Miniplug Transplants: Producing Large Plants Quickly

by Thomas D. Landis

Abstract

Miniplug transplants are a new nursery stocktype created when seedlings from very small containers are transplanted into bareroot nursery beds or larger containers. All miniplugs used in forest and conservation nurseries feature some sort of stabilized growing medium which allows transplanting before the plugs become rootbound. Miniplug transplants continue to grow in popularity because they are a quick way to produce large plants, they are very efficient in use of nursery production space, and have a very favorable seed-to-shippable plant ratio.

Introduction

To begin, what do we mean by a "miniplug"? 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 with volumes from 2 to 30 in^3 (33 to 492 cm^3). Miniplugs, therefore, are very small container plants grown in containers less than 2 in^3 (33 cm^3) in volume.

Types of Miniplugs

In the ornamental and vegetable industry, plants have been grown in small plug containers for many years, but 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.

Miniplug stocktypes. 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 one year are known as "Plug+1", whereas those that will remain another year are "Plug+2". There is no standard stock ype naming system for container miniplug transplants but, following this system, we can add whether they were transplanted to other containers (C) or bareroot beds (B):

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

Stabilized media. All of the 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. Stabilized media allow miniplugs to be extracted from their containers before a firm root plug has formed (Figure 1). This allows miniplugs to be transplanted weeks before the seedling root system would have formed a firm plug, and is one of the

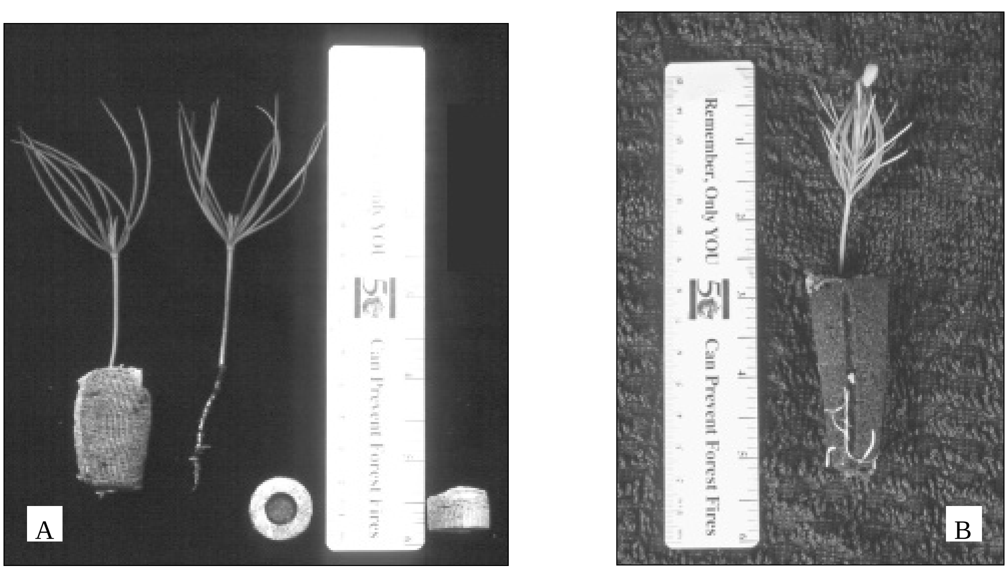


Figure 1—All miniplugs used in forest and conservation nurseries featuer stablilized media which holds the root plug together and allows earlier transplanting: A) Jiffy-7® forestry pellet, B) Q Plug®.

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

Brand Name	Manufacturer	Container	Growing Media	Plug Sizes
Q Plug®	International Horticultural Technologies Hollister, CA Website: www.ihort.com Email: info@ihort.com	Prefilled 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®		Prefilled 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-7® Forestry Pellets	Jiffy Products Norwalk, OH and Shippagan, NB, Canada Website: www.jiffypot.com Email: jiffy@vianet.ca	Compostable 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		Prefilled Styrofoam™ or plastic trays	Compressed peat mix with binding agent. Custom mixing available	Wide range, from 0.25 in^3 (3.6 cm^3) to large sizes
HortiPlug®		Prefilled Styrofoam™ or plastic trays	Patented Coir-Bark blend with binding agent	Wide range, from 0.25 in^3 (3.6 cm^3) to large sizes
Ellepot® System	Purchase machine from Blackmore Co. Belleville, MI. Website: www.ellepot.dk Email:kmarlin@blackmoreco.com	3 grades of porous biodegradable paper	Mixture of peat, vermiculite & perlite, or custom mix	0.6 x 1.6 in (15 x 40 mm) plug that fits into a standard 338 horticulture tray

system's primary advantages. In addition, roots in stabilized plugs haven't developed the deformities that characterize other root plugs, and often lead to structural defects in the transplants. There are two methods of stabilizing the media in miniplugs:

1. Physically Stabilized Plugs – This is the older method of keeping the growing medium together. Examples are Jiffy® Forestry Pellets which use plastic mesh (Figure 1A). and Ellepots® which feature treated paper (Table 1).

2. Chemically Stabilized Plugs - This newer system uses chemical binders to hold the growing media together (Figure 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 many miniplugs are on the market, only a relative few have been used for transplanting in forest and native plant nurseries (Table 1). Miniplugs are used in 2 distinct stocktypes: container-to-bareroot transplants, and container-to-container (plug-to-plug) transplants.

Bareroot miniplug transplants. Before we can discuss miniplug transplants, we need to look back at the whole concept of container plants transplanted to bareroot nurseries. The first published record of transplanting container seedlings was at the Ray Leach Nursery in Aurora, Oregon in 1971. Apparently, that first crop wasn't too successful, because it was four years until it was tried again. In the spring of 1975, Phil Hahn grew a small trial of Douglas-fir 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 and showed good uniformity and yield. The plants looked quite different from a normal bareroot transplant, especially in the root systems, which were very busy with many fine roots. Of course, the true test is on the outplanting sites, and these first trials were encouraging in spite of a severe summer drought. This new "plug+one" stocktype was slow to catch-on, but by the time of a 1983 survey, plug transplants had reached about 2 % of total forest nursery production (Hahn 1984).

Miniplug transplants are an even newer phenomenon. The first 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, California (Hee and others 1988). Extensive field testing on a variety of outplanting sites in western Oregon and Washington showed that 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

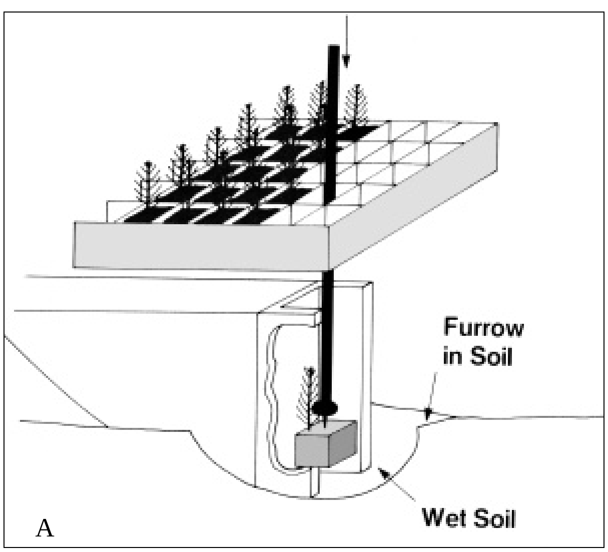
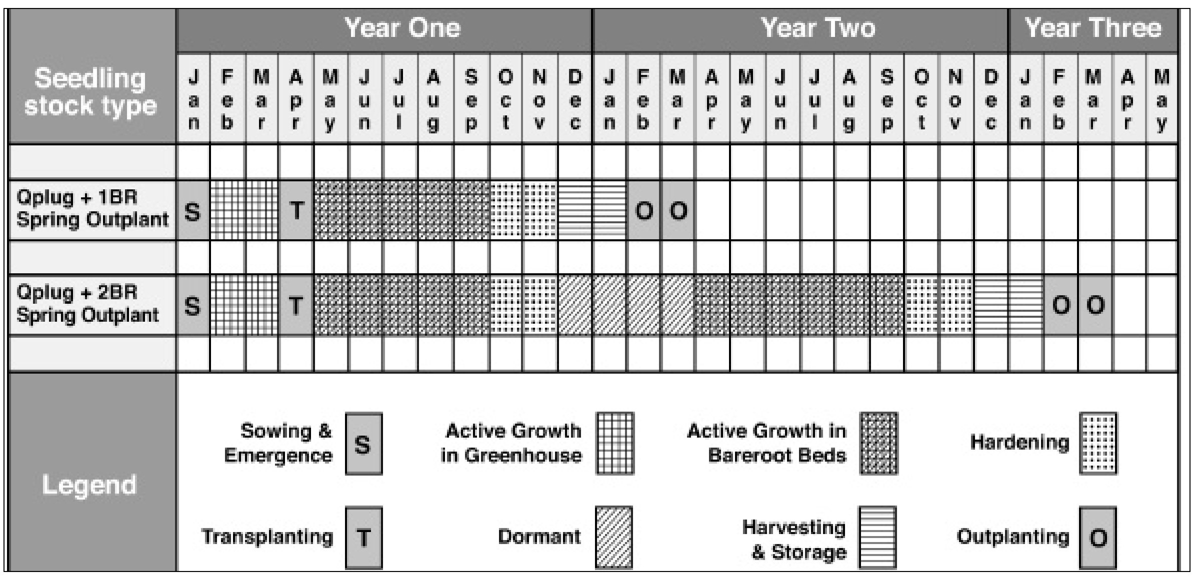
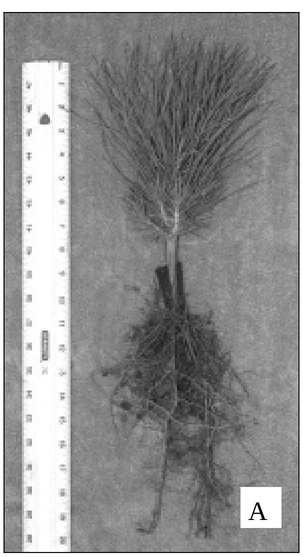


Figure 2—Although the MiniPlug™ Transplant System (A) proved impractical, the carousel-type transplanter (B) revived the popularity of miniplug transplants.

growth tray and into the soil, proved impractical (Figure 2A). Miniplugs were too small for standard clip-and-wheel type transplanters and so this new stocktype did not become popular until the development of the carousel-type transplanter (Figure 2B). The plants are dropped into the carousel tubes and so are not subject to the centrifugal forces that cause 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 2002).

Responding to the demand for large transplant stock produced in a short time, the JH Stone nursery in Central Point, Oregon decided to use Q Plugs® to produce miniplug transplants. They constructed an innovative 9-row transplanter can transplant an average of 25,000 miniplugs per hour (175,000/day) per machine at a density of 12 miniplugs per ft^2 ($130/m^2$) 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 one year. Slower growing species, including western white pine (*P. 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 (Figure 3A). The resultant plants have the thick stem diameter (Figure 3B) and extensive, fibrous root systems (Figure 3C). Outplanting trials have demonstrated their superior performance, especially on sites with heavy brush competition.





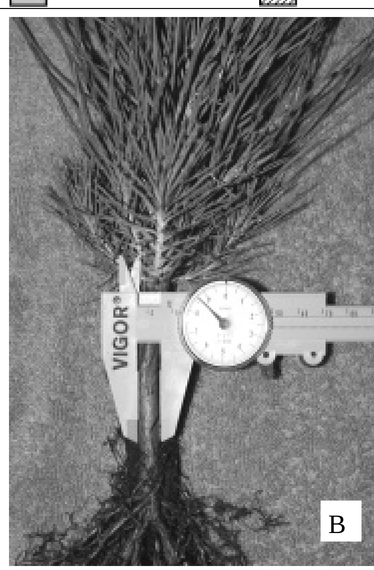


Figure 3—Miniplug bareroot transplants using Q Plugs® *can be produced in 1 to 2 seasons at the JH Stone Nursery (A). Their thick stem diameter (B) and fibrous root systems have proven popular with customers.*

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 tray and transplanting them into a container 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 and that 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) estimates that a $60,000 automatic transplanter 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, which 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 method of choice.

Microseed Nursery of Ridgefield, Washington (Moreno 2006) has developed a successful miniplug container transplant system based on Excel® miniplugs going into Hiko V265 containers (16 in^3 [265 cm^3]). The miniplugs are sown in late summer, and their stock takes 16 to 20 weeks to produce, depending on whether the customer wants fall or spring outplanting (Figure 4A). After the miniplug seedlings become established they are overwintered in the greenhouse and then transplanted the following spring. Then, they grow to shippable size and are hardened in outdoor compounds. One unique innovation is that seedlings destined for fall outplanting are treated with blackout to haste the hardening process. This growing regime produces seedlings with hefty stem diameters (Figure 4B), and full, well-balanced shoots (Figure 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 not only survive but will 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).

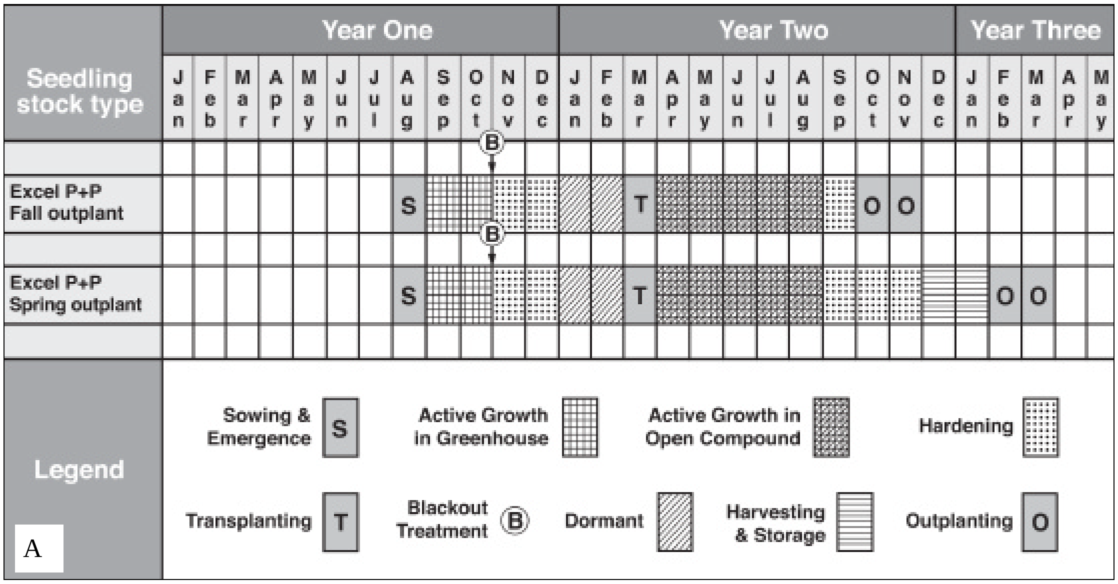
Larger native plants are also in demand for restoration projects. For example, when 3 stocktypes of blue oak (*Quercus douglasii* Hook. & Arn.) were grown in northern California, the miniplug transplants were considerably larger, especially in root mass and survived and grew as good or better than the 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, and so one-

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

Stocktype	Stem Wt.**	Root Wt.	Shoot:Root Ratio	Outplanting Survival%	Cost/100 Plants (1990$)
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

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



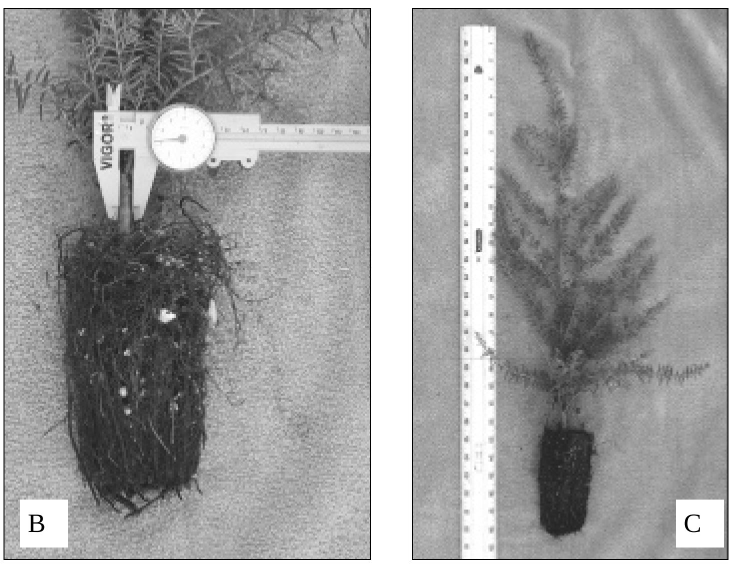


Figure 4—At Microseed Nursery, the crop schedule for container-to-container ("plug-to-plug") miniplug transplants includes a blackout treatment to induce hardiness before transplanting (A). The resultant stock have impressive stem diameters (B), and a well-balanced shoot-to-root ratio (C).

year stocktypes are increasingly popular. This is particularly true in fire restoration where the number of acres won't be known until the fire is suppressed. Then, restorationists want the nursery stock as soon as possible. A delay in outplanting allows competing vegetation 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 they produce large plants in one 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 per ft^2 (861 per m^2) 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 per ft^2 (161 per m^2) 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

Table 3—Growing space comparison between donor and destination container in plug to plug transplants		
Container Type	**Cell Volume - in^3 (ml)**	**Cells per ft^2 (m^2)**
Donor Container—Stryroblock™ 440/10	1.1 (18)	197 (2,121)
Destination Container—Stryroblock™ 35/340	20.5 (336)	19.8 (213)

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 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 seed is scarce or has irregular germination due to complicated dormancy requirements (Figure 5).

Figure 5—Native plants, like this red alder, 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:

- Close to 100 % yield – few culls
- Highest plant density per production area
- Maximum use efficiency of seeds or cuttings
- Shortest crop rotation
- Stock quality - plants with large stem diameter and fibrous root systems.

Acknowledgements

The author was to gratefully thank the following organizations and people for sharing their knowledge and experience:

JH Stone Nursery - Ken Wearstler and Steve Feigner
Microseed Nursery - Raúl Moreno
Weyerhaeuser Nurseries - Gale Thompson & Tina Herman
Jiffy Products - Don Willis
International Horticultural Technologies - Cor Baars
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. Ogden (UT): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28: 124-126.

Hahn, PF. 1984. Plug+1 seedling production. IN Duryea ML, Landis TD, eds. Forest Nursery Manual: Production of Bareroot Seedlings. Martinus Nijhoff/Dr W. Junk Publishers. The Hague/Boston/Lancaster, for Forest Research Laboratory, Oregon State University. Corvallis. 386 p.

Hee SM, Stevens TS, Walch DC. 1988. Production aspects of mini-plug transplants. IN: Landis TD, comp. Proceedings, combined meeting of the Western Forest Nursery Associations. Vernon ,BC. 8-11 Aug 1988. Ft. Collins (CO): USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Gen. Tech. Rep. RM-167: 168-171.

Klapprat, RA. 1988. Techniculture transplants - an innovation in planting stock production. IN: Taking stock: the role of nursery practice in forest renewal. OFRC Symposium Proceedings O-P-16. Kirkland Lake, ON. 14-17 Sep 1987. Sault Ste. Marie (ON): Canadian Forestry Service, Great Lakes Forestry Centre: 31-33.

Forest and conservation nursery trends in the northwestern United States. IN: Landis TD and Barnett JP, eds. National Proceedings: Forest and Conservation Nursery Association— 1998. Asheville (NC): USDA Forest Service, Southern Research Station:General Technical Report SRS-25. 78-80

Moreno RA 2006. Personal Communication. Ridgefied (WA): Microseed Nursery.

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.

Pelton S. 2003. Aspects to make plug-to-plug transplanting a success, or, "If you think that something small cannot make a difference -- try going to sleep with a mosquito in the room." IN: Riley LE, Dumroese RK, Landis TD, technical coordinators. . National Proceedings: Forest and Conservation Nursery Associations—2002. Ogden, (UT): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28: 117-123.

Rose R, Haase DL. 2005. Rapid response reforestation studies in fire restoration. IN: Dumroese RK, Riley LE, Landis, TD, comp. National proceedings, Forest and Conservation Nursery Associations, 2004. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Research Station, Proceedings RMRS-P-35: 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. Landis TD, comp. Proceedings, combined meeting of the Western Forest Nursery Associations; 1988 August 8-11; Vernon, British Columbia. Gen. Tech. Rep. RM-167. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 172-181.

Wearstler KA. 2006. Personal communication. Central Point (OR): USDA Forest Service, JH Stone Nursery.

Windell 2002. Tree seedling transplanters. IN: Riley LE, Dumroese RK, Landis TD, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2002. Ogden (UT): USDA Forest Service, Rocky Mountain Research Station. Proceedings RMRS-P-28: 108-116.