PERFORMANCE OF OPEN NURSERY BED AND CONTAINER-RAISED NATIVE PLANT SEEDLINGS ESTABLISHED ON HILLCOUNTRY, LAKE TAUPO CATCHMENT

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Layout of replicated blocks for the planting trials established at Waihaha, western Taupo – 2009 trial (right), 2010 trial above the natural kanuka (centre), and 2011 trial (left).

Tane's Tree Trust Project Report produced for the Lake Taupo Protection Trust in collaboration with Taupo Native Plant Nursery, Mahurangi Action, landowners, Opus, Scion, Future Forests Research, and Waikato Regional Council.

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SUMMARY

Planting trials comparing the cost and growth performance of open-nursery bed (open ground or bare-rooted) seedlings versus container-raised seedlings was established on a hill country site in the Lake Taupo catchment, central North Island, New Zealand. Trials tested a range of native shrub and monocotyledon species commonly used in revegetation programmes to provide rapid cover to control weed growth and shelter for emerging inter-planted or naturally regenerating native tree species. Open-grown stock for most of these species performed as well as seedlings of comparable size raised in PB3 containers. Growth of root trainer stock was in general slower than the other two seedling types. Open grown seedlings were less than half the cost of those raised in the PB3 planter bags, but similar to that of the smaller Hillson root trainer seedlings. Seedlings raised in PB3 containers required four times as much space for storage and transport to the planting site and took up to four times longer to distribute and plant than open-grown seedlings. Results indicate an opportunity to reduce the cost of establishing native forest on hill country sites using large nursery-raised bare-root seedlings.

INTRODUCTION

A considerable proportion of less productive pastoral land in New Zealand, particularly riparian and marginal steep hill country, could be converted into native tree species which would improve environmental outcomes (Davis et al. 2009). Establishing native forestry for sustainable timber production and carbon sequestration also has potential on retired pastoral hill country. Native forest could provide sustainable management opportunities that are integrated into agricultural land use throughout much of our productive landscapes (e.g. PCE, 2002). However, a major hindrance to establishing such forests is the cost of native seedlings compared with seedlings of comparable exotic species.

The most common method of establishment of native forest, excluding natural regeneration, is planting nursery-raised seedlings (Davis et al. 2009). Virtually all seedlings are produced by nurseries in containers including root trainers (Bergin and Gea 2007). The high cost of containerised nursery-raised seedlings and the often uneven quality of nursery-raised plants irrespective of raising method can be significant impediments to large-scale restoration of native forest cover on marginal land. While nursery practices and relative merits used to produce container-grown and bare-root plants have been described extensively (e.g. Evans 1983; Pollock 1986; Porteus 1993; Bergin and Gea 2007), there are few studies conducted to determine the quantitative benefits of seedlings of native tree and shrub species prepared by these methods (Davis et al. 2009).

Techniques for large-scale low-cost production of bare-root native trees and shrubs were developed at the Forest Research Institute from the 1960s up to the early 1980s (e.g. Forest Research Institute, 1980; 1988; van Dorsser 2010). These techniques were based on methods used for a wide range of exotic conifer and hardwood species by forest nurseries throughout the country. The open-ground method involves highly-mechanised production systems to raise and condition bare-root seedlings in readiness for planting. In spite of this, few native plant nurseries have adopted open-ground techniques for native plants. This is largely due to the piecemeal approach and lack of planning associated with most native revegetation programmes. Container-grown plants are easier to handle in small numbers and are the option favoured by large and small nurseries raising native trees and shrubs. A wide range of containers is available, and there is often debate about the suitability of root trainers, polythene planter bags or plastic pots for different species and planting programmes. Variation in type and size of containers means that costs are also variable. There is also continuing concern about the quality of planting stock of native trees and shrubs, especially the condition of root systems of container-grown plants (e.g. Smith 2010; Davis & Meurk, 2001; Bergin & Gea, 2007). In short, native plant nurseries are forced to produce relatively small numbers of a wide range of species in containers, thus providing greater flexibility awaiting uplift of orders, albeit at a high cost per seedling.

While the long term aim with native afforestation is to establish a range of conifer and hardwood tree species, successful establishment is often dependent on shelter provided by an initial cover of early successional species, sometimes referred to as nurse species (Davis et al. 2009). A range of native shrub hardwood and monocotyledon species have the advantage of providing rapid canopy cover to control regrowth of exotic weed species and to allow the slower growing planted or naturally regenerating later successional native tree species to emerge within their shelter, especially on exposed hill country sites.

A series of planting trials was established in the Lake Taupo catchment in the central North Island, New Zealand, in collaboration with Tane's Tree Trust, Lake Taupo Protection Trust, the Taupo Native Plant Nursery and local landowners (Smith 2010). The initial focus of these trials was on a range of hardy native shrub and monocotyledon species commonly used in revegetation programmes in New Zealand. The aim was to compare relative cost of nursery-raised open-ground versus container-grown seedlings of selected native shrub hardwood and monocotyledon species; differences in storage, handling and planting of the different nursery stock types; and early survival and growth on a steep hill country site.

METHODS

Nursery trials

Seedlings of shrub hardwood and monocotyledon species were raised within one year in the Taupo Native Plant Nursery in containers and as open-ground transplants using standard methods as described by Smith (2010). Two nursery stock type treatments were prepared for the first planting year in 2009 (open-ground, PB3 polythene planter bags), and three stock types for the second and third planting years 2010 and 2011 (open-ground, PB3 planter bags, root trainers) (Figures 1 & 2).

The selection of species trialled and numbers of seedlings raised for both nursery and field-based trials was dependent on seed available to the Taupo Native Plant Nursery. Ten species were raised in the nursery for planting out with karamu (*Coprosma robusta*), koromiko (*Hebe stricta* var. *stricta*), manuka (*Leptospermum scoparium*),

Coprosma propinqua, harakeke (*Phormium tenax*), toe toe (*Austroderia toetoe*) and *A. fulvida* in the first year, and kanuka (*Kunzea ericoides* var. *ericoides*) and kohuhu (*Pittosporum tenuifolium*) replacing *Coprosma propinqua* and *A. fulvida* in the second year and rautawhiri (*Pittosporum colensoi*) included in the third year. Totara (*Podocarpus totara*) was also planted in the 2011 trial.

Figure 1: Toetoe (top), manuka (middle) and karamu (lower) plants raised for nine months in the larger PB3 containers or equivalent size plastic containers (left); in open nursery beds (centre); and in smaller Hillson root trainers (right).

Figure 2: Open grown seedlings in nursery beds showing kanuka (left), toetoe (centre) and hebe (right) at Taupo Native Plant Nursery, Taupo.

Planting trials

The planting trial was located on a west Taupo farm at Waihaha, central North Island, typical of steep pastoral land (Figure 3). The 4-ha site comprised a steep north facing hill side dominated by exotic pasture grasses. A naturally-regenerating stand of 2-4 m high kanuka occurs on the lower slopes below the planted trial blocks. The lower slopes of the trial area had scattered cut stumps of kanuka where the landowner had controlled spread in previous years although there was no regeneration of kanuka observed at the site over the duration of the planting trials.

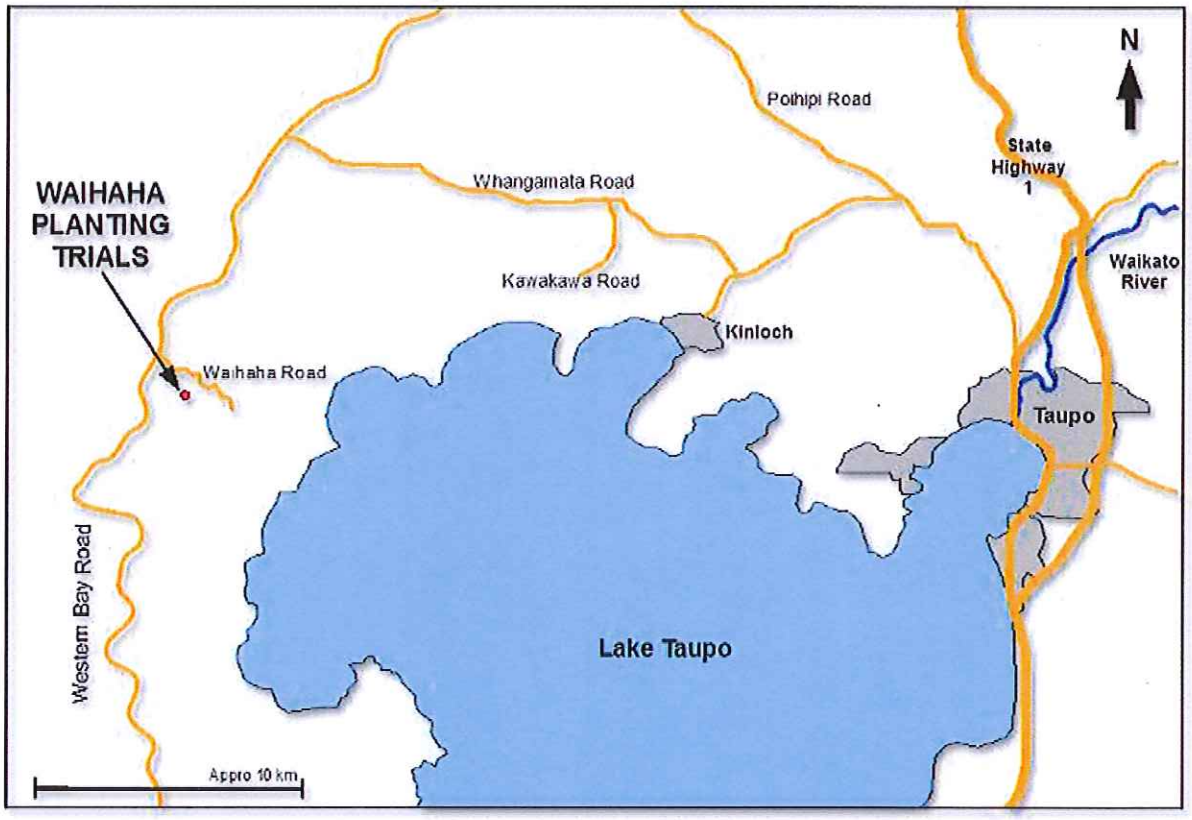


Figure 3: Location of the native species planting trial site, Waihaha, west Taupo.

Approximately 10,000 native seedlings were planted in separate trials across the three years, with each year of planting retired from grazing immediately before planting (Figure 4). Each trial was laid out as a Randomised Complete Block design with 6 replications comprising 12-tree rows. Each row comprised a single species and a single nursery stock treatment (open-ground, PB3, root trainer) with the 2 or 3 rows per species planted contiguously within each replicate block. The placement of the species rows and allocation of stock treatments to rows within each species was also done randomly (Figure 5).

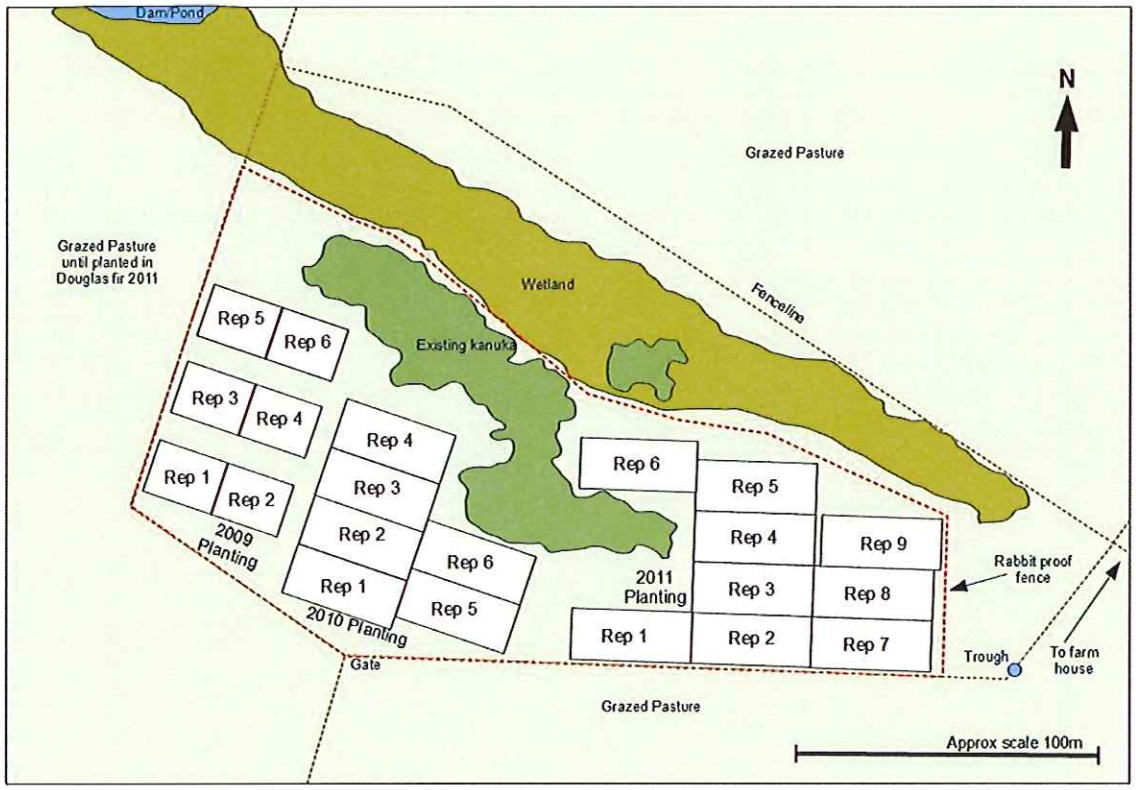


Figure 4: Layout of replicated blocks for the native species planting trials established in 2009, 2010 and 2011 comprising shrub hardwood and monocotyledon species, Waihaha, western Taupo.

Figure 5: Planting trial 2 years after establishment as a Randomised Complete Block design comprising 12 tree rows comparing performance of 10 native species.

Site preparation comprised pre-planting spot spraying of the planting site using a knapsack sprayer and glyphosate herbicide with a surfactant and marker dye at recommended label rates for exotic pasture grass (Figure 6). Rabbits and hares were excluded from the trial site before planting by the erection of a rabbit-proof fences and laying of pindone poison within the trial area at the time of planting. Plant spacing was 1.5 x 1.5 m, equivalent to 4444 stems per ha (Figure 7). Regrowth of exotic grass and annual weed species was controlled up to three times per year for up to two years after planting using glyphosate applied by knapsack sprayer and thereafter the majority of plants had outgrown the possibility of being overtopped by rank grass and weed growth (Figure 8).

Figure 6: Site preparation involved spot spraying using glyphosate immediately after fencing and exclusion of grazing stock. Open-ground nursery stock at the planting site, as packaged for transport.

Assessment of plant size and root condition was undertaken in the nursery for the shrub hardwood species raised for the planting trials in both 2009 and 2010. A minimum of 30 plants per species and stock type were selected at random and measured for plant height, root collar diameter and crown spread. Assessment of crown spread involved taking a first measurement of the maximum horizontal spread of live (green) crown and a second measurement taken at right angles (length x breadth).

Figure 7: Construction of the rabbit proof fence around the trial area to prevent rabbits, hares and livestock from entering the site at Waihaha, west of Lake Taupo.

Figure 8: Planted manuka within one year of planting showing intensive weed control of pasture grasses over first year (left) and 2 years after planting with plants now well above rank grass (right).

A representative sample of three seedlings per species was extracted from containers and open nursery beds for examination of root systems and root-to-shoot balance. Roots were visually examined and briefly described. Photographs were taken of representative plants of each species and nursery treatment comparing shoot and root development.

Once the planting trials were established, assessment included regular inspections of the site to determine early mortality, incidence of animal browsing and checking of fences and weed growth to allow prioritising of maintenance. For up to four years after planting, natural height and crown spread were measured. A subjective visual assessment was used to rate seedling vigour or health based on a comparison with each species using a 1-5 scale as follows:

1. Very unthrifty (few or no leaves, severe frosting or browsing, just alive);
2. Unthrifty (some defoliation, frosting or browsing, poor foliage colour, weak shoot growth);
3. Average (moderate health and vigour);
4. Good (minor leaf frosting or browsing, otherwise good growth); or
5. Excellent (robust plant with healthy foliage and shoot growth).

For analysis crown spread was calculated as the square root of the product of the crown length and breadth measurements. Mean height, crown spread, root collar diameter and vigour scores were calculated.

The cost of raising each species in containers was derived from the standard nursery pricelist for indigenous shrub hardwoods and monocotyledon species raised at the Taupo Native Plant Nursery for quantities of a minimum of 50 seedlings per species. Costs associated with the raising of open-ground plants were provided by the nursery (Philip Smith, Manager, Taupo Native Plant Nursery, pers. comm.). Storage and freighting capacity was calculated for each of the stock types and species based on cubic metre of space required for specific quantities of seedlings. Capacity was based on the assumption that multiple level shelving was available during storage

and transporting to allow stacking of boxes or bags of bare-root seedlings, trays of PB3 stock and baskets of root trainer stock. The number of plants that an average planter could carry at the site while planting was also recorded for the different stock types.

RESULTS

Size of one-year-old nursery-raised seedlings for the commonly planted native shrub hardwoods varied between stock type and year of production (Table 1). Taller plants with smaller crown spread were produced in 2009 compared to 2010 for both open-ground and PB3 container stock. In both years, particularly 2010, PB3 container stock was larger than open-ground stock - likely to be a reflection of the more severe growing conditions for open-ground stock in the nursery. In 2010 where seedlings of each species were raised in all three stock types – open-ground, PB3 containers and root trainers – mean height of root trainer seedlings at 43 cm was between that of PB3 stock (57 cm high) and open-ground (38 cm). However, root collar diameter of root trainers stock at under 4 mm was significantly smaller than PB3 stock (7 mm) and open-ground stock (6 mm) (Table 1). All species had an average plant vigour score close to 5 (excellent) before planting.

Table 1: A comparison of mean height, crown spread and root collar diameter growth for one-year old native shrub hardwood species raised as open-ground and container-grown plants at the Taupo Native Plant Nursery in 2009 and 2010 for planting in the Lake Taupo trials. Root trainers were not planted in the 2009 trial.

	2009		2010		
	Height (cm)	Crown spread (cm)	Height (cm)	Crown spread (cm)	Root collar diameter (mm)
Open ground	32.0	27.8	37.7	21.2	5.9
PB3 container	40.1	30.0	57.1	23.6	7.0
Hillson root trainer			43.0	10.9	3.7

Shoot and root development, and root collar size were dependent on the spacing of plants during propagation. Open-ground plants and the larger PB3 container raised

seedlings had better-developed shoot growth than plants grown in root trainers reflecting the greater available soil volume (nutrient source) and space for canopy expansion. Plant spacing at 20 x 20 cm provided 400 cm^2 of space per seedling raised in open beds and 225 cm^2 of space per plant for PB3 stock compared to only 25 cm^2 in Hillson root trainers packed in wire baskets. Plants raised in root trainers were particularly spindly with mean planting height similar to the open-ground and PB3 stock types and crown spread and root collar diameter on average only half the size of the other two stock types.

Plants lifted from the open-ground beds were transported within one day to the planting site in cardboard boxes each containing 20-40 plants depending on species. Plants in the larger PB3 containers were transported in plastic trays (12 containers per tray); those in the smaller root trainer containers in wire baskets each containing 60 plants (15 4-plant booklets).

Plants grown in the circular PB3 containers displayed some degree of root circling although none were root bound. Root development in the smaller root trainers was clearly restricted although vertical ridges in these containers prevented root circling – as intended by the root-trainer design. Open-ground plants had an abundance of unconfined roots with longer roots requiring trimming to provide a compact root ball for planting, standard practice for bare-root stock.

Four years after planting the first trial, survival was over 80% for most species for both open-ground and PB3 container seedlings (Figure 9a). The major exception was karamu where most plants irrespective of stock type died from an out-of-season frost in the first year after planting, although there was no significant additional mortality in subsequent years. There were no significant differences in mean annual height and spread increments between open-ground and PB3 stock across all species (Figure 9b & 9c). Mean height was up to 1.5 m and mean canopy spread up to 2 m four years after planting for the faster growing species – toetoe, koromiko, manuka and harakeke. Plant vigour score for each species was similar for both stock types for those species with higher survival (Figure 9d).

Three years after planting in the second trial (2010), survival for four species (karamu, koromiko, manuka and harakeke) was greater than 80% across all stock types (Figure 10a). Survival of open-ground stock was significantly less than PB3 container-raised stock for toetoe, kanuka, manuka and kohuhu. Less than 10% of kohuhu planted as open-ground seedlings survived compared to over 90% of seedlings planted as PB 3 containers and 30% of root trainer seedlings. Toetoe survival exceeded 50% for PB3 container stock, but other stock types for this species achieved less than half that. For all species, growth rate of surviving open-ground stock in terms of both height and spread increment was as good or better than either container type (Figure 10b & 10c). This was despite the fact that size of PB3 stock was considerably greater than the open-ground stock in both years. Root trainer stock lagged behind seedlings produced as either bare-root or PB3 container grown seedlings especially for toetoe, manuka and kohuhu. There was little difference in plant vigour between any species irrespective of planting stock types (Figure 10d). Koromiko and harakeke three years after planting are shown in Figure 11 and Figure 12 respectively.

Two years after planting the 2011 trial, only two species (koromiko and manuka) had high survival (>90%) across all three stock types (Figure 13a). Root trainer stock for five of the eight species had significantly poorer survival compared to the other stock types. Survival of PB3 container stock was equal or better than open ground stock across all species. In general, height and crown spread growth was similar for most species between PB3 container stock and open-ground stock with growth of root trainer stock significantly less (Figure 13b & 13c). Exceptions included kanuka where PB3 grown seedlings had mean annual height increment of nearly 40 cm, over double that of the other stock types; and toetoe PB3 stock with double the mean annual spread increment of the other stock types. Plant vigour varied from average to excellent with PB3 container stock of toetoe and rautawhiri scoring significantly higher than the other stock types (Figure 13d). There were also clear differences in performance for some species between years such as the substantial height growth of kanuka PB3 stock for the latest trial (Figure 13b) compared to kanuka planted in the trial one year earlier (Figure 10b).

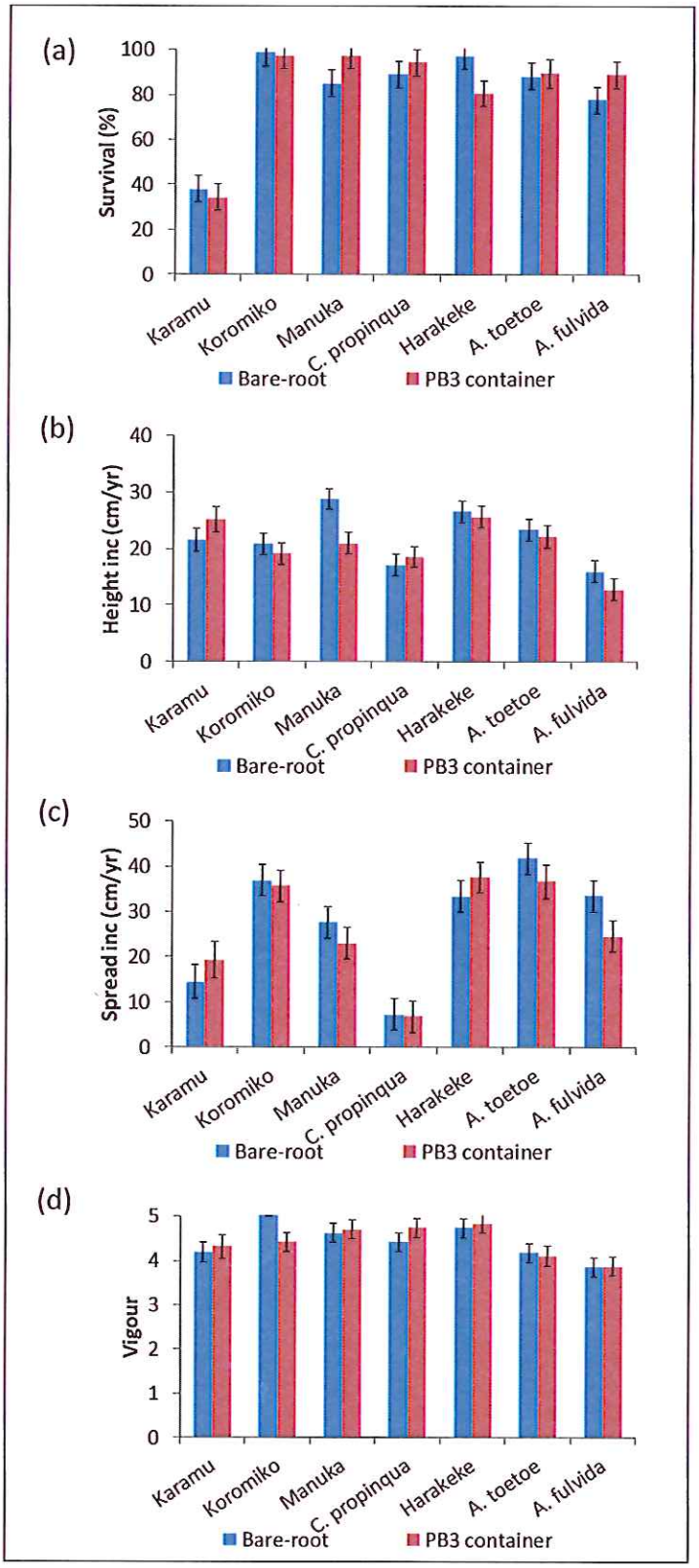


Figure 9: Comparison of mean survival (a), height increment (b), crown spread increment (c) and plant vigour (d) for plants raised as open-ground transplants and in PB3 containers for each of the 7 native species 4 years after planting at the Waihaha site in 2009.

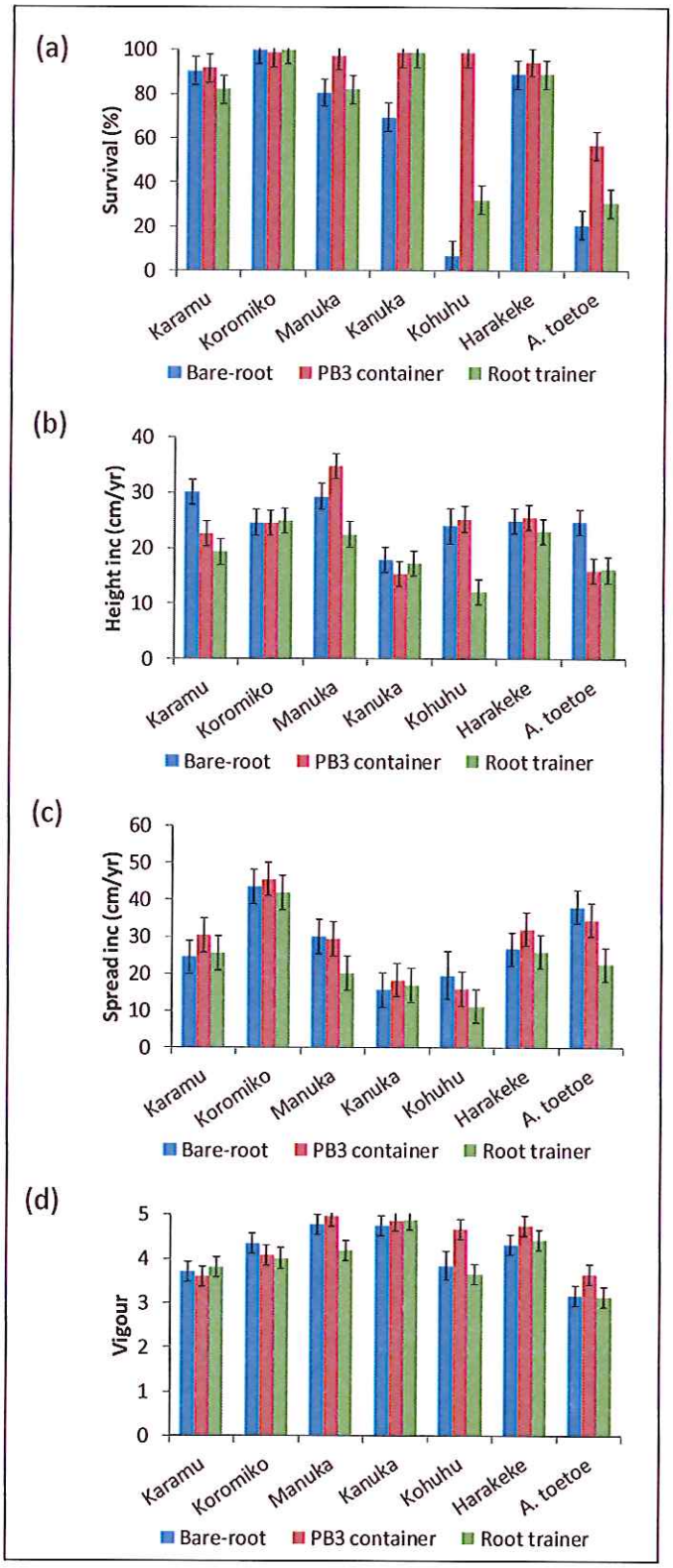
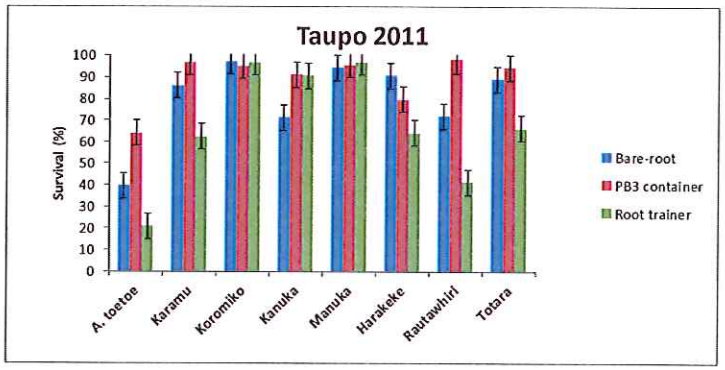


Figure 10: Comparison of survival (a), height increment (b) crown spread increment (c), and plant vigour (d) for plants raised as open-ground transplants and in PB3 containers and root trainers for each of the 7 native species 3 years after planting at the Waihaha site in 2010.

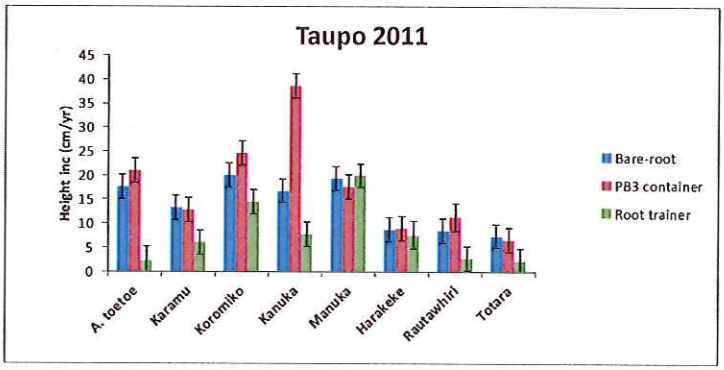
Figure 11: Hebe planted in 2010 3 years old, PB3 left, open ground/bare root centre and root trainer right

Figure 12: Flax planted in 2010 now 3 years old, PB3 left, open ground/bare root centre and root trainer right.

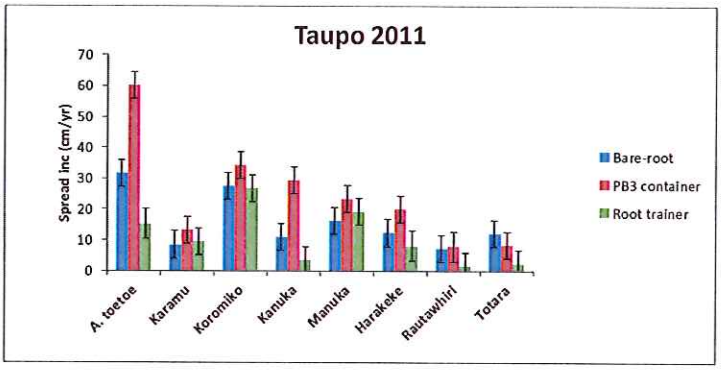
a)



b)



c)



d)

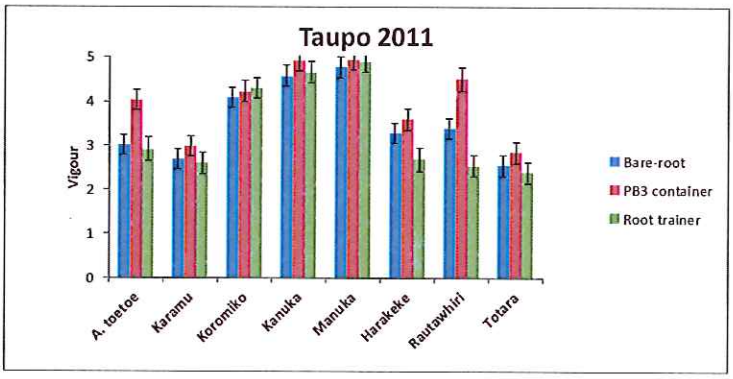


Figure 13: Comparison of survival (a), height increment (b) crown spread increment (c), and plant vigour (d) for plants raised as open-ground transplants and in PB3 containers and root trainers for each of the 8 native species 2 years after planting at the Waihaha site in 2011.

A comparison of the estimated nursery cost per seedling for production of native shrub and monocotyledon species is given in Table 2 based on small-scale production of open-ground plants and commercial supplies of container-raised plants from the Taupo Native Plant Nursery (Philip Smith, Manager, Taupo Native Plant Nursery). Estimated cost of open-ground stock at $1.50 per plant is less than half that of standard nursery costs of PB3 stock at over $3 each. Seedlings raised in Hillson root trainers are the lowest price from the nursery but are significantly smaller in root collar diameter and crown spread than seedlings raised either as open-ground or in PB3 containers (Table 1).

Table 2: A comparison of seedling cost from the nursery, transport capacity and maximum number of plants carried by a planter on the planting site for open-ground and container-grown plants of the native shrub hardwood and monocotyledon species commonly used in planting programmes. Estimates will vary due to size of seedling orders, distance to planting sites, access and site type.

	Open-ground	PB3 planter bag	Hillson root trainer
Nursery plant cost per seedling*	$1.50	$3.35	$1.35
Storage and transport capacity (plants/m^2)	Max. 800 (2 layers of boxes)	120 (2 layers of trays)	720 (2 layers of baskets)
Maximum no. plants carried/planter	40-50 (depends on species)	12	48 (basket of 12 books)

* Plant costs based on 2013 Taupo Native Plant Nursery catalogue for container stock (seedling orders 50+) and estimated cost for open-ground stock obtained from Philip Smith, Manager, Taupo Native Plant Nursery (pers. comm.).

Storage and transporting capacity for bare-root seedlings raised to about 50 cm height was similar to that of Hillson root trainer stock where 700-800 seedlings can be accommodated per cubic metre in shelved units compared to only 120 seedlings raised in PB3 seedlings (Table 2). Similarly, planters can carry 4-5 times the number of bare-root or root trainer stock compared with the larger PB3 stock. Up to 50 bare-root seedlings could be carried in a box or bag handled at one time, similar to the number of root trainer seedlings that could be carried in a wire basket. In contrast a maximum of only 12 PB3 seedlings could be comfortably carried by a planter. Preference was given to laying out stock of both container types as a separate operation whereas bare-root stock was carried by each planter using planter bags.

Differences were observed in both ease of planting and time taken to plant between seedling stock types. Open-ground were the easiest to plant. PB3 containers and Hillson root trainers required extra time to extract seedlings from containers and recover plastic waste.

DISCUSSION

Reducing the cost of nursery-raised seedlings of native species without compromising early growth and survival after planting is an essential requirement if the establishment of native forest by planting is to become more economically viable. The results in these trials indicate an opportunity to reduce the cost of establishing native forest on hill country sites using large nursery-raised seedlings of the hardy shrub hardwood and monocotyledon species required to provide the initial cover and shelter for inter-planting or encouraging natural regeneration of native trees.

In the first few years after planting, bare-root seedlings for most of these early cover species performed as well as seedlings of comparable size raised in PB3 containers. However, there is a substantial difference in cost of seedlings. Bare-root seedlings were less than half the cost of those raised in the PB3 planter bags, similar to that of the smaller Hillson root trainer stock. Growth of root trainer stock three years after planting was generally slower with lower plant vigour than the other two planting stock types. These results are consistent with earlier planting trials established on several sites in North Auckland where growth after planting of a similar suite of species was similar for plants raised in large containers and in open-ground nursery beds, but with poorer performance of plants raised in Hillson root trainers (Bergin and Cole 2010).

The choice of seedling raising method and seedling size for planting native forest will depend on a range of factors including the scale and resources of the proposed planting programme, site characteristics such as location and degree of exposure, and the weed and pest animal species present. In a review of establishment methods for native forest, Davis et al. (2009) indicates that while nurseries produce seedlings in a wide variety of sizes and container types, for successful plant establishment, it is essential that strong, healthy planting stock is used. Large, well-conditioned plants are likely to give the best results in large-scale planting programmes whereas smaller

plants will require more intensive weed and pest animal control (Bergin and Gea 2007). Pollock (1986) concluded that desirable plant size for planting out depends on the seedling's growth rate and site conditions, especially weed competition. Small, healthy seedlings with well-developed root systems were recommended because they are less affected by transplanting, for example, compared with larger planting stock in small containers. Pollock indicated that from experience fast growing species, such as some of shrub hardwoods (*Hebe*, *Coprosma* and *Pittosporum* spp.), attained planting size of 20-40 cm height after one growing season when grown in rootrainers of 200-400 ml volume or polythene bags of 800-900 ml volume.

There are exceptions for some species raised as open-ground transplants. Bare-root seedlings of kohuhu and rautawhiri, and to a lesser extent root trainers for both species, had a significantly lower mean survival compared to PB3 stock. Survival of open-ground kanuka and manuka seedlings was also less than the larger container-grown plants for each species although growth rates of both planting stock types were similar. For the *Pittosporum* species it can be difficult to form a compact fibrous root system without taking extra care during the root conditioning phase (Jaap van Dorsser, former manager Forest Research Institute nursery, pers. comm.). Three years after planting, root trainer stock for most species was comparable to the other stock types in terms of survival and growth, with the exception of kohuhu, toetoe, and to a lesser extent manuka. It is likely that at Waihaha the timely weed control and effective eradication of rabbits from the planting trial site has permitted the smaller root trainer stock to perform as well as the other stock types – for at least some species.

There are few other studies comparing container-grown stock with seedlings raised as bare-root stock. A mine-tailings restoration study in Westland found that container-grown stock generally performed better than bare-root stock for eleven native tree and shrub species planted into a range of substrates (Davis et al. 1995; Davis and Langer 1997). However, several species including the shrub hardwoods karamu and the local koromiko species (*Hebe salicifolia*) raised as bare-rooted stock performed sufficiently well to suggest their use be further explored for large-scale revegetation programmes.

Open-grown and Hillson root trainer grown seedlings required similar storage and truck space and have similar handling and transport costs. However, stock raised in PB3 containers required four times as much space for storage and for transfer to the planting site. Handling and planting of open-ground natives was easier than for container-grown plants with PB3 stock taking up to four times longer to distribute at the planting site, although extra care is required to ensure open-ground stock are planted within 2-3 days after lifting (Smith 2010). Recovery of plastic waste from container-grown stock is an additional task at the planting waste.

These comparative trials both in the nursery and the planting site were based on relatively small scale nursery production with less than 1000 plants raised per species each year for each of the nursery propagation methods. Larger scale production is likely to see the cost of open-ground production of native seedlings reduced further compared to container grown plants. Storage, transporting, site handling and planting of open-ground native shrubs species are closer to the costs of establishing radiata pine than they are to planting natives raised in containers.

ACKNOWLEDGEMENTS

The nursery and planting trials have been established as a collaborative project involving the Taupo Native Plant Nursery, Mahurangi Action Inc, Tane's Tree Trust, the Lake Taupo Protection Trust, local landowners, Opus, Scion, Future Forests Research, and the Waikato Regional Council.

REFERENCES

Bergin, D.; Cole, C. 2010: Comparisons between open-ground and container-raised indigenous shrubs in nursery and field trials. In Barton, I.; Gadgil, R.; Bergin, D. (Eds.). Managing native trees - towards a national strategy. *Proceedings of the Tane's Tree Trust 10th anniversary conference and workshop held at the University of Waikato 18-20 November 2009*. 64-74.

Bergin, D.O.; Gea, L. 2007: Native trees – planting and early management for wood

production. *New Zealand Indigenous Tree Bulletin No. 3.* Revised edition. New Zealand Forest Research Institute. 44p.

Davis, M.; Douglas, G.; Ledgard, N.; Palmer, D.; Bhubaneswor, D.; Paul, T.; Bergin, D.; Hock, B.; Barton, I. 2009: Establishing indigenous forest on erosion-prone grassland: land areas, establishment methods, costs and carbon credits. Report for the Ministry for Agriculture and Forestry. New Zealand Forest Research Institute. 97p.

Davis, M.; Meurk, C. 2001: *Protecting and restoring our natural heritage – a practical guide.* Department of Conservation, Christchurch. 94p.

Davis, M.; Ross, C.; Langer, E. 1995: Mine site restoration to native forest in Westland. *New Zealand Mining 17*: 11-17.

Davis, M.; Langer, E. 1997: Rehabilitation of native forest species after mining in Westland. *New Zealand Journal of Forestry Science 27*: 51-68.

Evans, B. (Comp.) 1983: *The revegetation manual: a guide to revegetation using New Zealand native plants*. Queen Elizabeth II National Trust, Wellington.

Forest Research Institute 1980: Raising native trees. *What's New in Forest Research No. 85.* New Zealand Forest Service, Forest Research Institute. 4p.

Forest Research Institute 1988: Raising indigenous trees and shrubs from seed. *What's New in Forest Research No.158.* New Zealand Forest Service, Forest Research Institute. 4p.

PCE, 2002: *Weaving resilience into our working lands. Recommendations for the future roles of native plants.* Parliamentary Commissioner for the Environment, Wellington. 39p.

Pollock, K.M. 1986: Plant materials handbook for soil conservation. Vol. 3: Native

plants. *Ministry of Works and Development, Wellington, Water and Soil Miscellaneous Publications No. 95.*

Porteus, T. 1983: *Native forest restoration. A practical guide for landowners.* Queen Elizabeth II Trust, Wellington.

Smith, P. 2010: Reducing costs associated with establishment of native plants in the Lake Taupo Catchment . In Barton, I.; Gadgil, R.; Bergin, D. (Eds.). Managing native trees - towards a national strategy. *Proceedings of the Tane's Tree Trust 10th anniversary conference and workshop held at the University of Waikato 18-20 November 2009.* 52-55.

van Dorsser, J. 2010: Options for successful establishment of natives . In Barton, I.; Gadgil, R.; Bergin, D. (Eds.). Managing native trees - towards a national strategy. *Proceedings of the Tane's Tree Trust 10th anniversary conference and workshop held at the University of Waikato 18-20 November 2009.* 56-57.

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PLANTING and MANAGING NATIVE TREES

Technical Article No. 5.3

Choice of Nursery Method - container or open-ground

Although large numbers of natives have been raised in containers, plants produced open-ground– forestry nursery style – are increasingly being chosen.

INTRODUCTION

Establishment of native forest species is normally performed by planting nursery-raised plants grown from seed, although cuttings and wildings are used for some species (Davis et al. 2009). The method of choice for raising native plants has been the use of containers, first introduced into the horticultural industry, including planter bags, impervious pots, peat pots, and root trainers.

The alternative method for raising nursery stock is in open-ground beds where plants are raised in the open and leave the nursery bare-rooted. This is the method used for more than 100 years for the economical production of radiata pine (*Pinus radiata*) seedlings and to a lesser extent other tree species in the plantation forest industry (MacLaren 1993).

While the vast majority of native trees and shrubs has been raised in containers over the last few decades, the use of open-ground beds for raising natives is not new. Kauri was raised in open ground beds from at least the early 1950s in New Zealand Forest Service nurseries (e.g. Reed 1953; Morrison 1955). Research and operational programmes for raising a wide range of native tree and shrub species open-ground were underway at the Forest Research Institute nursery from the late 1950s (van Dorsser 2010).

The role of nurseries in producing cost-effective and well-conditioned planting stock is critical to native tree establishment in New Zealand. In this article we explore the merits of these two plant production systems based on early work as well as recent fieldwork initiated by Mahurangi Action. This work has been supported by the Ministry for Primary Industries' Sustainable Farming Fund, Tane's Tree Trust, Scion, Future Forests Research, Auckland Council, Bay of Plenty Regional Council, Waikato Regional Council and the Taupo Native Plant Nursery.

CONTAINER VS. OPEN-GROUND NURSERY STOCK

Both CG (container-grown) and OG (open-ground) methods for nursery production of natives, when well executed, can produce the robust, well rooted planting stock that is critical to the success of a planting programme.

Container-grown methods allow wide flexibility in planting programmes as stock can be held in the nursery and in the field until planting conditions are favourable. While CG plants may allow greater flexibility for the nursery, these plants are prone to root circling and root binding and subsequent poor establishment if root distortions are not remedied prior to planting. A further disadvantage of CG is the large weight of potting mix to be carried to, and on the planting site.

The open-ground method, used almost exclusively in the exotic forest industry, was, until recently, rarely used for native species, despite effective techniques having been developed for them (Forest Research Institute 1980; van Dorsser 2010). The open-ground method is well suited to large production volumes at low cost but, because the plants must be 'lifted' from their open-ground beds to order and planted within the following few days, much tighter project management is required than for container-raised plants.

Capital start-up costs for large-scale OG production requiring specialised tractor-drawn machinery for conditioning plants is prohibitive for small operations. Good quality flat land with free-draining soil is also required (Smith 2010).

The two major advantages of OG plants, as seen in many trials with exotic species, are firstly the much-reduced cost of production and secondly the production of a conditioned plant with a compact, fibrous root system, ready to form new roots after planting.

'Open-ground' or 'bare-root'

'Open-ground' and 'bare-root' are often used interchangeably to refer to plants raised by open-ground methods. Here, to avoid the impression that the terms refer to different methods, 'open-ground' is used throughout, while 'bare-root' refers to the state of the plants raised in open-ground beds when they are lifted from the bed, packed, transported and replanted.

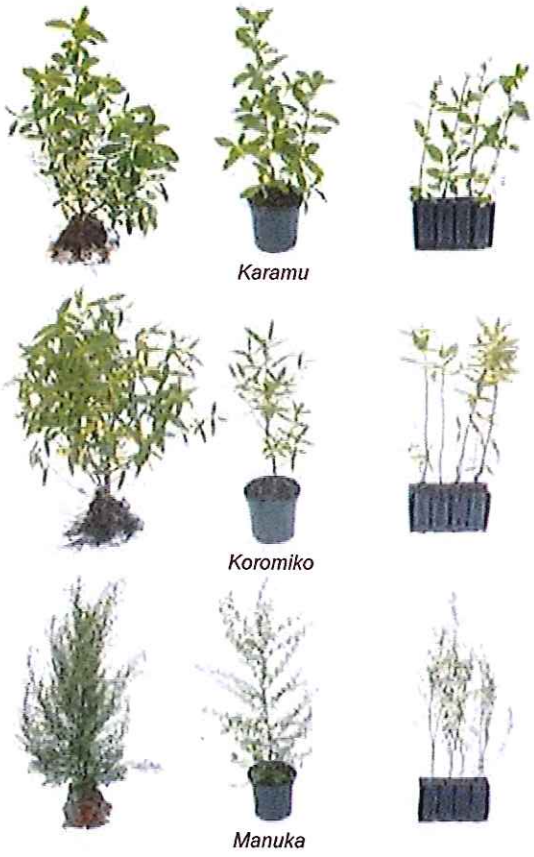
Manuka, toetoe and koromiko raised in open-ground beds, Taupo Native Plant Nursery

CONTAINER STYLES AND SIZES

Lightweight containers filled with moist, nutrient-rich potting mix provide an ideal rooting environment for developing plants. Choice of container will depend on species grown and the age and size of plants required. Most container-raised native shrubs and trees are produced in containers of three broad types:

- **Planter bags** made of flexible black polythene, usually PB¾, PB2 or PB3 where number corresponds to capacity of the bag, measured in pints—a PB3, 3 pints, or 1.7 litres. Bag diameter ranges from about 10 to 15 cm, height about 14 cm. Cost of seedlings varies from $2 to $5 per seedling, depending on the size of bag and volume of order.
- **Semi-rigid pots** are increasingly being used, particularly by nurseries using mechanisation. Because the pots are tapered, they are readily removed from the root ball, increasing their recycling potential. Sizes are in litres. Cost of plants raised in semi-rigid pots is similar to the equivalent planter bags.
- **Root trainers** are commonly available in two sizes:
  - *Tinus root trainers* come in 20 cm high "books," each having four cavities 5.1 x 3.8 cm in size. The hinged books open for easy removal of seedlings and 12 fit into a wire cage that holds them upright and elevated so that any roots that protrude below the container are "air pruned". The compact form of the cage makes root trainer plants cheaper to transport and easier to manhandle on the planting site than trays of planter bags or pots. However the plants are much smaller, reflecting the limited space available to each individual. Cost per seedling ranges from $1-2.
  - *Hillson root trainers* are 12.7 cm high, each book having four cavities 3.8 x 3.8 cm. Hillson root trainers have less than half the volume of the Tinus version, and only 9.4% of the volume of a PB3.

There are a wide range of other containers used for natives including peat pots of different sizes and moulded cavity trays featuring a range of sizes and number of cavities. These are sometimes used in mechanised production systems. However the vast majority of natives are raised in planter bags, semi-rigid pots and root trainers.



Plants raised for nine months in open-ground nursery beds (left); 1.2 -litre semi-rigid pots (centre); and in Hillson-sized root trainers (right).

Container-raised plants are often transferred from seed trays to small propagation cells before potting-on to final containers.

OPEN-GROUND METHOD

The production of bare-rooted plants

The philosophy and practice of open-ground techniques is to produce plants that are physiologically conditioned to allow them to be transported and planted in a bare-root state.

Techniques for the OG production of many native trees and shrubs were developed by the Forest Research Institute in the 1950s and 1960s, and used for forest rehabilitation by the New Zealand Forest Service (Forest Research Institute1980; Bergin and Gea 2007). For large-scale afforestation the costs of production are significantly less than for CG plants (van Dorsser 2010).

Typically seed is germinated indoors in seed trays, similar to the prevailing practice in container nurseries. Once sufficiently developed and hardened off, the seedlings are transplanted into open-ground beds with the plants spaced at 15 x 15 cm, or wider when plant-growth habit demands. The technique provides root volume at least twice that of containers set out at the same spacing.

Plant conditioning

To produce conditioned well-rooted plants, they are provided with adequate individual space to develop robust tops and to respond to mechanical treatments aimed at developing compact fibrous root systems.

These treatments are carried out during late summer and autumn, and comprise the following:

- Undercutting – cutting of tap roots at a pre-determined depth;
- Wrenching – a loosening operation to encourage fibrous root development;
- Lateral Pruning – cutting lateral root growth between adjacent rows;
- Box Pruning – cutting lateral root growth between trees in the row; and
- Topping – when necessary to contain excessive height growth.

Resultant, well-developed plants have dense, fibrous root systems close to the tap root. Plants are lifted from the beds by hand with the aim of preserving the fibrous root mass; excess soil is gently shaken off, and straggly roots trimmed.

Trimming of straggly roots systems of bare-root seedling at lifting.

Cool moist storage is essential between lifting and planting for bare-rooted plants. Where possible, placing seedlings in a cool store provides ideal short term storage.

Handling after lifting

Once lifted, OG plants, essentially free of soil, are light to transport and should be kept cool and moist prior to planting within a few days (ideally within 3 days of lifting). In contrast to CG plants that can be reserved for use over an extended period, OG plants have a relatively short 'shelf-life' between removal from the open-ground beds and planting.

While many species respond well to conditioning, once bare-rooted they can be intensely sensitive to drying out and need special attention to avoid transplantation shock and transport desiccation. Care in keeping root systems wet and cool after lifting, and during storage and transport is critical. Stored plants should be watered every day until planted.

Open-ground aptitude

Differing physiology means that some species are particularly well suited to the open-ground method. Species such as totara *(Podocarpus totara)*, kahikatea *(Dacrycarpus dacrydioides)*, many of the *Coprosma* species, manuka *(Leptospermum scoparium)* and kanuka *(Kunzea ericoides)*, readily develop dense fibrous root systems in response to root conditioning during the process of open-ground production. Harakeke responds particularly well by virtue of its rhizomatous root system, and is relatively immune to desiccation during the transplanting and planting stages.

In contrast, some native species such as kauri *(Agathis australis)* (Bergin and Steward 2004), tawa *(Beilschmiedia tawa)*, rewarewa *(Knightia excelsa)*, and some *Pittosporum* species can be reluctant at forming fine feeding roots. Kauri, and to a lesser degree rewarewa, often have one or more woody vertical taproots and a feeble network of fibrous roots irrespective of whether raised in containers or in open-ground beds. Further research aimed at increasing fibrous root development of these species is required.

EVALUATION OF PLANTING STOCK

Plant size

Size of nursery-raised plants can be measured in terms of plant height, canopy cover and root collar diameter. All of these parameters are influenced by the time taken to raise plants in the nursery as well as the method of raising and lateral space allowed for each plant during the nursery phase.

CG plants are normally grown close together to conserve valuable greenhouse or shadehouse space. Although smaller individual containers could be spaced out in the nursery to allow room for more foliage, and a more squat form to develop, in practice they are grown container-to-container both to conserve standout space and to limit capsize. Root-trainer plants are, by design, confined by 'books' tightly packed into wire frames with very limited growing space.

NURSERY TRIALS

In an evaluation of OG and CG nursery stock of six native species commonly used in revegetation programmes, canopy spread of most species of OG plants, nine months after seed sowing, was greater than that of CG plants (PB3 bags), which in turn was greater than that of plants in small containers (Hillson root trainers) (Bergin and Cole 2010; Smith 2010). Root collar diameter of OG plants was on average twice that of CG plants and three times that of plants in Hillson root trainers.

OG plants had better-developed shoot growth than plants grown in containers probably related to the available soil volume (including nutrient source) and space for canopy expansion. Nursery area allocated to each plant in this trial was:

- 20 x 20 cm in open-ground beds (equivalent to 25 plants per m^2);
- 15 x 15 cm in PB3 containers or equivalent (44 plants per m^2);
- 5 x 5 cm in Hillson-sized root trainers (400 plants per m^2).

High volume open-ground production will result in plant spacing in open-ground beds reduced from the 20 cm plant spacing used in the trials to 15 cm between plants, similar to PB3 containers at 44 plants per m^2 and therefore with similar space for shoot development. This plant spacing has been standard practice for native plants used at the Forest Research Nursery (now Scion) over the last three decades.

Plants raised in root trainers were particularly spindly in the trial reflecting a growing space of only 25 cm^2 whereas seedlings raised in larger containers such as PB3 planter bags have up to nine times the area (225 cm^2) available for crown development .

Stem diameters (at root collar) of 9-month-old open-ground plants (left) were on average twice those in pots (centre) and three times those in root trainers (right) - koromiko pictured.

Root growth

While plant tops are easily checked for vigour, size and presence of fungus and insect damage, the development and health of root systems is not routinely assessed for CG stock, while OG plants are readily inspected when lifting and culling takes place.

Root distortion can occur at the base of the stem when seedlings are transferred from the seed tray to the propagation cells. This can be difficult to identify later and can lead to root strangulation and tree toppling.

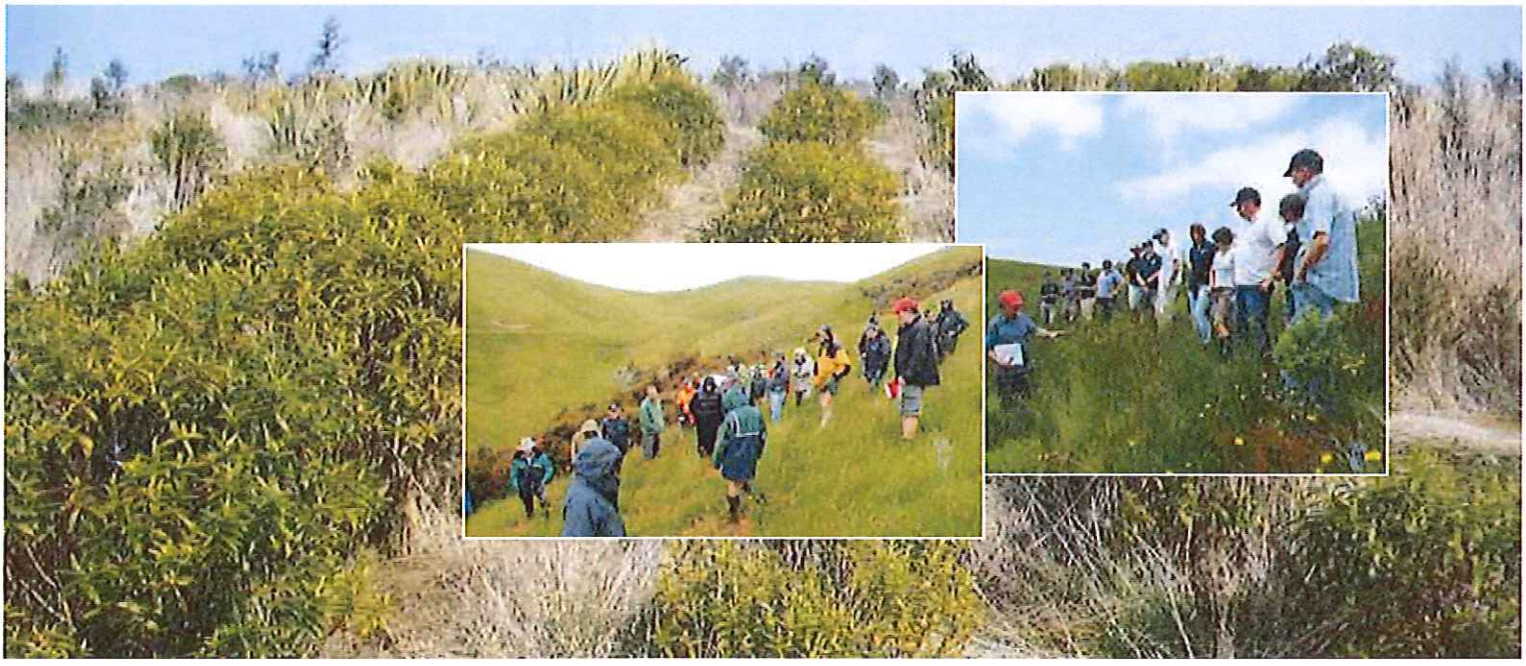
With CG stock, ideally plants will have been transferred to a larger bag or potted on as soon as the roots have bound the available potting mix in the first container. Any root distortion found during repotting must be rectified at the time to avoid later root strangulation and toppling.

Before planting, a random selection of plants, both OG and CG, should be carefully inspected. Root systems of OG plants should be inspected at lifting and those with distorted or poorly developed roots should be rejected if defects cannot be rectified. Roots of lifted OG plants should be trimmed to a compact root system.

For CG stock a sample should be removed from containers to check root development and quality. Where root systems are rootbound, have distorted taproots, or have poorly developed fibrous feeding roots, then whole batch should be rejected if the defects cannot be rectified. If the root systems have not had sufficient time to develop after potting-on into larger containers, the potting mix will fall away and root exposure may increase transplanting stress .

Check that container-grown plants are not rootbound; reject seedlings with grossly distorted root systems.

Rootbound plants should ideally be rejected. If they have to be used, the root mass should be loosened and any fibrous roots teased out or cut to encourage growth into the surrounding soil after planting. Seedlings with grossly distorted or underdeveloped root systems should be discarded.



Nursery-raised seedlings have been planted out on several sites in the upper half of the North Island to compare performance of seedlings raised as open-ground plants, in large containers or in root trainers. There has been wide interest in field-based workshops including these trials in the Taupo catchment with Tane's Tree Trust and NZ Farm Forestry Association members, and with regional council Land Management Officers.

COMPARING COSTS

A comparison of plant characteristics, operations at planting time and estimated nursery costs is provided for the more commonly planted native shrub hardwood species used in revegetation programmes in Table 1. OG stock is potentially half the cost of the commonly produced larger CG options. However, estimated 'shelf life' after lifting OG stock is very limited compared to container options (e.g. Smith 2010).

A significant cost for large container stock is the space that it takes up during storage and transport compared to OG and the small root trainer stock. Plants raised in PB3 planter bags require at least four times the space for storage and transport compared to OG stock. Similar numbers of OG stock can be transported to the site and carried around the planting site as the root trainer stock (Table 1).

PERFORMANCE AFTER PLANTING

It might be considered that CG plants with intact roots surrounded by potting mix might survive better than OG stock after planting out. However this has not been the case and a number of trials comparing the establishment performance of OG vs. CG plants have been carried out to show there is no significant difference in growth rates or survival.

Results of these trials, of native shrub hardwood species commonly planted in revegetation programmes, measured up to five years after planting are provided in Technical Article No. 5.4 in this Handbook.

Table 1: A comparison of plant size, estimated bulk cost, storage times, transport capacity and times involved at planting for open-ground and container grown plants for native shrub species commonly used in planting programmes.

	Open-Ground	1.2-litre pot or PB3 planter bag	Large root trainer (Tinus)	Small root trainer (Hillsons)
Species available	Most	All	All	All
Mean plant height[1]	50 cm	55 cm	Est. 50 cm	45 cm
Stem collar diameter[1]	8-10 mm	8 mm	Est. 6-7 mm	5 mm
Space available for crown development[2]	15 x 15 cm	15 x 15 cm	5 x 5 cm	4 x 4 cm
Estimated bulk cost[3]	$.50-$1.50	$2.60-$3.35	$1.50	$.90-$1.50
Estimated shelf life before planting[4]	1-3 days after lifting (max. 10 days cool storage)	Several months (max. 6 months)	Several months (est. 3 months)	Several months (est. 2 months)
Transport plants per m^2 of truck deck	480-800	120	500	720
Transport on site – plants carried by one person	20-50 depending on species	8-12	48 (based on 12 books packed into wire cage)	60 (based on 15 books packed into wire cage)

1. Based on average of the shrub hardwoods karamu, koromiko and manuka raised from seed within 12 months of sowing (Bergin and Cole 2010).
2. Based on cross-sectional area of containers and OG plants lined out at 15 x 15 cm spacing.
3. Low plant cost estimates based on planting minimum 20-hectare restoration project at 1.5 x 1.5 m plant spacing (approx. 4444 stems/ha) (Philip Smith, Manager, Taupo Native Plant Nursery, pers. comm.).
4. Estimated time container grown plants can be held in the nursery before planting is largely dependent on degree of root development before distortion occurs.

Planting trial comparing native shrub species raised as open-ground with container-raised plants 5 years after establishment along a riparian zone that forms part of the Mahurangi Farm-Forestry Trail, Auckland region.

References:

Bergin, D.; Cole, C. 2010: Comparisons between open-ground and container-raised indigenous shrubs in nursery and field trials. In: *In:* Barton, I.; Gadgil, R.; Bergin, D. (Eds.) Managing native trees. Towards a national strategy. *Proceedings of the Tane's Tree Trust 10th Anniversary Conference and Workshop, University of Waikato 18-20 November 2009.* Tane's Tree Trust. 64-74.

Bergin, D.O.; Gea, L. 2007: Native trees – planting and early management for wood production. *New Zealand Indigenous Tree Bulletin No. 3.* Revised edition. New Zealand Forest Research Institute. 44p.

Bergin, D.; Steward, G. 2004: Kauri ecology, establishment, growth and management. *New Zealand Indigenous Tree Bulletin No. 2.* New Zealand Forest Research Institute, Rotorua. 48p.

Davis, M.: Douglas, G.; Ledgard, N.; Palmer, D.; Bhubaneswor, D.; Paul, T.; Bergin, D.; Hock, B.; Barton, I. 2009: Establishing indigenous forest on erosion-prone grassland: land areas, establishment methods, costs and carbon benefits. Scion contract report for Ministry of Agriculture and Forestry. 97p.

Forest Research Institute 1980: Raising native trees. *What's New in Forest Research No. 85.* New Zealand Forest Service, Forest Research Institute. 4p.

MacLaren, J.P. 1993: *Radiata pine grower's manual.* FRI Bulletin No. 184. New Zealand Forest Research Institute. 140p.

Morrison, F.T. 1955: Nursery production of kauri at Waipoua Forest. *New Zealand Journal of Forestry* 7(2): 42-52.

Reed, A.H. 1953: *The story of kauri.* A.H. and A.W. Reed. Wellington. 373p.

Smith, P. 2010: Reducing costs associated with establishment of native plants in the Lake Taupo catchment: *In:* Barton, I.; Gadgil, R.; Bergin, D. (Eds.) Managing native trees. Towards a national strategy. *Proceedings of the Tane's Tree Trust 10th Anniversary Conference and Workshop, University of Waikato 18-20 November 2009.* Tāne's Tree Trust. 52-55.

van Dorsser, J.C 2010: Options for successful establishment of natives. In: *In:* Barton, I.; Gadgil, R.; Bergin, D. (Eds.) Managing native trees. Towards a national strategy. *Proceedings of the Tane's Tree Trust 10th Anniversary Conference and Workshop, University of Waikato 18-20 November 2009.* Tāne's Tree Trust. 56-57.

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ISSN: 2230-3014 2013

Printed by Scion Digital Print Centre, Rotorua

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PLANTING and MANAGING NATIVE TREES

Technical Article No. 5.4

Establishment Performance of Native Shrubs
- a comparison of container and open-ground plants

Trials comparing the establishment performance of New Zealand native shrubs raised in open-ground nursery beds with those container-raised. Site now forms part of the Mahurangi Farm-Forestry Trail.

INTRODUCTION

The previous article describes two quite different methods used to raise native plants in nurseries: containers and open-ground beds. This article reports on the establishment performance of plants raised using the open-ground method and two common types of container. These results were obtained from planting trials established in three North Island regions since 2008 using a variety of native shrub hardwood and monocot species. The trials have recently been re-measured providing a good indication of the establishment performance of each nursery method, three to five years after planting.

Collaborative project

This work, made possible by a grant from the Sustainable Farming Fund, builds on a previous SFF project initiated by Mahurangi Action. Collaborators include Tāne's Tree Trust, Lake Taupo Protection Trust, Auckland Council, Waikato Regional Council, Bay of Plenty Regional Council, Scion and Future Forests Research, and Taupo Native Plant Nursery.

Nursery methods

This article reports on the establishment performance of plants raised using the following 3 methods:

1. open-ground
2. pot, semi-rigid (1.2-litre) or planter-bag (PB3, 3-pint/1.7-litre)
3. root trainer (Hillson-sized)

Although some planter bag plants were used in the trials, for simplicity here both planter bags and pots are mostly referred to as pots.

Dissimilar siblings—although grown from the same seed source and germinated at the same time, because open-ground, pot and root trainer plants, progressively, have less room for canopy and root development, their respective sizes at planting differ markedly (see Technical Article 5.3).

PLANTING TRIALS

Trial sites

Planting trials were established in three North Island regions:

- Auckland region – Sandspit Road, Silverdale (a hill country site and a river terrace site);
- Waikato region – Waihaha, western Taupo;
- Bay of Plenty region – near Rotorua at Ngongotaha and Rerewhakaaitu.

Sites ranged from marginal erosion-prone hill country to recently retired riparian zones characteristic of productive landscapes throughout New Zealand. For all planting trials the trial layout is a randomised complete block design.

River terrace site at Silverdale, Auckland region, 6 months after planting the trial with native shrub species (right) and 4 years after planting (below).

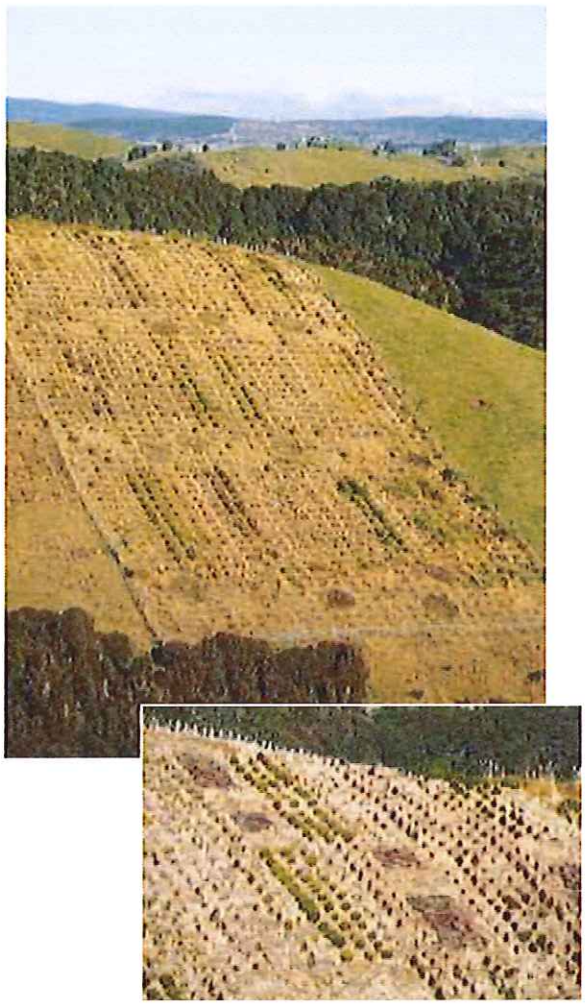
Species

The trials focussed on evaluating the performance of the native shrub species commonly used in forestry revegetation programmes. These were raised in less than one year at the Taupo Native Plant Nursery. Seven species were raised by each of the three nursery methods, and used in most of the planting trials:

- harakeke (flax, *Phormium tenax*)
- karamu *(Coprosma robusta)*
- koromiko *(Hebe stricta)*
- manuka *(Leptospermum scoparium)*
- ti kouka (cabbage tree, *Cordyline australis)*
- toetoe *(Austroderia fulvida* and *A. fulvida)*
- kohuhu *(Pittosporum tenuifolium).*

(Above) Kohuhu planted 4 years at Ngongotaha. Rows with smaller seedlings and gaps indicate the relatively poor establishment performance of the root-trainer plants, compared with plants raised open-ground or in planter bags

(Right) Kohuhu raised in a PB3 planter bag 4 years after planting in the Ngongotaha trial, near Rotorua – pole is 2m high.



Planting trial on a retired steep hill slope at Waihaha, western Taupo, 2 years after planting comparing the 3 nursery methods – open ground, pots, root trainers. Note the 3-tree rows for each species as part of the randomised complete block design (inset).

Site preparation and planting

In the Auckland region trials, rank grass sites were mowed before planting while recently retired sites had been grazed to leave short grass swards. There was no pre-plant spraying with herbicide.

At the Taupo and Rotorua trials, pre-plant spot spraying was used with glyphosate, surfactant and marker dye at label rates. For Taupo trials, rabbits and hares were excluded by the erection of a rabbit-proof fence and laying of pindone poison immediately after planting.

Plant spacing for the Auckland region trials was 1.4 x 1.4 m (5102 stems per ha) and 1.5 x 1.5 m (4444 stems per ha) elsewhere. Weeds were controlled at least twice per year for up to a maximum of 2 years after planting using glyphosate applied by knapsack sprayer.

PLANTING PERFORMANCE

Growth across all sites

Mean survival, and mean annual increment for height and crown spread for the 7 species within the first 3-5 years after planting across all sites is given in Figure 1. Survival averaged more than 80% for 6 of the 7 species and across most nursery methods, except for root-trainer ti kouka which averaged less than 40% survival, and for toetoe which averaged less than 60% survival for all nursery methods.

Height and crown spread increment was similar if not better for open-ground plants across most species compared to pot or planter bag plants (Figure 1). Manuka height growth for open-ground plants was the fastest for all species and methods. Height increment of root trainer plants, particularly for the monocots ti kouka, harakeke and toetoe, were less than the woody shrub hardwood species.

Differences in planting performance

There are exceptions for some species raised open-ground. Consistently higher survival was a feature of manuka raised in the pots across all sites, compared to open-ground or root trainer plants. However, this advantage is likely to be more than offset by the significant cost difference between the nursery methods.

It can be difficult to form a compact fibrous root system open-ground with species such as *Pittosporum*, which tends to stay sparse and woody without extra care in root conditioning. This was reflected in poor survival of open-ground kohuhu plants in the Bay of Plenty and Taupo trials.

Harakeke survival was similar for open-ground and pots, with root trainers, particularly in most of the North Auckland sites, significantly less.

Survival of karamu was reduced in the first year after planting at the Taupo site due to an out-of-season frost, but there has been no significant additional mortality in the second and third years after planting.

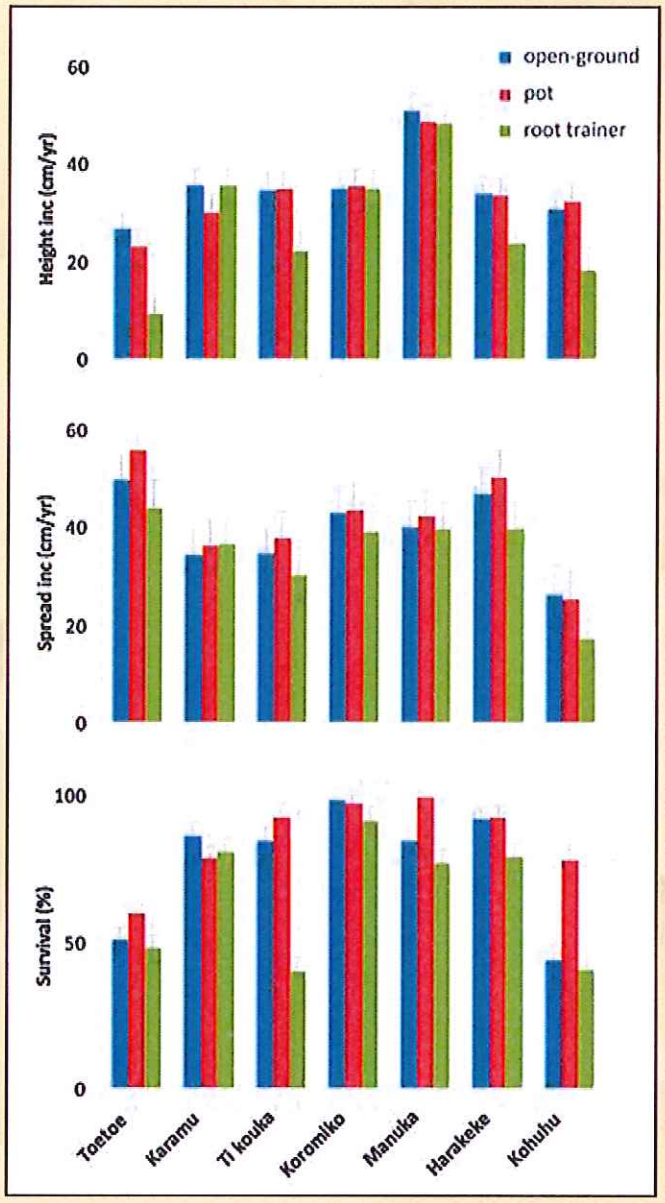


Figure 1: Mean annual increment of height and crown spread, and mean survival, for the 7 native species raised open-ground, in pots (or planter bags) and in root trainers, 3 to 5 years after planting. Not all species were trialled at all sites. Error bars indicate standard errors.

CONCLUSIONS

In general, there was no significant difference in survival and growth within the first 3-5 years between plants raised open-ground and in the larger containers (1.2-litre pots and PB3 planter bags) for the shrub hardwood and monocot species trialled. Higher mortality rates and/or maintenance costs, and slower growth can be expected in plants raised in small containers (Hillson-sized root trainers) with losses largely due to spindly plants being overtopped by grass competition, especially where timely weed control is not carried out.

These trials only evaluated establishment of some hardy pioneer shrub hardwood and monocot species often used to provide a protective cover as a first step in revegetation of indigenous forest. The results indicate an opportunity to significantly reduce the cost of establishing planted native forests using plants raised by the open-ground nursery method.

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ISSN: 2230-3014 2013

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