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Effects of sericea lespedeza residues on warm-season grasses

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Abstract

Soil incorporation of sericea lespedeza [*Lespedeza cuneata* (Dum. de Cours) G. Don.] residues has been reported to inhibit growth of some forage grasses. No information is available on the performance of sericea lespedeza grown in association with warm-season perennial grasses. Laboratory and greenhouse experiments were conducted to determine if sericea lespedeza residues affect seed germination and seedling growth of bermudagrass [*Cynodon dactylon* (L.) Pers.] and bahiagrass (*Paspalum notatum* Flugge); if any such response was cultivar dependent; and if the response was subject to manipulation by N fertilization. Sericea lespedeza residues inhibited bermudagrass and bahiagrass growth, but did not affect their seed germination and emergence. No differences among cultivars of bermudagrass and bahiagrass in response to sericea lespedeza residues were found in the greenhouse. Nevertheless, differences among bermudagrass cultivars for tolerance to sericea lespedeza residues were observed in the laboratory. The harmful effects of sericea lespedeza residues were small (17 and 16% reduction of dry weight for bermudagrass and bahiagrass, respectively) compared to the positive effects of N fertilization.

Key Words: allelopathy, legumes, plant litter, crop residues, *Lespedeza cuneata,* bermudagrass, *Cynodon dactylon,* bahiagrass, *Paspalum notatum*

Allelopathy refers to inhibitory or stimulatory reciprocal biochemical interactions among plants (Rice 1984). Incorporation of plant residues into the soil has occasionally reduced the yield of subsequent crops (Miller 1983, Menges 1987, Hicks et al. 1989). Luu et al. (1982) reported that water extracts of tall fescue (*Festuca arundinacea* Schreb.) herbage inhibited seed germination and seedling growth of birdsfoot trefoil (*Lotus corniculatus* L.). Rye (*Secale cereale* L.) residues inhibited seed germination and growth of several crops and weeds (Barnes and Putnam 1986). This reduction was associated with the release of phytotoxic compounds from the decomposed plant residues (Barnes and Putnam 1987, Barnes et al. 1987). In only a few instances has incorporation of plant residues been reported to stimulate crop growth. Kochhar et al. (1980) reported that the addition of tall fescue, ladino clover (*Trifolium repens* L.), or a mixture of tall fescue and clover debris to soil stimulated the growth of both clover and fescue.

Sericea lespedeza is a drought-tolerant, long-lived summer perennial legume that is well adapted to the infertile soils of the southeastern United States. It has been recommended for planting in association with some cool-season grasses, such as tall fescue and orchardgrass (*Dactylis glomerata* L.), to extend the productive season (Hoveland and Donnelly 1985). No information is available on the performance of sericea lespedeza grown in association with warm-season perennial grasses like bermudagrass and bahiagrass. Soil incorporation of sericea lespedeza residues depressed corn (*Zea mays* L.) growth (Langdale and Giddens 1967) and inhibited rye, ryegrass (*Lolium multiflorum* Lam.), and tall fescue growth (authors' unpublished data).

The objectives of this study were to determine if sericea lespedeza residues affect seed germination and seedling growth of bermudagrass and bahiagrass, if any such response was cultivar dependent, and if the response was subject to manipulation by nitrogen (N) fertilization.

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Materials and Methods

The effects of sericea lespedeza plant residues on seed germination, seedling development, and growth of bermudagrass and bahiagrass were examined in a series of laboratory and greenhouse experiments conducted at Auburn University, Ala. Three cultivars of bermudagrass ('CD-6.69', 'Arizona Common', and 'Guymon') and 2 of bahiagrass ('Pensacola' and 'Tifton 9') were included. Sericea lespedeza residues and soil samples were obtained from nurseries of high- or low-tannin genotypes planted in Tallassee, Ala., in 1986. The nurseries were located on a Bassfield loamy fine sand soil (coarse-loamy, siliceous, thermic, Typic Hapludults).

Laboratory Experiments

Two experiments were conducted for each species. In the first experiment, 20 seeds of the 3 cultivars of bermudagrass and the 2 cultivars of bahiagrass were germinated in water extracts from low or high tannin sericea lespedeza residues and distilled water (control). In the second experiment, 20 seeds of the same 5 cultivars were germinated in water extracts from topsoil (0 to 10 cm depth) and subsoil (10 to 30 cm depth) in which low- or high-tannin sericea lespedeza plants had grown. A distilled water treatment was also included.

Residue and soil extracts were obtained by mixing 50 g of residues or soil with 500 ml of distilled water in a blender for 10 min. The mixture was agitated for 2 hours, and filtered through Whatman No 1 filter paper. Electrolytical conductivity and pH were measured in each extract.

Percentage of seed germination and radicle and coleoptile lengths were recorded 7 days after placing the seeds between 2 Whatman No. 42 filter papers in petri dishes. The filter papers were moistened with 5 ml of extract or distilled water. The petri dishes were placed in an incubator in the dark at 35/20° C for 16/8 hours. Seeds were considered germinated if the radicle had protruded through the seed coat.

Data were analyzed by species as a factorial experiment in a split plot design where cultivars were the main plots and treatments were the subplots. In the first experiment treatments were tannin levels and, in the second, treatments were soil depths and tannin levels. There were 5 replications in each experiment.

Greenhouse Experiments

Ten seeds of each cultivar were planted in 1,890-cm^3 pots filled with potting soil (13% peatmoss, 57% fine sandy loam soil, and 30% sand). This potting soil contained 1.9% organic matter, 1.4 g kg^{-1} total N, and 72 g kg^{-1} P. Exchangeable cations were 3.8, 1.2, and 0.4 cmol kg^{-1} for Ca^{2+}, Mg^{2+}, and $K+$, respectively. Its pH was 5.6. The mean day and night temperatures during the time that the experiments were conducted were 30 and 18.3° C, respectively.

Treatments made up of a factorial combination of 3 rates of sericea lespedeza residues (0, 6, and 12 g pot^{-1}), 2 rates of N (0 and 30 mg kg^{-1} of soil) applied 4 times during the growth of the grasses, and 2 types of sericea residues (low and high tannin content) were applied to 3 or 2 cultivars, depending on the species. The rates of sericea lespedeza residues are representative of the amount found in fields with none, sericea lespedeza grown for hay (3,800 kg ha^{-1}), and sericea lespedeza grown for soil conservation or biomass production (7,600 kg ha^{-1}) for 4 years, cut once at the end of the summer. These rates were determined by sampling sericea lespedeza fields near Tallassee, Ala. Sericea lespedeza residues were thoroughly mixed with the soil. N was applied to each pot by diluting 135 mg of ammonium nitrate (33% N) in 50 ml of water at the beginning of the experiment and again every 15 days thereafter.

Seed emergence was recorded 7 days after sowing. Fifteen days after sowing, the plants were thinned to 5 plants per pot. Aboveground biomass of the plants was harvested 55 days after sowing, dried at 65° C for 72 hours, and weighed. This material was ground to pass through an 18-mesh sieve and total N was measured on a Leco N analyzer.

Within each species, data were analyzed as a factorial experiment in a split plot design where cultivars were the main plots and treatments (sericea lespedeza residue rates, N rates, and type of sericea lespedeza residue) were the subplots. There were 4 replications (pots). Comparison between treatment means were done according to the least significant test and single degree of freedom contrast (Gomez and Gomez 1984).

Results and Discussion

Laboratory Experiments

Germination of bermudagrass or bahiagrass was not affected by extracts of sericea lespedeza residue when compared to the control (Table 1). Extracts from low- and high-tannin residues reduced radicle length of bahiagrass 20 and 33%, respectively. Extracts from low-tannin residues had no effect on coleoptile length of either species. Extracts from high-tannin residues decreased coleoptile length of bermudagrass and bahiagrass 13 and 24%, respectively (Table 1). Similar effects of sericea lespedeza residues on rye, and tall fescue have been observed (authors' unpublished data).

Table 1. Effects of sericea lespedeza residue extracts on bermudagrass (BE) and bahiagrass (BA) seed germination and seedling growth, averaged across cultivars.

	Germination		Length		
			Radicle	Coleoptile	
Treatment	BE	BA	BA	BE	BA
	(%)		(cm)		
Control	65	58	1.5	2.4	2.1
Low tannin	63	54	1.2	2.2	2.0
High tannin	58	50	1.0	2.1	1.6
LSD (0.05)	ns	ns	0.2	0.2	0.3

A significant (P<0.01) cultivar-extract interaction for radicle length in bermudagrass suggested that allelopathy towards bermudagrass radicle elongation was cultivar dependent. Guymon radicle length was not affected by the extracts, while that of CD-6.69 was reduced 46% only by the high-tannin extract. Arizona Common radicle length was reduced by low- and high-tannin extracts to 41 and 49% of the control, respectively (data not shown).

Soil extracts had no effect on seed germination of bermudagrass or bahiagrass (data not shown). Radicle and coleoptile lengths of bahiagrass decreased when exposed to the soil extracts. Topsoil extracts reduced radicle and coleoptile lengths of bahiagrass more than subsoil extracts. Extracts from low-tannin areas reduced radicle length more than those from high-tannin areas. Coleoptile length was reduced more by high-tannin extracts than by low-tannin extracts (Table 2).

Table 2. Effects of sericea lespedeza soil extracts on bahiagrass early seedling growth, averaged across cultivars. Effects attributed to all extracts are averaged over depths and tannin levels.

Treatment	Radicle length	Coleoptile length
	(cm)	
Control	1.55	1.88
All extracts	1.15	1.63
Soil depth		
0–10 cm	1.07	1.49
10–30 cm	1.23	1.77
Tannin level		
Low	1.12	1.67
High	1.18	1.58

All comparisons within soil depths and tannin levels are significant (P = 0.05) according to analysis of variance.

A significant cultivar-soil extract interaction for radicle (P = 0.03) and coleoptile (P = 0.01) length of bermudagrass was detected. Radicle and coleoptile length of CD-6.69 were not affected by the soil extracts when compared to distilled water (data not shown). Guymon radicle length was reduced by soil extracts (control 1.13 cm vs average of all extracts 0.77 cm). Extracts from low-tannin areas reduced radicle length more than those from high-tannin area (0.71 vs 0.84 cm). Guymon coleoptile length was not affected by soil extracts.

Cultivar Arizona Common exhibited a complex response to soil extracts. A significant interaction between soil depth and tannin level was detected for radicle (P<0.01) and coleoptile (P<0.01) length (Table 3). Subsoil extracts from low-tannin areas reduced radicle length of Arizona Common more than extracts from high-tannin areas in this cultivar. Radicle length was also reduced by subsoil extracts from low-tannin areas more than by topsoil

Table 3. Effects of sericea lespedeza soil extracts on early seedling growth of bermudagrass cv. Arizona Common.

Treatment	Radicle length	Coleoptile length
	(cm)	
Subsoil		
Low	0.74	1.96
High	1.05	1.74
Topsoil		
Low	ns	1.13
High	ns	1.47
Low-tannins		
0–10 cm	1.08	1.13
10–30 cm	0.74	1.96
High-tannins		
0–10 cm	ns	1.47
10–30 cm	ns	1.74

All comparisons within soil depths and tannin levels are significant (P = 0.05) according to analysis of variance unless otherwise indicated.

extracts from the same areas. Subsoil extracts from high-tannin areas reduced coleoptile length of Arizona Common more than those from low-tannin areas, whereas topsoil extracts from high-tannin areas reduced coleoptile length less than those from low-tannin areas. Topsoil extracts from low- and high-tannin areas reduced coleoptile length of this cultivar more than subsoil extracts (Table 3).

The results from soil extracts indicate that soils from places where sericea lespedeza plants have grown for 4 years contain inhibitors of plant growth regardless of soil depth or tannin in the residues. This suggests that sericea lespedeza plants and their residues release phytotoxic compounds. Similar effects of sericea lespedeza residues were observed on cool-season grasses. These results further agree with Guenzi and McCalla (1966), who reported that compounds produced during crop residue and soil organic matter decomposition reduced the yield of several crop species. Also, living plants can release some substances that accumulate in the soil in amounts that are harmful to other species (Kil and Lee 1987, Dornbos et al. 1990).

The pH of residues and soil extracts ranged from 5.30 to 5.61 and from 5.25 to 6.32, respectively. Electrolytic conductivities of the residue and soil extracts ranged from 0.29 to 0.50 and 0.25 to 0.39 dS m^{-1}, respectively. No relationship was observed between pH or electrolytic conductivity and inhibition of seed germination or seedling growth. These findings are consistent with other reports (Yakle and Cruse 1984, Martin et al. 1990).

Greenhouse Experiments

Nitrogen rates, tannin levels, or increasing amounts of sericea lespedeza residues incorporated into the soil had no effect on emergence of either grass. Interactions among these factors were not significant (Table 4).

Table 4. Effects of sericea lespedeza residues with low or high tannin content and N fertilization on bermudagrass (BE) and bahiagrass (BA) seedling emergence and oven-dry standing crop, averaged across cultivars.

Treatment	Emergence		Dry weight	
	BE	BA	BE	BA
	(%)		(g pot^{-1})	
Nitrogen rate				
0 mg kg^{-1}	87	64	1.25	0.98
30 mg kg^{-1}	84	63	6.81	1.78
LSD (0.05)	ns	ns	0.26	0.15
Tannin level				
Low	86	65	4.01	1.37
High	86	62	4.05	1.40
LSD (0.05)	ns	ns	ns	ns
Residue rate				
0 g pot^{-1}	89	66	4.38	1.53
6 pot^{-1}	85	63	4.08	1.34
12 g pot^{-1}	84	62	3.64	1.28
LSD (0.05)	ns	ns	0.32	0.19

Effects of cultivars, N rates, and amounts of residues on aboveground biomass dry weight were significant. Nitrogen rates accounted for most of the variability. Nitrogen application increased aboveground biomass dry weight of bermudagrass and bahiagrass 445% and 82%, respectively (Table 4). Biomass dry weight of either species was not affected by the low amount of residues (6 g pot^{-1}) when compared to the control (0 g pot^{-1}). High amounts of residues (12 g pot^{-1}) reduced dry weight of bermudagrass and bahiagrass 17% and 16% compared to the control, respectively. Tannin level had no effect on plant growth (Table 4). Soybean residues had similar effects on wheat growth (Huber and Abney 1986).

Regardless of species, most interactions between cultivars, N rates, tannin levels, and residue rates were not significant for aboveground biomass dry weight. The interaction between cultivar and N rate was significant ($P<0.01$) in both species, but accounted for only a small portion of the variability.

In both species, effects of cultivar, N application, and amounts of residue on shoot N content were significant (Table 5). The effect of tannin level was also significant for bahiagrass shoot N content, but it accounted for only a small portion of the variability. Nitrogen rates accounted for most of the variability. Its application

Table 5. Effects of sericea lespedeza residues with low or high tannin content and N fertilization on N shoot content of bermudagrass (BE) and bahiagrass (BA), averaged across cultivars.

Treatment	Shoot-N	
	BE	BA
	(g kg^{-1})	
Nitrogen rate		
0 mg kg^{-1}	19.9	23.7
30 mg kg^{-1}	27.1	38.6
LSD (0.05)	0.7	1.0
Tannin level		
Low	23.2	30.1
High	23.8	32.1
LSD (0.05)	ns	1.0
Residue rate		
0 g pot^{-1}	27.9	34.7
6 g pot^{-1}	22.4	31.2
12 g pot^{-1}	20.2	27.6
LSD (0.05)	0.9	1.3

increased N shoot content 36% and 63% in bermudagrass and bahiagrass, respectively. Tannin level had no effect on bermudagrass shoot N content, but low-tannin residues reduced bahiagrass shoot N content 6%, when compared to the high-tannin residues (Table 5).

Sericea lespedeza residues incorporated in the soil reduced N shoot concentration in both species with higher amounts of residue reducing N content more than the low amount. When compared to the control, the reduction in N content caused by the low residue rate was 20% and 4% in bermudagrass and bahiagrass, respectively. The high residue rate reduced N content 28% and 21% in bermudagrass and bahiagrass, respectively (Table 5).

The interaction between N and residue rate was significant for N content in both species, indicating that N was used not only by the plants but also by the soil microorganisms for the decomposition of the sericea lespedeza residues. The interaction among bahiagrass cultivars, N rates, and tannin levels was also significant, but accounted for a very small part of the variability.

Sericea lespedeza residues inhibited bermudagrass and bahiagrass growth, but did not affect their seed germination and emergence. No differences among cultivars of bermudagrass and bahiagrass to sericea lespedeza residues were found in the greenhouse. Nevertheless, differences among bermudagrass cultivars were observed in laboratory experiments. The harmful effects of sericea lespedeza residues are small compared to the effect of N fertilization. Thus, N was the main factor limiting plant growth. Establishment of bermudagrass of bahiagrass in a sericea lespedeza field is not likely to be affected; however, N fertilization will be required to enhance grass growth which otherwise would be stunted.

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