NOTE

CONTAINER TYPES AND CONTAINERISED STOCK FOR NEW ZEALAND AFFORESTATION

WARRICK NELSON

Transplant Systems,
P.O. Box 29-074, Christchurch, New Zealand

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ABSTRACT

Although New Zealand tree plantations have traditionally been established by planting bare-root seedlings, there is now increased interest in the use of container-grown stock. Optimum container design is currently seen as one that incorporates lateral root-pruning. Size specifications for stock for planting out in New Zealand vary according to species.

Keywords: afforestation; containerised stock; seedling specifications.

INTRODUCTION

Some 90% of New Zealand forestry is based on *Pinus radiata* D.Don, with the rest made up primarily by *Pseudotsuga menziesii* (Mirb.) Franco (Douglas fir) and some *Eucalyptus nitens* (Deane et Maiden) Maiden and *Cupressus macrocarpa* Gordon. In recent years, there has been a considerable expansion of interest in *Ps. menziesii* and *E. nitens*. In addition, the demand for rooted cuttings of improved breeds of *P. radiata* is increasing year by year. Rooted cuttings are used as a means of bulking up plant supplies from limited and expensive control-pollinated seed sources (Forest Research Institute 1989) or to achieve even better form growth compared to similar genetic quality seedlings (Forest Research Institute 1991). These developments are leading foresters and forest nursery managers to consider alternative means of propagating the required number of seedlings and cuttings other than by the bare-root method.

The ½/½ method entails an initial growing period in a container, followed by lining out to produce a bare-rooted plant. This propagation method is commonly utilised internationally (Hahn 1990; Willingdon 1990; Ritchie 1993) and is currently being tested in New Zealand for producing rooted *P. radiata* cuttings, and *Ps. menziesii* and *E. nitens* seedlings. Efficient utilisation of nursery land and high genetic value seed are the major advantages, but a larger plant with a larger root system is also generally obtainable by this method (Moench 1994). The plant produced is still a bare-root plant. The early propagation phase is essentially a nursery decision, and not necessarily of any particular interest to plantation managers.

Comparison of stock types of 12- to 16-year-old trees in a large-scale Scandinavian study has shown root system deformations were most common in bare-rooted seedlings, with 80% of plants lacking a tap root as well as having strangled or spiralling laterals. Instability, indicated by crookedness at the base of the stem, is the most important above-ground characteristic for evaluating morphological root deformations (Parviainen & Antola 1986). Bare-root and base-of-cell only root-pruning of containerised stock showed greater incidence of moderate and severe stem deformities in 11-year-old trees than full lateral root-pruning of containerised stock in a Canadian study (Krasowski & Coates 1991). New Zealand studies of toppling in bare-root plants strongly implicate plant handling during lifting, transport, and planting as the cause (Mason 1985; Forest Research Institute 1987). Containerised stock in containers incorporating only root-pruning at the base of the cell tend to suffer more root deformities the longer the plants are held in the container (Barnett & Brissette 1986). A similar effect has not been reported with containers incorporating full lateral root-pruning. Use of fully root-pruned containerised stock for commercial planting can therefore be considered a means of reducing butt sweep of planted trees.

Full containerised propagation is an option only recently being used for plantation establishment in New Zealand. For the first time, *P. radiata* cuttings struck in containers will be available in numbers in excess of a million for the 1995 planting season, as well as about eight million containerised *E. nitens*, *E. fastigata* Deane et Maiden, and *Ps. menziesii* seedlings.

The full benefits of containerisation will be achieved only if the flexibility in sowing, striking, and planting time is used. In addition, container design and planting methods must be adjusted to ensure that the full potential is obtained.

CONTAINER DESIGN CONSIDERATIONS

Container design has undergone some radical changes since the early 1970s. The most important changes have been the use of full lateral root-pruning to avoid the development of a "root cage" and the change to a more squat shape (Fig. 1).

Full lateral root-pruning reduces the risk of poor root form induced by the container, a problem with many earlier designs. The root cage form of deformed root system is typical of many containers still in common use. These containers can and do produce seedlings with an acceptable plantation performance, provided the seedlings are grown quickly and outplanted at a young stage. Defining this young stage has not proved possible for practical afforestation purposes. Physically removing the bottom third of the root system before outplanting appears to reduce the risk of toppling in seedlings produced in these types of containers (Ellyard 1984).

Root cage deformities have been implicated in sudden tree death through honey fungus (*Armillaria ostoyae*) attack (Livingstone 1990). A preliminary study of 20-year-old Swedish pine tree roots indicated clear signs of honey fungus infection in about 50% of trees originally grown in containers, but with no signs of infection in direct-seeded trees (Alriksson 1994). *Armillaria* infection is more likely to occur in tissues containing high levels of sugars and starch (Entry *et al.* 1992). Root deformities are known to cause an increase in starch accumulation at the root collar (Hay & Woods 1978). This is commonly expressed as a swelling of the tap-root or root collar above the deformation (Kietzka 1991; Halter *et al.*

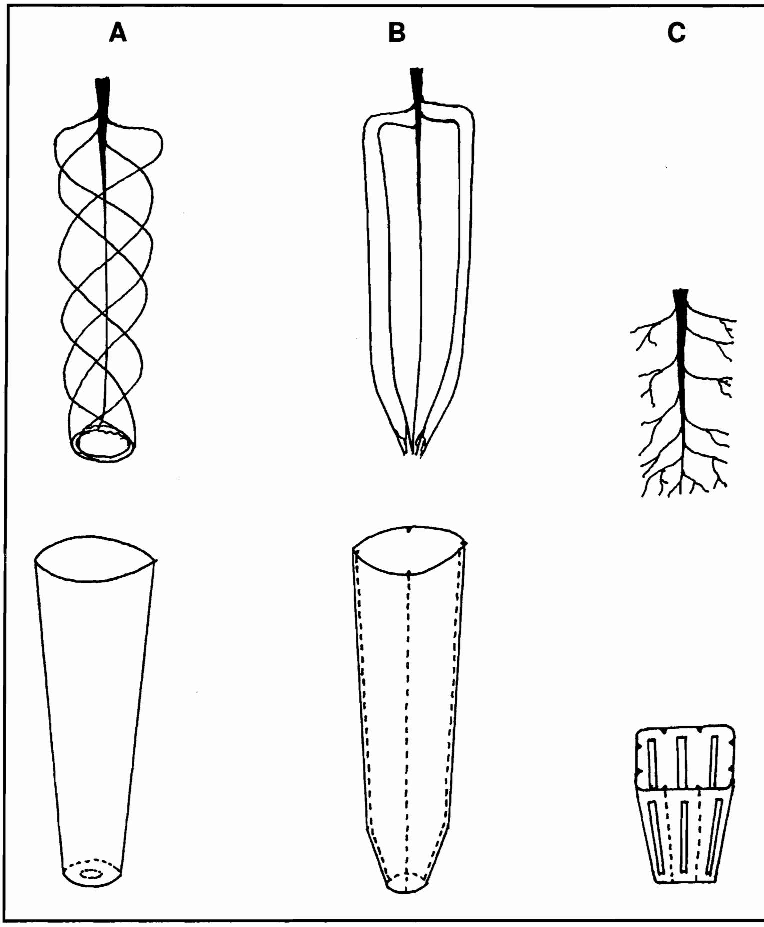

FIG. 1–The root form developed by forestry seedlings in various container designs can be quite readily predicted. Earlier container designs tended to be tall and thin, with the very early containers having a base with a drainage hole (A); later designs incorporated vertical ribs to guide roots down to the drainage hole (B). Development of a squat shape with the height less than 2.2 times the diameter of the top surface and incorporating full lateral root-pruning is much more recent. Many containers still in use incorporate one or more of these characteristics.

1993). A root collar infection is exactly the point where *Armillaria* is most likely to girdle the root system with resultant tree death (Klein-Gebbinck & Blenis 1991). *Armillaria* infections are sufficiently common in New Zealand to make this aspect of nursery practice a potential concern (Hood & Sandberg 1993).

Insistence on a deep container on the basis that trees produce long tap roots, combined with a high plant density in the containers to reduce the cost of the plants, has led to many containers which are very deep relative to their diameter. These root plugs tend to be long and flexible, thus requiring a reasonable level of planter skill and care to prevent J-rooting during outplanting. In practice, container depths of between 40 and 100 mm have proved perfectly acceptable for most tree species, and plantation soil conditions requiring very deep cells are not very common. When combined with full lateral root-pruning, virtually any shape of container could conceivably produce a plant with the potential to develop a natural root form. Practical handling and planting considerations suggest a spherical or cube shape will be the easiest to plant with the least skill and least potential to distort the roots. Squat root plugs have been demonstrated to be less likely to produce deformed roots, even with poor outplanting practices (Nelson 1991). A squat root plug would be one in which the depth is no more than 2.2 times the width at the top of the cell.

Adoption during the last few years by, amongst others, South African, Canadian, and Finnish foresters of containerised seedlings produced with full lateral root-pruning and shorter root plugs is indicative of these changes (Donald 1986, 1991; Scagel *et al.* 1993; Anon. 1994). Most of the containerised plants in New Zealand are already in containers featuring full lateral root-pruning.

Current emphasis on container designs incorporating lateral root-pruning should result in a significant increase in numbers of trees planted with the potential to regrow a natural root form. This will give positive plantation results. An informed management decision to choose an acceptable shape of root plug incorporating full lateral root pruning can reduce reliance on the skill of planters not to distort roots during the planting process.

SEEDLING SPECIFICATIONS

Specifications for seedlings will always be difficult to set because of the extremely wide range of factors which might affect viability. For practical purposes, most specifications are limited to physical parameters, assuming some degree of correlation between physiological parameters and subsequent field growth. Latent defects, such as diseases, nutritional imbalances, and genetic quality, are particularly difficult to guard against. Reliance on the experience and integrity of both nursery and plantation managers is required.

There is a growing body of evidence indicating that the parameters important for containerised stock are different from those for bare-root stock. Initially, containerised seedlings were evaluated on parameters such as root growth capacity and shoot/root ratios. The definition of a "balanced seedling" as developed for bare-root stock is inappropriate for containerised stock (McGilvray & Barnett 1981). For example, much higher shoot/root ratios are better for containerised stock (Walker & Johnson 1980). Current specifications tend to relate more to physical parameters such as stem height and diameter, and specify plant density in the container as well as the type of container to be used.

Size specifications for bare-root seedlings have been available for many years, the most relevant for New Zealand being those for *P. radiata* (Forest Research Institute 1988). Specifications for containerised seedlings have not been as easily available, nor probably as meaningful, as container designs have changed radically over the years. Finnish (Anon. 1992) and Canadian (Scagel *et al.* 1993) seedling specifications are based on combinations of seedling height and collar diameter, often with a specified seedling density in the nursery. A minimum collar diameter of 3.5 mm, height in the range 15–25 cm, and seedling density of 421 plants/m^2 have been suggested for *P. radiata* (Donald 1992). For *P. taeda* L., height between 15 and 20 cm, collar diameter between 1.5 and 2.5 mm, and the presence of secondary needles and woody tissue have been recommended (Barnett & Brissette 1986).

Pseudotsuga menziesii is an interesting species in that it appears to be far less influenced by shading when grown in containers at relatively high plant densities. A good guide indicating the various growth stages and suggested management to achieve the target seedling size is available (Wenny & Dumroese 1992). Early New Zealand research indicated the potential benefits of containerised stock, particularly for harsh sites, but poor root form resulting from container-induced deformities inhibited further work (Forest Research Institute 1982). A density of up to 1000 seedlings/m^2 appears to be quite acceptable to produce a seedling with root collar diameter >2.5 mm and a height of 15 to 20 cm. These seedlings should prove to perform well when planted in spring.

Eucalypts have been recommended to be ready for planting when they are 20–30 cm tall and grown at 270 plants/m^2 (25 plants per square foot) (O'Meara & Crow 1981). Much higher plant densities have been used successfully over many years in many countries (Donald 1991).

Some suggestions for stock types that should prove quite suitable in New Zealand are made in Table 1. In general, the more difficult the site for plant growth, the larger (thicker

TABLE 1–Suggested containerised stock types and size specifications for afforestation in New Zealand. Seedlings and rooted cuttings have not been separated. Where animal damage cannot be adequately controlled, larger and more animal-resistant plants should be used.

Species	Site type	Planting period	Collar diameter (mm)	Stem height (cm)	Comments
Pinus radiata	Good, well-prepared, fertile soils	Late spring to autumn	>3	15–20	<600 plants/m^2
Pinus radiata	Exposed, shallow, droughty, weedy or other difficult sites	Late spring to autumn	>3.5 on poor sites	15–25	<500 plants/m^2
			>4.5 on very difficult sites	30–50 in low-density containers	<450 plants/m^2
Pinus radiata	Good, well-prepared	Winter to late spring	>3	10–20	<600 plants/m^2
Pinus radiata	Nursery site	Spring and summer	>2	10–15	For ½/½ method
Cupressus macrocarpa	Well prepared	All year	>3	15–30	<500 plants/m^2
Pseudotsuga menziesii	Nursery site	Early summer	>2	10–15	For ½/½ method
Pseudotsuga menziesii	Well prepared, wet sites	Winter to late spring	>2.5	15 - 20	<900 plants/m^2
		Late summer to early autumn	>4	20–40	<500 plants/m^2
Eucalyptus nitens	Exposed, shallow, droughty, weedy or other difficult sites	All year	>3.5	<30	<500 plants/m^2
Eucalyptus nitens	Well prepared	Early to late summer	>3	15–25	<800 plants/m^2

collar diameter) and more hardened the transplant must be. These plants would need to be propagated in larger containers and at a lower plant density.

CONCLUSION

The wealth of information and experience with containerised forest plants available internationally allows New Zealand foresters the opportunity to move with confidence. As local experience is gained with the use of containerised plants, recommendations and size specifications are likely to change to more accurately match site, species, and planting time to stock type.

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