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Allelopathy of Bermudagrass, Tall Fescue, Redroot Pigweed, and Cutleaf Evening Primrose on Pecan

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Abstract. **Two studies were conducted to determine if selected grass and dicot species had an allelopathic interaction with pecan (*Carya illinoinensis* Wangenh. C. Koch). Leachate from pots with established grasses or dicots was used to irrigate container-grown pecan trees. Leachates from bermudagrass [*Cynodon dactylon* (L.) Pers.], tall fescue (*Festuca arundinacea* Shreb. cv. Kentucky 31), redroot pigweed (*Amaranthus retroflexus* L.), and cutleaf evening primrose (*Oenothera laciniata* Hill) reduced leaf area and leaf dry weight about 20% compared to the controls. Bermudagrass, tall fescue, and primrose leachate decreased pecan root weight 17%, trunk weight 22%, and total tree dry weight 19% compared to the control. In a second study, trees were 10% shorter than the control when irrigated with bermudagrass or pigweed leachate.**

Weed interference (competition + allelopathy) is detrimental to growth of young pecan trees (Foshee et al., 1995; Norton and Storey, 1970; Patterson and Goff, 1994; Patterson et al., 1990; Wolf and Smith, 1999). Weed interference can also dramatically reduce pecan yield (Foshee et al., 1997; Hunter, 1950). It has been generally assumed that the growth or yield reductions observed were primarily due to competition for water and nutrients; however, Wolf and Smith (1999) demonstrated that one weed growing in close proximity to a young pecan tree was sufficient to cause a substantial growth reduction with little effect on water or nutrient availability. Typical field studies cannot separate the effects of competition from allelopathy since they happen simultaneously. Artificial environments must be devised that remove any possibility of competition while allowing chemical exchange to take place.

Chemical inhibition of growth by one plant upon another has been demonstrated among several species (Rice, 1995). The compounds causing the growth inhibition are typically organic acids or phenolic compounds, but occasionally other compounds are identified.

We chose four species to test for their allelopathic interaction with pecan; tall fescue, bermudagrass, redroot pigweed, and cutleaf evening primrose. Both tall fescue and bermudagrass are commonly used ground covers in pecan orchards. They are resilient ground covers, withstanding orchard traffic and harvest operations, plus offering grazing opportunities for those that manage both cattle and pecans. Pigweed and primrose are weeds that are commonly seen in otherwise weed-free areas following herbicide treatment. Primrose germinates during the fall when residual herbicides are losing effectiveness, and primrose is more tolerant of the postemergent herbicides used in pecan orchards than most other weed species. Pigweed germinates throughout the summer, grows rapidly, and typically becomes a problem in the mid- and late-growing season as residual herbicides loose effectiveness.

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Materials and Methods

Expt. 1. Seedling pigweed ≈2 cm tall and bermudagrass rhizomes were planted in 15-cm-diameter × 23-cm-deep pots filled with calcined clay (Turface; AIM Corp., Buffalo Grove, Ill.) amended with 2 $kg \cdot m^{-3}$ dolomite. Containers without plants were filled with media at the same time and treated the same as those with plants. One-year-old container-grown dormant 'Giles' pecan seedlings were transplanted into 10-L pots using the media described above. All media was removed from the pecan roots before transplanting. Pecans, weeds and control pots were fertilized monthly with 20 g/pot Osmocote 14N–6.02P–11.7K (Grace-Sierra International, Milpitas, Calif.) and at 45-d intervals with soluble trace element mix applied at 60 $mg \cdot L^{-1}$ (S.T.E.M.; Peters Plant Products, Marysville, Ohio) until the solution drained through the pot. Plants were transplanted ≈2 weeks before the experiment was initiated.

Treatments were pecan trees irrigated with leachate from containers of pigweed, bermudagrass, or a control with no plant. Containers with pigweed, bermudagrass, or no plant were placed in funnels on an elevated bench. A flexible tube was connected to the funnel that directed water to the pecan tree below, similar to the apparatus described by Walters and Gilmore (1976), except fresh water was used for each irrigation rather than recirculating the water. All irrigation water applied to the pecan trees for the 4-month treatment period was from the elevated containers. Each treatment contained 10 single-tree replications in a randomized complete-block design. The experiment was conducted in a greenhouse with an average 33 °C day/18 °C night temperature and the day length was adjusted to 12 h with incandescent lights.

After 4 months, leaves were removed and area measured with a LI-COR area meter (LI-COR, Lincoln. Nebr.). Trunk diameter was measured 2.5 cm above the soil line, and seedling height was measured from the soil line to the terminal bud. Leaves and roots were dried at 70 °C until constant weight, then weighed. Data were analyzed by analysis of variance (ANOVA) and orthogonal contrasts were used to compare treatments.

Expt. 2. The second study determined the effects of leachate from bermudagrass, tall fescue, and cutleaf evening primrose on growth of seedling pecan trees. This study was conducted outside under 30% shade cloth. Fescue seed, bermudagrass rhizomes, and field-grown cutleaf evening primrose plants (rosette stage) were planted in 15-cm diameter × 23-cm deep pots filled with MetroMix 300 (Scotts Co., Marysville, Ohio) on 20 Apr. 2000. 'Giles' pecan seeds were germinated in water (Smith et al., 1997), then planted, one seed/pot, in 10 × 10 × 35-cm pots filled with the same media. Treatments were initiated on 30 May 2000, after the pecan seedlings had emerged. Plants were arranged to allow all leachate from the elevated containers to irrigate the pecan seedlings (described above). Each treatment contained 16 single-tree replications in a completely randomized design.

The pecan seedlings, grasses, dicots and control containers were fertilized monthly with 13 g/pot Osmocote 14N–6P–11.6K and at 45-d intervals with soluble trace element mix at 45 $mg \cdot L^{-1}$ until the solution drained through the pot. Zinc was applied as a foliar spray until run-off at 2-week intervals using 3.6 $g \cdot L^{-1}$ of 36% $ZnSO_4$.

The experiment was terminated on 1 Sept. 2000, and data were collected as described in Expt. 1. Data were analyzed by ANOVA with appropriate comparisons using orthogonal contrasts.

Results and Discussion

Expt. 1. Leachate from bermudagrass or pigweed suppressed tree height by 10%, and leaf area and leaf dry weight were reduced ≈20% compared to the control (Table 1). Trunk diameter and root dry weight were not affected by the treatments. There were no differences between leachate from pigweed or bermudagrass affecting the pecan growth parameters we measured.

Table 1. Expt. 1. The effect of leachate from bermudagrass or redroot pigweed on pecan tree growth.

Treatment	Tree height (cm)	Trunk diam (mm)	Leaf area (cm^2)	Leaf dry wt (g)	Root dry wt (g)
Control	40	6.7	1227	7.5	23.1
Bermudagrass	36	7.1	1009	6.0	27.0
Redroot pigweed	36	7.2	967	6.0	26.1
Contrasts					
Control vs. other	*	NS	*	*	NS
Bermudagrass vs. pigweed	NS	NS	NS	NS	NS

NS, *Nonsignificant or significant at 5%.

Table 2. Expt. 2. The effect of leachate from bermudagrass, tall fescue, and cutleaf evening primrose on pecan tree growth.

Treatment	Tree height (mm)	Trunk diam (mm)	Leaf area (cm^2)	Dry wt (g) Leaf	Trunk	Root	Total seedling
Control	242	6.8	1247	10.8	3.0	17.5	31.3
Bermudagrass	219	6.1	1110	9.1	2.4	15.0	26.4
Tall fescue	231	5.9	967	8.9	2.4	15.0	26.2
Cutleaf evening primrose	217	5.9	887	7.8	2.2	13.8	23.9
Contrasts							
Control vs. other	NS	**	*	*	*	*	*
Grass vs. dicot	NS	NS	NS	NS	NS	NS	NS
Bermudagrass vs. tall fescue	NS	NS	NS	NS	NS	NS	NS

NS, *, **Nonsignificant or significant at 5% and 1%, respectively.

In other studies, bermudagrass residue reduced dry weight of several annual vegetable and agronomic crops (Meissner et al. 1989). Bermudagrass residue also reduced radicle growth of barley (*Hordeum vulgare* L.), mustard (*Brassica juncea* L. Czern. and Coss.) and wheat (*Triticum aestivum* L.) (Friedman and Horowitz, 1970). Redroot pigweed water extracts reduced germination and growth of sorghum [*Sorghum bicolor* (L.) Moench] and cotton (*Gossypium hirsutum* L.) (Munger et al., 1984). In fact, cotton phytotoxicity occurred in pigweed treated soil at concentrations several fold less than the potential typical field concentrations. Palmer amaranth (*Amaranthus palmeri* S. Wats.), a member of the pigweed family, residues inhibited carrot (*Daucus carota* L.) growth by 49% and onion (*Allium cepa* L.) by 68% (Menges, 1987). His data indicated that phytotoxicity from field incorporated residues of Palmer amaranth persisted from 11 to 16 weeks.

Bermudagrass and pigweed compete for nutrients and water, and in some cases light, when growing with the cultivated crop. Growth reductions observed in young pecan trees with pigweed in close proximity to the tree were greater than could be explained by water and nutrient competition (Wolf and Smith, 1999). Bermudagrass also appears to reduce pecan growth more than can be explained by competition (Smith, unpublished data). This data and that of others suggests that a significant portion of the growth reduction observed under field conditions should be attributed to allelopathy.

Expt. 2. Leachate from bermudagrass, tall fescue, or cutleaf evening primrose reduced pecan trunk diameter 12%, leaf area 21%, leaf dry weight 20%, trunk dry weight 22%, root dry weight 17%, and total tree dry weight 19% compared to the control (Table 2). The two grass species did not affect the pecan growth parameters differently than cutleaf evening primrose. There were also no differences in pecan growth between leachates derived from bermudagrass or tall fescue.

Tall fescue interfering (grown in the same pot) with sweetgum (*Liquidambar styraciflura* L.) reduced plant dry weight 28% after 2 month and 95% after 4 months compared to a fescue free control (Walters and Gilmore, 1976). They also found that sweetgum dry weights were reduced 19% by leachate from living fescue after 30 d, and the leachate from dead fescue leaves reduced sweetgum dry weight by 60% during the same period. Similarly, leachates from red fescue (*Festuca rubra* L.) reduced growth of forsythia (*Forsythia intermedia* Spaeth.) (Fales and Wakefield, 1981). Tall fescue appears to be particularly competitive and have substantial chemical defenses that reduce growth of other plants. Field grown black walnuts (*Juglans nigra* L.) were 75% taller with 196% larger trunks after 2 years when grown in a mixed ground cover consisting of 70% forbs, 20% grasses, and 10% brambles and woody vegetation compared to a solid tall fescue sod (Todhunter and Beineke, 1979).

This data and that of others indicate that tall fescue is allelopathic and exceptionally competitive. Observations in young pecan orchards indicate that both bermudagrass and fescue allowed to grow next to the tree severely reduce growth, but fescue appears to be more detrimental than bermudagrass. However, studies that are in progress indicate that a sufficient weed-free zone can mitigate the negative effects of either species. This is the first report that we are aware of suggesting that cutleaf evening primrose is allelopathic. This conclusion supports earlier research suggesting that the pecan growth reductions observed when cutleaf evening primrose was present exceeded that attributable to competition (Wolf and Smith. 1999).

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