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Forage yield of *Urochloa brizantha* [(Hochst. Ex A. Rich.) R.D.] cv. Insurgente at different cutting heights

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ABSTRACT

Objective: Evaluate the forage yield of *Urochloa brizantha* cv. Insurgente at different cutting heights.

Design/methodology/approach: the experiment was carried out at the Universidad del Papaloapan, Loma Bonita, Oaxaca, Mexico. Four cutting heights were evaluated (5, 10, 15, and 20 cm) during the rainy, norther, and dry seasons. The experiment followed a randomized block design with four replicates. We evaluated plant height (PH), green matter yield (GMY), dry matter yield (DMY), growth rate (GR), and morphological components, such as leaf yield (LY), sheath yield (SY), and stem yield (StY).

Results: the cutting height and season interaction was significant for all the evaluated variables ($P \leq 0.01$). The highest PH (42 cm) was obtained with a cutting height of 20 cm during the rainy season. The highest GMY and DMY (2,484 and 606 kg ha⁻¹, respectively) were obtained with cutting heights of 15 cm during the rainy season. These values were similar ($P > 0.05$) to those obtained at 20 cm (2,410 and 582 kg ha⁻¹, respectively). The highest LY, SY, and StY values were obtained with cutting heights of 15 and 20 cm during the rainy season. The highest GR (31 kg MS ha⁻¹ day⁻¹) was observed during the rainy season, regardless of cutting height.

Findings/conclusions: for each of the evaluated seasons, cutting heights of 15 and 20 cm resulted in the highest forage yields of *U. brizantha* cv. Insurgente.

Keywords: *Urochloa brizantha*, Insurgent grass, forage production, cutting height.

INTRODUCTION

In the tropical wet climate of Oaxaca, cattle production is the main economic activity. Like other regions in the country, livestock is an extensive activity, where native grasses are the primary feed source. However, these grasses have low forage yields, and their seasonal production is an important problem in animal productivity; during the rainy season, there is a forage surplus, the contrary occurs

during the dry season due to water shortage (Hernández *et al.*, 2002). Therefore, new forage management strategies are necessary to increase forage availability and secure its constant production throughout the year (Araya and Boschini, 2005). *Urochloa brizantha* is a grass species with high dry matter yields that adapts to acidic soils with medium soil fertility, seasonal floods, and moderate droughts (Lascano *et al.*, 2002). However, the quality and yield of this grass depend on several factors, such as cultivar, climatic conditions, and pasture management (Juárez and Bolaños, 2007). Within pasture management, defoliation intensity is an important factor to consider. After defoliation, high forage yields are obtained if there is a sufficient carbohydrate reserve, with an adequate number of leaves and growth rate (Beltrán *et al.*, 2002). Thus, each forage species must be harvested at an optimal height to obtain the maximum forage yield. Dos Santos *et al.* (2008) concluded that the best harvesting height for *U. brizantha* cv. Marandu was 15 cm. Similarly, Cruz *et al.* (2017) observed maximum dry matter yields at cutting heights ranging from 13 to 15 cm, every 28 days, in *U. humidicola* cv. Chetumal. Rojas *et al.* (2018) reported the highest dry matter yield in hybrid *Urochloa* cv. Cobra at 15 cm. At this height, assuming that the plant has significant reserves, growth is faster, consequently increasing forage production.

Although there are studies regarding pasture management in Mexico, the information on harvest height in Insurgente grass is still deficient, so it is necessary to reinforce this information for said tropical grass.

Therefore, this study aimed to evaluate the effect of the cutting height on the productive behavior of *U. brizantha* cv. Insurgente.

MATERIALS AND METHODS

Localization of the experimental area

The study was performed, under rainfed conditions, from July to May, in the Experimental Field of the Universidad del Papaloapan, Loma Bonita Campus, Oaxaca, Mexico (18° 01' 19" N, 95° 51' 33" W, and 26 m of altitude). This region has a tropical climate with rainfall during summer and an annual mean temperature and precipitation of 25 °C and 1,845 mm. The average monthly temperature and total monthly precipitation throughout the study were 24.2 °C and 1,038 mm, respectively (FAM, 2011). Based on a fertility analysis, the soil had a sandy loam texture with a pH of 4.9, 1.8% of organic matter, and 14.8, 23.5, 37.0, 241.0, and 42.3 mg kg⁻¹ of N, P, K, Ca, and Fe, respectively.

Treatments and experimental design

Four cutting heights were evaluated: 5, 10, 15, and 20 cm above the soil surface during the rainy (June-October), norther (November-February), and dry (March-May) seasons. Treatments were distributed in a randomized complete block design with four replicates. The experimental plot consisted of four 4.8 m-long furrows spaced 80 cm apart; Insurgente grass shrubs were spaced 80 cm apart. Thus, the experimental plot size was 4.8×3.2 m, with a total area of 15.36 m² and an available area of 5.12 m² located in the two central furrows, leaving the last grass shrub at each end.

Experiment establishment and management

For this study, the vegetative material (stumps with three to five stems) of an Insurgente grass pasture, sown in November 2006, was used. At the beginning of each season of the year, forage was manually harvested at the height of 10 cm. Subsequently, at 30 days of regrowth, forage was subjected to the different experimental cutting heights to evaluate forage production. During the dry season (March-May), forage can only be harvested two times. Therefore, the same number of harvests was carried out in the three different seasons. Harvests were carried out at four, five, and six weeks after regrowth for the rainy, norther, and dry seasons, respectively. On August 1, 2009, during the rainy season, the pasture was subjected to the different experimental cutting heights. The first forage harvest occurred on August 29, the second on September 26. On December 1, during the norther season, the pasture was subjected to the different experimental cutting heights. The first forage harvest occurred on January 5 (2010), the second on February 9. On March 5, during the dry season, the pasture was subjected to the different experimental cutting heights. The first forage harvest occurred on April 16, the second on May 28. The pasture was not fertilized, but weeds were controlled with the herbicide 2,4-D amine at 15 days of regrowth and subsequent manual weeding.

Evaluated variables

We evaluated plant height (PH, cm), green matter yield (GMY, kg GM ha⁻¹), dry matter yield (DMY, kg DM ha⁻¹), growth rate (GR, kg DM ha⁻¹).

day⁻¹), and the yield of morphological components: leaf yield (LY), sheath yield (SY), and stem yield (StY).

PH was measured in four shrubs per plot, from ground level to the upper end of the plant, without stretching the leaves. GMY was determined by cutting and weighing the fresh forage obtained from four randomly selected shrubs per plot based on plant density. DMY was determined from a subsample of 150 g obtained from the total fresh forage collected. This subsample was separated into its morphological components: leaf, sheath, and stem. Subsequently, each component was dried in a forced-air oven at 65 °C for 48 h. The dry matter yield of each morphological component was calculated using the following equation:

$$DMY=(FW \times dw)/fw$$

where *DMY*=dry matter yield, *FW*=fresh weight of the sample, *dw*=dry weight of the subsample, and *fw*=fresh weight of the subsample. The total forage yield (kg DM ha⁻¹) for each season was obtained by adding the yield of the two harvests carried out. GR was calculated using the following equation:

$$GR=HF/t$$

where *GR*=growth rate (kg DM ha⁻¹ day⁻¹); *HF*=harvested forage (kg DM ha⁻¹), and *t*=days elapsed between treatment and harvest.

Statistical analysis

Data were subjected to an analysis of variance based on the randomized complete block experimental design with four replicates. Means were compared using the Tukey test with a significance level of 5% (SAS, 2011).

RESULTS AND DISCUSSION

Plant height and forage yield

Results show a significant effect of the interaction between cutting height and season on PH, GMY, and DMY ($P < 0.01$). The tallest plants (36 and 42 cm) were obtained during the rainy season at cutting heights of 15 and 20 cm. During the norther season, the tallest plants (27 and 31 cm) were obtained at 15 and 20 cm, respectively. Similar heights (25 and 31 cm) were observed during the dry season at cutting heights of 15 and 20 cm, respectively (Table 1).

Joaquín et al. (2019) reported similar results in *U. brizantha* cv. Insurgente. They obtained plant heights of 43, 29, and 19 cm with a cutting height of 15 cm during the rainy, norther, and dry seasons, respectively. Additionally, Martínez et al. (2008) observed the greatest forage yield of *U. humidicola* cv. CIAT 6133 at the harvesting height of 15 cm.

In this study, the highest plant heights obtained at 15 and 20 cm, regardless of the season, were attributed to a higher growth rate (Table 2).

These results indicate that with higher cutting heights, the plant remains with a greater number of leaves and reserve substances that influence plant growth and, consequently, result in higher plant heights (Beltrán et al., 2002).

Regarding GMY, the highest values (2,484 and 2,410 kg GM ha⁻¹) were obtained during the rainy season with cutting heights of 15 and 20 cm, respectively. These values ($P > 0.05$) were similar to those obtained at 5 and 10 cm (1,875 and 2,293 kg GM ha⁻¹, respectively); however, they were significantly different and higher ($P \leq 0.05$) to those obtained during the norther and dry seasons, with average values of 1,038 and 1,018 kg GM ha⁻¹, respectively (Table 1). DMY behaved similarly; the higher values (606 and 582 kg DM ha⁻¹) were observed during the rainy season at 15 and 20 cm, respectively. These values were similar ($P > 0.05$) to those obtained

Table 1. Plant height and green and dry forage yield of *Urochloa brizantha* cv. Insurgente at four different cutting heights and in three seasons of the year.

Season of the year	Cutting height (cm)			
	5	10	15	20
Plant height (cm)				
Rainy	24 ^{cd}	31 ^{bc}	36 ^{ab}	42 ^a
North winds	14 ^e	21 ^{de}	27 ^{cd}	31 ^{bc}
Dry	13 ^e	20 ^{de}	25 ^{cd}	31 ^{bc}
Fresh matter yield (kg FM ha⁻¹)				
Rainy	1,875 ^a	2,293 ^a	2,484 ^a	2,410 ^a
North winds	943 ^b	1,012 ^b	1,128 ^b	1,067 ^b
Dry	942 ^b	920 ^b	1,026 ^b	1,185 ^b
Dry matter yield (kg DM ha⁻¹)				
Rainy	387 ^b	525 ^a	606 ^a	582 ^a
North winds	212 ^e	226 ^{de}	255 ^{cde}	256 ^{cde}
Dry	316 ^{bcd}	326 ^{bc}	362 ^b	408 ^b

abcde Values with different letters within each variable, regardless of the row and column, indicate a significant difference ($P < 0.05$).

at 10 cm (525 kg DM ha⁻¹) but differed and were greater (P≤0.05) than those obtained at 5 cm (387 kg DM ha⁻¹). During the norther season, the highest dry matter values (255 and 256 kg DM ha⁻¹) were observed at cutting heights of 15 and 20 cm, respectively. The same occurred during the dry season, where the highest values (362 and 408 kg DM ha⁻¹) were obtained at 15 and 20 cm (Table 1). Similar results were previously reported for *U. humidicola* cv. CIAT 6133, where the highest forage yield (11,154 kg DM ha⁻¹ year⁻¹) was obtained with a cutting height of 15 cm (Martínez *et al.*, 2008). In *U. humidicola* cv. Chetumal, the highest forage production was obtained with harvesting heights of 13 to 15 cm every 28 days (Cruz *et al.*, 2017). Similarly, in hybrid *Urochloa* cv. Cobra, the highest amount of forage was obtained after harvesting at 15 cm every 35 days after regrowth (Rojas *et al.*, 2018).

The highest amount of green and dry matter forage obtained with 15 and 20 cm cutting heights during the rainy season was attributed to the precipitation recorded during August and September (250 and 580 mm, respectively), which influenced plant growth, and the higher number of remaining leaves, which resulted in a faster recovery of the photosynthetic capacity of the plant and, consequently, a higher forage yield (Dos Santos *et al.*, 2011).

In this study, the average distribution of forage yield was 48, 21, and 31% during the rainy, norther, and dry seasons, respectively. However, for this same species, cultivar, and study location, Joaquín *et al.* (2019) reported a forage yield distribution of 65, 30, and 5% during the rainy, norther, and dry seasons, respectively. Furthermore, a previous study in *U. humidicola* cv. Chetumal reported a forage yield distribution of 66, 26, and 7% during the rainy, norther, and dry seasons, respectively (Cruz *et al.*, 2017). While the forage yield of hybrid *Urochloa* cv. Mulato II, at a cutting height of 15 cm and harvesting at 28 days, was 48.8, 29.5, and 21.6% during the rainy, norther, and dry seasons, respectively (Cruz *et al.*, 2018). This difference in forage yield distribution could be attributed to the different climatic conditions, precipitation and temperature, and pasture management practices during the study.

Morphological composition

The interaction between the cutting height and season of the year was significant for LY, SY, and StY (P≤0.05; Table 2). The highest LY values (554 and 534 kg DM ha⁻¹) were observed during the rainy season with cutting heights of 15 and 20 cm, respectively. The average distribution for the rainy, norther, and dry seasons was 48, 22, and 30%, respectively. LY contributed 90% to the total forage yield. Similarly, during the norther season, the highest LY values (254 and 252 kg DM ha⁻¹) were observed at cutting heights of

Table 2. Growth rate and leaf, sheath, and stem yields of *Urochloa brizantha* cv. Insurgente at four different cutting heights and in three seasons of the year.

Season of the year	Cutting height (cm)			
	5	10	15	20
Lamina yield (LY; kg DM ha⁻¹)				
Rainy	371 ^b	476 ^b	554 ^a	534 ^a
North winds	204 ^f	219 ^e	254 ^{de}	252 ^{def}
Dry	265 ^{de}	278 ^d	320 ^{cd}	366 ^{bc}
Sheath yield (SY; kg DM ha⁻¹)				
Rainy	30 ^b	45 ^a	50 ^a	46 ^a
North winds	6 ^e	5 ^e	4 ^e	3 ^e
Dry	12 ^d	13 ^{cd}	14 ^{cd}	19 ^c
Stem yield (StY; kg DM ha⁻¹)				
Rainy	0.3 ^c	2.0 ^a	0.7 ^b	0.4 ^c
North winds	0.0 ^c	0.0 ^c	0.1 ^c	0.1 ^c
Dry	0.0 ^c	0.0 ^c	0.0 ^c	0.0 ^c
Growth rate (GR; kg DM ha⁻¹ d⁻¹)				
Rainy	27 ^{ab}	33 ^a	31 ^a	33 ^a
North winds	14 ^c	16 ^{bc}	19 ^{bc}	17 ^{bc}
Dry	13 ^c	15 ^c	15 ^c	17 ^{bc}

a,b,c,d,e,f Values with different letter within each variable, regardless of row or column, indicate significant difference (P≤0.05).

15 and 20 cm, respectively. The same occurred during the dry season, where the maximum values (320 and 366 kg DM ha⁻¹) were recorded at 15 and 20 cm. SY behaved similarly. The highest values (45, 50, and 46 kg DM ha⁻¹) were observed during the rainy season with cutting heights of 10, 15, and 20 cm. However, stems were only observed during the rainy season; the highest value (2 kg DM ha⁻¹) was obtained with a cutting height of 10 cm (Table 2).

These results confirmed the previous observations of Joaquín *et al.* (2019), who reported, for this same species and cultivar, that the highest leaf ratio was obtained during the rainy season, followed by the norther and dry season, where leaf yield contributed 80% to the total forage yield, regardless of the season of the year. In *U. humidicola* cv. Chetumal, a

previous study reported a leaf yield distribution of 86, 20, and 30% during the rainy, norther, and dry seasons, respectively (Cruz et al., 2017). Moreover, in hybrid *Urochloa* cv. Cobra, Rojas et al. (2018) observed the highest leaf yield value with the cutting height of 15 cm, 35 days after regrowth. Dos Santos et al. (2011) reported that pastures have good energy reserves and significant amounts of leaves when harvesting at mild intensities. However, with moderate to severe defoliation, the availability of stem photosynthates decreases, and, consequently, leaf yield also decreases. The low leaf yield observed in this study resulted from the low plant density (15,525 plants ha⁻¹; datum not included), since it has been indicated that the distribution of forage yield components is influenced by the season and plant density (Rojas et al., 2016).

Growth rate

The height and season interaction was significant for GR ($P \leq 0.01$). The highest values were obtained during the rainy season, regardless of the cutting height, with an average of 31 kg DM ha⁻¹ day⁻¹. Similar behavior was observed during the norther and dry seasons, with averages of 16.5 and 15.0 kg DM ha⁻¹ day⁻¹, respectively. Cruz et al. (2018), in a previous study with hybrid *Urochloa* cv. Mulato II, also reported the highest growth rate during the rainy season, followed by the norther and dry seasons. Furthermore, Garay et al. (2019) observed the highest growth rate (136 kg DM ha⁻¹ day⁻¹) in *Pennisetum ciliare* cv. H-17 at four weeks of age, during the rainy season. The growth rate during the dry season was 3.4 kg DM ha⁻¹ day⁻¹.

The highest growth rate was observed during the rainy season due to the higher precipitation and temperature (810 mm and 26 °C). During the dry and norther seasons, the growth rate decreased due to low precipitation (96 and 15 mm, respectively). According to Lemaire et al. (2000), humidity deficit limits grass growth during the dry season, which results in low growth rates. Furthermore, low temperatures decrease growth rate by inhibiting leaf growth, decreasing canopy development, leaf area index, and photosynthetic capacity.

CONCLUSIONS

This study suggests that the best cutting height for *Urochloa brizantha* cv. Insurgente ranges between 15 and 20 cm for each of the evaluated seasons. However, further research is required to determine more precisely the best cutting height for Insurgente grass.

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