Response of *Axonopus catarinensis* and *Arachis pintoi* to Shade Conditions

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The 22nd International Grassland Congress (Revitalising Grasslands to Sustain Our Communities) took place in Sydney, Australia from September 15 through September 19, 2013.

Proceedings Editors: David L. Michalk, Geoffrey D. Millar, Warwick B. Badgery, and Kim M. Broadfoot

Publisher: New South Wales Department of Primary Industry, Kite St., Orange New South Wales, Australia

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Keywords: Silvopastoral systems, yield, nutritive value

Introduction

In the north-east of Argentina, there are more than 100,000 hectares of silvopastoral systems where trees, forages and livestock are combined with the goal to diversify income, reduce financial risk, obtain more profit and enhance environmental benefit (Cubbage *et al*. 2013). The rapid adoption of this production system by farmers has generated high demand for information on shade tolerant grass and legume forage species.

Axonopus catarinensis is a native grass from Itajai Vally (Brazil) that was introduced to the north-east of Argentina 10 years ago; whereas *Arachis pintoi* is a subtropical legume (also native to Brazil) adapted to acid soils and tolerant of medium levels of shade (Fisher and Cruz 1994). Visual observation of these species in the field indicated high yields and acceptable tolerance to shade.

A trial was subsequently carried out with the aim to quantify dry matter yield and nutritive quality of the species under different levels of shade for silvopastoral use.

Materials and Methods

The trial was located on the experimental station of the National Institute of Agricultural Technology (INTA), Montecarlo, Misiones province, Argentina (26º33´27.98´´S and 54º33´25.01´´W). The climate is subtropical humid, with a mean annual precipitation of 1,824 mm ± 435 mm, evenly distributed through the year and an average annual temperature of 21ºC, with a maximum of 37.2ºC (January) and a minimum of -0.2ºC (July). Altitude was 210 m above sea level.

Both *Axonopus catarinensis* and *Arachis pintoi* were established in 15 m^2 plots (3x5 m) arranged as a randomized complete block design with four shade treatments (0%, 38%, 53% and 71% ambient light) and three replications. The shade condition was simulated using a method proposed by Peri *et al.* (2002) which provided continuous and fluctuating shade conditions in the field. Dry matter (DM) yield was estimated by sub-sampling five random 0.25 m^2 areas within each plot and this occurred six times during a period of 390 days (from the 23/05/07 to 16/06/08). The height of trimming was 10 cm for the grass and 5 cm for the legume. At each harvest, three samples of >100 g fresh matter/treatment were collected and sent to the Forage Quality Laboratory of INTA for nutritive analysis (Table 1).

The data were analyzed by ANOVA, using repeated measures to determine differences between variables by level of shade. The LSD test was used for comparing treatment means with a level of significance of 95%. The statistical software used was ESTATISTICA 6.0.

Results and Discussion

There was an effect of shade (P<0.001) and period (P<0.001) for both *A. catarinensis* and *A. pintoi* yield over the experimental period (Table 1). The highest accumulated DM yield for the grass occurred with 38% shade (617 g/m^2) producing 41% more DM yield than the full sun DM yield for the grass occurred with 38% shade (617 g/m^2), producing 41% more DM yield than the full sun treatment (437 g/m^2). Yields of grass at 53% and 71% of shade were

Table 1. Average of DM yield and chemical composition of *Axonopus catarinensis* and *Arachis pintoi* in a period of 390 days with different levels of shade.* Significant difference (P < 0.05) between sun and shade values.

Species	Shade treat-ment (%)	DM yield (g/m^2)	NDF (%)	ADF (%)	Lignin (%)	Protein (%)	P (%)	K (%)	Mg (%)	Mn (mg/g)	Cu (mg/g)	Fe (mg/g)	Zn (mg/g)
Axonopus catarinensis	0	437	59.9	37.5	4	9.1	0.16	1.5	0.19	475	5.6	278	39.7
	38	617*	60.9	38.2	3.8	9.4	0.13	1.8	0.2	396	5.7	344	39.9
	53	484	60.7	37.2	3.4	10.8*	0.18	2.3*	0.21	394	6.6	290	44.8*
	71	478	58.6	37.5	3.9	12.6*	0.14	2.4*	0.22	310	8.3*	615	42.8*
Arachis pintoi	0	478	38.5	28.7	8	22.8	0.2	1.9	0.3	240	14.2	402	47.1
	38	538	39.2	30	8.7	22.3	0.19	2	0.3	225	16.1	461	43.2
	53	542	38.7	32.3	9.8	22.3	0.2	2	0.4	284*	17.1	707*	48.2
	71	416	40.5	31.8	9.4	22.2	0.2	2	0.4	247	16.8*	683*	40.5

484 g/m^2 and 478 g/m^2 respectively. Increased DM production with 38% shade was due to the high rate of growth achieved from the beginning of spring until the start of drought in summer when plant available soil water did not limit growth. Increases in DM yield under artificial shade or trees has been reported for many grass and legume species and is generally attributed to the positive effect of shade on soil moisture and the increased availability of nutrients such as nitrogen (Wilson 1990).The accumulated DM yields of the legume were 538 g/m^2 and 542 g/m^2 under medium levels of shade (38% and 53% respectively). Although, the full sun treatment showed an intermediate yield of 478 g/m^2, it was not significantly different from the other treatments.

The shade treatments did not have a significant effect ($P>0.05$) on cell wall components in either species (Table 1). Overall, under shade, mineral concentration of Cu and Fe increased in both species, while Mg and Mn concentrations increased in the legume and K and Zn concentrations increased in the grass. There was a significant increase ($P<0.001$) in protein content of *A. caterinensis* with shade from 9.1 to 12.6%. However, the protein content of *A. pintoi* was high regardless of treatment (average of 22.4%).

The likely explanation for the positive effect of shade on yield and protein content of the grass is the rapid mineralization of organic matter due to improved soil moisture content and moderate temperatures generated by the shade (Wilson and Wild, 1991). This may also explain the improvement in the absorption rate of same macro and micro nutrients (Cruz, 1997). Therefore, the observed increase in DM yield and nutrient content in *A. catarinensis* and *A. pintoi* is likely due to of both enhanced soil moisture and greater nutrient availability.

Conclusions

Both species showed good performance under intermediate levels of shade, and thus are promising for use in silvopastoral systems. Future research should focus on plant responses in the field under tree canopies and animal grazing.

Acknowledgements

I would like to thank Associate Professor Max Shelton (UQ-SAFs) and Postgraduate student Hayley Giles (UQ) for their suggestions on this manuscript.

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