Sericea lespedeza production on acid soils in Swaziland

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Abstract

An adapted perennial low-input forage legume is needed on the very acid soils of Swaziland to feed cattle during the long winter dry season. Serala and Interstate 76 (high-tannin) and AU Donnelly and AU Lotan (low-tannin) sericea lespedeza (*Lespedeza cuneata*) cultivars developed in the southeastern USA were planted in yield trials in the low, middle, and highveld of Swaziland at 150, 950 and 1500 m elevation, and harvested over a 4-year period. At the middleveld location, the effect of rhizobia inoculation of seed and N fertilization on all cultivars was also studied.

After the establishment year, dry forage yields over the next three years were high. Interstate 76 and AU Donnelly cultivars averaged 12 210 and 9830 kg/ha in the middleveld (soil pH 4.8) and 9390 and 8710 kg/ha in the highveld (soil pH 4). At the lowveld location (soil pH 8.0), forage yields were low and plants died after two years. Seed inoculation and N fertilization had no effect on forage yield. Forage N concentration averaged 2.8 g/kg at all locations. Sericea lespedeza offers excellent potential for hay production on the very acid soils of the middle and highveld of Swaziland.

Resumen

*Se necesita una leguminosa forrajera perenne de bajos insumos y adaptada a los suelos altamente ácidos de Swaziland para alimentar al ganado durante el invierno largo y seco. Los cultivares Serala e Interstate 76 (alto-tanino) y AU Donnelly y AU Lotan (bajo-tanino) sericea lespedeza (*Lespedeza cuneata*), desarrollados al sur-este de EEUU, fueron plantados en un experimento para evaluar su rendimiento en las planicies bajas, medianas y altas de Swaziland, a una altitud de 150, 950, y 1500 m, y fueron cosechados durante 4 años. El efecto de la inoculación de las semillas con rhizobium y la fertilización con nitrógeno (N) fue también estudiado con todos los cultivares en las planicies de elevación mediana.*

El rendimiento de forraje fue alto durante los tres años subsiguientes al año de establecimiento. Los cultivares Interstate 76 y AU Donnelly promediaron 12210 y 9830 kg/ha en las planicies medianas (pH del suelo 4.8) y 9390 y 8710 kg/ha en las planicies elevadas (pH del suelo 4.0). En las planicies bajas (pH del suelo 8.0), el rendimiento de forraje fue reducido y después de dos años las plantas murieron. La inoculación de la semilla y la fertilización con N no tuvieron efecto en el rendimiento de forraje. La concentración de N en el forraje fue en promedio 2.8 g/kg en todas las localidades. Sericea lespedeza ofrece un potencial excelente para la producción de heno en los suelos altamente ácidos de las planicies medianas y las planicies elevadas de Swaziland.

Introduction

Cattle in Swaziland and similar southern African countries are grazed on communal natural veld or grassland throughout the year. Forage supply is adequate during the summer rainy season but totally inadequate during the long winter dry season, resulting in severe cattle weight losses and low conception rates. Stored roughage is needed for supplemental feeding during the winter dry season. It should preferably be a legume that will persist and be productive on the extremely acid soils common to the region (Murdoch 1970). The high cost of lime is prohibitive for ameliorating soil acidity in Swaziland and similar developing countries.

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Sericea lespedeza (*Lespedeza cuneata*), a perennial legume, has persisted well and been productive on soils with pH as low as 4.8_w in the southeastern USA (Hoveland *et al.* 1990). Sericea roots grow deeply in acid soils with over 0.8 cmol (1/3 Al^{3+})/kg exchangeable Al in the southeastern USA, resulting in good drought tolerance (Joost and Hoveland 1986). Sericea is tolerant of high levels of free Al^{3+} in the soil, a result of precipitating this element in cortical and epidermal root tissue (Joost and Hoveland 1985). Response to phosphorus fertilization is low; a result of deep rooting and excellent extraction of this element from soil (Joost *et al.* 1989). Tannins reduce palatability and animal performance (Terrill *et al.* 1989). The development of low-tannin sericea cultivars has greatly improved palatability and animal performance on sericea pasture (Schmidt *et al.* 1987). However, when high-tannin sericea cultivars are cut and stored for hay, tannin levels decline sharply and both palatability and digestibility are improved to about the same level as low-tannin cultivars, making it an attractive roughage (Terrill *et al.* 1989).

The objectives of this study were to determine (a) the adaptation and productivity of high- and low-tannin sericea cultivars in the high, middle, and lowveld of Swaziland and (b) the yield response to rhizobia inoculation of seed and N fertilization.

Materials and methods

Sites

Experiments were conducted at three locations in Swaziland (Table 1). The lowveld location has hot summers and warm frost-free winters with the relatively low rainfall concentrated during the summer months of October through March. The middleveld has warm to hot summers and mild dry winters with only a rare light frost. The growing season is defined by the rainfall which comes during September through April. The highveld location has warm summers, cool winters with frosts and fog. Rainfall is higher than the other two locations and extends over a longer period of the year.

Treatments

At the middleveld location, all combinations of two high-tannin sericea cultivars (Serala and Interstate 76), two low-tannin cultivars (AU Donnelly and AU Lotan), 100 kg/ha N *vs* none, and inoculated *vs* none were used in a randomized complete block design with four replications. At the high and lowveld locations the 4 sericea cultivars were planted in a randomized complete block design with 4 replications without N or inoculation treatments.

Procedure

Experiments were planted November 13, 1985, in the lowveld, January 16, 1986, in the middleveld, and January 17, 1986, in the highveld. A well-prepared seedbed was used which had been fertilized with 30 kg/ha P and 50 kg/ha K. The same P and K rates were applied annually thereafter. Sericea seed was broadcast at 20 kg/ha in 1.5 × 6.1 m plots. Commercial rhizobia inoculum from *Bradyrhizobium* strains 32H1, 3223, 4122, 150B1, and 176A22 was applied to seed moistened with a 50% syrup-50% water mixture and planted. At

Table 1. Physiographic and soil chemical characteristics of three sericea lespedeza experimental locations in Swaziland

Item	Highveld, Mangcongco	Middleveld, Malkerns	Lowveld, Big Bend
Elevation, (m)	1500	950	150
Mean annual rainfall, (mm)	1500	1020	500
Soil	Ruston clay loam (Typic Plinthudult)	Shortland clay loam (Typic Rhodoreralf)	Rensburg clay (Typic Pelludert)
pH_w[1]	4.0	4.8	8.0
Exchangeable Al,[2] cmol (1/3 Al^{3+}) kg^{-1}	0.73	0.24	—
Ca^3 mm kg^{-1}	2.0	2.5	—
P^3 mm kg^{-1}	0.6	0.9	—

[1] 1:1 soil/distilled water.
[2] 1:5 soil/1 M KCl
[3] 0.05 M HCl + 0.15 M H_2SO_4 extractant.

the middleveld site, the uninoculated seed was planted first to avoid contamination. The plots were raked lightly to cover the seed and then rolled to pack the soil. Hand weeding was done as needed during the establishment year. Nitrogen as ammonium nitrate was applied at 50 kg/ha N in October and February each year.

Forage was harvested by hand at a stubble height of 5 cm from a 0.7 × 6.1 m area of each plot. A sample was collected from each plot for moisture determination and ground for N analysis. Nitrogen was determined on all samples by a macro Kjeldahl method (Bremner 1965). One harvest was obtained in 1986 and two harvests in 1987, 1988 and 1989.

Table 2. Monthly rainfall at Malkerns in the middleveld, Swaziland, over the experimental period

Month	Rainfall			
	1986	1987	1988	1989
	(mm)			
January	141	99	72	88
February	144	54	469	389
March	120	121	122	56
April	194	23	60	27
May	1	6	12	5
June	7	7	22	74
July	10	0	18	0
August	8	49	15	5
September	22	147	50	25
October	54	128	267	100
November	49	138	77	272
December	122	103	217	143
Total	872	875	1401	1184

Results and discussion

Rainfall data for the study are available only from the middleveld location (Table 2). Total rainfall during the first two years was somewhat below the long-term mean of 1020 mm. During the third and fourth years, the rainfall was well above average. Rainfall at this location was fairly well distributed from October through April. The winter months of May through August were dry.

At the middleveld location over the 4-year period, there was no significant ($P \geq .05$) response to either rhizobia inoculation of seed or N fertilization. Therefore, data were combined for analysis of yield from the sericea cultivars. Establishment-year forage yields were low with AU Donnelly being the most productive (Table 3). Yields were higher the second year with three cultivars higher than AU Lotan. Third- and fourth-year yields were very high with the high-tannin Interstate 76 cultivar being most productive followed by the low-tannin AU Donnelly

Table 3. Forage yield of sericea lespedeza cultivars at three sites in Swaziland

Cultivar	Dry foliage yield			
	1986	1987	1988	1989
		(kg/ha)		
Malkerns (Middleveld)				
Interstate 76	560	5550	14 330	16 760
AU Donnelly	830	4990	12 360	12 130
Serala	320	4860	10 400	10 230
AU Lotan	680	3660	9 880	10 960
LSD 5%	130	950	1 440	1 260
Mangcongco (Highveld)				
Serala	380	7230	11 370	11 690
Interstate 76	480	7150	10 000	11 020
AU Donnelly	760	6940	9 640	9 560
AU Lotan	410	5880	9 090	8 900
LSD 5%	150	n.s.	n.s.	1 240
Big Bend (Lowveld)				
Interstate 76	1640	4460		
Serala	1740	3910		
AU Lotan	1320	4020		
AU Donnelly	1370	3060		
LSD 5%	n.s.	n.s.		

cultivar. Serala and AU Lotan were somewhat lower yielding. The much higher yields during the third and fourth years are probably a result of higher summer rainfall in those years.

Yields were somewhat lower at the highveld location (Table 3). This may have been a result of the somewhat shorter growing season at the higher elevation and higher soil Al levels (Table 1). AU Donnelly was the most productive in the establishment year (Table 3). No significant differences among cultivars occurred in the second and third years, but during the fourth year the two high-tannin cultivars were the most productive.

At the lowveld location, establishment-year yields were higher than at the other two locations (Table 3). However, stand deterioration in the second year resulted in abandonment of the experiment. Severe iron deficiency symptoms were apparent, indicating the lack of sericea adaptation to this high pH soil. In contrast, stand persistence was excellent at the middleveld and highveld locations.

Nitrogen content of sericea was adequate for ruminant nutrition at all locations (Table 4). There was little difference among cultivars or years.

Table 4. Nitrogen concentration of sericea lespedeza cultivars at three locations in Swaziland, four-year mean 1986–1989 in highveld and middleveld, two-year mean 1986–1987 in lowveld

Cultivar	Nitrogen concentration of dry forage		
	Highveld	Middleveld	Lowveld
		(g/kg)	
AU Lotan	2.7	3.0	2.6
AU Donnelly	2.7	2.9	3.0
Serala	2.6	3.0	2.6
Interstate 76	2.6	2.9	2.8
LSD 5%	n.s.	n.s.	0.3

Sericea lespedeza forage yields were high after the establishment year on acid soils at the middle and highveld locations. These yields are substantially higher than the 5000 to 7000 kg/ha normally obtained on acid soils in the southeastern USA (Hoveland *et al.* 1990). High-tannin cultivars in general were the most productive although the low-tannin cultivar AU Donnelly performed well at the middleveld location where the soil exchangeable Al level was relatively low. High-tannin sericea cultivars may have an advantage over low-tannin cultivars since root growth rates are much better in very acid soils (Joost and Hoveland 1986). Although sericea is generally more tolerant than alfalfa (*Medicago sativa* L.) of Al toxicity in acid soils, there is a wide range in tolerance among genotypes.

Although no lime was needed to obtain high forage yields, even on the highveld soil with high soil exchangeable Al, it cannot be concluded from these experiments that sericea is a low-input legume crop since both P and K fertilizers were applied each year. Thus, further work will be needed to determine the fertilizer requirements for sustained sericea production at the high yields obtained in these trials.

Sericea has been shown to provide adequate protein, energy and minerals for reproduction and growth of cattle in the southeastern USA (Hoveland *et al.* 1990; Schmidt *et al.* 1987). Hence, it has the potential to do the same in Swaziland. High-tannin cultivars are less palatable and digestible when grazed but the decline in tannin level with drying makes the forage quite satisfactory for hay to maintain animals during winter (Terrill *et al.* 1989).

Results of these trials suggest three main conclusions:

(1) The lack of response to legume rhizobia inoculation indicates that adequate numbers of effective indigenous rhizobia are present in soil on the middleveld site. This is further indicated by the lack of response to N fertilization and the high forage yields.

(2) Both high- and low-tannin sericea cultivars performed well in the trials and have potential for hay production.

(3) High dry forage yields of over 10 000 kg/ha were obtained on acid soils without the addition of lime and should provide forage of nutrient quality adequate for winter maintenance of cattle.

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