The Effect of Containerless Transport on Desert Shrubs

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The cost of shipping can be reduced if desert shrub seedlings can be removed from containers and transported to the field with roots wrapped in moist fabric "jellyrolls." But desert environments can desiccate exposed roots. In a laboratory experiment performed on bur-sage (Ambrosia dumosa) *seedlings, no difference was found in moisture potential between seedlings in jellyrolls and those in containers. In a field experiment on catclaw* (Acacia greggii) *seedlings, no differences were found in survival, health, or growth 1 year after outplanting between shrubs transported in jellyrolls and those in containers.* Tree Planters' Notes 45(3):82-85 1994

Because direct seeding is often unsuccessful in the deserts of the Southwest, planting seedlings is a common revegetation practice (Romney and others 1989, Bainbridge and Virginia 1990). Most desert perennials are easy and inexpensive to grow in a nursery. But the heavy sand mixes and bulky containers in which plants are grown are expensive to transport from the greenhouse to revegetation sites. Eliminating containers and substrate before transporting would greatly reduce shipping weight and bulk. However, many desert shrubs have fragile roots, and the hot, dry desert environment can quickly desiccate bareroot seedlings. Wrapping them in moist fabric (a technique known as "jellyrolling") may adequately protect seedling roots, improving outplanting efficiency.

Foresters commonly use jellyrolls with insulated shipping and planting bags to provide moisture to seedlings during transport (Lopushinsky 1986, Laird 1992). However, the use of jellyrolls in arid environments or in place of containers and substrate has been little studied. Jellyrolls are substantially lighter and less bulky than plants in containers: a rack of 98 sandfilled Ray-Leach™ supercells (164-ml containers) weighs more than an ice chest holding 500 jellyrolled plants and ice. Moreover, preliminary studies suggest that planting from jellyrolls is 1.5-2 times faster than planting from supercells. By removing plants from their containers at the nursery (where conditions are less stressful for workers and plants), expenses are reduced.

This paper presents results from two experiments assessing moisture stress and outplanting success of jellyrolled seedlings from two desert species, bur-sage *(Ambrosia dumosa* [A. Gray] Payne) and catclaw *(Acacia greggii* A. Gray). Moisture stress at planting is a major factor in reducing outplanting success (Rietveld 1990). In the first experiment, the moisture status of jellyrolled and containerized bur-sage seedlings was tested in a laboratory setting over a 24-hour period.

Preliminary studies suggested that survival of desert species shipped in jellyrolls to revegetation sites in the Sonoran and Mojave Deserts was comparable to that of plants shipped in containers (Bainbridge, unpublished data). But high variability and the relatively low number of plants shipped made a larger study desirable. In the second experiment, catclaw seedlings were transplanted in jellyrolls and containers to a mine spoils pile at a Mojave Desert gold mine. Survival, health, and height of the seedlings were tracked and compared over a 1-year period.

Methods

Laboratory study. In August 1992, approximately 150 bursage seeds were germinated on paper and planted in sandfilled supercells in a greenhouse. In December 1992, 90 seedlings of uniform size were taken from the greenhouse to a laboratory. Thirty-four seedlings were removed from containers and placed in four jellyrolls, two with 8 seedlings and two with 9 seedlings. In all four rolls, the seedlings were placed 10 cm (3.9 in) apart on 1-m (3.3-ft) sections of moist Kimtex™. The edges of the fabric were folded towards the center (covering shoot tops and root tips), and then the Kimtex™ was rolled up, completely enclosing the seedlings (figure 1). All 90 seedlings were left overnight in a dark, humid room at 20 /C (68 /F) so that the plants would not photosynthesize (and transpire) prior to (or during) the experiment.

A 3-by-2 incomplete factorial design was arranged for three packaging conditions (supercell, jellyroll, and bareroot) under two temperatures (unchilled, at 20 /C, or 68 /F; and chilled, at 4 /C, or 39 /F). The laboratory experiment measured seedling xylem pressure poten-

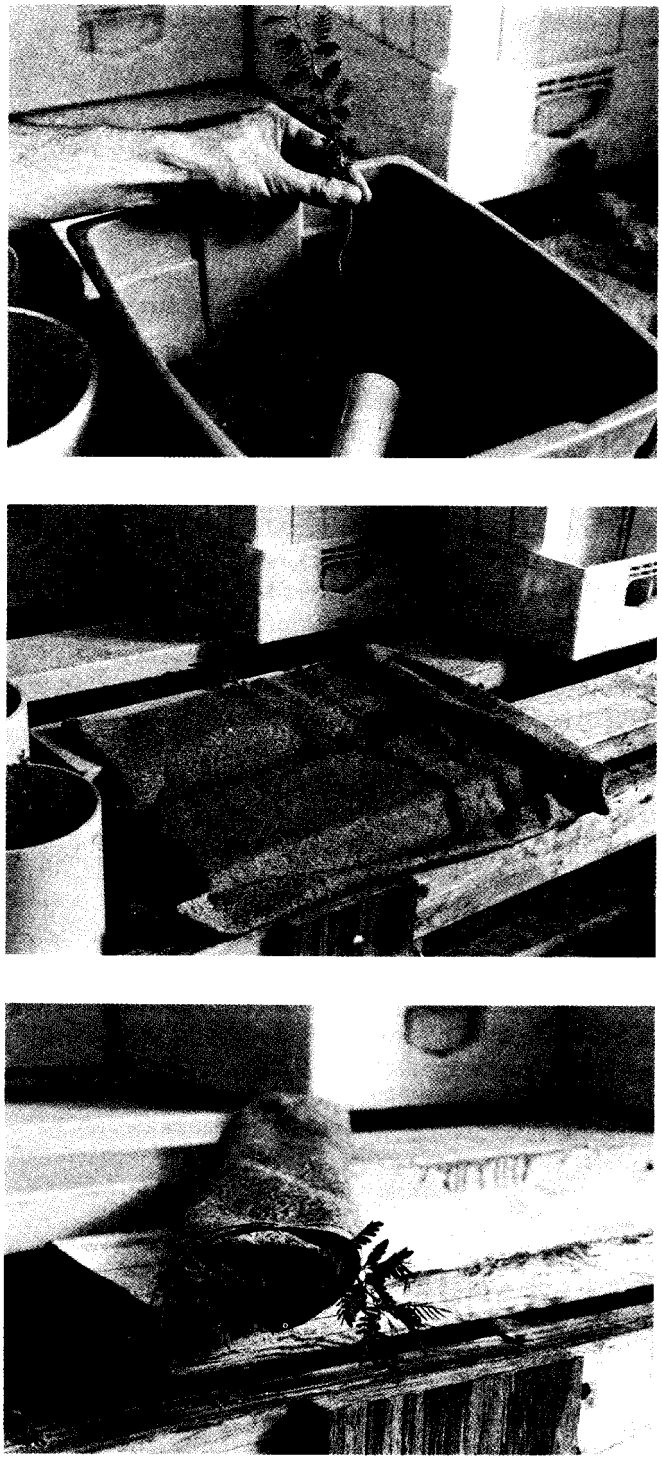

Figure 1—*Sequence for jellyrolling seedlings: (**A**) seedlings removed from supercells and rinsed to wash sand from roots; (**B**) seedlings placed 10 cm (3.9 in) apart on sections of moistened fabric; and (**C**) fabric rolled up around seedlings.*

tial (XPP, a measure of moisture status) over 24 hours for five treatments:

- *Supercell*— Plants left in supercells at room temperature (20 /C, or 68 /F).
- *Jellyroll*— Plants removed from supercells and rinsed to wash sand from roots, then wrapped in moist Kimtex™ (a non-woven synthetic fabric) and kept in an open tub at room temperature (20 /C, or 68 /F).
- *Bareroot*— Plants removed from supercells and rinsed to wash sand from roots, then kept in an open tub at room temperature (20 /C, or 68 /F), without being wrapped in fabric.
- *Chilled supercell*— Plants left in supercells and kept in an ice chest at 4 /C (39 /F).
- *Chilled jellyroll*— plants jellyrolled (as in treatment 2) and kept in an ice chest at 4 /C (39 /F).

The unchilled bareroot treatment was included as a control: if the bareroot seedlings did not show significantly more moisture stress than other seedlings during the experiment, then it could be concluded that conditions were inappropriate (i.e., too cool and humid) for testing the effect of jellyrolling on XPP.

The following morning, the XPP of 5 seedlings was measured immediately prior to treatment. Stems for sampling were cut with a sharp razor blade about 2 cm (0.8 in) above the root, and the shoots were immediately placed in individual ziploc bags until a measurement could be taken (Meron and others 1987). XPP was measured with a pressure bomb, as described by Waring and Cleary (1967). Only one measurement was taken per plant. The mean XPP of the 5 plants measured served as the potential at time zero for all five treatments.

Two jellyrolls were then chilled and two left unchilled. The remaining 51 plants were randomly divided among the other three treatments (17 seedlings per treatment). Two hours after treatment began, the XPP of 5 plants from each treatment was measured. After 4, 6, and 24 hours, the XPP of 4 plants per treatment was measured. Data were log transformed (to normalize them), and an analysis of variance (ANOVA) was used to compare differences in water potential between packaging conditions, temperature, and packaging-temperature interaction effects.

Field study. In May 1993, 300 catclaw seeds were germinated on paper and placed in sand-filled supercells in a greenhouse at San Diego State University (SDSU). In July, 280 seedlings of uniform height

and appearance were selected for outplanting at Castle Mountain Mine, in the east Mojave Desert. One day before planting, 140 plants were randomly selected and jellyrolled in the greenhouse. Seedlings were removed from containers, sand was washed from their roots, and the plants were placed 10 cm (3.9 in) apart on 1-m (3.3-ft) sections of moist Kimtex™, in sets of ten. The ends were folded over, and the plants were rolled up in the fabric (figure 1). The jellyrolls were placed in a chest with ice, and the remaining 140 plants were left in supercells. The ice chest and racks of supercells were loaded into an enclosed truck bed and transported from SDSU to Castle Mountain Mine (360 miles from San Diego). Plants remained in jellyrolls for approximately 24 hours.

The seedlings were planted on the top of an unvegetated mine spoils pile. A 30- by 60- m (98.4- by 196.8-ft) plot running east to west was ripped 60 cm (23.4 in) deep to reduce compaction, facilitate planting, and encourage root growth. Plants were spaced 80 cm (31.2 in) apart in four rows 5 m (16.4 ft) apart. Seedlings from jellyrolls were alternated with seedlings from supercells. As they were planted, seedlings were assigned protection and/or amendment treatments and given 1 liter (1.1 qt) of water. The temperature during planting ranged from 32 to 38 /C (90 to 100 / F), and humidity was low. Supplemental irrigation1 liter (1.1 qt) of water per plant-was provided four times between August and October 1993.

Survival, health, and height were recorded in July 1994 (1 year after planting). Plant health was rated on the following scale: 0 = dead; 1 = green stem, but no leaves; 2 = few leaves, chlorotic; 3 = some green leaves; 4 = many green leaves. Survival data were analyzed using a log rank test (Pyke and Thompson 1986); health ratings were analyzed using a Mann-Whitney U test (Sokal and Rohlf 1969); and height data were log transformed and analyzed by ANOVA.

Results

Laboratory study. The XPP of bareroot seedlings was more negative (seedlings were more moisturestressed) at every measurement time. After 6 hours, the XPP of bareroot seedlings was significantly ($P < 0.05$) more negative than that of all other treatments (figure 2). After determining differences among the three packaging conditions (bareroot, jellyroll, and supercell), the bareroot data were excluded, and data were reanalyzed as a 2- by-2 complete factorial.

After 2 and 4 hours, seedlings in jellyrolls had significantly ($P < 0.001$ at 2 hours, $P < 0.01$ at 4 hours) less negative XPP's than seedlings in supercells. Temperature did not affect XPP, and there was no significant interaction between temperature and packaging condition.

After 6 hours, plants packaged in jellyrolls continued to have significantly ($P < 0.001$) less negative XPP's than plants in supercells. But temperature had a significant ($P < 0.05$) effect on XPP: chilled seedlings had more negative XPP's than unchilled seedlings. There was no interaction effect between temperature and packaging condition.

After 24 hours, the XPP of plants in jellyrolls (both chilled and unchilled) remained significantly ($P < 0.01$) less negative than plants in supercells. Temperature also remained significant, but chilled seedlings now had less negative ($P < 0.01$) XPP's than unchilled seedlings. There was a significant interaction effect between temperature and packaging condition; plants in the chilled jellyroll treatment had less negative XPP's than plants in the unchilled jellyroll treatment (figure 2). In addition, the XPP of seedlings in unchilled jellyrolls was slightly more negative than the XPP of seedlings in unchilled supercells, but the difference was not significant. The decrease in XPP of plants in unchilled jellyrolls that occurred between 6 and 24 hours caused significant time-packaging condition (jellyroll) and time–packaging condition– temperature interaction effects (not shown).

Field experiment. Differences in survival, health, and height were not significant ($P > 0.50$) for plants shipped in jellyrolls and those shipped in supercells. Survival was 88% for jellyrolled seedlings and 91% for containerized plants; mean health ratings were 2.0 and 2.1, and mean heights were 8.9 cm and 8.5 cm, respectively. There was no interaction effect between jellyrolls or containers and other experimental treatments.

Discussion

Jellyrolls were found to improve the moisture status of bur-sage seedlings for 24 hours under lab conditions similar to those in an enclosed truck. Because the hydrating effect of jellyrolls is immediate, the XPP of jellyrolled plants became less negative by approximately 1 MPa after 2 hours (figure 2), and stayed that way for an additional 4 hours. In general, seedlings did not become more moisture-stressed over time. However, after 24 hours, the XPP of plants in unchilled jellyrolls was significantly more negative than in chilled jellyrolls, and slightly more negative than in supercells. Chilling jellyrolls may thus be

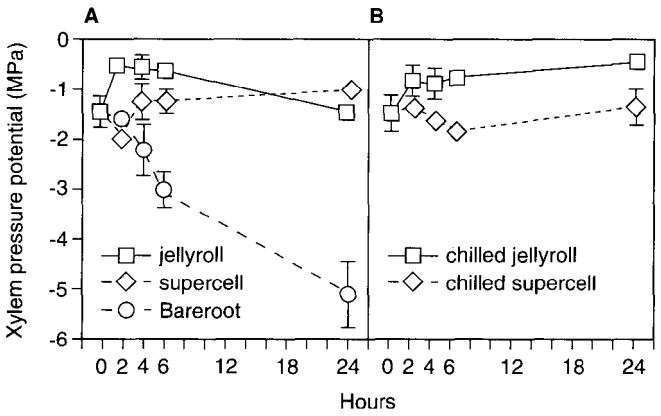

Figure 2—*Mean xylem pressure potential over 24 hours for bursage seedlings stored (**A**) unchilled at 20 °C (68 °F), and (**B**) chilled at 4 °C (39 °F). Bars indicate standard errors.*

unnecessary for durations of 6 hours or less, but is desirable for longer periods. Jellyrolls are not only less expensive to transport than heavy and bulky containers, they also reduce moisture stress.

Planting catclaw seedlings from jellyrolls was quicker and easier than planting from supercells, and survival and growth were unaffected by packaging conditions. The fact that jellyrolls did not reduce outplanting survival in the xeric environment where the field study took place indicates that jellyrolling did not damage the sensitive seedling roots and provided excellent protection from desiccation during transport. Similar success is likely to be found in climates where temperatures are lower, humidity is higher, and seedling moisture status may be less critical than in the Mojave Desert.

Some projects may require that seedlings spend several days in transport or storage before planting. Although survival of plants jellyrolled for more than 1 day has not been thoroughly studied, anecdotal evidence indicates that plant reactions to extended periods in jellyrolls vary from species to species. Twenty out of 24 creosote bush *(Larrea divaricata* [DC.] Cov.) seedlings left in jellyrolls for 9 days survived after being planted in pots in a greenhouse, but only 20% of bladder-pod *(Isomeris arborea* Nutt.) seedlings survived under the same conditions (Bainbridge, unpublished data). Species-specific reactions to fabric moisture content have also been observed. Although creosote bush has been successfully shipped in jellyrolls, seedlings that spent several days in a saturated batch of rolls died, presumably from poor root oxygenation (Bainbridge, unpublished data). The species being shipped and the time plants will spend in jellyrolls should be considered to ensure planting success. If used carefully, jellyrolls are a safe and cost effective alternative to transporting plants in containers.

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Jellyroll fabric supplier:
I.R.S.
PO Box 5547
Eugene, Oregon 97405
tel. (800) 321-1037

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