Effects of Mulch on Soil Moisture and Growth of Desert Willow

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ADDITIONAL INDEX WORDS. *Chilopsis linearis*, soil surface management

SUMMARY. The objective of this research was to consider the effects of gravel, wood chip, and tire mulches and turf on soil moisture and root and shoot growth of *Chilopsis linearis* (Cav.) 'Burgundy' (desert willow). Gravel, wood chip, and tire mulches retained greater soil moisture than bare soil (control) with little difference in soil moisture between the mulches. Mulched trees and bare soil had greater height and shoot and root dry weights than trees in turf. Turf conserved soil moisture better than bare soil but appeared to compete with desert willow for water and nutrients resulting in less growth. Trees with gravel and tire mulches had greater shoot dry weight in the second year of growth and greater root dry weight, root length, and root area in both the first and second years of growth after transplanting.

Mulches, whether organic or inorganic, are applied in landscapes to reduce soil moisture losses, decrease compaction and erosion, and serve as nonchemical weed controls (Harris, 1983). Organic mulches have the additional benefits of improving soil structure and soil fertility. Additionally, mulches add to the aesthetic beauty of a landscape. Air and water permeability, color and texture, ease of application, fire resistance, wind and erosion resistance, toxicity, and longevity are all considerations when choosing a mulch for use in the landscape (Harris, 1983).

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Texas Tech University College of Agriculture and Natural Resources publication T-4-428. Thanks go to Max Recycling for donating the tire mulch. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

Mulches increased shoot (Fraedrich and Ham, 1982; Green and Watson, 1989; Holloway, 1992; Skroch, et al., 1986) and root (Fraedrich and Ham, 1982; Green and Watson, 1989; Watson, 1988) growth in a variety of woody plant species. Additionally, mulches increased soil moisture (Munn, 1992; Smith and Rakow, 1991; Watson, 1988) and decreased weed growth (Holloway, 1992). With the application of mulch, the increased soil moisture alone may result in better establishment and growth of newly transplanted trees. In landscape situations where turf was growing up to the trunks of trees, the removal of the competition for water and nutrients by some grasses and addition of mulch further benefited tree growth (Parker and Meyer, 1996; Watson, 1988). However, based on the current body of literature, woody plant species may respond differently to various mulches (Holloway, 1992; Skroch et al., 1986). Additionally, the impacts of mulches may vary with environmental conditions (Green and Watson, 1989; Holloway, 1992).

This research was conducted with *Chilopsis linearis* 'Burgundy' (desert willow) in Lubbock, Texas, which is located in a semiarid mixed prairie with an annual rainfall of 38 to 53 cm (15 to 21 inches), high light intensity, warm drying winds, alkaline soils, and practically no native trees. No research on the effects of different soil surface treatments on growth of desert willow has been conducted. Early and successful establishment of a tree's root system, following transplanting, would greatly increase survivability in such a demanding environment. Decreased soil moisture loss due to evaporation with the application of mulch may promote faster establishment of newly planted trees by increasing the growth of roots from the root ball into the surrounding soil. Therefore, the objective of this research was to evaluate the impacts of five soil surface management treatments (three mulches, bare soil, and turf) on soil moisture, tree growth, and establishment of tree roots.

Materials and methods

The field experiment, a randomized complete-block design with a factorial treatment arrangement and five replications, was conducted at the Texas Tech University Erskine Street Research Farm in Lubbock, Texas,

from September 1995 through July 1997. Treatments included five soil surface treatments (tire mulch, gravel, wood chip mulch, turf, and bare soil) and two harvests (11 Oct. 1996 and 15 July 1997) resulting in 10 trees per replication. Tire mulch (Max Recycling, Bryan, Texas) was black, organic, irregularly shaped, and ranged in particle size from 0.7 to 1.0 cm. The gravel was light tan, inorganic, rounded, and ranged in particle size from 2.0 to 3.0 cm. The hardwood wood chip mulch consisted of light tan, organic, elongated strips, and ranged in particle size from <1.0 mm to 5 cm. Before planting, existing weeds were herbicided, the Amarillo fine sandy loam soil was tilled, and 1.2 × 1.2 m plots were established. A single specimen from a population of *Chilopsis linearis* 'Burgundy' (desert willow) trees growing in 3.8-L containers was planted into the center of each plot on 22 Sept. 1995. At planting, mulches were applied to a depth of 5.1 cm and bermudagrass (*Cynodon dactylon* L.) turf was laid as sod. Plots were irrigated weekly with 2.5 cm of water supplied by a spray stake irrigation system. Weeds that germinated and grew after planting were removed by hand. Turf was mowed as needed to maintain a height of 5 cm. No fertilizer was applied.

Height was measured on 24 May, 30 July, 5 Sept., and 20 May 1997. Soil moisture was measured on the south side of each plot ≈60 cm from the base of each tree weekly from 1 Jan. through 9 Oct. 1996 at a depth of 9 cm using a Quick Draw soil moisture probe (model 2900FI, SoilMoisture Equipment Corp. Santa Barbara, Calif.). For the 11 Oct. 1996 harvest only, root systems of each tree were dug by hand and total root length and total root area (new and existing roots) were determined using an AgVision Monochrome System (Decagon Devices Inc., Pullman, Wash.). Due to their large size, root systems were not dug in 1997. For the 1996 and 1997 harvests, shoots were removed at ground level, dried at 62 °C for 5 d and weighed.

All variables were tested for differences using analysis of variance procedures (ANOVA) (SAS, 1985). Means were compared between soil surface treatments using least significant difference (lsd) comparisons at $p \leq 0.05$. Tensiometer data were ana-

Table 1. Soil surface treatment effects on soil moisture in 1996.

Treatment	Soil surface treatment means (centibars)									
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Turf	9.5 ab ^z	10.3 a	8.5 a	11.2 a	3.3 a	3.7 b	6.0 bc	11.2 c	3.0 b	6.1 a
Bare	15.3 a	12.3 a	7.2 a	11.1 a	1.7 b	5.7 a	9.3 a	25.6 a	4.5 a	7.4 a
Gravel	8.0 b	3.8 b	3.8 b	6.5 b	1.2 b	2.5 bc	7.2 b	18.4 b	2.9 b	8.1 a
Tire	6.2 b	4.7 b	3.8 b	6.3 b	1.9 ab	1.7 c	6.3 bc	12.8 c	2.8 b	7.1 a
Wood chip	5.7 b	3.6 b	3.4 b	5.8 b	2.1 ab	1.9 c	5.2 c	12.8 c	3.3 b	7.3 a
Significance ^y	NS	0.001	0.01	0.005	NS	0.003	0.005	0.002	0.009	NS

^zMean separation by lsd at $p \leq 0.05$. Means with the same letter were considered nonsignificant.

^yNS = Nonsignificant. P value considered significant at $p \leq 0.05$.

Table 2. Soil surface treatment effects on desert willow growth over 2 years.

	Soil surface treatment means (centibars)								
	Shoot dry wt (g)		Ht (cm)				Root (11 Oct. 1996)		
			1996			1997	Dry wt	Area	Length
	1996	1997	24 May	30 July	5 Sept.	20 May			
	1996	1997	24 May	30 July	5 Sept.	20 May	(g)	(cm ²)	(cm)
Gravel	815 a ^z	1093 a	42.1 a	108 a	139 a	148 a	406 a	1146 ab	3154 ab
Tire	715 a	1018 ab	39.7 a	109 a	138 a	137 ab	362 a	1297 a	4010 a
Wood chip	589 a	718 c	38.5 a	101 a	129 a	128 b	284 b	1167 ab	3658 ab
Bare	623 a	859 bc	42.2 a	102 a	128 b	142 ab	260 b	879 b	2478 b
Turf	164 b	76 d	38.1 a	84 b	111 b	87 c	41 c	268 c	1073 c
Significance ^y	0.005	0.001	NS	0.02	0.02	0.001	0.001	0.004	0.007

^zMean separation by lsd at $p \leq 0.05$. Means with the same letter were considered nonsignificant.

^yNS = Nonsignificant. P value considered significant at $p \leq 0.05$.

lyzed based on means of the samples taken for each month.

Results and discussion

The effect of soil surface treatment on soil moisture varied with the time of year the sample was collected (Table 1). The gravel, tire, and wood chip mulches did not significantly differ in their ability to retain soil moisture; however, the mulches maintained greater soil moisture (smaller tension values) than the bare soil. Newspaper and straw mulches (Munn, 1992) and shredded bark, fine bark, wood chips, and medium grade gravel (Smith and Rakow, 1992) have also been reported to maintain higher soil moisture than bare soil. The effects of turf on soil moisture were less consistent (Table 1). From January through April, soil moisture under the turf was comparable to the bare soil and drier than the mulches. From June through October, soil moisture under the turf was similar to the mulches and wetter than the bare soil.

Soil surface treatment affected shoot dry weight in 1996 and 1997 (Table 2). For both years, trees with the mulches and bare soil had greater shoot dry weight than with the turf. Turf may have competed with the

desert willow for nutrients and water. Parker and Meyer (1996) found that growth of peach trees with some species of grass was reduced apparently due to the competitive nature of some grass species. In 1996, no differences existed in shoot dry weight between the gravel, tire, and wood chip mulches or the bare soil (Table 2). In 1997, trees with the gravel and tire mulches had greater shoot dry weight than with the wood chip mulch. As the wood chip mulch decomposed, microorganisms involved in decomposition may have competed with the desert willow for nitrogen. Holloway (1992) reported that growth and plant nutrition of a variety of woody plant species was poorest with hardwood chip mulch and best with black basaltic rock.

Early in the experiment, soil surface treatment did not affect the height of desert willow (24 May 1996), but did impact desert willow height later in the experiment (30 July 1996, 5 Sept. 1996, and 20 May 1997) (Table 2). Trees grown with the mulches were taller than trees grown with turf. Similar reductions in growth and market value of hemlock (*Tsuga canadensis* L.) and eastern white pine (*Pinus strobus* L.) were reported when these trees were grown with tall fescue

(*Festuca arundinacea* Schreb.) compared to a variety of other mulches (Skroch et al., 1986).

Root dry weight was greater with the gravel and tire mulches than the wood chip mulch, bare soil, and turf (Table 2). Root area and root length were greater with all the mulches and bare soil than with turf. Green and Watson (1989) reported similar reductions in root growth of transplanted bare-root Green Mountain sugar maples [*Acer saccharum* (Marsh.) 'Green Mountain'] grown with turf. Watson (1988) reported that root density, root surface area, and the number of fine roots were increased by the removal of turf and the addition of mulch to the root zone of several established tree species.

Based on these data, mulches modified the soil environment and increased root and shoot growth, while, turf impaired establishment of desert willow. Mulching aided the establishment of desert willow.

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Using Commercial Bumble Bee Colonies as Backup Pollinators for Honey Bees to Produce Cucumbers and Watermelons

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ADDITIONAL INDEX WORDS. *Bombus impatiens*, *Apis mellifera*, pollination, *Cucumis sativus*, *Citrullus lanatus*, fruit and seed set

SUMMARY. The effectiveness of bumble bees, *Bombus impatiens* Cresson, and honey bees, *Apis mellifera* L., on the pollination of cucumber, *Cucumis sativus* L., and watermelon, *Citrullus lanatus* (Thunb.) Matsum. & Nakai, was compared under field conditions. Comparisons were based on fruit abortion rates and seed set as influenced by bee type (honey bee or bumble bee) and the number of bee visits to treatment flowers (1, 6, 12, and 18 bee visits), plus two controls: a no-visit treatment and an open-pollinated (unrestricted visitation)

This research was funded in part by the North Carolina Agricultural Research Service (NCARS projects NC 6355 and 6187) Raleigh, NC; Koppert Biological Systems, Inc., Ann Arbor, MI 48103; and the North Carolina State Beekeepers Association. Use of trade names in this publication does not imply endorsement by the NCARS of products named nor criticism of similar ones not mentioned. We gratefully acknowledge Cavell Brownie and Mary Peet for their advice and Dennis Adams, Leslie Newton, Jason Doherty, Lane Tabor, Mark Scepanski, Paul Lineberger, Clifton Ryan, and Watson Hall for their technical assistance. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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treatment. For both crops, an increased number of bee visits had a strong positive effect on fruit and seed set. All cucumber and watermelon flowers bagged to prevent insect visitation aborted, demonstrating the need for active transfer of pollen between staminate and pistillate flowers. Bumble bee-visited flowers consistently had lower abortion rates and higher seed sets in the cucumber and watermelon studies than did honey bee-visited flowers when compared at the same bee visitation level. Only slight differences in fruit abortion rates were detected between bee types in the watermelon study. However, abortion rates for bumble bee-visited flowers were consistently less than those for honey bee-visited flowers when compared at equal bee visitation levels, with one exception at the 12 bee visit level. As the number of honey bee colonies continues to decline due to parasitic mite pests and based on the data obtained, we conclude that bumble bees have a great potential to serve as a supplemental pollinator for cucumbers, watermelons, and possibly other vine crops, when honey bees available for rental are in limited supply.

Most crops that require insect pollination to set marketable produce rely on honey bees, *Apis mellifera* L. Without these diligent pollinators, yields of many fruit and vegetables would be well below the levels required to meet the demands of an ever increasing human population, and production of bee-pollinated crops would be significantly less profitable for growers. Honey bees have certain attributes which make them dependable and efficient pollinators: they have large population sizes (up to 60,000 individuals per colony), exist on a perennial basis, can be managed using established practices, and can be transported over considerable distances to selected locations.

Over two million honey bee colonies are rented for crop pollination in the United States every year, adding an estimated \$1.6 to \$9.3 billion to the value of those crops that require insect pollination to set quality fruit (Robinson et al., 1989; Southwick and Southwick, 1992). McGregor (1976) lists >130 crops that benefit from or depend on insect pollination, the vast majority of which rely on honey bee colonies for the large numbers of pollinators necessary to adequately pollinate crop plants at typical field densities. For example,