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PLANT MATERIALS TECHNICAL NOTE

Effects of Water Delivery Method and Herbaceous Competition on Seedling Survival, Height Growth, and Vigor Rating: Four-Year Summary Results

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Green Ash – Fallow (2008)

Green Ash – Vegetated Cover (2008)

INTRODUCTION

Evaporative losses and competition for soil moisture, nutrients, and light from competing vegetation contributes significantly to the failure of tree and shrub (woody) plantings in the northern Great Plains and Intermountain West. A lack of site preparation and poor control of sod-forming grasses and rhizomatous forbs prior to tree and shrub installation frequently results in conservation planting failures. A popular misconception is that modest supplemental watering offsets moisture losses to herbaceous competition. In order to determine the effects of water delivery methodology and herbaceous plant competition on woody plant survival and growth under a conventional irrigation schedule, two replicated studies were installed at the USDA-NRCS Plant Materials Center in Bridger, Montana, in May 2005. Only summary results are provided here. For a detailed description of this study, as well as additional information, contact the Plant Materials Center at Bridger, Montana at (406) 662-3579. The study supports on-going field research sponsored by the Little Beaver Conservation District and funded in-part by a Grazing Lands Conservation Initiative grant. This research is conducted in cooperation

with the Montana Department of Natural Resources and Conservation and the Montana Conservation Seedling Nursery in Missoula, Montana.

MATERIALS AND METHODS

Two deciduous species (bur oak *Quercus macrocarpa* and green ash *Fraxinus pennsylvanica*) and two coniferous species (ponderosa pine *Pinus ponderosa* and Rocky Mountain juniper *Juniperus scopulorum*) were tested in the study. These species were selected for their varied leaf retention characteristics and rooting patterns, two traits that may influence plant survival and growth relative to water delivery method. One test plot was maintained fallow over the 2004 through 2008 growing seasons by a combination of mechanical and chemical weed control. The other plot was maintained under a cover of established thickspike wheatgrass *Elymus lanceolatus* ssp. *lanceolatus*, with intermittent patches of bluebunch wheatgrass *Pseudoroegneria spicata*, 'Bozoisky' Russian wildrye *Psathyrostachys juncea*, and sainfoin *Onobrychis viciifolia*. Tall competing vegetation in the vegetated plot was managed by mowing between-rows. Although planting directly into sites with established sod-forming grass is not a recommended practice, testing under these conditions was necessary to determine the ability of sub-irrigation tubes and subsurface watering to offset moisture loss from herbaceous competition.

Experimental design was a Randomized Complete Block with three replications (Blocks). Each block contains 20 seedlings of each of the four species, 10 seedlings of each species with sub-irrigation tubes; 10 seedlings without sub-irrigation tubes. All seedlings were randomized within an individual block. Statistical analysis by Analysis of Variance (ANOVA), All Pair-Wise Comparison (for mean separation), p=0.05 level.

Irrigation tubes consisted of 10.2-cm (4-inch) inside-diameter non-perforated, polyvinylchloride (PVC) sewer pipe (see FIGURE 1). Each pipe measured 91.4 centimeters (36 inches) long, with 5.1-centimeter (2-inch) wide, horizon openings every 5.1 centimeters (2 inches) along the length of the pipe, beginning 15.2 centimeters (6 inches) from the top of the pipe. The width of each horizontal opening was the width of standard circular saw blade kerfs. A 76- to 81-centimeter (30- to 32-inch) deep hole was augured for each tube with a 10.2-centimeters (4-inch) auger. Tube holes were located approximately 25.4 centimeters ± 10.2 centimeters (10 inches ± 4 inches) upslope from the seedling with the tube openings facing the seedling. Each tube was inserted in the hole and then residual soil inside the tube removed with a hand auger. The inside base of each tube was sealed with a pre-moistened, baseball-size sphere of bentonite clay.

All seedlings in both plots were irrigated at planting in early May 2005. Trees with tubes received approximately 7.2 liters (1.9 gallons) in the tube plus 3.8 liters (1 gallon) on the soil surface around each plant. Trees without tubes received approximately 11 liters (2.9 gallons) on the soil surface only. This protocol was used to guarantee that some supplemental water reached the root systems of all trees during early establishment. All plants in both plots received a second irrigation in late May, and a final irrigation in late July. It should be noted that Bridger, Montana, falls within a 10- to 12-inch annual precipitation zone.

Based on wetting front trials conducted in late 2005, it was concluded that supplemental water was not adequately reaching the root systems of trees with sub-irrigation tubes with the initial tube design. To remedy the situation, 76-centimeter (30-inch) extensions were added to the top of each sub-irrigation tube in 2006, increasing storage capacity to approximately 13.2 liters (3.5 gallons) per tube. The 2005 watering protocol was also changed in 2006. Trees without tubes received 11.4 liters (3 gallons) directly on the plant, whereas trees with irrigation tubes only received supplemental water subsurface by the sub-irrigation tube.

FIGURE 1. Sub-irrigation tube design

RESULTS

Results of the sub-irrigation tube study for 2005 through 2008 appear in TABLE 1 and CHARTS 1 and 2. Numbers in blue represent a statistically positive effect of using sub-irrigation tubes for a given species and plot; red indicates a statistically negative effect of using tubes, i.e., in these cases, water placement directly on top of the root system proved more effective. In year one, sub-irrigation tubes did not result in significant improvements (Analysis of Variance, Least Significant Difference Separation, p=0.05) in survival or height growth of any species on either site, but did result in significantly better vigor rating in bur oak on the vegetated site. In year two of the study, only green ash on the fallow site demonstrated significantly better height growth and vigor rating where sub-irrigation tubes were used. In year three on the fallow site, bur oak had significantly greater height growth and green ash had significantly better vigor rating where sub-irrigation tubes were used. Additionally in year three, ponderosa pine on the vegetated site had significantly better height growth where tubes were used. In year four on the fallow site, green ash had significantly better vigor rating where tubes were used. There were no significant differences in survival of any species on either site as a result of water delivery method. With the exception of ponderosa pine in year one, each species by treatment had equal or greater survival, height growth, and vigor rating on the fallow versus the vegetated site.

RESULTS (CONTINUED)

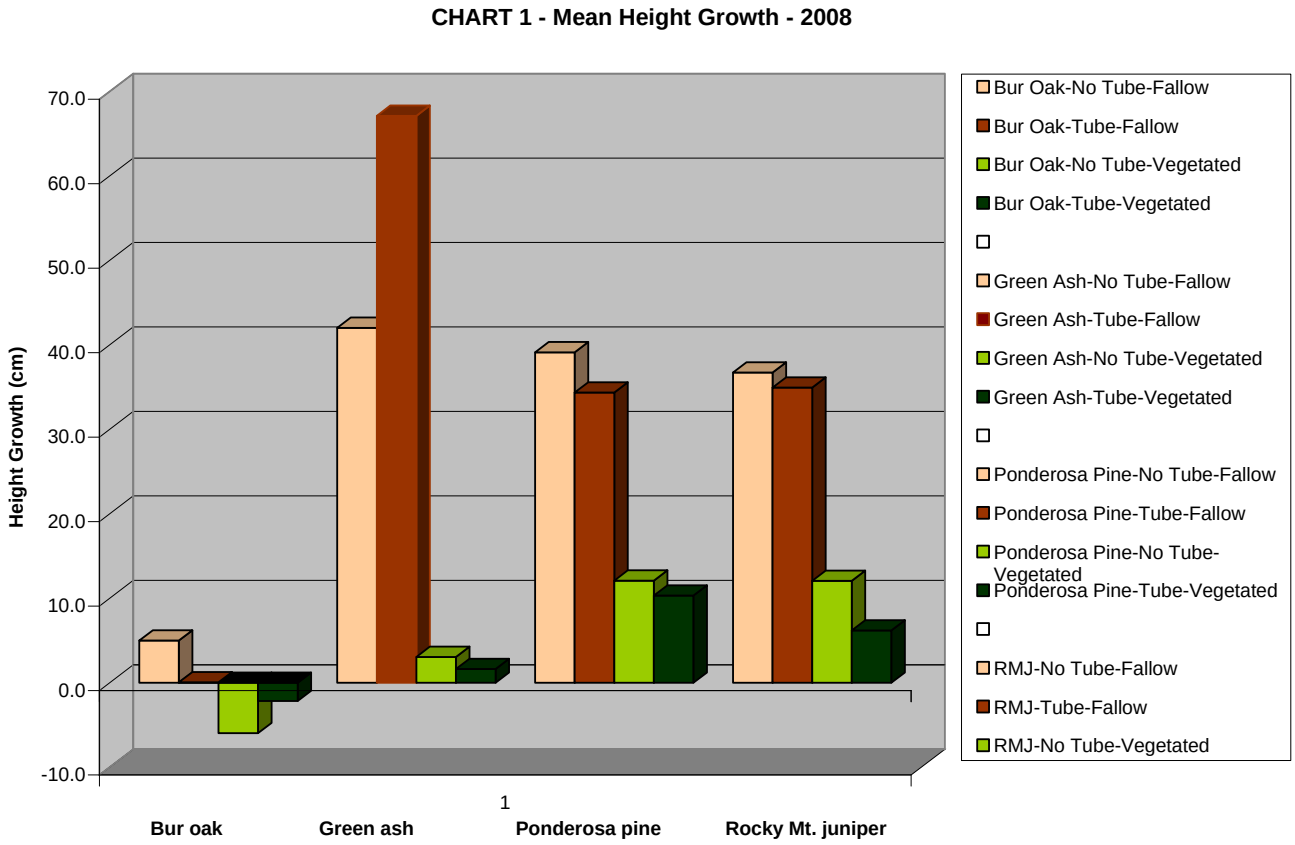
TABLE 1. SUB-IRRIGATION TUBE STUDY RESULTS, BRIDGER PMC, 2005 THROUGH 2008.

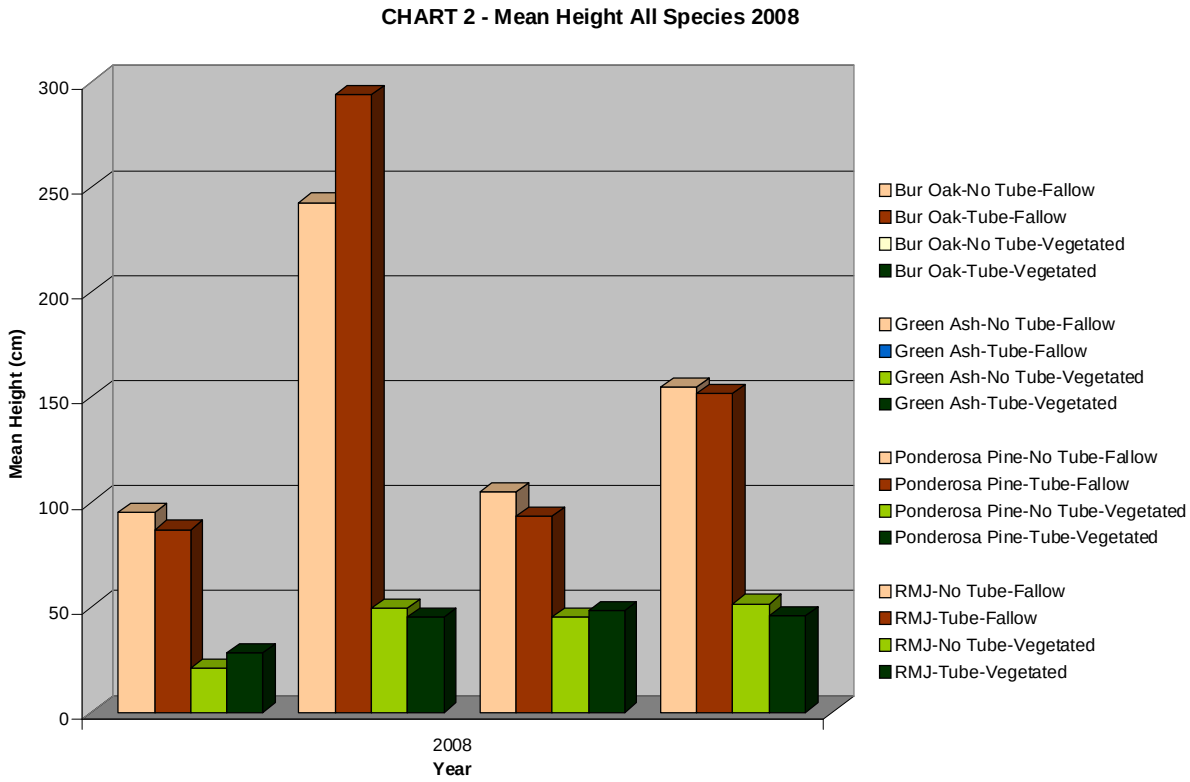
	Cover	2005 Survival %	2006 Survival %	2007 Survival %	2008 Survival %	*2005* Height Growth cm	*2006* Height Growth cm	*2007* Height Growth cm	*2008* Height Growth cm	*2005* Vigor Rating (1-9) 1=best	*2006* Vigor Rating (1-9) 1=best	*2007* Vigor Rating (1-9) 1=best	*2008* Vigor Rating (1-9) 1=best
Field 3													
Oak-NT	**fallow**	**100**	**100**	**100**	**97**	**24.5**	**27.3**	**8.6**	**5.0**	**3.8**	**3.6**	**3.1**	**4.3**
Oak-T	**fallow**	**100**	**100**	**100**	**97**	**20.6**	**18.8**	**17.2**	**0.1**	**4.2**	**3.9**	**3.5**	**4.0**
Ash-NT	**fallow**	**100**	**100**	**100**	**100**	**34.0**	**60.8**	**65.7**	**42.0**	**3.7**	**4.2**	**4.3**	**4.9**
Ash-T	**fallow**	**100**	**100**	**100**	**100**	**33.7**	**75.9**	**74.3**	**67.1**	**3.4**	**3.4**	**3.6**	**4.0**
Pine-NT	**fallow**	**100**	**100**	**100**	**100**	**6.3**	**18.2**	**19.9**	**39.1**	**3.9**	**3.2**	**2.6**	**3.4**
Pine-T	**fallow**	**100**	**100**	**100**	**100**	**6.3**	**10.7**	**21.9**	**34.4**	**4.2**	**4.0**	**3.3**	**3.8**
RMJ-NT	**fallow**	**100**	**100**	**100**	**100**	**14.9**	**38.2**	**38.9**	**36.7**	**3.5**	**2.7**	**2.2**	**2.7**
RMJ-T	**fallow**	**100**	**100**	**100**	**100**	**13.3**	**32.8**	**40.6**	**35.0**	**3.5**	**2.9**	**2.2**	**2.6**
Field 14													
Oak-NT	**veget.**	**100**	**90**	**90**	**80**	**15.4**	**-3.3**	**-18.4**	**-6.0**	**5.1**	**6.1**	**7.7**	**7.5**
Oak-T	**veget.**	**100**	**90**	**90**	**87**	**16.8**	**-2.3**	**-17.9**	**-2.2**	**4.6**	**6.0**	**7.2**	**6.9**
Ash-NT	**veget.**	**100**	**100**	**100**	**97**	**7.8**	**-2.4**	**-7.9**	**3.1**	**5.4**	**6.4**	**7.2**	**7.1**
Ash-T	**veget.**	**100**	**93**	**93**	**90**	**7.2**	**-2.1**	**-6.2**	**1.6**	**5.5**	**6.8**	**7.3**	**7.3**
Pine-NT	**veget.**	**100**	**100**	**97**	**90**	**10.0**	**5.1**	**-4.5**	**12.1**	**4.6**	**5.1**	**5.9**	**6.9**
Pine-T	**veget.**	**100**	**93**	**93**	**90**	**6.8**	**6.6**	**2.9**	**10.3**	**4.6**	**4.9**	**5.4**	**6.6**
RMj-NT	**veget.**	**100**	**100**	**100**	**100**	**8.0**	**3.0**	**-0.2**	**12.1**	**5.4**	**5.8**	**6.5**	**6.6**
RMj-T	**veget.**	**100**	**100**	**100**	**100**	**6.9**	**3.0**	**1.1**	**6.2**	**5.5**	**6.2**	**6.5**	**7.2**

NT=No Tube
T=Tube
negative growth indicates tip dieback

Blue indicates a statistically significant positive effect when sub-irrigation tube is used.
Red indicates a statistically negative effect when a sub-irrigation is used or conversely, a positive effect when water is applied atop the seedling.

RESULTS (CONTINUED)





CONCLUSIONS

Although the effect of sub-irrigation tubes and cover type were erratic, some patterns did emerge.

1) Green ash had consistently greater height growth and vigor rating on the fallow site with the tubes. This may be the result of roots from this fast growing species accessing soil moisture near the tube before the other species.

2) Unexpectedly, seedling survival remained relatively high at both sites over the course of the study, although plant height growth and vigor decreased substantially on the vegetated site. This could prove problematic if planting success is based solely on seedling survival within fours years of planting, at least given the climatic and environmental conditions characterized by this study.

3) Rhizomatous grasses, and other types of herbaceous vegetation, are more competitive than tree seedlings in extracting soil moisture. Furthermore, modest amounts of supplemental water, such as the amount applied in this study, are insufficient to offset losses to competitive grasses. It is not known at what level of supplemental water, if any, developing seedlings are able to compete with herbaceous cover for enough soil moisture to sustain adequate growth. Adequate site preparation that includes control of competing vegetation is critical in establishing woody plantings that function properly and provide the intended conservation benefit.

Based on these results, it appears the initial distance between the sub-irrigation tubes and the seedlings (~10 inches) was probably too great. Additionally, deep placement of sub-irrigation tubes is unnecessary and inefficient, resulting in poor placement of water relative to the developing root system. Future testing will minimize the distance between the tube and seedling, as well as limit the depth of tube placement to the surface 6 to 10 inches of the soil profile. Additionally, supplemental water on the vegetated site was inadequate to maintain acceptable seedling growth and vigor.

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