Vegetative and reproductive behavior of *Brachiaria decumbens* cv. Basilisk under different shade levels

P.H. M. Carrilho[1], J. Alonso[2], L.D. T. Santos[3] and R. A. Sampaio[4]

[1]*Universidad Federal de Minas Gerais. Av. Antônio Carlos, 6627. Pampulha, Belo Horizonte, Brasil*
[2]*Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, Mayabeque, Cuba*
[3]*Instituto de Ciências Agrárias. Universidad Federal de Minas Gerais. Av. Antônio Carlos, 6627. Pampulha, Belo Horizonte, Brasil*
[4]*Instituto de Ciências Agrárias. Universidad Federal de Minas Gerais. Av. Antônio Carlos, 6627. Pampulha, Belo Horizonte, Brasil*
Email: jalonso@ica.co.cu

A field trial was conducted to study the morphological, productive, and reproductive characteristics of signal grass (*Brachiaria decumbens* cv. Basilisk), cultivated at 30 and 50 % shade and full sunlight. For the shade trials, black polyethylene was used because it retains the incident light. Biomass production (t ha^{-1}), percentage of dry mass/plant (%), plant height (cm), number of plants/m^2, weight of roots/plant (g/plant), index of specific foliar area (cm^2/g), number of spikes/ha, and seed production (t ha^{-1}) were assessed. The biomass production and the number of plants/m^2 were similar in all the trials. In the shade environments, the plants had lower percentage of dry mass (22.01 and 23.24 %) and they differed ($P < 0.05$) from the trial at full sunlight (25.38 %). The shade levels (50 and 30 %) stimulated the root growth (7.31 and 4.59 g/plant), contrary to the plants at full sunlight (2.80 g/plant). The height and the index of specific foliar area reached higher values (72.80 cm and 111.62 cm^2/g), with 50 % shade and they differed from the rest of the trials. The number of spikes/ha did not show differences between the trials, and varied between 344 and 621 thousands. The seed production was higher ($P < 0.05$) with 50 % shade and reached 0.054 t ha^{-1} in the first productive cycle. *Brachiaria decumbens* cv. Basilisk had favorable performance in the different shade levels. The further evaluation of the seed production potential in this species is recommended under the conditions of this study, with larger number of productive cycles.

Key words: *shaded pasture, pasture ecophysiology, systems ILPF, signal grass.*

It is unquestionable and well-known the importance of pastures for cattle production in the tropics. Santos *et al*. (2009) linked this fact with the low cost of pasture production in this region. However, according to the phenology of tropical forages and the climate conditions throughout the year, pasture production is seasonal; thus, animal production responds to this behavior.

In the globalized world, within the context of a competitive cattle production, this problematic is discussed and studied, with the aim of developing management and animal production systems that allow market stability. In tropical conditions, systems should be productive and sustainable, demanding investment in new technologies and viable production processes from the environmental point of view (Neto *et al*. 2010).

Agricultural silvopastoral systems, as associated or mixed method, are one of the most sustainable forms of land utilization. They are also known as systems of agriculture-livestock-woods integration (Santos *et al*. 2010) and they emerged as a technique permitting to enhance the use of natural resources, providing integrated goods and services. In these systems, the microclimatic variations hamper the definition of adequate practices of management of forage plants from the subforest. Martuscello *et al*. (2009) noted that the modifications in light environment affect significantly the productivity of grasses in these systems.

Cattle activity in Brazil is supported on around 180 million of pasture hectares. The Brachiaria genus occupies around 85 % of this area, and *Brachiaria decumbens* Stapf 55 % out of that total (Fonseca *et al*. 2006). Due to the excellent adaptation of this genus to the Brazilian ecosystems in monoculture, it is necessary to study the response of this forage to the application of production technologies more compatible with the environment, as the agricultural silvopastoral systems, where the interaction between the plant and the environment is more complex.

The objective of this work was to study the morphological, productive and reproductive characteristics of *Brachiaria decumbens* cv. Basilisk in different shade levels.

Materials and Methods

The trial was developed at the Experimental Farm "Profesor Hamilton Abreu Navarro", in the Institute of Agrarian Sciences of the Federal University of Minas Gerais in Montes Claros, Minas Gerais, Brazil. This facility is between the 16 º 51'38" of latitude and 44º55'00" of longitude, on dystrophic latosolic red-yellowish soil (EMBRAPA 1999).

The signal grass sowing was conducted by the sprinkling method on December 8, 2009, in an area with previous land preparation, plowing and two harrow passes. Six kilograms of pure viable seeds were used as dose for the sowing. The trials were established immediately after emergence (December 22, 2009), in a homogeneous area. They consisted in having 30 and 50 % shade and keeping plants at full sunlight as experimental control. In order to implement the trials without sunlight, black fabric was used for shade, having 30 and 50 % of retention of the incident light. The experimental area in each trial was of 60.0 m^2 (20.0 m x 3.0 m) and the distance between them was of 5 m. The trials were oriented from East to West, leaving edge effect on both sides of the plots to guarantee that in the interior there were the wanted shade levels. The shade fabrics were put 1.5 m above the soil and they were held with wire to the wood stakes that support the structure. A complete randomized design was used with 15 repetitions per trial.

The trial was performed in the rainy season, although during it, there was drought in the rainy season, with days of intense heat and sunlight (Indian summer). Table 1 shows the behavior of some meteorological variables during the experimental period. The rainfall did not surpass 50 mm in January and February.

formula of Dias-Filho (2001) was used to calculate the index of specific foliar area:

Index of specific foliar area = A/DW

Where,

A = leaf area

DW = dry weight of the leaf

The variables number of plants/m^2 and number of spikes/ha were subject to test of normality (Shapiro and Wilk's) and homogeinity (Levene's) and the statistical processing was performed through analysis of variance to compare the confidence intervals. Student's t test ($P < 0.05$) (Banzatto and Kronka 1992) was used in each indicator under study.

Results and Discussion

The number of plants/m^2 did not have differences between the trials at shade and full sunlight. The plants exposed to the sunlight and with 30 % shade showed ($P < 0.05$) lower height (54.87 and 60.53 cm) compared with those of 50 % shade, and they did not differ statistically between themselves (figure 1).

Table 1. Average monthly values of maximum temperature, minimum temperature, pluviometric rainfall and water accumulation in the soil (mm) during the experimental period

Month/year	Maximum temp. (°C)	Minimum temp. (°C)	Rainfall (mm)	Water accumulation in the soil (mm)
December/2009	29.1	18.7	384.5	68.5
January/2010	29.1	19.5	31.3	43.9
February/2010	29.8	19.9	48.2	22.5
March/2010	29.8	19.2	249.5	66.8

Source Automated Meteorological Station (INMET) of Montes Claros-MG

The samplings were performed 81 d after the emergence in the central area of each trial. In order to limit the sampling area, a square frame of 0.25 m^2 was used at random. Biomass production (t ha^{-1}), percentage of dry mass/plant (%), plant height (cm), number of plants/m^2, weight of the roots/plant (g/plant), index of specific foliar area (cm^2/g), number of spikes /ha and seed production (t ha^{-1}) were assessed.

In order to determine the plants per m^2, they were counted in each experimental unit of sampling. The average height of the plants within the frame was measured with a ruler graduated in centimeters. All the plants from the sampling area were cut for the biomass production. In all the instances, the spikes were separated. These materials were weighed individually in a precision balance. They were deposited in paper bags previously conditioned and were put in a forced air circulation oven. After 72 h, they were weighed anew to calculate the dry mass.

In order to determine the index of specific foliar area, the third leaf of a plant was used in each repetition. Its length and latitude were measured with a ruler graduated in centimeters. The measured material was put in a forced air-circulation oven to determine the dry weight. The

The adaptation of the pastures to the light intensity variation is related, mainly, to the morpho-physiological and ecophysiological changes in the plant. Gobbi (2007) found out that the rise in the shade levels in cut systems decreased linearly the tuft density (number/m^2) in grasslands of *B. decumbens*. The culture of several grass species at different sunlight reduction levels showed that the plants reached greater height and have longer stems (Morita *et al*. 1994). Skuterud (1984) considered this response as a form of compensation for the light deficiency.

In general, plants respond to adverse environmental conditions through modifications in their growth rate and changes in the nutrient mobilization. These transformations constitute defense mechanisms to reduce to the minimum the growth limitations, caused by certain individual factor. The length of the stems and the petioles in shaded plants is higher, as well as the total foliar surface (Lambers *et al*. 1998).

Samarakoon *et al*. (1990) noted that these morphological changes in the shade conditions have as objective to compensate the light deficiency. The

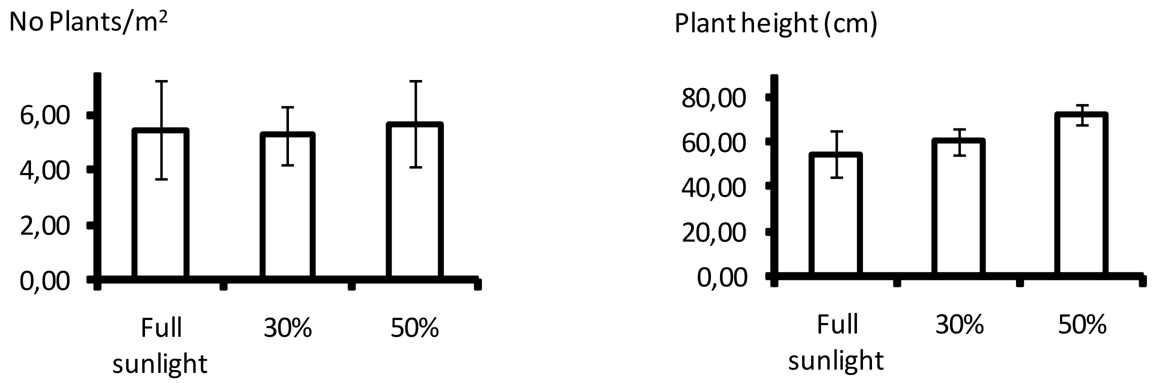

Figure 1. Number of plants/m^2 and plant height (cm) of *Brachiaria decumbens* cv. Basilisk, grown under different conditions of shade and at full sunlight

low light availability affects the photosynthesis and diminishes the capture of carbon for plant growth (Lambers *et al*. 1998).

The plants of *B. decumbens* cv Basilisk, cultivated in the trials with 30 and 50 % shade, showed lower ($P < 0.05$) percentages of dry mass compared with those grown at full sunlight (figure 2). The grasses cultivated under shade tend to be succulent, with lower percentage of dry mass, due to their slower growth and the reduced rate of water loss by the plant tissues (Castro *et al*.1999 and Peri *et al*. 2007).

Studies of Gobbi (2007) showed that the Basilisk cultivar of *B. decumbens* had significant linear reduction in the percentage of dry mass according to the shade, for the levels of 50 and 70 %, compared with the trial at full sunlight. Castro *et al*. (1999), by submitting this cultivar to a light decrease with artificial shade at 30 and 60 %, found decline of 31 and 46 % in the production of dry matter. In silvopastoral systems, Paciullo *et al*. (2007) reported decline of 53 % in forage production, with 65 % shade. When the shade reached only 35 %, the decline was of 8 %.

The photonic flow at which plants reach the light compensation point vary according to the species and the microclimatic conditions. These factors also determine the photosynthetic activity in plants that grow at full sunlight or at certain shade levels (Taiz and Zeiger 2009). In shaded plants, the values to reach the compensation point are lower than in those exposed to full sunlight because their respiration rate is much lower, thus, a small rate of liquid photosynthesis is enough to equilibrate the rates for the CO_2 exchange.

The total biomass production of the aerial part did not show differences between the trials (figure 3). The shade levels under study stimulated the root biomass of the plants and differed ($P < 0.05$) from those at full sunlight (figure 4).

The moderate water deficit, such as the drought during the trial, should affect the growth of the root system (Taiz and Zeiger 2009). The superficial soil layers are the first in drying when there is water deficit. The plants exposed to this stress show preferential growth of the root toward the soil areas that remain wetter. This performance can be considered (Taiz and Zeiger 2009) a defense

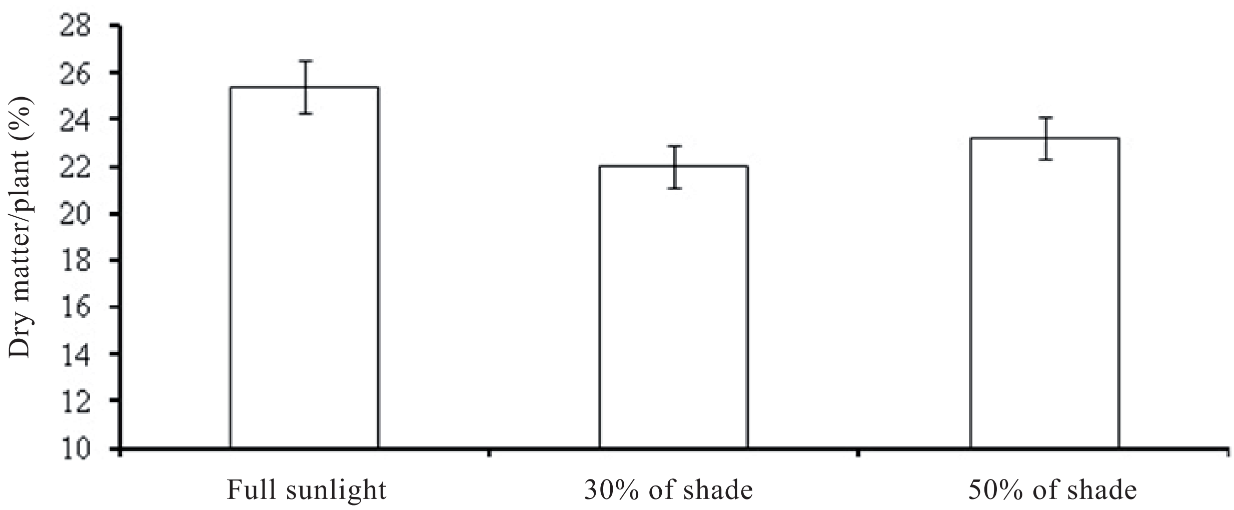

Figure 2. Dry mass/plant (%) of *Brachiaria decumbens* cv. Basilisk grown under different conditions of shade and at full sunlight

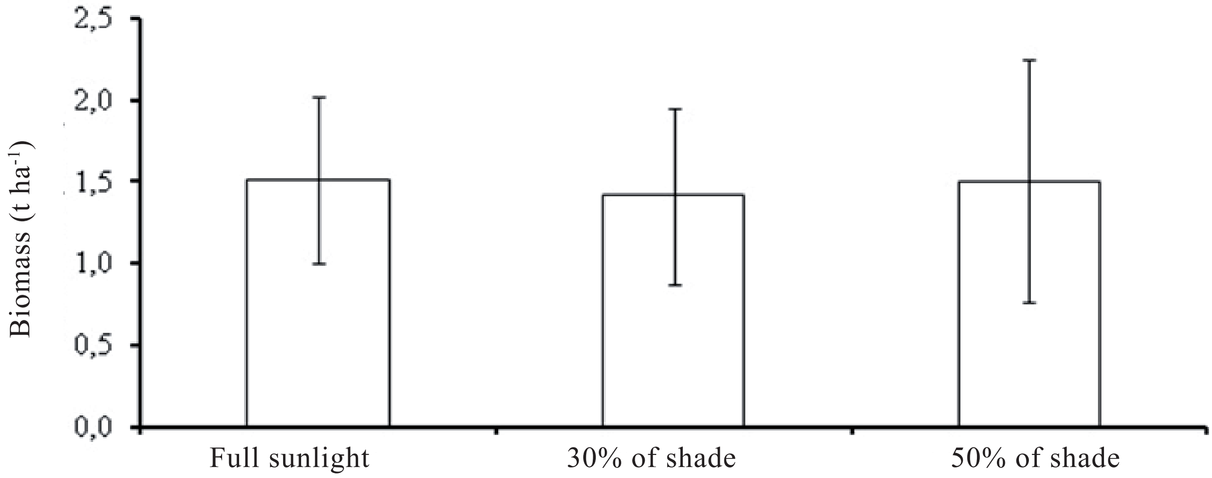

Figure 3. Biomass production (t DM ha-1) of *Brachiaria decumbens* cv. Basilisk, grown under different conditions of shade and at full sunlight

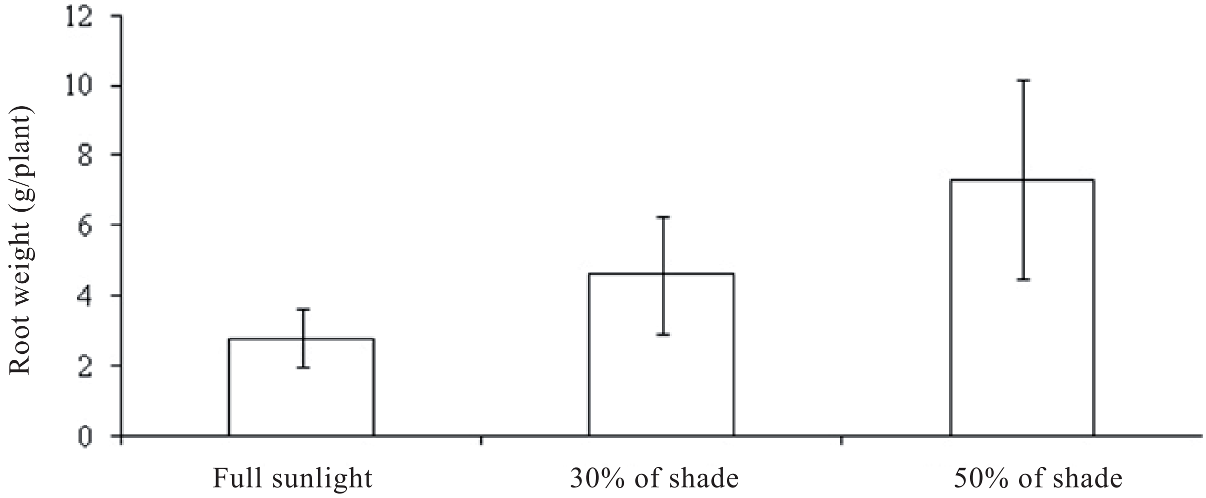

Figure 4. Root weight (g/plant) of *Brachiaria decumbens* cv. Basilisk grown under different conditions of shade and at full sunlight

mechanism of the plant against the drought.

However, other works prove that the production of roots in grass species such as signal grass, which has fasciculate root growth, is affected when grown in environments with more than 50 % shade. Martuscello *et al*. (2009) studied the reduction in the production of roots from three grasses (*B. decumbens* vc. Basilisk and *B. brizantha* vc. Marandú and Xaraés) in response to the rise in the shade levels. In all the instances, it was proved the fall in root production, from 45 to 65 %, with cultivation using 50 % shade, and from 73 to 93 % when the shade was increased at 70 %.

The plants of *B. decumbens* cv Basilisk attained the highest indices of specific foliar area, when grown with 50 % shade, thereby differing (P □ 0.05) from the rest of the light intensity levels (figure 5).

Ribaski *et al*. (1998) suggested that the presence of shade with the use of the tree component in grazing areas has significant influence on the performance of the specific foliar area of the grasses cultivated in silvopastoral systems. The index of specific foliar area reflects the modifications in size and shape of the leaves, in response to the light changes.

Usually, shaded leaves have higher length and width and they are thinner than those produced under high light intensities (Dias Filho 2001). Besides these changes, Neto *et al*. (2010), highlighted the area, the thickness, and the orientation of the foliar layer, the length of the stem, the number of leaves, and the leaf-stem ratio, as changes in the plants in shade environments that affect the forage amount and quality.

The rise in the index of specific foliar area in grasses grown under shade is of great interest, because it is associated with the shade tolerance of the plant (Alonso *et al*. 2006). Ribaski (1999) noted that the highest index of specific foliar area imply rise in the capacity of light intersection by the plant. Maybe, this is a mode of increasing the photosynthetically active surface, which ensures the more efficient use at low light intensities.

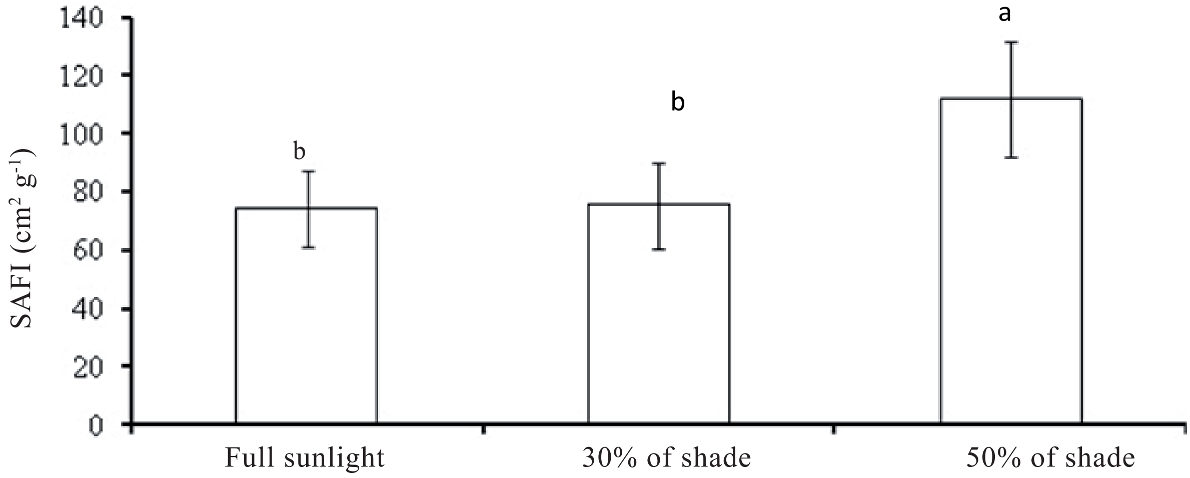

Figure 5. Index of specific foliar area of *Brachiaria decumbens* cv. Basilisk grown under different conditions of shade and at full sunlight

Mota (2009) found that plants grown under shade (*Andropogon gayanus* cv Planaltina and *Panicum maximum* cv Tanzania) have physiological changes with rise in chlorophyll a. This allowed better use of the light in this environment. Soares *et al*. (2009) noted the increase in the foliar nitrogen concentration as response to the shade, where the plant reduces the dry mass percentage to accumulate water, minerals, and other components, and produces chlorophyll a.

The spike number/ha did not show differences between the plants cultivated under shade and at full sunlight (figure 6). According to Ryle (1961), the blooming of grasses seems to be influenced by the light intensity, even when the culture conditions are favorable for blooming. Castro *et al*. (2000) observed, for the genus Brachiaria, that environments with low light intensity do not affect the density of inflorescences. These authors reported that the rise in the shade levels inhibited progressively the blooming of *P. maximun*. However, for *Setaria sphacelata*, the response was the opposite, it increased the flowering as the luminosity was diminished.

The seed production was higher ($P < 0.05$) in the plants that grew with 50 % shade. The trials at full sunlight and at 30 % did not show differences between them (figure 6). Contrary to these results, Ovalle and Avendaño (1994) reported delay in all the phenological stages of the grasses and legumes exploited in the tree cover of *Acacia caven*, with 80 % shade. Oliveira and Humphreys (1986) noted that the shade contributed to decrease the pasture seed production, by reducing the number of inflorescences in the varieties Aruana, Makueni and Marandú.

In *B. decumbens*, Castro and Carvalho (2000) also observed reduction in the average production of inflorescences in terms of shade (0, 30, 60 %). However, the seed production in shade environments should be analyzed with higher number of production cycles. Its study should include the tests of viability and the vigor of the seeds produced.

The outcomes of this work show favorable performance of *Brachiaria decumbens* cv. Basilisk when grown under shade. In these conditions, index of specific foliar area, the root biomass, the plant height and the seed production are stimulated. It is recommended to further evaluate the potential of seed

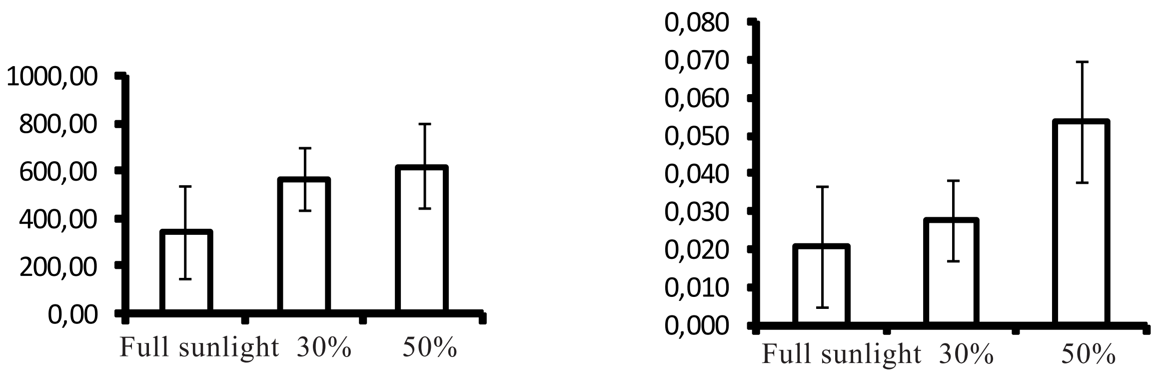

Figure 6. Spike number/ha (x103) and seed production (t ha-1) in *Brachiaria decumbens* cv. Basilisk grown under different conditions of shade and at full sunlight

production of this species in the conditions of this study with higher number of productive cycles.

Acknowledgements

Thanks are due to the National Council of Scientific and Technological Development (CNPq) for the financial support to conduct this research. Thanks are also due to the Coordination of Perfect of the Higher Education Staff (CAPES) and to the Direction of Foreign Relations of the Federal University of Minas Gerais for the scholarship for the postdoctoral studies.

References

Alonso, J., Febles, G., Ruiz, T.E. & Achang, G. 2006. Efecto de la sombra en la gramínea asociada en un sistema silvopastoril de leucaena-guinea durante sus diferentes etapas. Rev. Cubana Cienc. Agríc. 40:503

Banzatto, D.A. & Kronka, S.N. 1992. Experimentação agrícola. Segunda Edición. Jaboticabal: FUNEP, 247p.

Castro, C.R.T. & Carvalho, M.M. 2000. Florescimento de gramíneas forrageiras cultivadas sob luminosidade reduzida. Ciência Rural 20:163

Castro, C.R.T., Garcia, R., Carvalho, M.M. & Couto, L. 1999. Produção forrageira de gramíneas cultivadas sob luminosidade reduzida. Rev. Brasileira de Zootecnia 28:919

EMBRAPA. 1999. Sistema Brasileiro de Classificação de Solos-Brasilia. Centro Nacional de Pesquisa de Solos-Rio de Janeiro. Produção de informação-Rio de Janeiro. Ed. EMBRAPA Solos. 412 pp.

Dias-Filho, M. 2001. Processos e causas de degradação e estratégias de recuperação em pastagens tropicais. Primer Foro Latinoamericano de Pastos y Forrajes. CD-ROM. La Habana, Cuba

Fonseca, D.M., Martuscello, J.A. & Faria, D.J.G. 2006. Adubação em gramíneas do gênero Brachairia: mitos e realidades. Simpósio sobre manejo estratégico das pastagens. Universidade Federal de Viçosa, Brasil. Pp. 153-182

Gobbi, K. F. 2007. Características morfoanatômicas, nutricionais e produtividade de forrageiras tropicais submetidas ao sombreamento. PhD Thesis. Universidade Federal de Viçosa. Brasil. p. 82

Lambers, H., Chapim III, F.S. & Pons, T.L. 1998. Plant physiological ecology. New York: Springer. 540 pp.

Martuscello, J.A., Jank, L., Neto, M.M.G., Laura, V.A. & Cunha, D.N. 2009. Produção de gramíneas do gênero Brachiaria sob níveis de sombreamento. Rev. Brasileira de Zootec. 38:1183

Morita, O., Goto, M. & Ehara, H. 1994. Growth and dry matter production of pasture plants grown under reduced light conditions of summer season. Bulletin of the Faculty of Bioresources. Mie University. 12:11

Mota, V.A. 2009. Integração Lavoura-pecuaria-Floresta na recuperação de pastagens degradadas no Norte de Minas Gerais. Dissertação. Master Science Thesis. Universidade Federal de Minas Gerais, Brasil. 112 pp.

Neto, A.F., Garcia, R., Moot, D. J. & Gobbi, K. F. 2010. Aclimatação morfológica de forrageiras temperadas a padrões e níveis de sombreamento. Rev. Bras. Zootec. 29:42

Oliveira, P.R.P. & Humphreys, L.R. 1986. Influence of level and timing of shading of seed production in *Panicum maximum* cv. Gatton. Australian J. Agric. Res. 3: 417

Ovalle, C. & Avendaño, J. 1994. Influencia del árbol sobre la vegetación en los espinales (*Acacia caven*) de la zona mediterránea de Chile. Congresso brasileiro sobre sistemas agroflorestais. Porto Velho. Anais. Colombo. Brasil. EMBRAPA-CNPF. Pp.151-159

Paciullo, D., Castro, C. & Pires, M. 2007. Desempeño de novillas lecheras en pasturas de *D. decumbens* y sistemas silvopastoriles constituidos por *Eucalyptus grandis* y leguminosas arbóreas. Available: <http://www.inta.gov.ar/montecarlo/INFO/documentos/Publicaciones/15 / ArgentinaSSPaciullo.pdf> [Consulted: 21/05/2011]

Peri, P.L., Lucas, R.J. & Moot, D.J. 2007. Dry matter production, morphology and nutritive value of *Dactylis glomerata* growing under different light regimes. Agroforestry Systems. 70:63

Ribaski, J. 1999. Influencia del algarrobo (*Prosopis juliflora*) en la disponibilidad y calidad del forraje de pastos buffel (*Cenchrus ciliaris*) en la región semiárida brasilera. Agroforestería para la producción animal sostenible. CD-ROM.

Ribaski, J., Inoue, M.T. & Lima Filho, J.M.P. 1998. Influência da Algaroba (*Prosopis juliflora* (Sw.) Dc.) sobre algunos parâmetros ecofisiológicos e seus efeitos na qualidade de uma pastagem de Capim búfel (*Cenchrus ciliaris* L.), na região semi-árida do Brasil. Congresso Brasileiro em Sistemas Agroflorestais, 2. Anais. Belém: Embrapa-CPATU. Pp. 219-220

Ryle, G.J.A. 1961. Effects of light intensity on reproduction in S 48 timothy (*Phleum pratense* L.). Nature. 4784:196

Samarakoon, S.P. & Wilson, J.R. & Shelton, H.M. 1990. Growth, morphology, and nutritive quality of shaded *Sthenotaphrum secundatum*, *Axonopus compressus*, and *Pennistetum clandestinum*. J. Agric. Sci. 114:161

Santos, M.R., da Fonseca, D.M., Euclides, V.P., Júnior, J.R., Júnior, D. N. & Moreira, L.M. 2009. Produção de bovinos em pastagens de capim-braquiária diferidas. Rev. Bras. Zootec. 38:635

Santos, M.V., Machado, V.D. & Tuffi Santos, L.D. 2010. Uso da integração Lavoura-Pecuária-Floresta na recuperação de pastagens degradadas. Simpósio de Integração Lavoura-Pecuária-Floresta: Alternativa para produção sustentável nos trópicos. Eds. L.D. Tuffi, N.L. Pereira, E.R. Duarte, F.L.R. Olivera, L.R. Mendes. Montes Claros. Instituto de Ciências Agrárias da UFMG. Universidade Federal de Minas Gerais, Brasil

Skuterud, R. 1984. Growth of *Elymus repens* (L.) Gould and *Agrostis gigantea* Roth. at different light intensities. Weed Res. 24:51

Soares, A.B., Sartor, L.R., Adami, P.F., Varella, A.C., Fonseca. L. & Mezzalira, J.C. 2009. Influência da luminosidade no comportamento de onze espécies forrageira perenes de verão. Ver. Brasileira de Zootecnia. 38:443

Taiz, L. & Zeiger, E. 2009. Fisiologia Vegetal. Cuarta edição. Porto Alegre. Artmed, p. 820.

Received: June 8, 2011