Using Tree Shelters as Deep Containers

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Abstract

Tubex™ tree shelters worked well as containers for growing mesquite (*Prosopis glandulosa* Torr.) for a desert restoration site. The double-wall shelter resulted in increased growth in the container and development of a robust root system and shoot for planting on severe sites. With the tree shelter installed after planting, very little material remains to be returned to the nursery. Gravity wick irrigation worked well for these deep-rooted plants and appears to be a promising method for remote sites.

Introduction

Planting containerized stock is essential for successful revegetation or restoration of most dry sites (Bainbridge 2007). More than 25 years of desert restoration projects on a variety of very challenging sites have demonstrated the value of choosing a container that best meets the biological and bureaucratic requirements of the project while still resulting in high field survival at minimal cost. Choosing an appropriate container is one of the most important considerations of a successful planting program. Many projects and experiments have demonstrated that good seedling survival and growth can be expected from a wide range of container sizes, even in areas with annual precipitation of less than 3 in (76 mm) if plants are cultured appropriately, irrigated as needed, and protected from herbivory using cages and/or tree shelters.

Deep Containers for Improved Survival on Difficult Sites

Seedling survival on dry sites is dependent on the root system's ability to access soil moisture and generate new roots. The use of a deeper container can be helpful for increasing survival. I first read about deep containers in Smith (1950) and was interested in the possible application of these for my desert restoration work. To help assess their value, I undertook a series of root growth studies using desert-type soils in layflat polyethylene tubing set in steeply slanted gutter sections. These studies showed that aboveground shoot growth often lagged behind root growth, and that within a few weeks a root could reach 18 in (45.7 cm) or more in length (figure 1). It was also observed that virtually all of the containers in use disrupted taproot development. Subsequent field studies have shown that plants grown in deep containers with a high root:shoot ratio are desirable (Bainbridge 1987, 1994a; Bainbridge and others 1995). Deep planting is also very effective for establishing cuttings in the field (Dreesen and Fenchel 2008).

Although container type often refers simply to volume, shape is also important (Bainbridge 1994a). One of the most biologically important container dimensions is height (depth), because of its effect on the water-holding properties of the growing medium and root development of the seedling. The relation of width to height is the aspect ratio (W/H = AR). Aspect ratios of common containers range from 0.14 to 0.85. Growth media in deep containers with a low aspect ratio have different physical properties, water relations, and porosity than in traditional shallow containers with a high aspect ratio. Growing-medium components may need to be adjusted to compensate for these changes to optimize nutrient and water availability.

The best container to use depends on the planting season (although unpredictable rainfall can confound seasonal timing), the handling process, the species, and the project. One of the most important considerations is determining which container size and depth is most cost effective, with the lowest cost per surviving plant. The emphasis on deep rooting leads to preference for containers that are tall but narrow (Felker and others

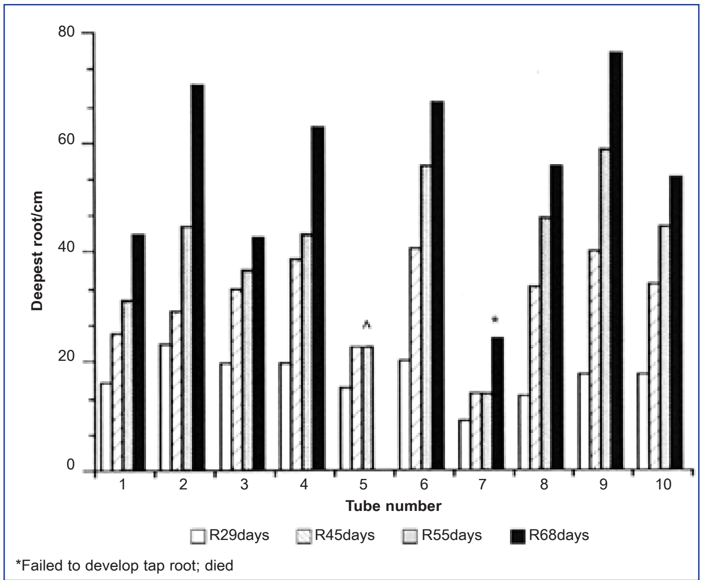

Figure 1. Root growth in the desert plant *Parkinsonia floridum*. (Data source: Unpublished experiment by David Bainbridge).

1988, Bainbridge 2007). Taller containers are more expensive both to grow in the nursery and to plant in the field, but they can improve survival significantly and should constitute at least part or most of the stock used in outplanting efforts on harsh, dry sites.

Plants are typically started in flats or smaller containers and are then transplanted into tall containers. Root growth can be very rapid for many desert species, and roots typically reach the bottom of the container within a few months, even if the seedling is only 8 in (20 cm) tall or less. Tall containers do not take up as much space for plant production as wider, shorter containers with similar volume. Tall containers benefit from racks or holders at the nursery and during transportation to the field. The staff at Joshua Tree National Monument (JTNM) discovered the value of racks after the 1992 Landers earthquake toppled their tall pots (but did little damage to the plants). The large soil volume protects the roots during transport and planting and sets the stage for rapid growth of the undamaged roots in the field.

Figure 2. Tall pots, Joshua Tree National Monument. (Photo by David Bainbridge, 1990).

Success with Deep Containers

I first tried the deep containers made with 10 cm (4 in) layflat plastic tubing in 1987, but found that they were too pliant and hard to handle. Around the same time, Bob Moon and his staff at JTNM (now Park, located in the Mojave Desert of southern California) had also discovered the value of tall containers in their effort to meet a visual restoration goal of only 7 years. They developed and refined a robust tall pot container made with 32 in tall (81.3 cm), 6 in diameter (15.2 cm) (AR = 0.18) smooth wall PVC pipe (APACHE 2729) with a wire mesh base held in place by crossed wires (figure 2) (Holden 1992). With smooth-walled PVC, the plant can simply be eased out of the container into the planting hole with minimal disruption to the roots.

In one of JTNM's largest revegetation projects, with more than 1,500 plants, survival was 77 percent after 3 years (Holden and Miller 1995). A large percentage of plants produced flowers and fruit within the first year in the field. Palo verde (*Parkinsonia florida* [Benth. ex A. Gray] S. Watson) has even established at JTNM without supplemental irrigation (Connor and others 2008). Survival and growth of many species is impressive, reaching 3 ft (1 m) within 2 or 3 years after planting.

After visiting the JTNM nursery, I switched to the tall pot system and found it worked well for the desert restoration work I was doing for the California Department of Transportation; California State Parks; U.S. Department of the Interior, Bureau of Land Management; and the U.S. Department of Defense in the Sonoran and Mojave Deserts.

Other deep container solutions have also been developed. In Australia, split pipe tied together has been used as a deep container for planting on unconsolidated sands after mining (Newman and others 1990); and, the Las Lunas Plant Material Center (LLPMC) in New Mexico modified the tall pot design to a split pipe, 30 in tall (76.2 cm), 4 in diameter (10.2 cm) (AR = 13), held together with filament tape (LLPMC undated). Commercial tree pots that are quite deep have also been developed, for example the tapered TP430 Long Pot (Stuewe and Sons 2012).

Planting Deep-Rooted Seedlings

The planting process for plants produced in tall pots is simple. A hole is made with a 6 in (15 cm) auger or post-hole digger and moistened with at least 1.6 gal (10 l) of water. The screen at the bottom of the tall pot is removed, and the walls of the pipe are rapped with a hammer to loosen the mix. The container is then gently placed in the hole, partially back-filled, then the container is eased out of the planting hole as as backfilling continues using a stick to ensure that air pockets are filled. The plant is then watered again and a tree shelter is installed around the shoot. An experienced planting crew of 5 people can plant 50 plants per day under average conditions.

The cost per plant is high, but survival is generally excellent and rapid growth is common. Creosote bush (*Larrea tridentata* [DC.] Coville) or mesquite (*Prosopis glandulosa* Torr.), for example, may be 3 ft tall (0.9 m) 1 year after outplanting from an initial size of 6 to 12 in (15 to 30 cm). Tall pots are highly recommended for achieving a high percentage of larger living plants on harsh sites. Tall pots also provide excellent protection from bureaucratic delays (which can lead to plants outgrowing container size) and biological uncertainty (lack of rainfall). To minimize costs, however, nursery staff must collect the tall pots and return them to the nursery, where they clean them and use them again and again.

Wick Irrigation for Deep Containers

Delivering water deep into the soil can be done with deep pipes (Bainbridge 2006a, Bainbridge 2006b, Dreesen and Fenchel 2010) or with wicks. I first read a paper from India where wicks were used in conjunction with buried clay pot irrigation (Mari Gowda 1974; Bainbridge 2001, 2002). As a result, I began a series of trials in 1988 with gravity wicks. Wick irrigation uses a fiber wick to transfer water by gravity, capillary flow, or pressure (figure 3). Capillary mat systems have become increasingly popular in greenhouses, container production, and interior plantscaping as a way to conserve water and minimize runoff (Neal and Henley 1992). Capillary fiber wicks have also been used to water houseplants and were recently reintroduced as a window box watering system (Editor 1955, Wickinator 2012). Capillary wicks have also been used more recently in greenhouses, with the wick fed into the plant container (Millon and others 2007). It also appears, however, that capillary or gravity wicks have excellent potential for field use in gardening, farming, agroforestry, and environmental restoration (Bainbridge 2007).

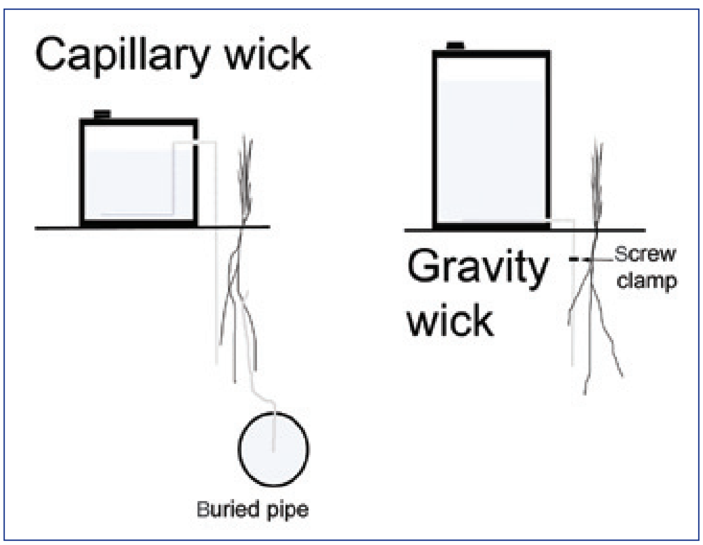

Figure 3. Wick system options: gravity and capillary flow. (Data source: unpublished by author).

Wick materials can range from solid braid nylon (very good durability and capillary rise) to polyester felt, cotton fabric, or many other fibers. My experience has led me to use a gravity nylon solid braid wick system when plant growth is desired, while capillary wicks may be used where the goal is to keep a plant alive until it finally rains. In a recent test, I found that a 7/16 in (11 mm) solid braid nylon wick wetted to 12 ft (3.6 m) within 15 min, suggesting wicks may be very useful in guiding deep roots to groundwater.

Trial to Evaluate Tree Shelters as Deep Containers Along with Wick Irrigation

Tree shelters, and particularly twin-walled tree shelters, have proved very valuable for increasing growth and survival of most outplanted desert species (Bainbridge 1994b). In 2008, I initiated an experiment to evaluate Tubex™ tree shelters (Tubex Ltd, South Wales, UK) as both deep containers and subsequent tree shelters. After planting, the tree shelter (that had been used as a deep container) was used to protect the plant; this procedure eliminated the need to return anything to the nursery.

Growth in the Nursery

Mesquite seedlings were sown into Ray Leach Super Cell Cone-tainers™ (1.50 in [3.8 cm] diameter and 8.25 in [21.0 cm] depth) in July 2008 at the Alliant International University in Scripps Ranch, San Diego, CA. After seedlings reached about 4 in (10.0 cm) in height they were transplanted into either Tubex™ twin-wall, light green containers 24 in tall (61.0 cm), 6 in diameter (15.2 cm) (AR = 0.25) or white PVC pipe sections 12 in tall (30.5 cm), 4 in diameter (10.0 cm) (AR = 0.33). Shade cloth was taped to the bottom of the containers to hold in the growing medium.

After 4 months, the mean height of plants grown in the Tubex™ containers (n = 5) was 15.4 in (39 cm) compared with 5.3 in (13.5 cm) for those grown in the pipe containers (n = 17) (figure 4). One additional plant was grown in a Tubex™ container with a Tubex™ tree shelter added to protect the shoot. This resulted in even greater height, (23.2 in [59 cm]) (figure 5). All plants had roots visible at the bottom of the container after 4 months. Temperatures in the container-growing medium were not measured, but it is likely that the double wall increased the temperature in the Tubex™ containers, leading to more rapid growth. Mesquite root growth is enhanced at higher temperatures; in one study under favorable conditions, mesquite roots grew nearly 2 in (5 cm) in 12 hr at 90.5 to 93.2 °F (32.5 to 34 °C) (Cannon 1917).

Figure 4. The difference in plant growth between container types. (Photo by Laurie Lippitt, 2008).

Figure 5. The added improvement in growth from a tree shelter container and a tree shelter protecting the shoot. (Photo by David Bainbridge, 2008).

Outplanting Performance

In April 2009, the seedlings grown in Tubex™ were outplanted to a very dry site in the Colorado Desert (average annual precipitation = 3 in [76 mm]) with gravity wick irrigation systems. The trees and wicks were installed by augering a hole with an AMS, Inc., soil auger. The gravity wick system used on this project consisted of a 5 gal (18.9 l) reservoir (recycled fire foam container) with a thread to barb fitting, vinyl tube, hose clamp, and 7/16 in (11 mm) solid braid nylon wick (figure 6). The wicks, about as long as the containers were deep, were laid into the hole next to the roots. On other projects, the wicks have been driven much deeper with a steel rod. The trees released easily from the tree shelter and PVC containers by the same technique used with tall pots, although one that had been watered before planting was a bit harder to remove. After release as a container, Tubex™ was immediately reinstalled on the seedling as a shelter. Water in the reservoirs for wick irrigation lasted 2 to 3 weeks and was refilled periodically.

As of March 2012, all of the trees grown in Tubex™ containers have survived. Some species may not benefit from the increased rooting temperature and container depth, but for mesquite it was ideal. The gravity wick system provided sufficient water to support establishment in the field. Ideally wicks would be placed in a hole drilled to groundwater at 10 to 15 ft (3 to 5 m) for this site. It was useful not to have to return containers to the nursery and convenient to have the tree shelter on hand at the time of planting.

Figure 6. Transplant from TubexTM container with gravity wick irrigation system; backfill not completed. (Photo by David Bainbridge, 2009).

Conclusion

For most projects on severe desert or seasonally arid sites, a variety of container sizes can be used to maximize survival at reasonable cost. Multiple size classes and more diverse plant architecture can be both biologically and aesthetically desirable and provide a wide range of resilience and survivability. Deep-rooted plants can be grown in tree shelters and watered after outplanting with gravity wicks for good survival on dry sites.

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