INFLUENCE OF SITE PREPARATION AND STOCK SIZE ON THE ESTABLISHMENT OF ARIZONA CYPRESS PLANTINGS IN THE MIDDLE RIO GRANDE REGION

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Abstract

Establishment of tree plantings in arid and semi-arid regions where available irrigation water is limited is often costly and problematic. This study examined the effects of site preparation, specifically V-ditching and use of synthetic weed barrier alone and in combination, and stock size based on container volume on early, 1- and 6month, mid, 12- and 15-month, and late, 72-month, survival and height growth of fall planted, Arizona cypress *(Cupressus ari.Zonica)* seedlings planted in Los Lunas, New Mexico. The study was installed at the New Mexico State University Los Lunas Experiment Station in October of 1994. Seedlings were planted by hand using an auger. Immediately following planting the study site was irrigated with 7.5 centimeters of irrigation. Seedlings received no further supplemental irrigation. The effects of both site preparation and stock size became discernable only after 12 months. In general, survival was improved with site preparation with the 12and 15-month survival averaging 80% for the V-ditch alone and in combination with weed barrier, compared to 55% for the control group. After 15 months, the two larger stock sizes evaluated, 262 ml and 656 ml container volumes, had survival averaging 80% compared to the two smaller container sizes, 115 ml and 164 ml whose survival was averaging 64%. After 72 months, the 262 ml container size had the greatest survival at 62% across the four site preparation treatments. The combination of the weed barrier/V ditch site preparation treatment and the 262 ml stock size yielded the greatest survival after 72 months, 86%. After 72 months, there was little difference in survival between site preparation treatments. The use of weed barrier as a site preparation treatment consistently improved height growth from the 12-month measurement period until the 72-month measurement period. The 262 ml container size consistently had the greatest height growth from the 15-month measurement period through the 72-month measurement period. These results indicate it is possible to establish trees in semi-arid environments when using appropriately sized stock in conjunction with appropriately prepared sites.

Key Words

Container stock

Most New Mexico farms are individually or family-owned and approximately 60% have annual revenues less than $10,000 (Mosbacher and Darby 1987). Agricultural output from New Mexico is primarily produced in arid and semi-arid conditions with limited water availability and highly erodible soils. One mechanism that can improve the conservation of land and water resources and enhance overall agricultural productivity is using windbreaks or shelterbelts. However, establishing tree windbreaks in the southern Great Plains and the southwestern United States can be problematic due to high costs and/or poor tree survival.

Several factors can influence the success of tree plantings in the southwestern U. S., including site preparation methods and type of planting stock. Poor site preparation and post-planting maintenance have been significant contributors to planting failures in the Great Plains (Nickerson 1990). The influence of planting stock size on outplanting performance has been well investigated for bare-root stock (Mexal and Landis 1990); however studies on the influence of stock type on outplanting performance are not as abundant.

A recommended approach for windbreak establishment in arid and semi-arid regions of New Mexico involves planting container grown seedlings in a prepared V-ditch covered with a woven weed barrier and providing supplemental irrigation following planting. Although this approach helps ensure survival during periods of drought, it is cost prohibitive for most landowners.

This study examined the influence of four site preparation techniques and four planting stock sizes on Arizona cypress *(Cupressus arizonica)* windbreak establishment in the Middle Rio Grande Valley agricultural region. Site preparation treatments were V-ditch, weed barrier, V-ditch and weed barrier, and control. Arizona cypress grown in four container sizes, 115, 164, 262, and 656 ml root volume, were used to evaluate site preparation and planting stock size treatments.

MATERIALS AND METHODS

Arizona cypress seedlings were propagated at the New Mexico State University Forestry Greenhouse in Las Cruces, New Mexico under a standard production regime described by Harrington (1991). Four container sizes were used to obtain four stock size treatments: 115 ml RayLeach Conetainer, 164 ml Ray-Leach Conetainer, 262 ml Deepot, and 656 ml Deepot (Steuwe and Sons Inc., Corvallis, Oregon). The planting site was located at the New Mexico State University Los Lunas Agricultural Experiment Station in Los Lunas, New Mexico. Prior land use for this plot was a four-wing saltbush *(Atriplex canescens)* seed production field from 1979 through 1994. Soil texture was a sandy clay loam (53% sand, 20% silt, and 27% clay).

Four site preparations evaluated in this study were a 2-meter wide V-ditch, a 2-meter wide synthetic weed barrier, a 2-meter wide V-ditch with a 2meter wide synthetic weed barrier, and an undisturbed control. The synthetic weed barrier used in this study was a tightly woven synthetic burlap, which allowed water penetration but restricted weed growth. In the weed barrier alone plot, existing vegetation was mowed using a tractor mounted rotary mower. Residual saltbush stems and bushes were pulled to reduce the amount of air pockets between the weed barrier and the soil surface. After seedlings were planted, the weed barrier was laid over the planting area and incisions were made in the weed barrier and the seedling shoots pulled through the opening. A V-ditch is a shallow (10 to 15 cm deep) trench with two tapering sides, each approximately 1meter wide. Seedlings are planted in the bottom of the trench. The V-ditch functions by directing the surface flow of water during heavy rain events to the bottom of the trench. The V-ditch treatment was installed using a tilting blade on a three-point hitch of a farm tractor. Each site preparation by seedling size treatment consisted of an 11-meter long by 2-meter wide plot. Ten seedlings were planted in each site preparation by container size treatment combination. Seedlings were planted using a handheld power auger with 7.5 cm diameter bit. Following site preparation and planting, the entire planting site received 7.5 cm of flood irrigation. No further irrigation was performed. Seedlings were planted in early October 1994.

Survival and shoot height were measured at 6, 12, 15, and 72 months following outplanting. Survival was recorded as either dead or alive. Shoot height was measured to the nearest centimeter using a graduated plastic pole. Relative shoot height was computed by subtracting a seedling's height at time of planting from height at 72 months, and then dividing by height at planting.

The experimental design was a randomized complete block design with three blocks for each planting date by site preparation combination. The response unit was the individual seedling and the experimental unit was the average of the ten-tree row plot per treatment combination. Growth and survival data were analyzed with a general linear model (PROC GLM, SAS Institute, 1999). Means were compared using Tukey's Studentized Range (HSD) Procedure, which controls experiment-wise error rates. Alpha values (a) of 0.05 or less were considered significant.

RESULTS

Survival

Stock size did not influence 6 month survival but did influence survival at 12 and 72 months (Figure 1). At 12 months after planting, seedlings grown in the 164 ml containers had lower survival, 68%, compared to those produced in the other three sizes (mean = 86%). Survival decreased among seedlings regardless of container size from 12 to 72 months, but the amount of variability associated with the mortality increased in the seedlings produced in the 115 ml containers such that no difference between these seedlings and those produced in the 164 ml containers could be detected. At 72 months after planting, the seedlings produced in the 164 ml containers continued to exhibit lower survival (35%) than either those produced in the 262 or 656 ml size containers (> 50%), but was not different than seedlings produced in the 115 ml containers (45%).

As was the case with stock size, differences in site preparation treatments were not detected until the end of the first growing season (12 months). After 12 months, survival among the control, weed barrier, and weed barrier/V-ditch site preparation treatments was similar, while the Vditch treatment had greater survival (92%) than either the control or weed barrier plots (Figure 2). Of all treatments, only the weed barrier/V-ditch treatment had greater survival (55%) than the untreated control, which had 35% survival at 72 months. Survival within the two less intensive treatments (control and V-ditch) declined more rapidly after 12 months than within the two weed barrier treatments. Mortality in the weed barrier treatment was less during the 12 month through 72 month interval than in non-weed barrier treatments (Figure 3). Trees within the V-ditch treatment had the highest mortality from 12 to 72 months comparable to the control mortality rate but higher than the mortality rates in the two weed barrier containing treatments.

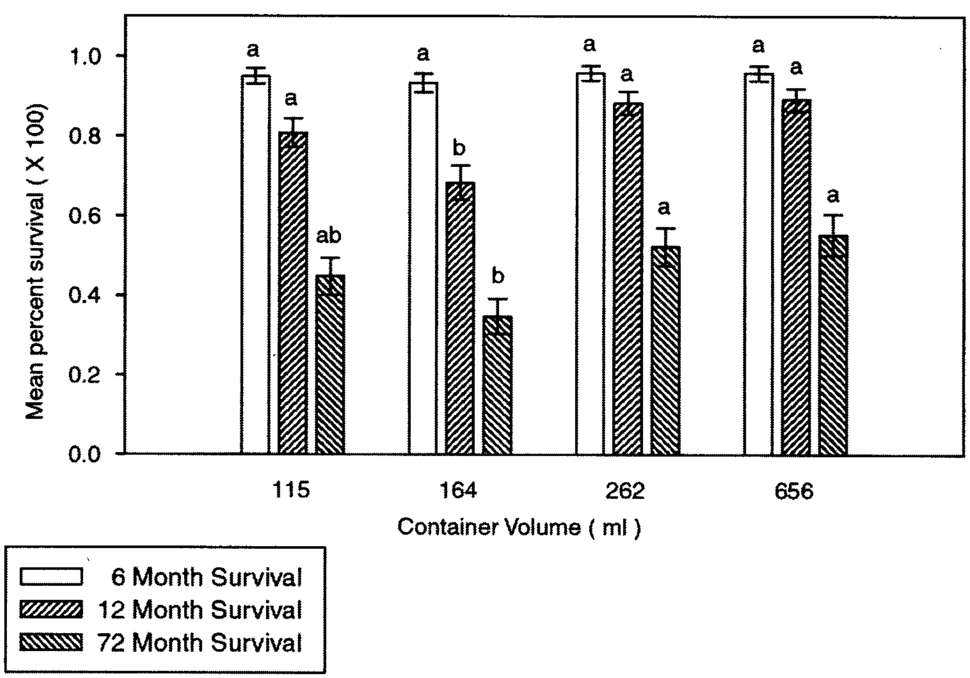

Figure 1. Mean survival by stock size for Arizona cypress planted in fall 1994 at Los Lunas. Means with same letter groupings within each measurement period did not differ significantly at $\alpha = 0.05$.

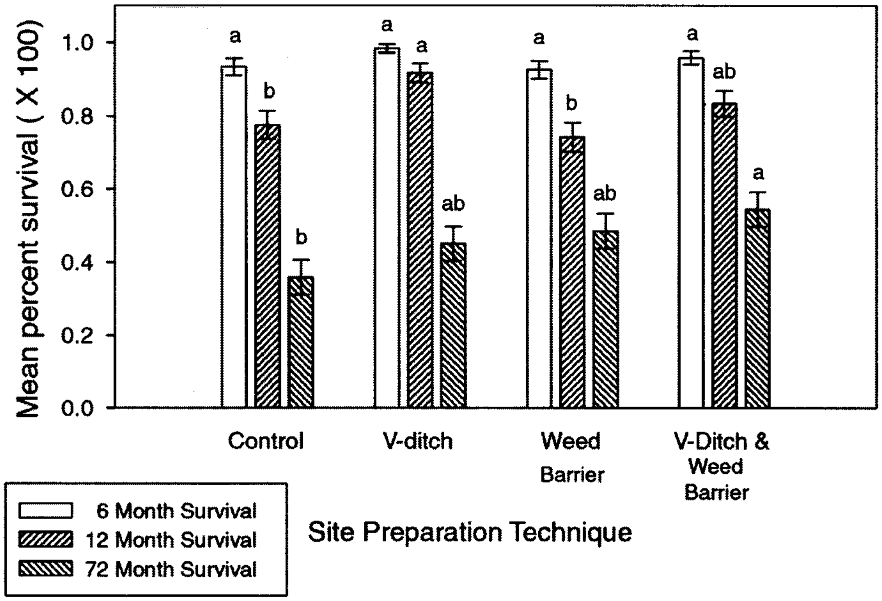

Figure 2. Mean survival by site preparation for Arizona cypress planted in Fall 1994 at Los Lunas. Means with same letter groupings did not differ significantly within each measurement period at $\alpha = 0.05$.

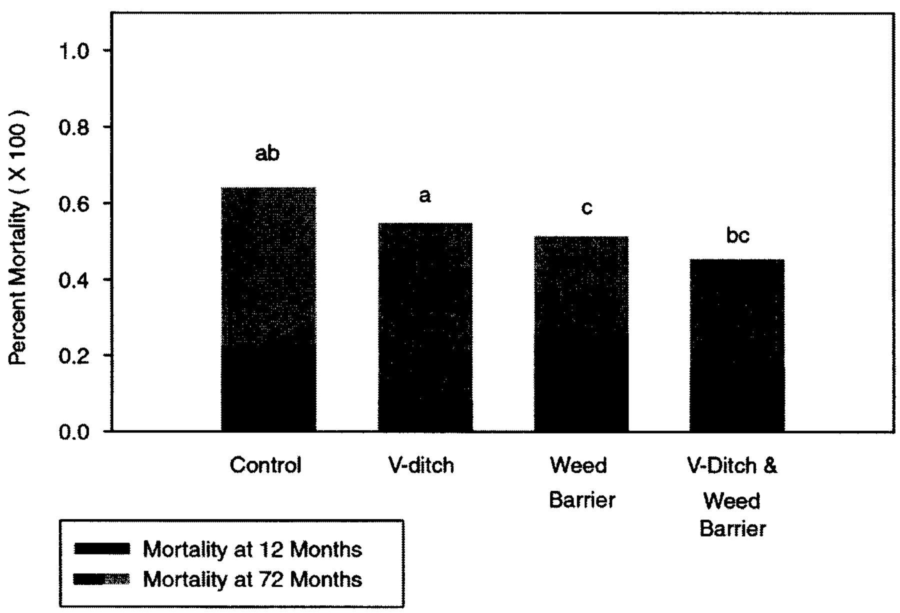

Figure 3. Proportion of 72-month mortality observed at 12 months by site preparation for the fall 1994 planting at Los Lunas. Mortality means for the 12 to 72 month growth period with same letter groupings did not differ significantly at $\alpha = 0.05$.

Table 1. Twelve-month mean survival by site preparation and stock size for Arizona cypress planted in fall 1994 at Los Lunas.

	Container Size (ml)							
	115		164		262		656	
	Survival[a] %	S.E.[b]	Survival %	S.E	Survival %	S.E	Survival %	S.E
Control	77cd	7.8	67de	8.7	77cd	7.8	90abc	5.57
V-Ditch	83abcd	6.9	97ab	3.3	90abc	5.6	97ab	3.33
Weed Barrier	77cd	7.8	53e	9.3	87abc	6.3	80bcd	7.43
V-Ditch / Weed Barrier	87abc	6.3	57de	9.2	100a	0.0	90abc	5.57

[a] Percentages followed by the same letter are not significantly different at $\alpha = 0.05$.
[b] S.E. = Standard Error.

Table 2. Seventy-two-month mean survival by site preparation and stock size for Arizona cypress planted in fall 1994 at Los Lunas.

	Container Size (ml)							
	115		164		262		656	
	Survival[a] %	S.E.[b]	Survival %	S.E	Survival %	S.E	Survival %	S.E
Control	40bcd	10.0	34cd	9.0	8e	5.5	62ab	10.1
V-Ditch	38cd	9.2	43bcd	9.2	58bc	10.3	43bcd	9.2
Weed Barrier	53bc	9.3	34cd	9.0	50bcd	9.3	60bc	11.2
V-Ditch / Weed Barrier	47bcd	9.3	27de	8.2	87a	6.3	60bc	11.2

[a] Percentages followed by the same letter are not significantly different at $\alpha = 0.05$.
[b] S.E. = Standard Error.

Survival rates for container size and site preparation treatment combinations varied considerably at both 12 and 72 months after planting. Seedlings produced in the 164 ml containers had consistently low survival in the two weed barrier treatments at both 12 months (Table 1), and 72 months (Table 2). At 72 months, survival of seedlings produced in the 656 ml and 115 ml containers was unaffected by site preparation treatment. In contrast, survival of seedlings produced in the 262 ml containers benefited as site preparation intensity increased. In this size category, seedling survival was 8% in the control and averaged 54% in the V-ditch and weed barrier treatments, but was 87% in the Vditch/weed barrier combination treatment. Within the control group, seedlings produced in the largest containers (656 ml) had 60% survival after 72 months.

Size and Growth

Container size influenced shoot height in all measurement periods (Figure 4). At time of planting and six months thereafter, mean shoot heights for all container sizes were significantly different from one another. After 15 months, seedlings produced in the two largest container sizes had similar shoot heights, as did seedlings produced in the two smallest container sizes. At 72 months, seedlings produced in the 262 ml containers were taller than all others, while those produced in the largest (656 ml) and smallest (115 ml) containers had similar heights. Seedlings grown in 164 ml containers had the lowest mean

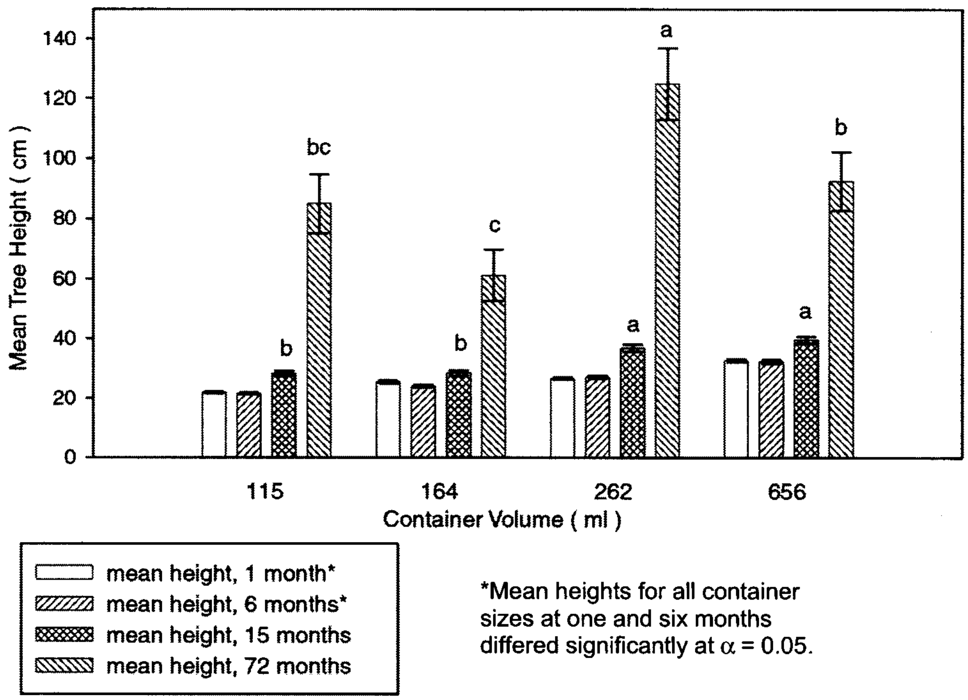

Figure 4. Mean height by stock size for Arizona cypress planted in fall 1994 at Los Lunas. Means within same letter groupings did not differ significantly within each year at $\alpha = 0.05$.

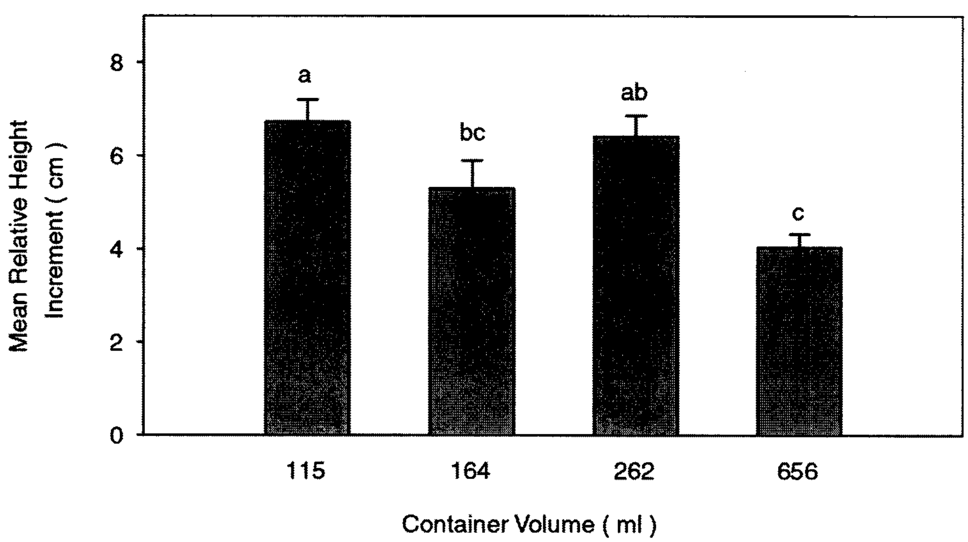

Figure 5. Mean relative height increment by stock size of Arizona cypress from time of planting to 72 months. Means within same letter grouping did not differ significantly within each year at $\alpha = 0.05$.

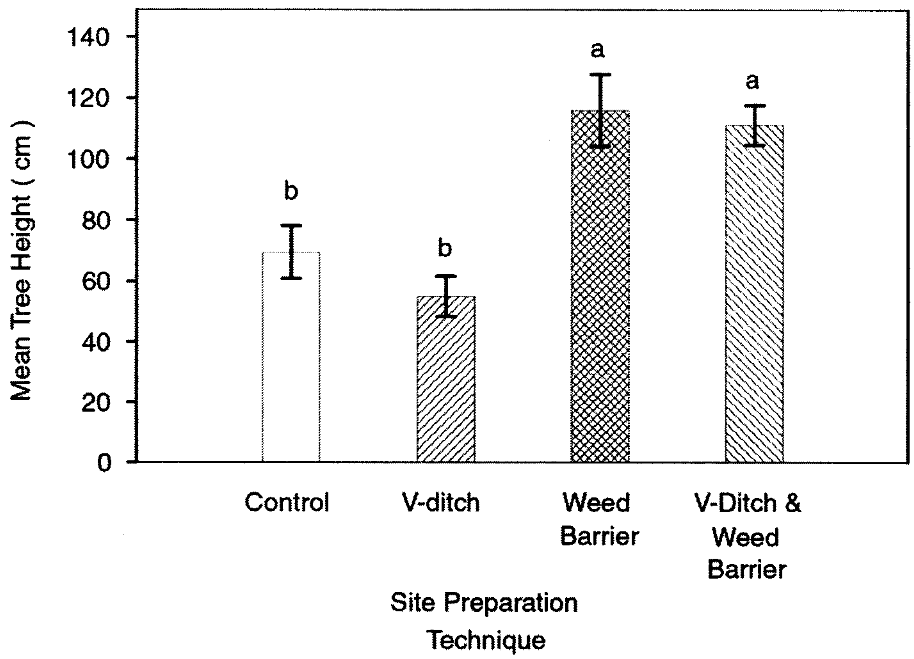

Figure 6. Mean height by site preparation technique for Arizona cypress 72 months after fall 1994 planting at Los Lunas. Means within same letter grouping did not differ significantly within each year at $\alpha = 0.05$.

height, but were not different than seedlings produced in the 115 ml containers.

Seventy-two month relative height increment was greatest for seedlings produced in the smallest containers and lowest for those produced in the largest containers (Figure 5). Seedlings produced in the two intermediate container sizes had relative height increments comparable to each other. Relative height increment was also similar between the 115 and 262 ml sizes, and the 164 and 656 ml sizes.

Site preparation treatments containing weed barrier increased 72 month seedling height relative to the control and V-ditch treatments (Figure 6). Mean seedling height for the two weed barrier treatments was 113 cm. In comparison, mean seedling height was 61 cm for seedlings growing in the control and V-ditch site preparation treatments. After 72 months, seedlings growing in the V-ditch treatment were small, but not significantly different from seedlings growing in the control treatment.

Trees in the weed barrier/V-ditch plots grown in 262 ml containers had a mean height of 193 cm after 72 months, which were substantially taller than trees growing in any other treatment combination (Table 3). The smallest mean height of 14.8 cm was found in trees from 262 ml containers grown in the untreated control plots. Height means within the weed barrier treatment were more similar across stock sizes than the other two site preparations.

DISCUSSION

The most widely recommended site preparation technique for windbreak establishment in New Mexico is a V-ditch/weed barrier combination with drip irrigation (Brown and others 1992). While this protocol often results in survival rates of greater than 90% after one year (Harrington unpublished data), many sites lack an available or reliable water source for irrigation. Furthermore, drip irrigation systems can be cost prohibitive to install and/or maintain (Table 4).

While no overwhelming trends appeared in either site preparation treatment or stock size in this study, three notable outcomes were observed. First, in the absence of any site preparation, the largest stock size had the highest (60%) survival,

Table 3. Seventy-two-month mean height (cm) by site preparation and stock size for Arizona cypress planted in fall 1994 at Los Lunas.

	Container Size (ml)							
	115		164		262		656	
	Height[a]	S.E.[b]	Height	S.E	Height	S.E	Height	S.E
Control	64cdef	16.1	64cdef	15.7	15 f	10.0	107bcd	16.5
V-Ditch	52def	14.3	39f	10.4	80bcdef	16.1	55def	12.5
Weed Barrier	108bc	20.1	105bcd	25.0	122b	23.4	128b	27.5
V-Ditch / Weed Barrier	97bcde	20.5	52ef	16.7	194a	17.0	98bcde	20.2

[a] Heights followed by the same letter are not significantly different at $\alpha = 0.05$.
[b] S.E. = Standard Error.

Table 4. Estimated[1] costs of establishing windbreaks in New Mexico based on material costs of plant material and site preparation material. Costs are presented on a per 300m (1000 feet) of windbreak basis.

	Stock (Container) Size (ml)			
Site Preparation	115	164	262	656
Control	$70	$80	$130	$175
V-Ditch Alone	$70	$80	$130	$175
Weed Barrier Alone	$622	$632	$682	$727
Drip Alone	$202	$212	$262	$307
V-Ditch & Weed Barrier	$622	$632	$682	$727
Drip & Weed Barrier	$754	$764	$814	$859
V-Ditch, Weed Barrier, & Drip	$754	$764	$814	$859

[1]Estimates based on average of 2 to 3 quotes or catalog prices for the materials. In the case of seedling costs some were estimated, as they are not commercially available.

and almost 50% more than any other stock size evaluated. This may have been due to this plant material being better able to compete with existing vegetation. The larger root system volume and shoot size (Maiers 1997) associated with this stock type may have allowed them to compete with neighboring vegetation for site resources (in other words, soil moisture and light) more effectively.

In this study and those published elsewhere, one of two trends usually occur in seedling survival relative to stock size. Survival is either unaffected by stock size or larger stock has greater survival (Amidon and others 1981; Harrington and Maiers 1999; Harrington and Loveall unpublished data). A second notable and somewhat perplexing outcome in this study was the high mortality of stock produced in the 164 ml containers after the first growing season. Evaluation of stock attributes, including root volume, shoot height, root: shoot ratio found no unique features associated with this stock size (Maiers 1997). In three subsequent spring plantings related to this study, the 164 ml stock type was consistently intermediate in survival when compared to seedlings produced in the other three container sizes (Maiers and Harrington 1999). A third notable outcome of this study was the exceptional performance of the 262 ml stock size in the combined V-ditch and weed barrier site preparation treatment. This treatment combination resulted in greatest survival (87%) along with the largest trees after 72 months (190 cm). This survival rate is considerably higher than the 72 month survival rate (36%) of spring planted Arizona cypress in New Mexico produced in the 262 ml container (Harrington and Loveall, unpublished data). As in this study, seedlings were only irrigated at time of planting.

An overall objective of site preparation is to improve seedling survival and growth by conserving site resources. In the arid and semiarid southwest, water is often the most limiting site feature to seedling establishment. Inadequate site preparation in arid and semi-arid environments can result in planting failure (Fisher and Montano 1977; Nickerson 1990). Two techniques to increase moisture availability to plants were examined in this study. First, removing or eliminating competing vegetation and second, harvesting rainfall. The benefits of removing competing vegetation for improving seedling survival and early growth is well documented in the forestry literature. Often times the focus of these efforts is not to improve moisture availability, but to reduce light and nutrient competition. However, in the southwest reducing water loss to competing vegetation can increase transplant survival (Maiers and Harrington 1999). Improving moisture availability by rainfall harvesting has also been shown to be a highly effective technique to improving transplant survival (Al-Qurashi 1997; Maiers and Harrington 1999).

Effects of site preparation were not evident in this study until after the first growing season where the two V-ditch treatments improved survival. The V-ditch treatment captures and stores rainfall for the seedlings to utilize. In addition, V-ditching appeared to provide some weed control throughout the first and some of the second growing season. After the second growing season, any weed control benefit from V-ditching was not readily apparent at this site or similarly treated sites elsewhere in New Mexico (Harrington pers. obs.).

A concern of using weed barriers or mulches in the southwest and southern Great Plains is the potential heating effects. Increased surface soil temperatures have been reported for synthetic soil mulches (Peacock and others 1990; Duncan and others 1992; Traux and Gagnon 1993). A study in Finland, found daily soil surface temperatures of up to 50 °C over a polypropylene mulch (Heiskanen and Raitio 1992). During this study, ambient temperatures reached or exceeded 30 °C. Conifer seedling exposures to 36 °C for two hours and 42 °C for one hour have been reported to be lethal (Roberts and Dong 1993). However, AlQurashi (1997) found no difference among control, weed barrier and V-ditch treatments on tree crown, and air and soil temperature within a windbreak study in the Middle Rio Grande Valley. In the same study, air temperature immediately above the weed barrier and control plots ranged from 32.'C to 38 °C for an 8-week period during the growing season. Benefits of the weed barrier site preparation treatments became apparent over time (72 month) in this study since survival and growth of seedlings improved. However, the benefits appeared to be stock size dependent.

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