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# Production of tropical forage grasses under different shading levels

***Produção de gramíneas forrageiras tropicais sob diferentes níveis de sombreamento***

**Francisco Eduardo Torres, Larissa Pereira Ribeiro, Paulo Eduardo Teodoro, Marcos Vinicius Morais De Oliveira, Katiane Secco Castro**

Universidade Estadual do Mato Grosso do Sul, Unidade de Aquidauana. Rodovia Aquidauana-CERA Km 12, Zona Rural, 79200-000 - Aquidauana, MS - Brasil - Caixa-postal: 25. Email: feduardo@uems.br

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**Abstract:** This study aimed to evaluate the forage production of three tropical forage grasses under different shading levels. The experiment was conducted in a greenhouse at Universidade Estadual de Mato Grosso do Sul, University Unit of Aquidauana (UEMS/UUA), in a soil classified as Ultisol sandy loam texture. The treatments consisted of three grasses species combinations (*B. brizantha* cv. Marandu, *B. decumbens* cv. Basilisck and *Panicum maximum* cv. Tanzania), submitted to four shading levels (0, 30, 50 and 75%), arranged in a completely randomized blocks design in a factorial 3 x 4, with eight replications. After harvest, the plants were separated into shoot and roots for determination of shoot fresh mass (SFM), shoot dry mass (SDM) and roots dry mass production. After analysis of variance, the qualitative factor was subjected to comparison of averages by Tukey's test, and the quantitative factor to analysis of polynomial regression, being interactions appropriately unfolded. It was verified that *B. decumbens*, by its linearly increasing production of forage and less decrease of root formation, is the most recommended for shading conditions compared to grasses Tanzania and Marandu.

**Keywords:** *Brachiaria brizantha*, integração lavoura-pecuária, *Panicum maximum*.

**Resumo:** O objetivo do presente trabalho foi avaliar a produção de forragem de três espécies de gramíneas forrageiras tropicais submetidas a diferentes níveis de sombreamento. O experimento foi realizado em casa de vegetação no setor de Fitotecnia da Universidade Estadual de Mato Grosso do Sul, Unidade Universitária de Aquidauana (UEMS/UUA), sendo o solo da área classificado como Argissolo Vermelho Amarelo distrófico. Os tratamentos foram compostos pela combinação de três espécies de gramíneas (*B. brizantha* cv. Marandu, *B. decumbens* cv. Basilisck e *Panicum maximum* cv. Tanzânia), submetidas a quatro níveis de sombreamentos (0, 30, 50 e 75%), sendo dispostos em um delineamento experimental inteiramente casualizado, em esquema fatorial 3 x 4, com oito repetições. Após a colheita, as plantas foram separadas em parte aérea e raízes, para determinação da produção de massa verde fresca da parte aérea (SFM), massa seca da parte aérea (SDM) e massa seca da das raízes (RDM). Após a análise de variância, o fator qualitativo foi submetido à comparação de médias pelo teste Tukey e o quantitativo à análise de regressão polinomial, sendo as interações desdobradas adequadamente. Verificou-se que *B. decumbens*, por sua produção de forragem linearmente crescente e menor decréscimo de formação de raízes, é a espécie mais recomendada para condições de sombreamento em relação aos capins Marandu e Tanzânia.

**Palavras-chave:** *Brachiaria brizantha, Panicum maximum*, integração lavoura-pecuária.

## Introduction

Given the competitive livestock of globalized world, the intensification of animal production systems in Brazil is required. Apart from productive, the systems must be sustainable, which requires investment in new technologies and environmentally viable production processes. A promising alternative is the establishment of silvopastoral systems, which can help reduce the problems of deforestation and ecosystem degradation (Martuscello et al., 2009).

According to these authors, the adequate choice of forage species is a prerequisite for the success of silvopastoral systems and integrated crop/livestock, which must possess competitive ability, resistance and adaptation to shading. Thus, the study of morphological adaptation of these species in environments with low light is important because the production of dry matter between different parts of the plants is a process strongly influenced by environmental conditions (Oliveira et al., 2014).

Brazil has about 180 million hectares of pastures and, according to estimates, 80-90% of pasture areas in Brazil are composed of *Brachiaria* forage species, especially *B. decumbens* and *B. brizantha* (Boddey et al., 2004). The successful cultivation of these forages is due mainly to its excellent adaptability to various soil and climatic conditions of tropical ecosystems, particularly in Cerrado.

However, *Panicum maximum* Jacq. is considered more tolerant to shading compared to the genus *Brachiaria* because most of the researches that obtained positive answers to the different levels of shading were conducted with *P. maximum* (Oliveira et al., 2014; Torres et al., 2015). Nevertheless, some authors (Andrade et al., 2001; Martuscello et al., 2009) found good adaptability and productivity of *Brachiaria* to shading. In view of this, the aim of this study was to investigate the production of three tropical forage species under different shading levels.

**Material and Methods**

The experiment was conducted in the months from June to September 2005 in a greenhouse at the experimental area of Universidade Estadual de Mato Grosso do Sul – Aquidauana Unit (UEMS/UUA), situated in the transition region between Cerrado and Pantanal, comprising the geographic coordinates 20º27'S and 55º40'W, with an average altitude of 170 m.

The soil of the area was classified as Ultisol sandy loam texture (Embrapa, 2013), and the climate of the region, according to the classification described by Köppen (Peel et al. 2007), is Aw (Tropical savanna). The maximum and minimum temperatures were 33 and 19ºC, respectively, throughout the experiment, with an average relative humidity of 52%

Treatments consisted of combinations of three grasses species (*B. brizantha* cv. Marandu, *B. decumbens* cv. Basilisck and *Panicum maximum* cv. Tanzânia), submitted to four shading levels (0, 30, 50 e 75%), obtained with the use of polypropylene meshes of 100, 70, 50 and 25% of light transmission, respectively, being arranged in a completely randomized design in a factorial 3 x 4, with eight replications.

The experimental unit consisted of polyethylene containers with a capacity of 5 L that were filled with soil region (Table 1) and placed on a wood countertop at 1 m of the soil. The sowing of fodder was held on June 4, 2005, being held at this moment, maintenance fertilization with 300 kg ha$^{-1}$ of 04-20-20 commercial formulation. In each pot were placed ten seeds at 1 cm depth. Thinning was done 30 days after sowing, being left six plants per pot. The plants were irrigated daily over the experiment, during the morning, with 50 mL de water at each polyethylene container.

**Table1.** Soil chemical analysis of the experimental area at depth 0 to 20 cm.

| pH ($H_2O$) | P | Ca | Mg | K | Al | H+Al | S | CEC | OM | V |
|---|---|---|---|---|---|---|---|---|---|---|
| --- | ppm | --------------------------- | cmol$_c$ dm$^{-3}$ | ------------------------------ | | | | | ---- % ---- | |
| 7.2 | 7.29 | 5.50 | 1.40 | 0.32 | 0.10 | 1.60 | 7.22 | 8.82 | 1.70 | 81.86 |

P: Mehlich. CEC: cation exchange capacity; OM: organic matter.

On September 2005, a single cut was performed with the aid of a stylus to plants fractionation in shoot and root, using as reference the collect. It was subsequently measured the shoot fresh mass (SFM) of all sub-samples using a digital scale analytical precision. For the evaluation of shoot and root dry mass (SDM and RDM, respectively) the plants were oven-dried at 65°C for 72 hours, then measured the mass of each sub-sample.

Initially, data were submitted to analysis of individual variance of forage grasses species for each cultivation environment, and subsequently the evaluation of residuals mean squares was performed (Banzatto & Kronka, 2006) and joint analysis of environments, using the statistical program Sisvar 5.3 (Ferreira, 2011). The significant interactions between factors were split adequately. The qualitative factor (forages) underwent comparison of averages by Tukey's test and the quantitative (shading level) to polynomial regression. The best fitted equation was chosen according to the coefficient of determination and significance of the regression coefficients.

## Results and Discussion

For all variables in this experiment, the relation between the residual mean square of the analysis of individual variance did not exceed the relation 7:1, allowing to follow the implementation of joint analysis of experiments and comparison of cultivation environments (Banzatto & Kronka, 2006). In Table 2 the mean squares for the effects of forage species (F), shading levels (S) and interaction between these factors (F x S) for measured characteristics are presented. For shoot fresh mass (SFM), shoot dry mass (SDM) and root dry mass (RDM), for relations F, S and F x S, it was observed that the treatments differ statistically at 1% probability, except the DMR in F x S interaction, which was at 5% probability.

**Table 2.** Mean square for the effects of forage species (*B. Brizantha* cv. Marandu*,* *B. decumbens* cv. Basilisk *e P. maximum* cv. Tanzania), shading levels (0, 30, 50 and 75%) and interaction F x S for measured characteristics.

| VS | DF | SFM | SDM | RDM |
|---|---|---|---|---|
| Forage species | 2 | 259,58** | 16,94** | 32,48** |
| Shading | 3 | 63,83** | 2,59** | 138,6** |
| F x S | 6 | 26,32** | 1,00** | 7,25* |
| Error | 84 | 2,75 | 0,29 | 3,63 |
| Average | | 11,72 | 3,77 | 5,30 |
| CV% | | 14,16 | 14,41 | 35,94 |

* and ** Significant at 5 and 1% probability, respectively, by F-test. MS: mean square; VS: variation sources; DF: degrees of freedom; CV: coefficient of variation.

The average values of the shoot fresh mass production of three tropical forages species under different shading levels are shown in Table 3. *B. decumbens* showed the highest shoot fresh mass in relation to other species at all levels of shading, with the exception of total luminosity (0% shade), which did not differ from Tanzânia grass. It is possible to observe an increased SFM with the higher level of shading for *B. decumbens*, a fact that has been noted by others authors (Castro et al., 1999; Paciullo et al., 2007; Paciullo et al., 2008). A higher plant growth can be observed under shading conditions because shade reduces soil temperature by 5 to 10 ° C, depending on its movement during the day. This is important factor in increasing plant growth, both by reducing the water deficit and favoring microbial activity in litter and soil (Wilson, 1998).

**Table 3.** Shoot fresh mass production (g plant$^{-1}$) of *B. Brizantha, B. decumbens* and *P. maximum* cv. Tanzânia under four shading levels (0%, 30%, 50% and 75%).

| Forage species (F) | Shoot fresh mass ---(g plant$^{-1}$)--- Shading (S) | | | |
|---|---|---|---|---|
| | **0%** | **30%** | **50%** | **75%** |
| *B. brizantha* | 10.80 b | 10.73 b | 6.21 b | 11.68 b |
| *B. decumbens* | 12.92 a | 13.86 a | 15.01 a | 18.17 a |
| *P. maximum* | 11.57 ab | 11.03 b | 7.61 b | 10.94 b |

Averages followed by the same letter in the column do not differ by Tukey's test at 5% probability.

It was verified that for shoot fresh mass parameter, with the exception of *B. decumbens*, which showed a linear response to shading levels, the Marandu and Tanzânia grasses showed quadratic behavior (Figure 1). In this variable, except Tanzânia grass which obtained the maximum forage production under full sun (11.57 g plant$^{-1}$), the other species had greater efficiency with 75% of shading, with values of 11,68 and 18,17 g planta$^{-1}$ for grasses Marandu and *B. decumbens*, respectively

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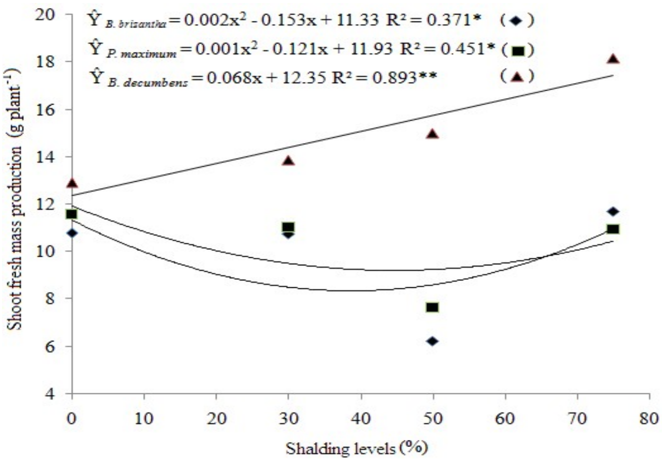


**Figure 1.** Shoot fresh mass production (g plant$^{-1}$) of *P. maximum, B. brizantha* and *B. decumbens* under four shading levels.

According to Bernades (1987), radiation regime is a major determinant variable of plant growth in this study due to its effects on photosynthesis and other physiological processes, such as transpiration and nutrients absorption. Dias Filho (2002) to evaluate photosynthetic responses of *B. brizantha* and *B. humidicola* observed, in these species reduction of ratio chlorophyll *a:b* according to the shading of 70%. The largest relative proportion of chlorophyll *b* can be advantageous under shading, because it allows greater absorption efficiency of less intense light, as well as generating significant economies of nitrogen, necessary for light capture (Percy, 1999). This saving can result in increase of cell production, resulting in a higher rate of leaf elongation (MacAdam et al., 1989).

This explains the different behavior of SFM production of different species studied because each species has specific photosynthetic behavior at different shading levels. Probably the *B. decumbens* had better utilization of nitrogen in these conditions, resulting in greater SFM production.

Table 4 presents the average values of dry matter production for three tropical forage species at different shading levels evaluated. *B. decumbens* was higher than to other species independent of the level of shading, although these did not differ among themselves in the full sun treatment. Again, *B. decumbens* responded satisfactorily to shading, maintaining SDM production with increasing levels of shading.

**Table 4.** Shoot dry mass production (g plant$^{-1}$) of *B. Brizantha, B. decumbens* and *P. maximum* cv. Tanzania under four shading levels (0%, 30%, 50% and 75%).

| Forage species (F) | Shoot dry mass ---(g plant$^{-1}$)--- Shading (S) | | | |
|---|---|---|---|---|
| | 0% | 30% | 50% | 75% |
| *B. brizantha* | 3.65 a | 3.52 b | 2.77 b | 3.68 b |
| *B. decumbens* | 4.15 a | 4.58 a | 4.50 a | 5.19 a |
| *P. maximum* | 3.67 a | 3.49 b | 2.64 b | 3.36 b |

Averages followed by the same letter in the column do not differ by Tukey's test at 5% probability.

For shoot dry mass production (Figure 2) it was found quadratic behavior for Marandu and Tanzania, while the *B. decumbens*, again, showed a linear response to shading levels. Except for Tanzania and *B. brizantha*, which had the highest SDM production only under full-sun (3.67 g planta$^{-1}$), the shading of 75% provided to *B. decumbens* the highest mean for this parameter (5.19 g plant$^{-1}$, respectively). Results found in this work differed from the literature, where a decreasing in DM production of *B. decumbens* under reduced light intensity is reported (Castro et al., 1999; Martuscello et al., 2009; Soares et al., 2009).

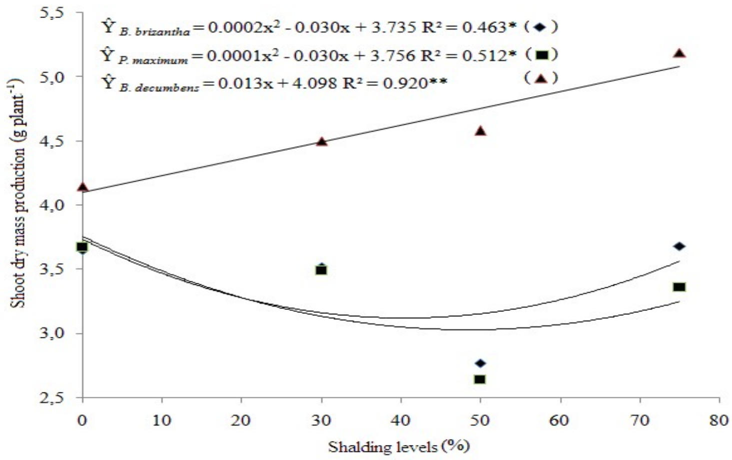


**Figure 2.** Shoot dry mass production (g plant$^{-1}$) of *P. maximum, B. brizantha* and *B. decumbens* under four shading levels (0%, 30%, 50% and 75%).

The results obtained in this experiment disagree with Martuscello et al. (2009), that when evaluating *Brachiaria* grasses production under different shading levels (0, 50 and 70%), found no statistical difference between *B. decumbens* and *B. brizantha* for cumulative production of SDM in different shades evaluated. These authors also found that there was a linear decrease of this parameter with increasing levels of shading for both species.

According to Torres et al. (2015), the development of the photosynthetic apparatus is noticeably influenced by the luminosity, being observed for several species significant increases in dry mass production of plants under low light conditions. This occurs because species adapted to shading have lower light compensation point, resulting in lower respiration rate per unit leaf, maintaining a positive carbon balance, which ensures the photosynthetic rate and biomass accumulation (Dias Filho, 2002). Thus, the *B. decumbens* can be considered a tolerant forage species to shading (Andrade et al., 2001).

There was a considerable reduction in roots production of the three grasses, with linear response (P<0.01) to increasing the level of shading (Figure 3). *B. decumbens* excelled statistically when compared with other forage species at different shading levels, except for full sun treatment, in which there were no differences between the species (Table 5).

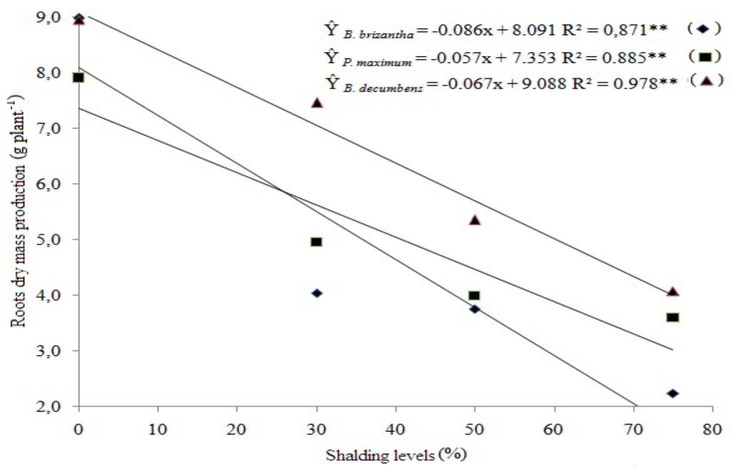


**Figure 3.** Root dry mass production (g plant$^{-1}$) of *B. Brizantha, B. decumbens* and *P. maximum* under four shading levels.

**Table 5.** Root dry mass production (g plant$^{-1}$) of *B. Brizantha, B. decumbens* and *P. maximum* cv. Tanzania, under four shading levels (0%, 30%, 50% and 75%).

| Forage species (F) | Root dry mass production ---(g plant$^{-1}$)--- Shading (S) | | | |
|---|---|---|---|---|
| | 0% | 30% | 50% | 75% |
| *B. brizantha* | 8,98 a | 4,04 b | 3,75 b | 2,23 c |
| *B. decumbens* | 8,96 a | 7,46 a | 5,35 a | 4,07 a |
| *P. maximum* | 7,91 a | 4,95 b | 3,99 b | 3,59 b |

Averages followed by the same letter in the column do not differ by Tukey's test at 5% probability.

The competition for light is also a factor of great importance for roots, and in shading conditions, there is a reduction in its growth and decreased ability of these roots to capture water and nutrients for plant (Langer, 1979), generating direct consequences on biomass accumulation.

Considering that the root ensures the plants persistence over the time and the evaluated plants are perennial forages, *B. decumbens* is the most indicated for shading conditions up to 75% by having low reduction percentage in the RDM production (45.42%) associated with higher forage yield.

**Conclusions**

*Brachiaria decumbens*, by its linearly increasing forage production and low decreasing in root formation, is the most recommended for shading conditions compared to grasses Tanzania and Marandu.

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