STOCK SIZE AND SITE PREPARATION EFFECTS ON ESTABLISHMENT OF ELDARICA PINE AND ARIZONA CYPRESS IN THE PECOS RIVER VALLEY.

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ABSTRACT: The number of windbreaks being planted in arid and semi-arid regions in the southern Great Plains and southwestern United States has increased steadily over the previous 10 years. Often, these projects suffer high mortality rates or require elaborate irrigation systems to sustain them. Many factors can influence the success of windbreak plantings. This study examined the influence of seedling stock type and site preparation on eldarica pine (Pinus brutia subs. eldarica) and Arizona cypress (Cupressus arizonica) seedling establishment in windbreak plantings. Four container stock types (115 ml, 164 ml, 262 ml, and 656 ml) and three site preparation treatments (synthetic weed barrier, v-ditch, synthetic weed barrier and v-ditch combined), and an undisturbed control were evaluated for suitability in dry-land agroforestry plantings. The only irrigation provided was immediately after planting. Survival at the end of the first growing season ranged from 30% to 100%. Overall, the larger stock types, 262 ml and 656 ml, and the more intensive site preparation treatments had the greatest survival. Seedlings planted in the weed barrier treatments had the greatest relative height and caliper growth. In general, as initial stock size increased, relative caliper growth increased and relative height growth decreased following outplanting. These results suggest that in the Pecos River Basin in southeastern New Mexico low cost systems are available for establishment of agroforestry trees.

INTRODUCTION

*** Agriculture contributes significantly to New Mexico's economy. Much of New Mexico's agriculture output is derived in arid and semi-arid regions which have limited water availability and highly erodible soils. Approximately 84% of the farms in New Mexico are family or individually owned (Mosbacher and Darby 1987). Sixty percent of farms in New Mexico have an annual revenue less than $10,000 (Mosbacher and Darby 1987).

*** The town of Artesia is on the southwestern boundary of the Great Plains within the Pecos River drainage basin in southeastern New Mexico. The agricultural region associated with this area occurs at elevations around 1,000 m. Currently, alfalfa, cotton and small grains are the primary cash crops grown in the region. All of these principle crops are grown in irrigated production systems. The shortage of water, hot and dry climate, and high wind velocities contribute to the challenge of sustaining this agricultural community.

*** The general classification of the climate is semi-arid. Some prevalent climatic characteristics of this area include a dry environment, unpredictable rainfall, and wide fluctuations in diurnal temperatures (Chugg et. al. 1971). As of 1984 the precipitation range was from a low of 12 cm in 1967 to 65 cm in 1978 (Barnes 1984) with the average precipitation ranging from 25 to 36 cm. Most of the precipitation, approximately 80%, falls during the 183-day growing season-April through September (Barnes, 1984). Pan evaporation ranges from 254-280 cm per year, with 67 percent taking place during the growing season. (Chugg et. al. 1971). High winds are common in March and April (Barnes 1984). Some areas, especially east of the Pecos River, have soil erosion problems due to sandy textured soils and previous grazing practices.

*** One mechanism that can improve the conservation of these resources and enhance the overall agricultural productivity in these regions are windbreaks. However, establishing conservation trees in this area has been problematic or cost prohibitive to most farmers. One reason for the failure of most tree plantings in the Great Plains is attributed to poor site preparation and failure to upkeep the trees after they are planted (Nickerson 1990). It has been known for a long time that planting stock size and stock type, to lesser extent, influence outplanting performance (Mexal and Landis 1990, Owston 1990). For instance, Region 3, (New Mexico and Arizona) of the U.S.D.A. - Forest Service has converted from using bareroot

planting stock to exclusively using container grown material for all reforestation activities involving conifers (Jeffers 1994 pers. comm.).

*** The selection of the proper site preparation technique can also determine the success or failure of seedling establishment in the Southwest. Practices currently recommended for establishing windbreaks in New Mexico involve planting containerized seedlings in rows defined by a machine prepared v-ditch covered with a woven weed barrier and supplemental drip irrigation after planting. Although these practices collectively assure survival during periods of drought, they are cost prohibitive for most landowners.

*** Eldarica pine (Pinus brutia subsp. eldarica) is known locally by many names: Mondell, Afghan, Eldarica, Quetta, and Eldar Pine. Although Afghanistan was the source of its introduction to the United States, eldarica pine's native distribution is a 550 ha area in the state of Georgia in south central Russia (Fisher and Widmoyer, 1978). Eldarica pine can withstand prolonged droughts of up to seven months at a time, is able to withstand high temperatures and frosts, and is suitable for alkaline soils (Fisher and Widmoyer, 1978). A tap root system along with aggressive root system growth make this species ideally suited to plantings in the semi-arid southwest. With the increased establishment of multiple use windbreaks, eldarica pine may create additional income and protection. This species may be used in short-rotation production of pulpwood, fuelwood, biomass plantings, and Christmas trees (Fisher and Widmoyer 1978).

*** The genus Cupressus has also shown promise in arid and semi-arid afforestation plantings (Long 1977). Arizona cypress is adapted to alkaline soils and has a reputation of being drought resistant once established. Traditionally, cypresses have been propagated mainly for landscaping, Christmas trees, erosion control, windbreaks, and lumber to a minor extent (Young and Young 1992). The native range for Arizona cypress includes the mountainous areas of southeastern and central Arizona and southwestern New Mexico.

*** This study examined several site preparation techniques and planting stock sizes, and their impact on eldarica pine and Arizona cypress windbreak establishment in the Pecos Valley Agricultural region (Artesia). The site preparation techniques evaluated included v-ditching, weed barrier, and a combination of v-ditching and weed barrier. Also, four container sizes, 115, 164, 262, and 656 ml root volume of eldarica pine and Arizona cypress were tested.

MATERIALS AND METHODS

*** The planting site is located at the New Mexico State University - Artesia Experiment Station approximately 10 km south of the town of Artesia, New Mexico. The planting site was an agricultural field left fallow for one year with a cover crop of sorghum. Crops previously grown in the area included alfalfa and cotton. The soil of the planting area was relatively uniform silt loam.

*** The seed source for the eldarica pine was from collections at the Fabian Garcia Research Center in Las Cruces, NM. Arizona cypress seed was purchased from a commercial vendor, who collected the material from southwestern New Mexico (Dean Swift, Inc. Jaroso, CO.). Seedlings were propagated in the NMSU Forestry Greenhouse in Las Cruces, NM from seed under a standard production regime as described by Harrington (1991). Four container sizes were used to generate four stock sizes within each species. The containers used were: 115 ml Ray-Leach Cone-tainer, 164 ml Ray-Leach Cone-tainer, a 262 ml Deepot, and a 656 ml Deepot (Stuewe and Sons, Corvalis, OR). A total of 480 seedlings of each stock type and species combination were evaluated in Artesia.

*** A factorial combination of two site preparation technologies were used in this study generating three site preparation treatments and an undisturbed control. These treatments were a 2-m wide synthetic weed barrier, a 2-m synthetic weed barrier with a v-ditch; a v-ditch alone; and an undisturbed control. The synthetic weed barrier consisted of a tightly woven synthetic burlap. This material allows for water penetration but restricts weed growth. Seedlings were first planted then the weed barrier was laid over the top of the planting area and a slit was made in the fabric for the seedling. The term "v-ditch" refers to a shallow trench 2-m wide and 10 cm deep prepared by a tilting blade on a three-point hitch of a farm tractor.

*** Each site preparation by container size treatment consists of an 11 m by 2 m area. A total of 10 seedlings were planted in each site preparation by container treatment. All seedlings were planted using a hand-held power auger with a 7.5 cm diameter bit. All seedlings were irrigated once with 9 cm of water from an overhead irrigation system immediately following planting. No further irrigations were performed.

*** Immediately prior to planting, shoot height and root collar diameter (caliper) were measured on each seedling. Shoot height was measured to nearest 1.0 mm using a ruler. Root

collar diameter was measured to the 0.01 mm using digital calipers. An additional 50 seedlings of each species by container size were destructively sampled to measure shoot dry weight and root dry weight. This information was used to determine root to shoot ratios on a dry weight basis. Survival was recorded at one and six months following outplanting. At six months after planting shoot height and root collar diameter were measured on surviving seedlings as described before. The wide range of seedling sizes generated by the different container sizes necessitated that growth measures be made relative to initial planting size for comparison purposes. Relative height growth was calculated by dividing the difference between six month height and initial height by initial height and multiplying the product by 100. Relative caliper growth was calculated by dividing the difference between six month caliper and initial caliper by initial caliper and multiplying the product by 100.

*** The study design was a split-plot design within a complete block with site preparation treatment being the whole plot and container size being sub-plots. This arrangement was replicated 3 times (blocks). The response unit for one and six month survival was the percent of the 10-tree row plots per site preparation by container size combination per block. The response unit for growth was the average growth of the surviving trees from the 10-tree row plots per site preparation be container size combination per block.

*** Analysis of the data was performed using PROC GLM of SAS (SAS Institute, Cary, NC). Orthogonal contrasts were used to delineate differences among treatment levels of container size and site preparation. A treatment effect was considered significant only if the observed probability level (Pr>F) was less than 0.10.

RESULTS

*** As expected the seedlings of both species were progressively larger as container size increased (Table 1). However, the root to shoot ratios were relatively uniform regardless of size of container the seedlings were produced in.

*** Early survival was high for both species with no discernable effects of container size. Eldarica pine survival ranged from 100% in the v-ditch containing treatments to 85% in the weed barrier treatment (Figure 1). The trend in Arizona cypress early survival was similar to eldarica

Table 1. Seedling Morphological Parameters Prior to Planting at Artesia.

	Eldarica Pine							
	115 ml		164 ml		262 ml		656 ml	
Attribute	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Height	16.60	0.26	18.82	0.28	20.48	0.54	28.69	0.59
Caliper	2.15	0.02	2.21	0.02	2.56	0.03	3.41	0.03
Root Dry Weight	0.48	0.01	0.58	0.01	0.85	0.02	1.43	0.06
Shoot Dry Weight	1.26	0.02	1.44	0.08	2.20	0.05	4.09	0.09
R:S Dry Weight Ratio	0.38		0.40		0.38		0.35	

	Arizona Cypress							
	115 ml		164 ml		262 ml		656 ml	
Attribute	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Height	15.40	0.40	23.80	0.45	22.10	0.53	30.10	0.77
Caliper	1.82	0.03	1.99	0.03	2.00	0.04	2.50	0.05
Root Dry Weight	0.37	0.01	0.46	0.02	0.62	0.03	1.05	0.05
Shoot Dry Weight	1.30	0.04	1.76	0.06	1.82	0.08	3.46	0.15
R:S Dry Weight Ratio	0.29		0.26		0.34		0.30	

pine; however, somewhat less with survival ranging from 95% in the v-ditch containing treatments to 72% in the weed barrier alone site preparation treatment (Figure 2). Little additional mortality (less than 5%) occurred during the remainder of the growing season in eldarica pine on the three site preparation treatments. However, seedlings planted in the control plots exhibited an additional 19% loss of seedlings , from 92% survival 1 month following planting to 72% survival at the end of the first growing season (Figure 1). No further significant mortality in Arizona cypress occurred in the v-ditch containing site preparation treatments by the end of the first growing season.

*** While there was no discernable effect of container size on early survival, larger seedlings had better survival at the end of the first growing season (Figure 3). Both species showed a linear increase in percent survival as container size increased. In eldarica pine this increase went from 70% for seedlings grown in 115 ml containers to 95% for seedlings grown in 656 ml containers. In Arizona cypress the increase was less dramatic increasing from an average survival of 72% for seedlings produced in 115 ml containers to 85% in seedlings produced in 656 ml containers.

*** Both site preparation techniques individually and in combination enhanced relative caliper growth in both species. However, in eldarica pine as container size increased the response of seedlings to site preparation technique increased (Figure 4). Weed barrier containing site preparation treatments had the greatest improvement on relative caliper growth in both species. Eldarica pine growing in both weed barrier containing treatments had more than three times the relative caliper growth than seedlings growing in the control plots (Figure 5). The v-ditch alone site preparation treatments had slightly less than twice the relative caliper growth when compared to seedlings growing in the control plots.

*** Similarly, relative height growth was improved by site preparation in both species (Figure 6). As was the case with relative caliper growth, the improvement in relative height growth was more pronounced in the weed barrier containing treatments. Only Arizona cypress growing in the v-ditch alone site preparation treatment did not have greater relative height growth than seedlings growing in the control plots.

*** In both species relative height growth was greater for seedlings produced in smaller containers. In both species, these seedlings were shorter than seedlings produced in the other

three larger containers when planted in the field. In eldarica pine the seedlings produced in the 115 ml and 165 ml containers had greater relative height growth than those produced in the two larger containers (Figure 7). In Arizona cypress, relative height growth was greatest in seedlings produced in the 115 ml and was similar for seedlings produced in the three larger containers (Figure 7).

*** Only in Arizona cypress was relative caliper growth sensitive to container size. As container size increased so did relative caliper growth (Figure 8). When put in absolute terms and not relative to initial planting size, this increase in growth was almost two times the caliper growth of seedlings produced in the smallest containers (Figure 8).

DISCUSSION

*** The overall purpose of site preparation is to improve seedling survival and growth so that trees are established reliably under existing conditions. In arid and semi-arid regions site preparation can potentially improve seedling establishment by reducing the severity of transplant moisture stress. Means by which this can occur include soil capture of precipitation and improved soil moisture infiltration and storage. Site preparation can also greatly reduce the loss of soil moisture to weeds. In the absence of proper site preparation, seedlings fail altogether or make such poor growth that the project is abandoned (Fisher and Montano 1977; Nickerson 1990).

*** The aim of our work was not to determine if site preparation is needed but rather to compare seedling establishment responses across a range of treatments encompassing materials, methods or conditions previously untested in the region. Most noteworthy, perhaps, was the inclusion of woven plastic weed barrier in specific treatments . Although considerable attention has been directed toward mulches and synthetic plastic barriers for landscaped plantings, the use of the latter as continuous sheets or woven plastics in conservation plantings remains inadequately tested.

*** Concerning site preparation treatments, the v-ditch containing treatments were effective in improving both early and long-term survival in this study. This is likely due to two reasons. First, the v-ditch treatment effectively channels moisture to the base of the ditch during heavy rains. Short duration, heavy rains are characteristic of the type of rains in this area. This feature

in combination with a silt loam soil allows for a larger percentage of the moisture input to be channelled and held in the root zone of the seedling. Second, the early removal of weed sod cover during shaping the v-ditch reduces the competitive loss of soil moisture from the seedling root zone.

*** In comparison to the v-ditch, the weed barriers also effectively reduced weed competition for water but were ineffective in directing precipitation to the root zone of the newly transplanted seedlings. Weed barriers improve soil moisture availability by reducing the competition for available water. The high early mortality in the weed barrier alone treatment may be due to higher temperatures generated at and immediately above the soil surface. When the treatments were initially installed, some vegetation had already begun to grow. This resulted in the weed barrier being suspended slightly (2 - 4 cm) above the soil surface.

*** Soil mulches have been shown to increase the soil surface temperature when compared with non-mulched treatments (Duncan et al. 1992, Peacock et al. 1990, Stapleton and Garza-Lopez 1987, and Truax and Gagnon 1993). As early as 1947, Moulopoulos documented the effect of high soil surface temperatures on planted conifer seedlings, stating that they were prone to stem damage near the soil surface. Heiskanen and Raitio (1992) conducted a study in Finland on polypropylene mulches and found that daily temperatures at the soil surface were up to 50 C. In this study daily ambient temperatures reached or exceeded 30 C several times during the month following planting. Lethal temperatures for conifer seedlings have been defined as two hours at 36 C, or one hour at 42 C at the soil surface (Roberts and Dong 1993).

*** The beneficial response of both site preparation techniques alone and in combination on relative height and caliper growth is also likely due to the improved water availability to the seedlings during the first growing season. The large improvement in growth for seedlings in the weed barrier containing treatments is related to the ability of this treatment to suppress competition for water in the rooting zone of the seedlings thus making it available for seedling growth.

*** In the western United States the use of small (65 ml to 165 ml) container grown stock began to flourish in the 1970's. One premise behind the use of container grown seedlings was establishment would be improved by the more fibrous, less disturbed root systems relative to the traditional bareroot stock types (Romero et al. 1986). When planted on more adverse sites such

as this one, container grown stock has proven to be more successful (Barnett and McGilvray 1993). For example, when planted on a droughty site in southwestern Oregon, container grown Douglas-fir seedlings outperformed 2-0 bareroot stock (Hobbs et al 1981).

*** The size of the container used to produce the seedling strongly influences the size and performance of the seedling. In longleaf pine planted in the late summer and early spring in Jasper, Texas seedlings produced in 131 ml containers had better survival than seedlings produced in 66 ml containers (Amidon et al 1981). While overall survival was much better in this study the trend for seedlings produced in larger containers was still evident. On severe sites seedlings with larger root dry weight had greater survival (Mexal and Landis 1990).

*** Other studies have reported greater shoot growth for stock grown in larger containers as was found in both species evaluated in this study (Amidon et al., 1981). However, in those studies growth was not made relative to initial planting size. In this study the seedlings produced in smaller containers had greater relative height growth than did larger seedlings even though the larger seedlings had greater measured height growth.

*** This response could be attributed to several factors. First, the smaller seedlings were able to establish themselves at the planting site and resume growth faster than larger seedlings given the site conditions. Second, the intervals between adequate and inadequate moisture availability may be of sufficient duration to inhibit the growth of the larger seedlings with greater transpirational demands. Third, the larger seedlings may have allocated carbohydrates into other areas of growth such as root growth. Subsequent visits to the planting site support the latter theory.

*** After seven months of no measurable rain on the site, the seedling produced in the two smaller size containers had almost no survival while seedlings produced in the larger two container sizes still maintained relatively high survival in the weed barrier containing treatments. This would indicate the larger seedlings had greater root egress and were able to exploit a greater volume of soil moisture.

CONCLUSIONS

*** The results of this study indicate the potential for a low cost system for establishing agroforestry trees in the southern Great Plains does exist. Using a v-ditch site and weed barrier site preparation treatment along with larger stock types will help ensure first year survival.

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