Growth of *Pistacia chinensis* in a Red Cedar–Amended Substrate©

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INTRODUCTION

Pine bark (PB) continues to be the industry standard material for container grown plant production of woody ornamentals throughout the Southeast U.S.A. (Yeager, 2007). However, because of the closing and relocation of timber mills, as well as increased use of PB as a fuel source for power mills, PB has become less available and more costly for use in the nursery industry (Laiche and Nash, 1986; Lu et al., 2006). This has lead to a demand for alternative substrates to supplement PB particularly in regions that lack indigenous pine species (such as the Great Plains). Abundant tree species in the Great Plains could potentially be used in a similar manner to Clean Chip Residual (CCR) and WholeTree (WT) which have been used in the Southeast U.S.A. Eastern red cedar (*Juniperus virginiana*) grows in most areas of the Great Plains. Once held back by grazing and wild fires from fully entering the grasslands, community development and farming have reduced these natural control measures. Additionally, the use eastern red cedar as windbreaks, erosion control, and wildlife cover since the 1960s has increased the seed population (Ganguli et al., 2008; Ownesby et al., 1973).

Movement of eastern red cedar into the Great Plains can impact the environment by affecting soil moisture, blocking incoming solar radiation, decreasing soil temperature, and altering litter dynamics by increasing litter size and slowing decomposition creating a mechanical barrier that prevents germination. Even isolated trees can have a negative effect on species composition well beyond its canopy diameter affecting stem density, species richness, forb cover, and grass cover. As a tree becomes older and larger the understory environment becomes unfavorable for most herbaceous plants and rapid recovery to the original species composition (prairie) seems unlikely the longer a single tree is in place. Nonetheless tree stands full of eastern red cedar exist across the Great Plains (Linneman and Palmer, 2006; Gehring and Bragg, 1992). In addition to decreasing species diversity, eastern red cedar increases livestock handling costs and decreases forage area (Ortmann et al., 1998). In Oklahoma an estimated 762 acres of land are lost to eastern red cedar infestation per day (Drake and Todd, 2002).

Utilization of eastern red cedar chips as a component of nursery potting substrates could alleviate PB demand in the Great Plains with a sustainable, local resource while providing economic incentive to decrease the eastern red cedar population and its effect on the Great Plains ecosystem and economy. Previous work has demonstrated that red cedar may be an acceptable substrate for production of some woody species (Griffin, 2009). The purpose of this investigation was to determine if red cedar could act as a substrate or PB extender for containerized nursery crop production of ornamental species.

MATERIALS AND METHODS

Eastern red cedar chips were obtained from Queal Enterprises (Pratt, Kansas). Whole trees were harvested from Barber County, Kansas, and aged for 6 months. Trees were then processed into chips using a horizontal woodgrinder (Rotochoper, St. Martin, Minnesota). Further processing occurred through a hammermill (Model 5–2 0–4 WW Grinder Inc., Wichita, Kansas) to pass a 3/4 inch screen at the John C. Pair Horticultural Research Center (Haysville, Kansas). Red cedar was then used to create six substrates containing 0%, 5%, 10%, 20%, 40%, or 80%, red cedar (by vol.). Sand (20% by volume) was incorporated into each substrate and the remaining volume contained PB. Each substrate treatment was pre-plant incorporated with 1.5 lbs/yd^3 of Micromax (The Scotts Company, Marysville, Ohio) and either a low (7.5 lbs/yd^3) or high (15 lbs/yd^3) rate of controlled-release fertilizer (Osmocote 19-6-12; 12 to 14-month release; The Scotts Company, Marysville, Ohio) resulting in 12 treatments on 19 and 20 May 2009. Chinese pistache (*Pistacia chinensis*) seeds were collected at the Haysville station, germinated in Spring 2008, and grown in 2-in. by 2-in. by 6-in. bottomless bands in a PB and sand (8 : 1, v/v) mix with controlled-release fertilizer (Osmocote Plus 15-9-12, The Scotts Company, Marysville, Ohio) incorporated at the high label rate (12 lbs/yd^3). Seedlings were overwintered in an unheated polyhouse. On 20 May 2009 1-year-old Chinese pistache seedlings were planted into 3-gal. containers (Olympian Heavy Weight-Classic 1200, Marysville, Ohio) containing the treatment substrates and placed on a gravel production pad where they received 1 inch of irrigation water daily via overhead sprinklers. The experiment was terminated on 9 Sept. 2009, 113 days after planting (DAP). The experimental design was a randomized complete block with a factorial arrangement of treatments. There were six substrate blends and two fertilizer rates. The experiment was replicated eight times. Substrate physical properties were determined using North Carolina State University porometers (Raleigh, North Carolina) which measured substrate air space (AS), water holding capacity (WHC), substrate bulk density (BD), and total porosity (TP) (Fonteno and Bilderback, 1993). Data collected included pH and electrical conductivity (EC) using the PourThru technique and leaf greenness as measured with a SPAD meter at 15, 29, 43, 57, 71, 85, 99, and 113 days after planting (Wright, 1986). Shoot dry weight (SDW) and root dry weight (RDW) were recorded at the conclusion of the study (113 DAP) by drying in a forced air oven at 160 °F for 7 days. Tree caliper was measured at termination. Data was analyzed using SAS (Version 9.1 SAS Institute Inc. Cary, North Carolina).

RESULTS

Substrate pH of the fertilizer treatments did not differ but the differences between red cedar content was significant. Water pH used for irrigation ranged from 7.46 to 7.96 with an average of 7.61. Substrate pH of 0% red cedar increased by 27% to 7.20 from 15 DAP to 113 DAP while pH of 5% red cedar increased by 25% to 6.95 at 113

DAP. Substrate pH of 10% red cedar increased by 28% to 7.01 at 113 DAP and the pH of 20% red cedar increased by 23% to 7.18 at 113 DAP. Substrate pH for 40% red cedar increased less than other treatments, 7% to 7.28 at 113 DAP. Substrate pH of treatments containing 80% red cedar decreased by 3% to 7.48 at 113 DAP. The high pH of substrates containing larger amounts of red cedar changed less over time most likely due to having a higher starting pH with red cedar alone having a pH of 6.60. Both fertilizer level and red cedar content was significant for EC. Low fertilizer treatments with 0% red cedar decreased by 51% to 0.59 $\mu S \cdot cm^{-1}$ at 113 DAP and 5% red cedar decreased by 47% to 0.60 $\mu S \cdot cm^{-1}$ at 113 DAP. Substrates with 10% red cedar decreased EC by 52% to 0.61 $\mu S \cdot cm^{-1}$ at 113 DAP while 20% red cedar decreased EC by 51% to 0.66 $\mu S \cdot cm^{-1}$ at 113 DAP. In containers with 40% red cedar EC decreased 17% to 0.75 $\mu S \cdot cm^{-1}$ at 113 DAP while 80% red cedar decreased EC by 8% to 1.04 $\mu S \cdot cm^{-1}$ at 113 DAP. High fertilizer rate with 0% red cedar decreased EC by 63% to 0.72 $\mu S \cdot cm^{-1}$ at 113 DAP and 5% red cedar decreased by 53% to 0.87 $\mu S \cdot cm^{-1}$ at 113 DAP. Substrates with 10% red cedar decreased by 46% to 0.86 $\mu S \cdot cm^{-1}$ at 113 DAP while 20% decreased by 42% to 0.77 $\mu S \cdot cm^{-1}$ at 113 DAP. In containers with 40% red cedar EC decreased by 34% to 0.81 $\mu S \cdot cm^{-1}$ at 113 DAP while 80% red cedar decreased by 51% to 0.77 µS·cm at 113 DAP. Water EC ranged from 0.86 $\mu S \cdot cm^{-1}$ to 0.94 µS·cm with an average of 0.91 $\mu S \cdot cm^{-1}$ (data not shown).

Plants exhibited no differences in height based on fertilization at 113 days after planting and there were no significant differences between red cedar content except 80% red cedar, which had less growth (115 cm for 0% to 40% red cedar; 95 cm for 80% red cedar) (Table 1). Fertilizer had a significant effect on caliper with the higher rate producing larger caliper trees (1.61 cm low, 1.72 cm high). Within the low fertilizer treatment there were no significant differences in caliper between red cedar content. The high fertilizer treatment, however, had slightly more variability between treatments with 0% and 20% red cedar having thicker trunks and 80% red cedar having the smallest trunk size while 0%, 5%, and 40% red cedar were similar. Fertilizer level also affected shoot dry weight with the low fertilizer level having similar shoot growth in 0% to 20% red cedar and 40% to 80% red cedar having less growth. The high fertilizer shoot dry weight had had similar shoot growth from 0% to 40% red cedar with 80% red cedar being smaller than the others. Root dry weight did not differ between fertilizer levels. However red cedar content did influence root dry weight with 0% to 10% red cedar being similar and 80% red cedar being the lowest with 20% and 40% red cedar similar to both levels (Table 1). Leaf greenness was measured on four new fully expanded leaves every 2 weeks. Leaf greenness was significantly different between fertilizer levels at 29 and 43 DAP and within those two treatment dates leaf greenness varied greatly between red cedar treatments. However, at 57 DAP through the end of the study neither fertilizer level nor red cedar content had a significant effect on leaf greenness (data not shown).

Substrate physical properties for container capacity and total porosity remained within recommended levels with the exception of the container capacity of 80% red cedar container (39.3%) which fell slightly below the recommended range of 45% to 65%. Two red cedar treatments fell below recommended ranges for air space as well (5% and 10% red cedar) with, respectively, 9.1% and 8.2% (recommended air space: 10% to 30%) (Table 2) (Yeager, 2007).

Table 1. Main effects of pine-bark- and *Juniperus virginiana*-based substrates and fertilizer treatment on the growth of *Pistacia chinensis* 113 days after planting.

	Plant height (cm)[z]	Caliper (mm)[y]		Shoot dry weight (g)[x]		Root dry weight (g)[w]
Substrate[v]		Low[u]	high[u]	Low	High	
80% PB: 0% red cedar	109.78 a[t]	1.60 a[t]	1.69 ab[t]	94.74 a[t]	114.91 ab[t]	54.56 a[t]
75% PB: 5% red cedar	115.41 a	1.70 a	1.73 ab	94.86 a	122.96 ab	68.76 a
70% PB: 10% red cedar	120.03 a	1.70 a	1.88 a	113.38 a	138.66 a	64.32 a
60% PB: 20% red cedar	116.75 a	1.57 a	1.79 a	95.64 a	129.13 a	56.07 ab
40% PB: 40% red cedar	113.16 a	1.57 a	1.75 ab	74.35 b	116.63 ab	51.36 ab
80% red cedar	94.99 b	1.53 a	1.51 b	57.40 b	79.18 b	34.77 b

[z]Plants were measured from the top of the substrate to the apical meristem (1 cm = 0.397 in.).

[y]Plants were measure six inches from the top of the substrate.

[x]Shoots were harvested at the container surface and oven dried at 70 °C for 48 h (1 g = 0.0035 oz.).

[w]Roots were washed of substrate and oven dried at 70 °C for 48 h (1 g = 0.0035 oz.).

[v]Substrate treatments were: PB = pine bark, red cedar = *Juniperus virginiana* chips (1 in. = 2.54 cm). Substrates mixed by volume basis with each treatment containing 20% sand.

[u]Substrates were pre-plant incorporated with either a low or high rate of controlled release fertilizer Osmocote (The Scotts Company, Marysville, Ohio; 19-6-12; 12 to 14 month release) consisting of either a low rate (7.5 lbs/yd3) or a high rate (15 lbs/yd3).

[t]Means within column followed by the same letter are not significantly different based on Waller-Duncan k ratio t tests ($\alpha = 0.05$, n = 3).

CONCLUSION

Plants grown in substrates containing 0% to 40% red cedar had similar growth while plants grown in 80% red cedar consistently (with the exception of caliper on the low fertilizer treatment) had less growth. This decrease in plant growth may be due to the physical properties in the 80% red cedar treatments. Substrates containing 80% red cedar had more air space and a lower than recommended container capacity which resulted in less available water than plants grown in other treatments. Eastern red cedar can be used to supplement but not replace existing PB supplies though a 100% red cedar substrate may be viable with further particle size manipulation (chipping and processing) to increase available water. Additionally, Chinese pistache is an adaptable plant suited to growing in substrates with high pH. Other ornamental crops could exhibit more variability of responses depending on their sensitivity to pH. However, savings on substrate costs by using eastern red cedar to grow pH-adaptable species could make up for crops that must be grown in a more acidic substrate. This data is encouraging for nursery growers in the Great Plains, as they will have more options for affordable substrates for container-grown plants in the future.

Table 2. Physical properties of pine bark- and *Juniperus virginiana*-based substrates.

Substrates[z]	Air space[y]	Container capacity[x]	Total porosity[w]	Bulk density (g·cm^{-3})
	(% Vol)			
80% PB: 0% red cedar	12.6 c[v]	63.0 b[v]	75.5 a[v]	0.51 bc[v]
75% PB: 5% red cedar	9.1 cd	66.5 a	75.6 a	0.50 c
70% PB: 10% red cedar	8.2 d	62.0 b	70.2 b	0.52 b
60% PB: 20% red cedar	10.4 cd	63.9 ab	74.3 a	0.51 bc
40% PB: 40% red cedar	20.8 b	55.2 c	75.9 a	0.51 bc
0% PB: 80% red cedar	29.9 a	39.3 d	69.1 b	0.58 a

[z]Treatments were: PB = pine bark, red cedar = *Juniperus virginiana* chips. Substrates mixed on by volume basis with each treatment containing 20% sand.

[y]Recommended air space: 10 to 30%.

[x]Recommended container capacity 45 to 65%.

[w]Recommended total porosity 50 to 85%.

[v]Means within column followed by the same letter are not significantly different based on Waller-Duncan k ratio t tests ($\alpha = 0.05$, n = 3).

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