23:16-18.

Schultz, R.C. and **J.R. Thompson.** 1990. Hardwood tree root systems. pp. 83-98. In: Proceedings, Northeastern state, Federal and Provincial Nurserymen's Conference, Montreal, Canada.

Seaby, D.A. and **C. Selby.** 1990. Enhanced seedling root development in eight conifer species induced by naphthalene acetic acid. Forestry 63:197-207.

Selby, C. and **D.A. Seaby.** 1982. The effect of auxins on *Pinus contorta* seedling root development. Forestry 55:125-135.

Simpson, D.G. 1990. NAA effects on conifer seedlings in British Columbia. pp. 269-275. In: Target Seedling Symposium, Proceedings, combined meeting of the Western Forest Nursery Associations, Oregon, U.S.A.

Smith, I.E. and **P.D. Mccubbin.** 1992. Effect of copper tray treatment on *Eucalyptus grandis* (Hill ex Maiden) seedling growth. Acta Hort. 319:371-376.

Whitcomb, C.E. 1988. Plant production in containers, revised. Lacebark Pub.

A Review of the Propagation of *Pinus radiata* by Cuttings, with Emphasis on Juvenility

Michael B. Thomas and Mervyn I. Spurway
Soil, Plant and Ecological Sciences Division, Lincoln University, Canterbury

INTRODUCTION

Ritchie (1991) surveyed the production of forest trees from cuttings and reported that the annual world production at that time was more than 65 million rooted cuttings. He also noted that half of this production was in Japan where *Cryptomeria japonica* had been grown by this method for more than five centuries. Another 10 million or more cuttings of radiata pine (*Pinus radiata*) were reported to be grown in Australia and New Zealand at that time. Canada, Scandinavia, and the U.K. together were annually producing about 21 million cuttings of various spruce species (*Picea* spp.). New Zealand sales of *P. radiata* cuttings in 1992 were 6.1 million and this rose to a peak of 24 million in 1996 and have steadied to 19.8 million sold in 1998 (Anon., 1999).

The propagation of *P. radiata* in New Zealand was for many years based solely on raising open-ground seedlings. Seed was initially collected from existing forest trees to provide bulk seed. Then in the early 1950s breeding programmes were commenced based on the selection of superior types, which were then collected together in separate open-pollinated seed orchards. Grafts were taken from trees that showed high quality due to such desirable characteristics as high growth rate, good tree form, few stem cones, etc. Control pollinated (CP) seed orchards were introduced in 1986. In this system bags are placed over the female cones and only specific previously collected pollen is used on individual trees. Good pollination is ensured by several applications of pollen resulting in seed which can have a large proportion of potential high-grade individuals. Although plants had been successfully raised from cuttings in New Zealand by the early 1930s (Field, 1934), it was not an economic proposition until the cost of CP seed rose to high levels in the late 1980s. It was found that cutting production became economically viable when seed costs were greater than or equal to $1800 per kg (Arnold, 1990).