

Miniplug Transplants: Producing Large Plants Quickly

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Abstract: Miniplug transplants are a new nursery stocktype created when seedlings from very small containers are transplanted into bareroot nursery beds or larger containers. Most miniplugs used in forest and conservation nurseries feature some sort of stabilized growing medium—this allows the seedlings to be transplanted before they grow sufficient roots to form a root plug. Miniplug transplants continue to grow in popularity because they are a quick way to produce large plants, are very efficient in use of nursery production space, and have a very favorable seed-to-shippable plant ratio.

Introduction

The concept of transplanting container seedlings began in the bareroot nursery industry. The first published record of transplanting container seedlings was at the Ray Leach Nursery in Aurora, OR in 1971. That first crop was not very successful, and it was 4 years until it was tried again. In the spring of 1975, Phil Hahn grew a small trial of Douglas-fir (*Pseudotsuga menziesii*) container seedlings at the Georgia-Pacific container facility in Cottage Grove, Oregon and then transplanted them to the Tyee Tree Nursery near Roseburg, Oregon. The following fall, the crop was harvested, showing good uniformity and yield. The plants looked quite different from normal bareroot transplants, with the production of many fine roots. With the true test being outplanting survival, these first trials were encouraging in spite of a severe summer drought. This new “plug+1” stocktype was slow to catch on. However, a 1983 survey showed plug transplants had reached about 2% of total forest nursery production (Hahn 1984).

Miniplug transplants are an even newer phenomenon. In nursery jargon, seedlings produced in containers are called “plugs” because of the firm root mass formed by the end of the growing season. In forest and conservation nurseries, container stock has traditionally been produced in multi-celled containers, filled with a variety of growing media, with volumes ranging from 2 to 30 in³ (33 to 492 cm³). Miniplugs are very small container plants grown in predominantly stabilized medium in containers less than 2 in³ (33 cm³) in volume. In contrast to standard container seedling culture, miniplug seedlings are grown with the objective of transplanting following a short period of culturing in this container.

In the ornamental and vegetable industry, plants have been grown in small plug containers for many years; this practice is relatively new for forest trees and other native plants. The published literature is also rather sparse. Whereas there are whole books on plug culture for horticultural crops (for example, Styer and Koranski 1997), only a few articles have been published about miniplugs in forest and conservation nurseries.

Stabilized Media

Most miniplugs used in forest and conservation nurseries feature stabilized growing media, which I define as any growing medium that holds the root system together when removed from the container regardless of root development. Stabilized media allow miniplugs to be extracted from their containers before a firm root plug has formed (fig. 1). This allows miniplugs to be transplanted weeks before the seedling root system would have formed a firm plug, and is one of the system’s primary advantages. In addition, roots in stabilized plugs haven’t developed the typical deformities that often lead to structural defects in the transplants. There are two methods of stabilizing the media in miniplugs:

1. Physically Stabilized Plugs. This was the first method of keeping the growing medium together. Examples are Jiffy® Forestry Pellets, which use plastic mesh (fig. 1A), and Ellepots®, which feature treated paper (table 1).

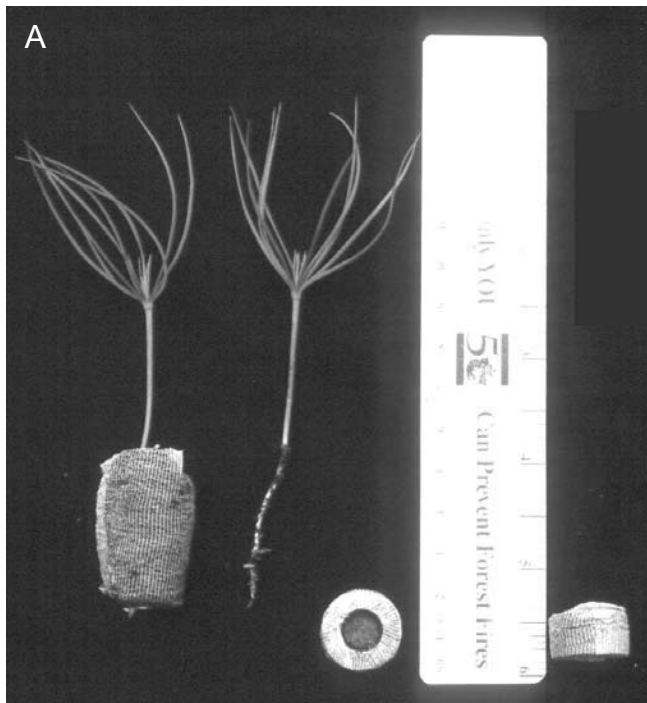
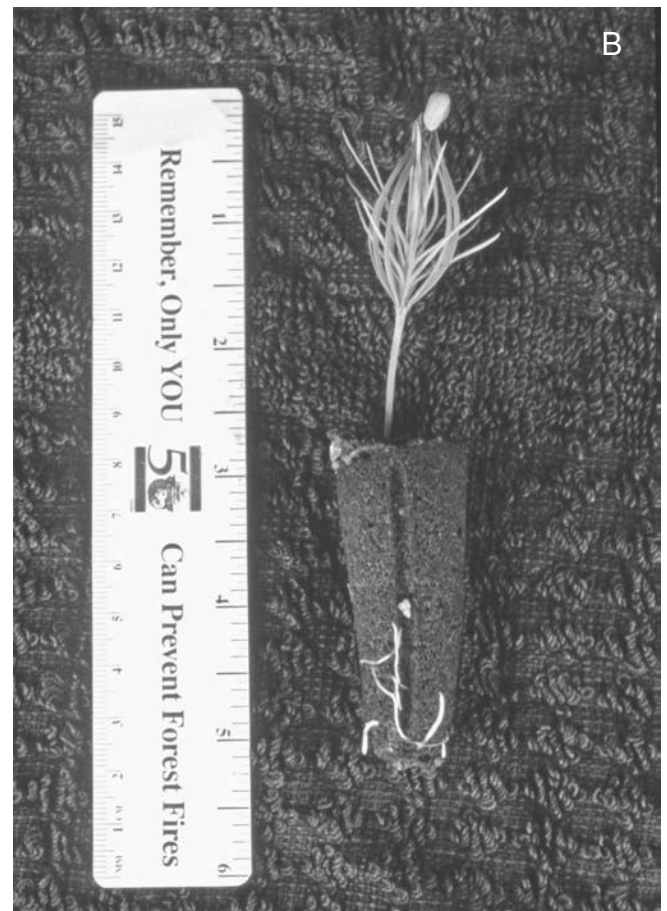


Figure 1—Most miniplugs used in forest and conservation nurseries feature stabilized media that hold the root plug together and allow earlier transplanting: (A) Jiffy-7® Forestry Pellet, (B) Q plug®.



2. Chemically Stabilized Plugs. This newer system uses chemical binders to hold the growing media together (fig. 1B). All of the chemical binders are trade secrets, but examples include Q plugs®, Excel® plugs, Preforma® plugs, and HortiPlugs® (table 1).

Types of Miniplug Transplants

Although there are many miniplugs on the market, only a relative few have been used for transplanting in forest and native plant nurseries (table 1). Miniplugs are used in two distinct stocktypes: container-to-bareroot transplants, and container-to-container (plug-to-plug) transplants.

Bareroot plug transplants have a traditional stocktype nomenclature, “plug” followed by the number of years in the transplant bed. For example, container seedlings that will be in the transplant bed for 1 year are known as Plug+1, whereas those that will remain another year are Plug+2. There is no standard stocktype naming system for miniplug transplants but, following this system, we can add whether they were transplanted to bareroot beds (B) or other containers (C):

- Miniplug+1BR = Miniplugs that have been transplanted to bareroot beds and grow there for 1 year.
- Miniplug+1C = Miniplugs that have been transplanted to larger containers and remain there for 1 year.

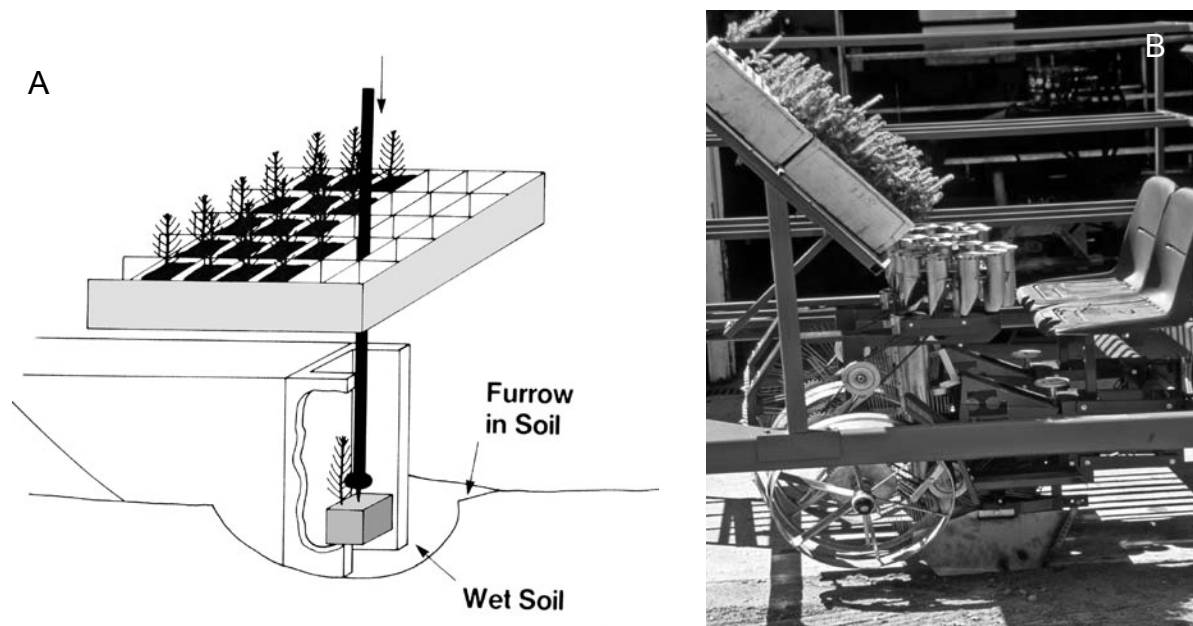
Bareroot Miniplug Transplants

The first bareroot miniplug transplants that I saw were grown in Techniculture® peat plugs in Thunder Bay, Ontario in the early 1980s. Although these early trials were very successful (Klapprat 1988), this technology was never adopted on a large scale. A few years later, the Weyerhaeuser Company purchased the rights to the MiniPlug™ Transplant System from Grower's Transplanting of Salinas, CA (Hee and others 1988). Extensive field testing on a variety of outplanting sites in western Oregon and Washington showed that bareroot miniplug transplants survived and grew as well as, or better than, other bareroot stocktypes (Tanaka and others 1988). Their transplanter, which used pneumatic plant setters to push the miniplug from the growth tray and into the soil, proved impractical (fig. 2A). Miniplugs were too small for standard clip-and-wheel type transplanters, so this new stocktype did not become popular until the development of the carousel-type transplanter (fig. 2B). The plants are dropped into the carousel tubes and are not subject to the centrifugal forces that result in root sweep. The individual carousel transplanter units are ganged on a tool bar in a staggered array to produced row spacing as close as 12 in (31 cm) (Windell 2003).

Responding to the demand for large transplant stock produced in a short time, the USDA Forest Service J Herbert Stone Nursery in Central Point, OR, decided to use Q plugs® to produce miniplug transplants. They constructed an

Table 1—Types of miniplugs currently used for transplanting in forest and native plant nurseries.

Manufacturer	Brand name	Container	Growing media	Plug sizes
International Horticultural Technologies Hollister, CA Website: www.ihort.com E-mail: info@ihort.com	Q Plug®	Pre-filled Styrofoam™ or plastic trays	Patented peat and bark mixture, or custom mixes	Wide range, from 0.22 in ³ (3.6 cm ³) to large sizes
	Excel® Plug	Pre-filled Styrofoam™ or plastic trays	Patented peat and bark mixture, or custom mixes	Wide range, from 0.22 in ³ (3.6 cm ³) to large sizes
Jiffy Products Norwalk, OH and Shippagan, NB, CANADA Website: www.jiffypot.com E-mail: jiffy@vianet.ca	Jiffy-7® Forestry Pellets	Disintegrating plastic net around plugs in plastic trays	Compressed peat mixture, or Carefree™ pellets	0.7 in (18 mm) diameter pellet expands to 0.9 in (22 mm), with heights of 1.3 in (32 mm) or 1.6 in (42 mm)
	Preforma® Plug	Pre-filled Styrofoam™ or plastic trays	Peat or mixtures with vermiculite or perlite with binding agent, or custom mixing available	Wide range, from 0.25 in ³ (4 cm ³) to any larger size cavity
	HortiPlug®	Pre-filled Styrofoam™ or plastic trays	Coir-based blend with binding agent	Wide range, from 0.25 in ³ (4 cm ³) to any larger size cavity
Purchase machine from Blackmore Company Belleville, MI Website: www.ellepot.dk E-mail: kmarlin@blackmoreco.com	Ellepot® System	3 grades of porous, biodegradable paper	Mixture of peat, vermiculite and perlite, or custom mix	0.6 x 1.6 in (15 x 40 mm) plug that fits into a standard 338 horticulture tray
Grow-Tech Inc. PO Box 298 Boothbay, ME 04537 Tel: 207.353.5005 FAX: 207.353.5155 Website: www.grow-tech.com	Flexiplug®	Pre-filled expanded polystyrene trays, or custom filled	Composted bark and peat	Wide range of plug sizes and shapes starting at 0.5 x 0.7 in (13 x 18 mm)

**Figure 2**—Although the MiniPlug™ Transplant System (A) proved impractical, the carousel-type transplanter (B) revived the popularity of miniplug transplants.

innovative 9-row transplanter that can transplant an average of 25,000 miniplugs per hour (175,000/day) per machine at a density of 12 miniplugs/ft² (130 miniplugs/m²) in a standard 4-ft (1.2-m) wide transplant bed (Wearstler 2006). Species trials showed that ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*P. jeffreyi*), sugar pine (*P. lambertiana*), Douglas-fir (*Pseudotsuga menziesii*), western redcedar (*Thuja plicata*), incense cedar (*Calocedrus decurrens*), western larch (*Larix occidentalis*) and red alder (*Alnus rubra*) could be produced in

1 year. Slower-growing species, including western white pine (*Pinus monticola*), western hemlock (*Tsuga heterophylla*), Engelmann spruce (*Picea engelmannii*) and noble fir (*Abies procera*) required an extra season in the transplant beds to reach shippable size (fig. 3A). The resultant plants have thick stem diameter (fig. 3B) and extensive, fibrous root systems (fig. 3C). Outplanting trials have demonstrated their superior performance, especially on sites with heavy brush competition.

A Seedling stock type	Year One												Year Two												Year Three					
	J a n	F e b	M a r	A p r	M a y	J u n	J u l	A u g	S e p	O c t	N o v	D e c	J a n	F e b	M a r	A p r	M a y	J u n	J u l	A u g	S e p	O c t	N o v	D e c	J a n	F e b	M a r	A p r	M a y	
Qplug + 1BR Spring Outplant	S				T																									
Qplug + 2BR Spring Outplant	S				T																									
Legend	Sowing & Emergence Active Growth in Greenhouse Active Growth in Bareroot Beds Hardening Transplanting Dormant Harvesting & Storage Outplanting																													

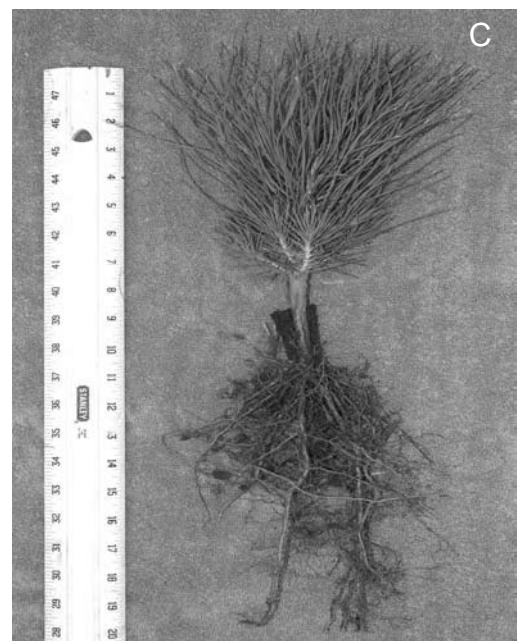
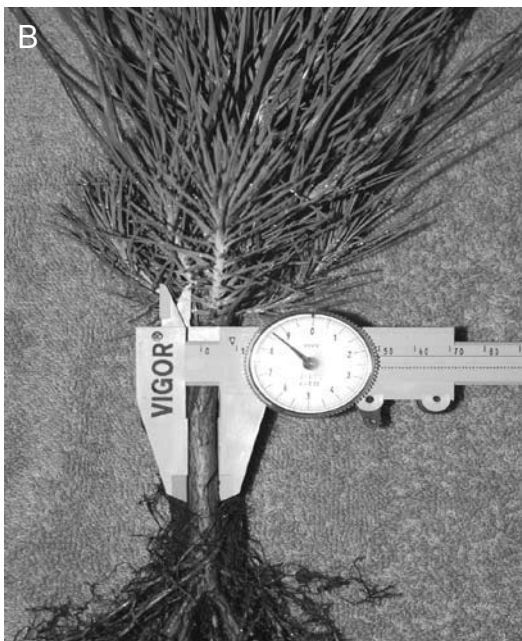


Figure 3—Miniplug bareroot transplants can be produced in 1 to 2 seasons at the USDA Forest Service J Herbert Stone Nursery (A). Their thick stem diameter (B) and fibrous root systems (C) have proven popular with customers.

Miniplug Container Transplants (Plug-to-Plug)

Transplanting miniplug seedlings to other containers is a much newer phenomenon. The traditional practice of “pricking out” young seedlings from germination trays and transplanting them into containers has been done since container plants became popular in the 1970s. This practice has several operational drawbacks, especially root deformation and resultant stunting of the transplant.

Starting plants in miniplugs and transplanting them to containers has only become popular in forest and conservation nurseries in the last 10 to 15 years. Initially, all transplanting was done by hand, which is still the most popular technique. Mechanical transplanters are common in horticulture (Bartok 2003), and larger forest nurseries have experimented with the newest equipment, some of which use computer vision to deal with blank cells in the miniplug blocks (Pelton 2003). However, the high cost of the transplanters has limited their acceptance in most nurseries. Bartok (2003) estimated that an automatic transplanter (U.S. \$60,000) will take at least 3 years to pay for itself in labor savings. This estimate is based on large numbers of a uniform crop. However, this is rarely the case in forest and conservation nurseries who deal with smaller orders and many different species and seed sources. So, for the near future, hand transplanting will remain the transplanting method of choice.

Microseed Nursery of Ridgefield, Washington (Moreno 2006) has developed a successful miniplug container transplant system based on Excel® miniplugs into Hiko™ V265 containers [16 in³ (265 cm³)]. The miniplugs are sown in late summer. After the miniplug seedlings become established, they are overwintered in the greenhouse and then transplanted the following spring. They grow to shippable size and are hardened in outdoor compounds. This stocktype takes 16 to 20 weeks to produce, depending on whether the target is fall or spring outplanting (fig. 4A). One unique innovation is that seedlings destined for fall outplanting are treated with blackout to hasten the hardening process. This growing regime produces seedlings with hefty stem diameters (fig. 4B), and full, well-balanced shoots (fig. 4C).

Benefits Of Miniplug Transplants

Several factors have contributed to the increasing attraction for this new stocktype by both nursery managers and customers.

Demand for Larger Stocktypes

Foresters and other native plant customers have been asking for larger and larger seedlings, and several things have contributed to this trend. New “Free-to-Grow” reforestation standards have created a demand for larger nursery stock that will not only survive, but grow quickly. For example, reforestation laws in the state of Oregon require that trees outplanted on cutover lands must have grown above the competing vegetation in only 5 years. In addition, fewer mechanical and chemical site preparation options are available

nowadays, and larger plants with more buds seem better able to tolerate browsing (Landis 1999).

Larger native plants are also in demand for restoration projects. For example, when three stocktypes of blue oak (*Quercus douglasii* Hook. & Arn.) were grown in northern California, the miniplug transplants were considerably larger, especially in root mass, and survived and grew as well or better than the other stocktypes after outplanting (table 2).

Shorter Nursery Crop Cycles

In addition to larger plants, nursery customers are asking for their stock in less time. Planning horizons for reforestation and restoration are becoming shorter and shorter; therefore, 1-year stocktypes are increasingly popular. This is particularly true in fire restoration where the number of acres is not known until the fire is suppressed. As a result, restorationists want the nursery stock as soon as possible. A delay in outplanting allows competing vegetation to become established, which increases planting costs and decreases seedling growth and survival (Rose and Haase 2005). The miniplug transplant is ideally suited for these situations because large plants are produced in 1 year or even less.

Efficient Use of Nursery Production Space

Nursery efficiency is best measured by the number of shippable plants harvested per area of production space, either in the greenhouse or in nursery beds. Miniplugs are popular with nursery managers because they take up so little space. For example, the Q plugs® used for transplanting at the JH Stone Nursery come from Styroblock™ containers that yield 80 plants/ft² (861 plants/m²) and are ready for transplanting in as little as 12 weeks. This space efficiency carries over into the transplant beds in the bareroot nursery because the precise spacing of 15 plants/ft² (161 plants/m²) produces plants with few culls at harvest time. This greatly reduces the costs of lifting and packing.

Container-to-container miniplugs make the most efficient use of expensive greenhouse bench space in both the donor container and the destination container. For example, if miniplugs were grown in a Styroblock™ 440/10 container and then transplanted to a Styroblock™ 35/340, there would be an almost 10X savings in bench space (table 3). In actual practice, the savings would be even higher because the miniplugs would be graded before transplanting and produce almost 100% yield. Pelton (2003) estimates that sowing in miniplugs saves approximately 70% in heating costs during that production phase when compared to direct sowing in the same size destination container. After transplanting, most nurseries move the large containers to open growing compounds where production costs are much lower than in greenhouses.

Increased Seed Use Efficiency

One of the most attractive advantages of miniplug transplants is that they have much better seed-to-seedling ratios than other stocktypes. This is because weak seeds or seedlings are culled out early in the crop cycle, and only vigorous miniplug seedlings are transplanted to bareroot beds or other

A Seedling stock type	Year One												Year Two												Year Three							
	J a n	F e b	M a r	A p r	M a y	J u n	J u l	A u g	S e p	O c t	N o v	D e c	J a n	F e b	M a r	A p r	M a y	J u n	J u l	A u g	S e p	O c t	N o v	D e c	J a n	F e b	M a r	A p r	M a y			
										B																						
Excel P+P Fall outplant								S							T									O	O							
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Excel P+P Spring outplant								S							T													O	O			
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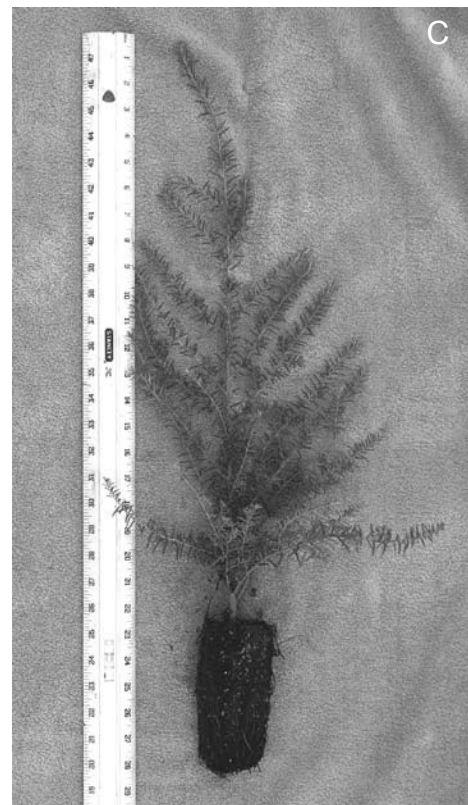


Figure 4—At Microseed nursery, the crop schedule for container-to-container (“plug-to-plug”) miniplug transplants includes a blackout treatment (labeled B on the chart) to induce hardiness before transplanting (A). The resultant seedlings have impressive stem diameters (B), and a well-balanced shoot-to-root ratio (C).

Table 2—Comparison of blue oak (*Quercus douglasii* Hook. & Arn.) stocktypes in California^a.

Stocktype	Stem weight ^b	Root weight ^b	S:R ratio	Outplanting survival	Cost/100 plants
				percent	(1990 U.S.\$)
1+0 Container	—	—	—	88	\$92
1+0 Bareroot	1.4 a	3.9 a	0.36 b	91	\$50
2+0 Bareroot	3.8 b	5.3 a	0.68 a	97	\$65
Miniplug + 1BR transplant	4.6 b	10.4 b	0.43 b	95	\$111

^a Modified from McCreary and Lippitt (2000)
^b In each column, means followed by different letters are significantly different by a Fishers Protected Least Significant Difference (LSD) Test.

Table 3—Growing space comparison between donor and destination containers.

Container type	Cavity volume—in ³ (ml)	Cavities/ft ² (m ²)
Donor container—Styroblock™ 440/10	1.1 (18)	197 (2,121)
Destination container—Styroblock™ 35/340	20.5 (336)	20 (213)

containers. In some of the very first trials with miniplugs in Ontario, they were able to reduce the seed-to-seedling ratio from 12:1 to 3:1 (Klapprat 1988). Increased seed use efficiency is even more important with genetically-improved forest tree seeds, or with native plants where seeds are scarce or have irregular germination due to complicated dormancy requirements (fig. 5).



Figure 5—Native plants are being sown in miniplugs because it is easier to manage uneven germination rates.

Summary

Miniplug transplants are the newest stocktype in forestry, conservation, and native plant nurseries, and I predict their popularity will continue to increase because they come closest to achieving nursery production goals:

- Almost 100% yield, resulting in few culls;
- Highest plant density per production area;
- Maximum use efficiency of seeds or cuttings;
- Shortest crop rotation;
- Stock quality is improved, as plants with large stem diameter and fibrous root systems are produced.

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- Nursery-to-Forest Solutions—Steve Grossnickle

References

Bartok JW Jr. 2003. Container-to-container transplanting operations and equipment. In: Riley LE, Dumroese RK, Landis TD, technical coordinators. National proceedings: forest and conservation nursery associations—2002. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28. p 124–126.

Hahn PF. 1984. Plug+1 seedling production. In: Duryea ML, Landis TD, editors. Forest nursery manual: production of bareroot seedlings. Boston (MA): Martinus Nijhoff/Dr W Junk Publishers. p 165–181.

Hee SM, Stevens TS, Walch DC. 1988. Production aspects of miniplug transplants. In: Landis TD, compiler. Proceedings, combined meeting of the Western Forest Nursery Associations; 1988 August 8–11; Vernon, British Columbia. Fort Collins (CO): USDA Forest

- Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-167. p 168–171.
- Klapprat RA. 1988. Techniculture transplants—an innovation in planting stock production. In: Taking stock: the role of nursery practice in forest renewal. In: Smith CR, Reffle RJ, editors. Taking stock: the role of nursery practice in forest renewal; 1987 Sep 14–17; Kirkland Lake, Ontario. Sault Ste Marie (Ontario): Canadian Forestry Service, Great Lakes Forestry Centre. OFRC Symposium Proceedings O-P-16. p 31–33.
- Landis TD. 1999. Forest and conservation nursery trends in the northwestern United States. In: Landis TD and Barnett JP, editors. National proceedings, Forest and Conservation Nursery Associations—1998. Asheville (NC): USDA Forest Service, Southern Research Station. General Technical Report SRS-25. p 78–80.
- McCreary DD, Lippitt L. 2000. Blue oak mini-plug transplants: how they compare to standard bareroot and container stock. *Native Plants Journal* 1(2): 84–89.
- Moreno RA. 2006. Personal communication. Ridgefield (WA): Manager, Microseed Nursery.
- Pelton S. 2003. Aspects to make plug-to-plug transplanting a success. In: Riley LE, Dumroese RK, Landis TD, technical coordinators. National proceedings: forest and conservation nursery associations—2002. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28. p 117–123.
- Rose R, Haase DL. 2005. Rapid response reforestation studies in fire restoration. In: Dumroese RK, Riley LE, Landis TD, technical coordinators. National proceedings, forest and conservation nursery associations—2004. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-35. p 90–93.
- Styer RC, Koranski DS. 1997. Plug and transplant production: a grower's guide. Batavia (IL): Ball Publishing. 315 p.
- Tanaka Y, Carrier B, Dobkowski A, Figueroa P, Meade R. 1988. Field performance of mini-plug transplants. In: Landis TD, compiler. Proceedings, combined meeting of the Western Forest Nursery Associations; 1988 August 8–11; Vernon, British Columbia. Fort Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-167. p 172–181.
- Wearstler KA. 2006. Personal communication. Central Point (OR): Nursery Manager, USDA Forest Service J Herbert Stone Nursery.
- Windell 2003. Tree seedling transplanters. In: Riley LE, Dumroese RK, Landis TD, technical coordinators. National proceedings: forest and conservation nursery associations—2002. Fort Collins (CO): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28. p 108–116.