Tree-Based Mulches and their Leachate Suppress Weed Seed Emergence[1]

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Abstract

The objectives of this research were to compare the effects of eastern redcedar (bark and wood), hardwood (bark and wood), pine bark nugget (bark), pine (bark and wood), eucalyptus (bark and wood), cypress (bark and wood), and red-dyed (bark and wood) mulches on emergence of large crabgrass, johnsongrass, common lambsquarter, and redroot pigweed and to determine the possible chemical effects of these mulches by treating seeds with mulch leachate before and after planting. In the first experiment, seeds were planted in pots and one of each mulch type was applied directly above seeds. In the second study the seeds were pre-soaked and watered with mulch leachate. Although interactions between mulch type and weed species occurred, mulch reduced weed emergence by an average of 79% compared to non-mulched pots with eucalyptus having the least effect of the mulches (average 50% reduction). Leachate treatments had less of an effect than mulch, but reduced weed emergence by 16% averaged across all treatments. Red-dyed mulch leachate lowered weed emergence by 41%, more than all other mulch leachate, while eastern redcedar leachate reduced emergence by 23%. Overall, the wood mulch treatments had beneficial effects of reduced weed emergence compared to not using mulch and the response was dominated by physical rather than chemical influences.

Index words: allelopathy, emergence, weed seedling, leachate, wood mulch.

Species used in this study: large crabgrass (*Digitaria sanquinalis* L.), johnsongrass (*Sorghum halepense* L.), common lambsquarter (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.).

Significance to the Nursery Industry

Tree-based mulches are a standard landscaping application. One of the benefits tree-based mulches provide is to suppress weed abundance. This research compared the benefits of commonly used tree-based mulches on weed seed emergence and determined the potential chemical effects of mulch leachate. We found that all seven of the tested mulches decreased weed emergence but that eucalyptus mulch had the least effect, while all other mulches had similar effects. The chemical effects of mulch leachate on weed emergence were relatively minor with only two mulch types, red-dyed and eastern redcedar, having any effect. We recommend application of tree-based mulches to reduce weeds. While some mulch types might have a small chemical effect on weeds, the physical effects appear to be most important.

Introduction

Tree-based mulches such as wood chips and shredded bark are commonly used in landscaping and horticultural applications and represent a large economic market. In 2006, Taylor (17) predicted that the demand for bagged mulch could increase by 5.5% per year, approximately doubling annual sales from around 550 million dollars to 915 million dollars within a decade. Many types of tree-based mulches are commercially available and several such as cypress (*Taxodium distichum* (L.) Rich.), eucalyptus (*Eucalyptus* sp.) and eastern redcedar (*Juniperus virginiana* L.) are marketed as containing chemical compounds that suppress weed seed emergence. There is interest in finding alternative mulches to replace the potential nonsustainable harvest of species such as cypress as well as woody residues from other industries that are no longer available due to their use as biofuels (11). One mulch of particular interest is eastern redcedar which is harvested to restore function and value of grassland ecosystems in the southern Great Plains and which is reported to be insect resistant (2, 12, 13, 16, 18).

One benefit of mulches is to reduce competition from weeds (e.g., 1, 4, 6, 10). Mulch serves as a barrier that suppresses emergence of weeds. Mulch, like the accumulation of organic litter, also affects seed germination and establishment by altering light, temperature, and soil moisture as well as through possible release of phytotoxins (8). The objectives of this research were to compare the effects eastern redcedar (*Juniperus virginiana* L.), hardwood (mix of *Acer* sp. and *Quercus* sp.), pine bark nugget (*Pinus* sp.) Southern yellow pine (SYP), pine (*Pinus* sp.) SYP, eucalyptus (*Eucalyptus grandis* W. Hill ex Maiden), cypress (*Taxodium distichum* (L.) Rich.) and red-dyed (mix of *Acer* sp. and *Populus* sp.), mulches on the emergence of large crabgrass, johnsongrass, common lambsquarter, redroot pigweed and to determine the possibility of chemical or allelopathic effects of mulches by pre-soaking and watering weed seeds with mulch leachate.

Materials and Methods

Mulch study. The study was conducted in a shadehouse at The Botanic Garden at Oklahoma State University in Stillwater, Oklahoma (36°07'N, 97°06'W). Forty 13 liter pots with drainage holes were arranged in five rows of eight pots.

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Each pot had a top diameter of 28.9 cm and a surface area of 656 cm^2 at the top of the pot. Artificial substrate[1] was used in the study to avoid using soil contaminated with outside seeds. Ingredients in the substrate included the following: hypnum peat, forest products (compost), sand, perlite, and pine bark. Substrate was placed to a depth of 10 cm in each pot. Within each pot, the surface was divided into six equal wedges using wooden dividers. The eight pots within each row were randomly assigned one of seven mulch types or a non-mulched control. Mulch types were eastern redcedar [shredded wood and bark (redcedar mulch, Eastern Redcedar Mulch LLC., Stillwater, OK)], pine bark nugget (bark), pine (ground bark and wood), cypress (shredded bark and wood), hardwood (shredded bark and wood), red-dyed mulch [shredded bark and wood (Green Country Soil, Inc., Miami, OK)] and eucalyptus [shredded bark and wood (Eucalyptus mulch, AAction Mulch Inc., Fort Myers, FL)].

Before adding mulch, pre-soaked seed (tap water for 15 hrs) of six species were placed on the substrate surface with one species per surface wedge. The weed species and approximate number of seed placed (based on three counted samples) were large crabgrass 452.3 ± SE 5.9, johnsongrass 127.3 ± SE 2.9, common lambsquarter 774.7 ± SE 24.4, and redroot pigweed 1080 ± SE 41.4. Once seeds were placed on the substrate, they were covered with 1.0 to 1.5 cm of additional substrate. Approximately 3.8 cm of mulch was placed over the substrate with one mulch treatment per pot. Pots were placed in a shadehouse (59% light transmittance) and watered by an automated sprinkler system once per day for 40 minutes (1.5 cm per pot per day). The study was conducted from May 26 through June 21, 2010, and repeated from August 31 through September 20, 2010.

Seedling emergence was monitored every three days until emergence ceased, i.e., for 26 days for the first experimental period and 20 days for the second experimental period. Each emerged seedling was counted and the entire seedling was removed. The experimental design was a split-plot with mulch treatment ($n = 10$) as the whole plot factor and weed species ($n = 80$) as the sub-plot factor. Because the weed species × mulch type interaction was significant, each weed species also was analyzed separately for mulch effects. When the effects of mulch were significant ($P < 0.05$), a Duncan's multiple range test was conducted to determine differences among mulch types.

Leachate study. This study was conducted in the same location as the mulch study and with a similar design. However, instead of testing the overall effects of mulch, the effect of leachate from the mulch on seedling emergence was tested. Leachate was created from each mulch type by placing 5 liters of each of the different mulches in different 22 liter buckets about ¾ full of tap water. The mulch was soaked for two days. New leachate was made every two days for the duration of the study.

Similar numbers of seeds were used as described above for the mulch study. Seeds were pre-soaked in the appropriate leachate the night before planting (approximately 15 hrs). After soaking, pots were planted as described above with the exception that no mulch was applied. Seeds were watered every day with approximately 440 ml (0.67 cm) per pot of the appropriate mulch leachate treatment. Control pots were watered with approximately the same amount of tap water (440 ml or 0.67 cm).

The experiment was conducted twice with five replications (blocks) each time. The first study was conducted from August 19 through August 25, 2010, and the second from September 24 through September 30, 2010. Seed emergence was monitored daily. The studies were terminated when no more seed emergence occurred, i.e., at seven days after planting each study. The leachate study had a shorter experiment time then the mulch study because of faster emergence rates likely due to the lack of mulch. The experimental design was a split-plot similar to that described above. When the effects of leachate were significant ($P < 0.05$), Duncan's multiple range test was conducted to determine differences among leachate types.

Results and Discussion

Compared to the non-mulched control, mulch decreased emergence by 70% for large crabgrass, 47% for johnsongrass, 84% for common lambsquarter, and 82% for redroot pigweed. However, the effects of mulch type differed and varied among weed species (weed species × mulch type; $P < 0.0001$). The difference in the size of each weed species seeds may have caused such variation among weed species. Common lambsquarter and redroot pigweed are the smaller seeds used in the study, compared to johnsongrass and large crabgrass. The larger seeds likely provided more resources for recent germinants to grow through mulch compared to smaller seeds, producing larger and stronger seedlings or sprouts capable or emerging through the mulch resulting in variation of their response (8). When weed species were analyzed separately, the effects of mulch on emergence were significant for all four species ($P < 0.0001$) with emergence in the non-mulched control treatment greater than in the all mulch treatments with the exception of johnsongrass where emergence of the non-mulched control was similar to eucalyptus (Fig. 1). Mulch type did not affect crabgrass emergence. For johnsongrass, the seeds under eucalyptus mulch had similar emergence to those in the non-mulched control and greater emergence than those in pine, pine nugget, and redcedar mulch treatments. Common lambsquarter and redroot pigweed emergence was greater under eucalyptus than the other mulches.

Lower effectiveness of eucalyptus mulch at decreasing seed emergence may have been related to its finer particle size and lower bulk density, i.e., weight per volume Eucalyptus had the smallest particle size with 87% of the particles (measured by weight) passing through a 1.3 ×1.3 cm sieve. In comparison, 84% of pine, 73% of hardwood and red-dyed mulch, 67% of cypress, 66% of redcedar, and 9% of pine bark nugget particles passed through a 1.3 × 1.3 cm sieve. Oven-dried bulk density of a mulch sample for eucalyptus and cypress was 0.07 $g \cdot cm^{-3}$ compared to 0.08 $g \cdot cm^{-3}$ for pine bark nugget and redcedar, 0.09 $g \cdot cm^{-3}$ for red-dyed mulch, 0.11 $g \cdot cm^{-3}$ for pine, and 0.15 $g \cdot cm^{-3}$ for hardwood. The difference in bulk density of the hardwood and red-dyed mulch is likely due to a difference in species composition. The hardwood and red-dyed mulch is likely used were commercially available and combine a mixture of various hardwood species and can be different at certain times of the year and can vary by manufacturer. The hardwood mulch we used in this study consisted of a mixture of oak (*Quercus* spp.) and maple (*Acer* spp.) and the red-dyed mulch consisted of poplar (*Populus* spp.) and maple. Duryea et al. (7) also noted that eucalyptus and cypress mulch had low bulk density. The greater weed

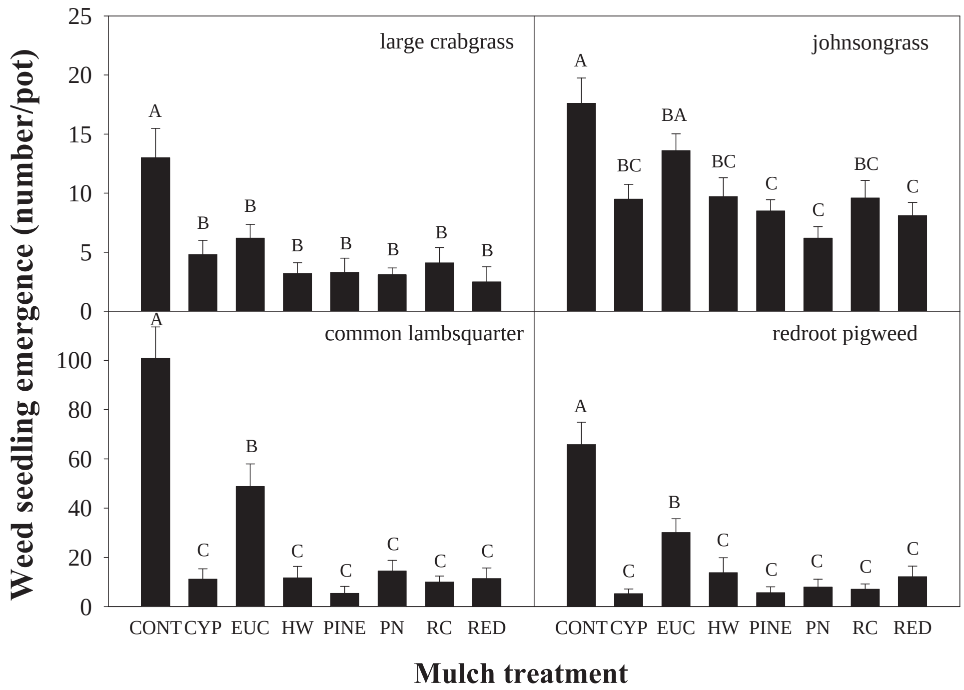

Fig. 1. Mean weed seedling emergence (± S.E.) by mulch treatment for large crabgrass, johnsongrass, common lambsquarter, and redroot pigweed. Means with the same letter are not significantly different (Duncan's *post hoc* multiple range test, α = 0.05). CONT = control, CYP = cypress mulch, EUC = eucalyptus mulch, HW = hardwood mulch, PINE = pine mulch, PN = pine bark nugget mulch, RC = redcedar mulch, RED = red-dyed mulch (n = 10).

suppression of cypress than eucalyptus in our study might indicate that particle size is more important than bulk density (larger particle size for cypress). Similar results were found by Billeaud and Zajicek (3), who noted that coarser mulch, i.e., larger particle size, had the greatest negative effect on weed growth. Related to the bulk density and its relationship to mulch mass, weed growth also is reduced with increased mulch depth (9).

Leachate affected emergence less than mulch. Compared to the non-mulched control, leachate, decreased weed emergence by 23% for large crabgrass, 16% for johnsongrass, 16% for common lambsquarter, and 16% for redroot pigweed when averaged over all mulch treatments. Type of mulch leachate affected seedling emergence which differed depending on weed species (leachate × species interaction; $P < 0.0001$). In general, emergence was reduced most by red-dyed and redcedar mulch leachate. Large crabgrass emergence was affected by leachate type ($P = 0.006$) and was lower with redcedar and red-dyed mulch leachate than with the control, eucalyptus, pine, and pine bark nugget leachate treatments (Fig. 2). Johnsongrass emergence was greater with eucalyptus leachate than all other treatments except the control and the redcedar leachate treatment (leachate effect; $P = 0.07$). Mulch leachate affected common lambsquarter emergence ($P = 0.0001$) which was lower with red-dyed mulch leachate than all other leachate treatments and lower with redcedar leachate than the control. Redroot pigweed emergence was affected by leachate ($P = 0.0002$) and was lower with red-dyed mulch leachate than any other leachate except redcedar leachate. Lower emergence occurred with redcedar leachate than with the eucalyptus leachate. The pH of the leachates were 4.7 for pine bark nugget, 5.5 for eucalyptus, 5.7 for pine, 6.4 for redcedar, 6.5 for cypress, 6.5 for red-dyed mulch, 6.6 for hardwood, and 8.0 for tap water, suggesting that pH was not the cause of reduced emergence with red dyed or redcedar mulch leachate.

Decreased emergence in response to the red-dyed leachate treatments was likely caused by chemicals used in the dye. The dye used to color the mulch included a water base formulation of iron oxide pigments, resins, suspension aids and an antimicrobial agent (5). The reduction in seedling emergence in response to redcedar leachate could be related to the cedar oil and other secondary compounds prevalent in wood of this species (15). Although the greatest seedling emergence occurred with eucalyptus mulch, eucalyptus leachate did not stimulate emergence compared to the control. This suggests that the lesser effect of eucalyptus mulch on emergence compared to other mulches was probably physical (such as low bulk density) rather than chemical.

Other studies also have shown that mulch can have chemical effects on seed germination and emergence. Duryea et al. (7) demonstrated that water extracts from cypress, eucalyptus, melaleuca, pine bark, pine straw, and mulch containing utility prunings from oaks, cherry, and small amounts of cedar and pine mulches inhibited germination of lettuce (*Lactuca sativa* L.) seeds. Aleppo pine (*Pinus helepensis* Mill.) needles reduced turfgrass growth (14). Similarly, leachates of organic litters commonly inhibit germination and emergence of several species of seeds (8).

The chemical effects of the mulches on seedling emergence were small compared to the overall effects of mulching. Red-dyed and redcedar mulch, whose leachates reduced emergence, resulted in similar emergence rates compared to other mulches (except eucalyptus), emphasizing the importance of physical effects rather than chemical effects. The leachate treatment in this study probably resulted in greater

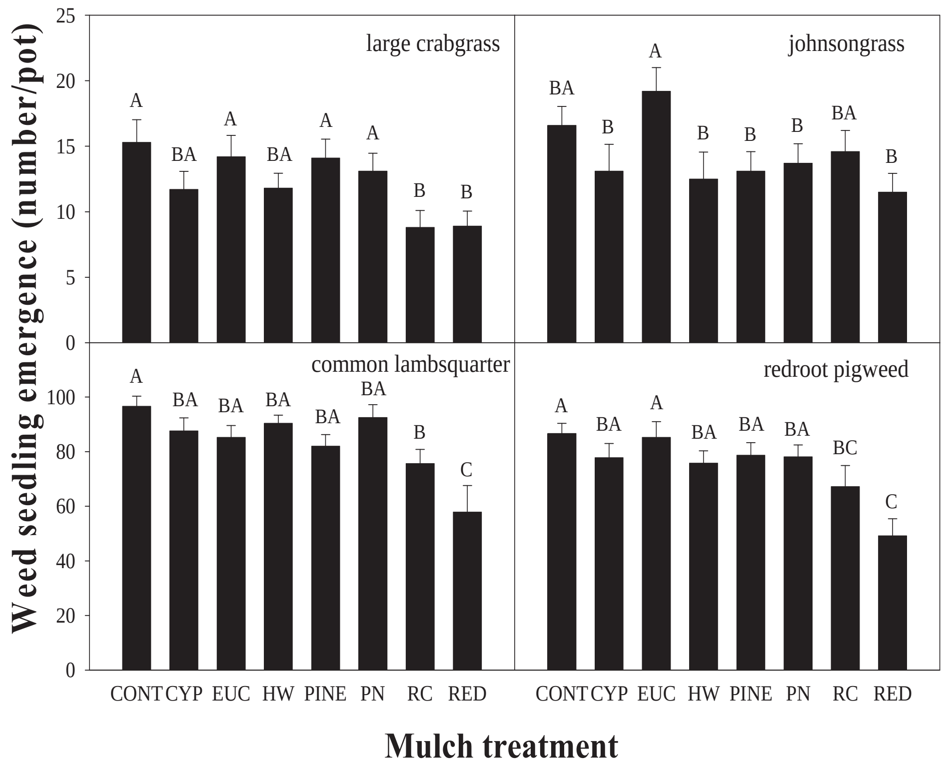

Fig. 2. Mean weed seedling emergence (± S.E.) by mulch leachate type for large crabgrass, johnsongrass, common lambsquarter, and redroot pigweed. Means with the same letter are not significantly different (Duncan's *post hoc* multiple range test, α = 0.05). CONT = control, CYP = cypress leachate, EUC = eucalyptus leachate, HW = hardwood leachate, PINE = pine leachate, PN = pine bark nugget leachate, RC = redcedcar leachate, RED = red-dyed leachate (n = 10).

exposure of seedlings to chemicals than would be expected from a 5 to10 cm covering of mulch. However, decomposition of mulch over time might add chemical compounds to the soil that could further influence seed germination.

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