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THE USE OF LIGHT-TRANSPARENT ACETATE SHEET TO MEASURE CANOPY HEIGHT OF MARANDU PALISADEGRASS: THE INFLUENCE OF DEVELOPMENT STAGE AND SWARD HEIGHT

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Abstract
The use of light-transparent acetate sheet (LAS) may generate variations in the height measured in the sward. However, we compared the use or non-use of LAS to measure the average sward height of marandu palisadegrass (*Urochloa brizantha* syn. *Brachiaria brizantha* cv. Marandu) pastures. In the first experiment, the methods were applied in pastures with different average heights (15, 25, 35, and 45 cm), managed under continuous stocking with sheep, and with predominance of vegetative tillers. The shorter pastures (15 and 25 cm) had similar heights with or without the use of the LAS. However, in the taller pastures (35 and 45 cm), the use of LAS resulted in lower height values, compared with its absence. In the second experiment, we compared both methods for measuring the height of deferred marandu palisadegrass and fertilized with two nitrogen levels (50 and 200 kg ha^{-1}) and with high presence of reproductive tillers. A completely randomized design with four replicates was adopted. With 200 kg ha^{-1} of N, the canopy height was greater than when it was fertilized with 50 kg ha^{-1} of N. With the use of LAS, the height of deferred and reproductive canopy was greater than without it. In a taller marandu palisadegrass pasture with predominance of vegetative tillers, the use of LAS results in smaller height, contrary to what occurs in deferred swards with reproductive tillers.

Keywords: Height Measurement. Reproductive Tiller. Tropical Grass. *Urochloa brizantha*.

1. Introduction

The pasture management is important because it ensures its perenniality and productivity, besides allowing for an efficient harvest of the forage by the grazing animals. Today, the control of the pasture has been recommended based on the average sward height, which is specific for each forage grass and variable according to the grazing method (da Silva and Nascimento Jr. 2007). The advantages of sward height as a criterion for the grazing management are its practicality, rapidness, and low cost. In addition, the sward height influences the responses of plants and animals under grazing (Nantes et al. 2013).

In general, the sward height is measured as the distance from the soil surface to the highest live leaf in the sward, trying to cause the least disturbance, and using a graduated measuring stick or sward stick (Gimenes et al. 2011; Santos et al. 2013; Pessoa et al. 2016). However, the point variation of canopy height is very high. Therefore, it seems advantageous to try to integrate the height of small areas than to measure too many points or stations. This could be done by using a light-transparent acetate sheet (LAS) on the plants of naturally shorter swards, such as those with *Cynodon* (Pedreira et al. 2018) or *Brachiaria* (Yasuoka et al. 2018) genus.

The LAS can be placed on the forage canopy without compressing it, which allows to integrate a larger area of the canopy to measure the height. The average height of the canopy area under the LAS can be measured with the positioning of a ruler in the median portion of that LAS. However, the use of LAS allows the measurement of canopy height more quickly and easily when compared to height measurements at several points in the same canopy area (Pedreira et al. 2005).

Against this background, there is no information on possible differences in the measurement of forage canopy height with the use or not of LAS. The hypothesis of the present study was that the use or non-use of LAS may cause variations in the measured height, depending on the development stage of plant forage (predominance of vegetative or reproductive tiller) and on the sward height at which the pasture is managed (short or high).

Nevertheless, we compared the use and non-use of LAS for measuring the sward height of vegetative *Urochloa brizantha* syn. *Brachiaria brizantha* cv. Marandu (marandu palisade grass) with different targets heights and on deferred swards fertilized with two nitrogen levels (50 and 200 kg ha^{-1}) with high presence of reproductive tillers.

2. Material and Methods

Two experiments were conducted at Federal University of Uberlândia, located in Uberlândia, MG (18°30' S and 47°50' W). The climate of the region is tropical savannah (Aw) type (Alvares et al. 2013), with well-defined dry and rainy seasons. A pasture with marandu palisadegrass (*Urochloa brizantha* syn. *Brachiaria brizantha* cv. Marandu) with no signs of degradation was utilized. The chemical analysis of the soil in the 0-10 cm layer showed the following results: pH in H_2O: 6.0; P: 4.9 (Mehlich-1) and K^+: 139 mg dm^{-3}; Ca^{2+}: 5.0; Mg^{2+}: 2.9; and Al^{3+}: 0.0 cmol$_c$ dm^{-3} (KCl 1 mol L^{-1}).

The first experiment (Experiment 1) took place from January to March 2014, in the pasture that was already divided into twelve 800 m^2 paddocks. Phosphate (50 kg ha^{-1} of single superphosphate), nitrogen (70 kg ha^{-1} of urea), and potassium (50 kg ha^{-1} K_2O) fertilizations were applied in January 2014. Four average pasture heights (15, 25, 35, and 45 cm), and two methodologies to measure the average pasture height (with and without LAS) were evaluated in a completely randomized design in a split-plot arrangement with three replicates. The plot corresponded to the average pasture height, and the subplot to the height-measurement method. From January 2014, the paddocks (experimental units) were managed under continuous grazing by sheep, and pastures were kept with an average height of 25 cm until mid-February 2014. From that date, each group of three paddocks was lowered to 15 cm; kept with 25 cm; managed with 35 cm; and kept with 45 cm. To control the swards heights, the height of the plants was measured weekly in 30 random points of each paddock, utilizing a sward stick only. The height was measured from the soil surface to the highest live leaf of the canopy, attempting to cause the least disturbance in the sward. When the height was greater than the target, more animals were added to the paddock, and the opposite procedure was performed when the height was below the target. At the end of March 2014, all paddocks had their pastures close to the target swards heights, and then their height was measured similarly to the method described before. Additionally, to reduce the high point variation of canopy height (Figure 1A), a rectangular (21 × 29,7 cm) LAS weighing 9 g was used to measure the canopy height. The LAS was placed on the plants in the same points where the height had been measured with the sward stick (Figure 1B), and then the height was measured with a graduated ruler, considering the distance from the soil surface to the place of accommodation of the transparency. When the transparency was inclined on the sward, its middle region was used as the point for measuring the height. In Experiment 1, the marandu palisadegrass presented tiller predominantly in the vegetative stage.

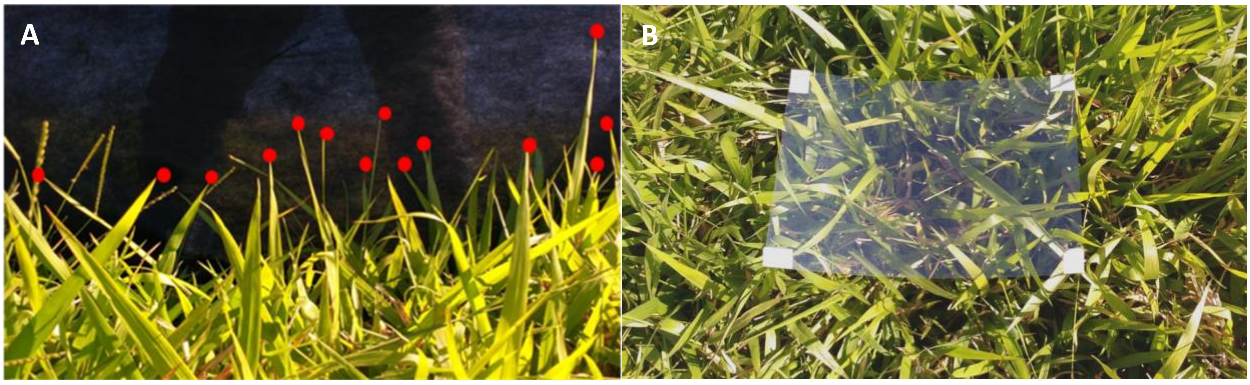

Figure 1. A – high point variation of canopy height, where the red dots indicate the height variability of the highest live leaves in the canopy; B – light-transparent acetate sheet placed on the plants to measure the canopy height.

The second experiment (Experiment 2) was held from January to June 2014, on a pasture adjacent to that used in Experiment 1. On January 10, 50 kg ha^{-1} of P_2O_5 (single superphosphate form) and 50 kg $ha^{-1}$of K_2O (potassium chloride form) were applied. Two nitrogen fertilization levels were evaluated: 200 kg ha^{-1} of urea, split into one part applied on January 10, 2014 (50 kg ha^{-1}) and another two on February 17, 2014 (70 kg ha^{-1}) and March 15, 2014 (80 kg ha^{-1}); and 50 kg ha^{-1} at a single dose on January 15, 2014. Additionally, the two methods for measuring the sward height applied in Experiment 1 were also assessed in Experiment 2. A completely randomized design in a split-plot arrangement, with four replicates, was adopted. The plot corresponded to the fertilization strategy, and the sub-plot to the height-measurement method. Experimental units were 9 m^2 plots. From January to March 15, 2014, the marandu palisadegrass was kept with 30 cm through weekly cuts. On March 15, 2014, the plants were no longer cut, to simulate the beginning of deferment period of the grass. After 90 days of deferment, the height of the plants was measured in ten points of each plot. In Experiment 2, the marandu palisadegrass presented tiller predominantly in the reproductive stage.

The statistical analysis was performed separately for the two experiments, at the significance level of 5% of probability of occurrence of type-I error. In Experiment 1, after the analysis of variance, the data were compared by Tukey's test. The percentage variation in height with the use of the sward stick was estimated compared with the use of the LAS, and its values were subjected to regression analysis as a function of the target sward height. The analysis of regression of the values of heights measured with and without LAS was run based on the t test and on the coefficient of determination. Data from Experiment 2 were subjected to analysis of variance only (F test).

3. Results and Discussion

In Experiment 1, the sward height was different (p=0.0004) between the target heights for the marandu palisadegrass (Table 1), because contrasting height values were set intentionally. The shorter pastures (15 and 25 cm) had similar heights (p=0.1322), with or without the use of the LAS. However, in the taller pastures (35 and 45 cm), the use of LAS resulted (p=0.0390) in lower height values, compared with its absence (Table 1).

Table 1. Average height of marandu palisadegrass pasture under continuous grazing by sheep, measured with or without the use of light-transparent acetate sheet (LAS).

Measurement method	Average sward height target (cm)			
	15	25	35	45
With LAS	14.9^{dA}	24.4^{cA}	32.1^{bB}	40.9^{aB}
Without LAS	16.2^{dA}	26.4^{cA}	35.5^{bA}	47.6^{aA}

Means followed by equal lowercase letters in the row and uppercase letters in the column do not differ according to Tukey's test at 5% of probability.

The percentage variation in canopy height with the use of LAS, compared with its no use, was always negative, and decreased with the sward height (p=0.0305) (Figure 2A). Moreover, the slope of the equation obtained without its use was higher (p=0.0312) compared with that of the equation with the use of the LAS (Figure 2B).

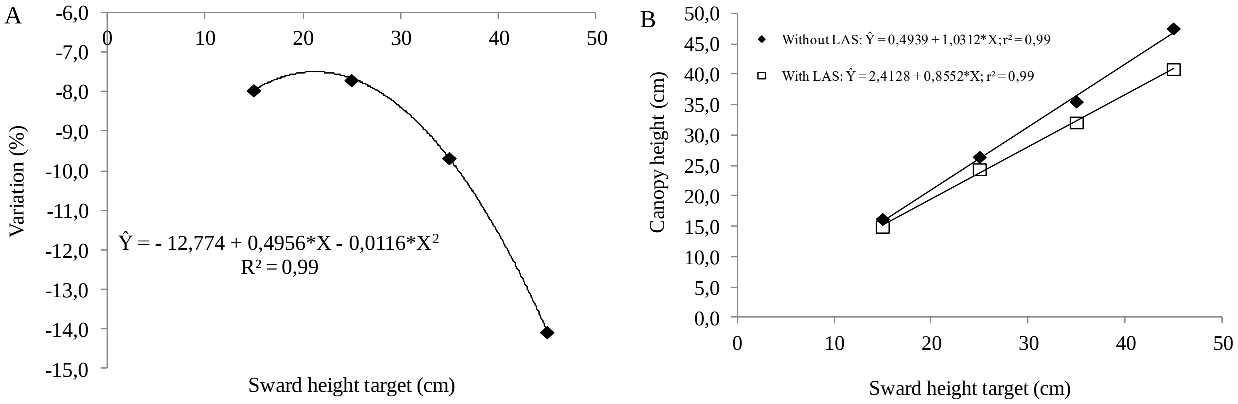

Figure 2. A – percentage variation in canopy height with the use of light-transparent acetate sheet (LAS), compared with its no use; B – canopy height with and without the use of LAS in marandu palisadegrass pasture managed with four sward heights target.

In Experiment 1, a shorter pasture has a higher number of small tillers (Sbrissia et al. 2010; Paula et al. 2012), which contributes to the formation of a denser sward, capable of supporting the small weight of the LAS without it causing significant impairment to the natural architecture of the highest leaves. The shorter pasture also has shorter leaf blades (Paula et al. 2012) that are less susceptible to being compressed by the weight of the LAS, contrary to what occurs in taller pastures (35 and 45 cm). Therefore, only in swards with 35 and 45 cm canopy height was lower when measured with LAS, compared to only the sward stick (Table 1 and Figure 1B).

It is noteworthy that, in Experiment 1, most tillers in the marandu palisadegrass pastures were in the vegetative stage. In fact, the pastures with 15 and 25 cm did not show reproductive tillers, whereas those with 35 and 45 cm had only 0.8% and 1.8% of reproductive tillers, respectively. However, the upper stratum of the pastures consisted mainly of live leaves, and the fact that the leaf is an organ that does not provide much resistance to the weight of the LAS explains the lower height values measured by the transparency, compared with its absence (Table 1 and Figure 1B).

Due to these results (Table 1), in marandu palisadegrass pastures with tillers predominantly in the vegetative stage, it is recommended that the height be measured with the sward stick in a greater number of points. Another alternative could be the use of lighter LAS that does not cause compression of the forage canopy.

In Experiment 2, there was no (p=0.1566) interaction between the nitrogen (N) levels and the height-measurement method. The deferred marandu palisadegrass fertilized with 200 kg ha^{-1} of N was taller (p=0.0236) (45.7 cm) than that fertilized with 50 kg ha^{-1} of N (37.2 cm). In addition, the light-transparent acetate sheet resulted in a greater (p=0,0001) canopy height (44.5 cm), compared with the measurement without it (38.4 cm).

Nitrogen (N) increases the growth rate of the marandu palisadegrass (Paiva et al. 2011), which made the sward receiving the highest N level in Experiment 2 reach the greatest height at the end of deferment period regardless of height measurement method.

In Experiment 2, during the deferment some vegetative tillers became reproductive, as the grass fertilized with 200 and 50 kg ha^{-1} of N contained 11% and 18% reproductive tillers, respectively. Because the inflorescence is above the live and highest leaves of the sward, and because it is a more lignified organ, the use of LAS usually results in a greater height value (Figure 3). Due to this result, in marandu palisadegrass pastures with tillers in predominantly reproductive stage, it is recommended that the canopy height be measured with the sward stick in a greater number of points. In this condition, the use of LAS is not recommended for canopy height measurement.

Figure 3. The light-transparent acetate sheet above the inflorescences of the marandu palisadegrass at the reproductive stage overestimates the canopy height.

4. Conclusions

The use of light-transparent acetate sheet results in smaller canopy height of marandu palisadegrass swards kept higher (35 and 45 cm) and with the predominance of vegetative tillers, contrary to what occurs in deferred and fertilized swards with significant participation of reproductive tillers.

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Ethics Approval: Not applicable.

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