Morphological acclimation and canopy structure characteristics of *Arachis pintoi* under reduced light and in full sun

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Introduction

Canopy structure is a key variable in determining the adaptive potential of forages and influences the radiation use efficiency (RUE) under different light conditions. The light extinction coefficient calculated from the Beer-Lambert formula (k) shows the canopy architecture and light interception patterns of plants and thus their potential ability to convert light energy (photosynthetically active radiation, PAR) into plant biomass (Hirose 2005). Under shade, forages may experience changes in plant morphology and canopy structure. Many authors have reported those changes and related them to modifications in light quantity and quality (Varella et al. 2011). The magnitude of these morphological changes may be a determinant in screening forages for shaded environments such as in silvopastoral systems.

The objective of this study was to determine the light interception patterns and extinction coefficients of *Arachis pintoi* under 2 artificial shading levels and to relate them to the adaptive potential of this legume for silvopastoral systems.

Materials and Methods

The experiment was conducted at Embrapa South Animal Husbandry and Sheep Research Centre located in Bagé, Rio Grande do Sul State, Southern Brazil from October 2009 to April 2011. It aimed to evaluate the light interception patterns and extinction coefficient (k) of *Arachis pintoi* (hybrid ecotype AGK12787 vs. NC1579 − Embrapa Cenargen) at 2 artificial shading levels (50 and 80% black shade cloth) and in full sun. The experimental design was a randomized block with 3 replicates. Additional methodological details were described by Barro et al. (2012). The leaf area index (LAI) was calculated from destructive samples collected in a 625 cm^2 quadrat. Each experimental unit grown with *A. pintoi* measured 2 m^2. The green herbage material was weighed and sub-sampled, followed by morphological separation into green leaf, stem and dead material. Total leaf area was measured using an optical planimeter (LI-3100, LICOR Inc.). The leaf area index was estimated using the equation: LAI = LA / S where: LA was the green leaf area of the sub-sample (cm^2) and S the soil sampled area (cm^2).

The photosynthetically active radiation (PAR) was measured with a ceptometer (Decagon model AccuPAR) prior to each cut. To determine both the incident PAR (PARi) and the transmitted PAR (PARt), ceptometer readings were made above and below the legume canopy, respectively. The PAR readings were taken between 11.00 and 13.00 h under clear sky conditions. The percentage of light interception (LI) was calculated as the amount of the intercepted PAR (PARi - PARt) divided by PARi and this result multiplied by 100. The light measurements were taken monthly over the experimental period.

The relationship between LAI and LI was fitted according to the model of light attenuation within the canopy, described by Monsi and Saeki (Hirose 2005). From the Beer-Lambert formula, k was determined using the regression model: $LI = LI\ max\ [1 - exp\ (k \times LAI)]$ where: LI is the amount of PAR intercepted by the canopy, LI max is the asymptote of the curve for this exponential relationship and LAI is the leaf area index.

For the relationships between variables (LI and LAI), the data were submitted to a regression analysis at 5% probability level using the PROC REG feature of SAS (Statistical Analysis System, version 9.2).

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Results and Discussion

While growth under moderate shade (50%) was similar to that under full sunlight, 80% shading significantly ($P<0.05$) reduced total dry matter yield (DMY) of *A. pintoi* (Table 1). There was insufficient light energy under 80% shade to support high growth, as indicated by LAI and DMY data.

The relationship between LI and LAI was adjusted to different exponential models, according to shade levels, and results are shown in Figure 1. The light extinction coefficient (k) was determined from these regressions and based on the interpretation of their biological responses and by examining the confidence intervals generated. Whenever k (slope of equation) was in the same confidence interval, the relationships were expressed by a single regression for different shading levels. In this study, after reaching the critical LAI level (95% LI), *A. pintoi* leaf area continued increasing at constant-maximal levels of LI (Figure 1). Results indicated similar k values for plants grown under both 50% and 80% shading levels (Figure 1), showing that no structural changes occurred in the legume canopy. However, under 80% shading, LAI was the lowest of all treatments and this was probably related to lower forage yields associated with this intense level of shading (Barro et al. 2012).

Equal values of k (Figure 1) were obtained for 50 and 80% shading levels ($k = 0.915$), which indicated that structural changes occurred in the legume canopy in comparison with the full sun treatment where the k value was significantly lower ($k = 0.536$). This response confirmed that *A. pintoi* adapted well to shade by reducing leaf angle and by structuring a planophile canopy to intercept more light.

Conclusions

The light extinction coefficients under shade differed from those under full sunlight, showing adaptation of *A. pintoi* by decreasing canopy angle. While growth was strongly reduced under heavy shade (80% sunlight restriction), *A. pintoi* showed potential to grow under moderate shade. This has implications for use of this legume in different types of silvopastoral systems and at different stages of development of the trees.

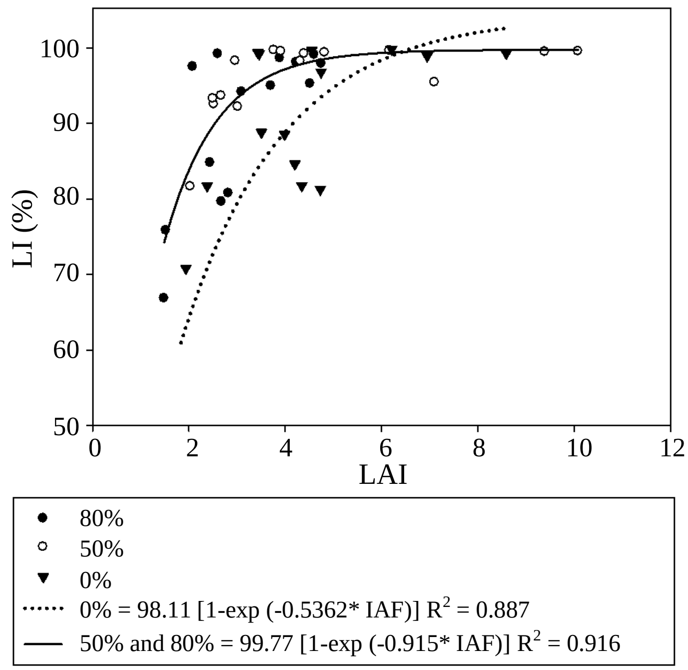

Figure 1. Relationship between leaf area index (LAI) and light interception (LI) of *Arachis pintoi* growing in full sun (▼) and under 50% shade (○) and 80% shade (●) in Bagé, RS.

References

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Table 1. Leaf area index (LAI), specific leaf area (SLA, cm^2/g), light interception (LI, %) and dry matter yield (DMY, g/m^2) of *Arachis pintoi* under heavy shade (80% shade cloth), moderate shade (50% shade cloth) and in full sunlight (0% shade). Data are averages of 10 evaluations conducted from November 2009 to April 2011.

Shading level	LAI	s.e.	SLA	s.e.	LI	s.e.	DMY	s.e.
0%	4.5 ab[1]	0.48	243.3 a	12.0	89 b	1.7	655.4 a	33.0
50%	5.3 a	0.48	255.4 a	12.0	96 a	1.7	613.0 a	33.3
80%	3.5 b	0.54	257.0 a	13.0	92 ab	1.7	394.6 b	33.0

[1]Values within columns followed by the same letters differ at $P<0.05$.

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