Article

Structural characteristics of grasses: Mulato II, Convert 330 and Convert 431 (hybrid *Urochloa*)

Herminio Aniano-Aguirre[1]
María de los Ángeles Maldonado-Peralta[2]
Lauro Gasga-Pérez[1]
Urfila Victoria Pelaez-Estrada[1]
José Antonio Hernández-Marín[3]
Adelaido Rafael Rojas-García[2§]

[1]National Technological Institute of Mexico-*Campus* Technological Institute of Pinotepa. National Pinotepa, Oaxaca, Mexico. (herminioaa@hotmail.com; gasper253@hotmail.com; urfila.pe@pinotepa.tecnm.mx). [2]Faculty of Veterinary Medicine and Zootechnics No. 2-Autonomous University of Guerrero. Cuajinicuilapa, Guerrero, Mexico. (mmaldonado@uagro.mx). [3]Department of Veterinary, Medicine and Zootechnics-Division of Life Sciences-University of Guanajuato. Irapuato-Salamanca *Campus*. (jahmarin@ugto.mx).

[§]Corresponding author: rogarcia@uagro.mx.

Abstract

The objective was to evaluate the grasses of the genus *Urochloa*: Mulato II, Convert 330 and Convert 431 by varying the cut ages in the attributes: stem population dynamics, tissue replacement, leaf:stem ratio, weight per stem and dry matter yield. The research was carried out in the grasslands of the Technological Institute of Pinotepa, in the locality of San José Estancia Grande, Oaxaca. The treatments were the genotypes: Mulato II, Convert 330 and Convert 431. The data were analyzed using a completely randomized block design arranged in split plots and four repetitions, the procedure used was PROC GLM of SAS. The Mulato II grass had the highest stem density with an average of 540 stems m^{-2}, while the Convert 330 grass had the lowest stem density throughout the research, with an average of 220 stems m^{-2}, tending to increase slower over time ($p< 0.05$). The grass that obtained the highest net growth was Convert 330, followed by Mulato II and, at the end, Convert 431, with an average of 169, 133 and 104 cm $stem^{-1}$, respectively ($p< 0.05$). On day 49 after cutting, the Convert 330 grass obtained the highest yield with 4 091 kg DM ha^{-1} ($p< 0.05$). In conclusion, the Convert 330 genotype showed better structural characteristics in the grassland, which reflects a higher dry matter yield.

Keywords: *Urochloa*, leaf elongation, stem population, weight per stem.

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Introduction

In the Mexican tropics, the management of animal production systems is carried out extensively; where the forages used are native and the grasslands are managed with annual burns, the grasses have adapted to the conditions and the cattle are fed with the natural regrowth, which emerges from the reactivation of carbohydrates and nutrients stored in the dormant meristems (Li *et al*., 2016; Wang *et al*., 2017), in the rainy season, this management generates nutritional imbalance and loss during the dry season. This indicates that the native grasslands respond to seasonality, as they present wide resistance and maintain the population density of stems (Ramírez *et al*., 2011).

In the different systems of forage production, for grazing, the study of yield components, such as tissue replacement rate and stem dynamics, should be established in all regions of the country, because it seeks strategies that allow the management of grasslands, including the response of the crop to the intensity of grazing (Landsberg *et al*., 2003); in addition to fact that it decreases their loss and deterioration (Hodson and Da Silva, 2002; Castro *et al*., 2013), in such a way that the persistence of simulated or real grazing has a direct effect on the morphology and physiology of plants (Fornoni *et al*., 2003); it is worth mentioning that this is coupled with plasticity (Wang *et al*., 2017).

Studies conducted by Ramírez *et al*. (2011) in *Megathyrsus maximus* (Jacq.) B. K. Simon & S. W. L. Jacobs (syn. *Panicum maximun* Jacq.) *cv* 'Mombaza' mention that the plants had lower dynamics of stem replacement during the dry season, contrary to the rainy season, but in this season, there was less survival of the population, Castro *et al*. (2013) report a similar situation in forages that develop in temperate climate. Ramírez *et al*. (2010) recommend that, to decrease loss due to leaf senescence and death, the Mombaza grass should be harvested every five weeks during the dry season and every three weeks in the rainy season. Other study conducted on different cultivars of *Cenchrus purpureus* (Schumach.) Morrone (syn. *Pennisetum purpureum* Schumach) indicates that the stems of young grasses showed a higher mortality rate, compared to tillers of older grasses and, in the dry season, they have a higher population density (Rueda *et al*., 2018).

Hybrids of the genus *Urochloa* (syn. *Brachiaria*) respond to edaphoclimatic conditions and when they are appropriate, they have higher growth rate, yield, leaf:stem ratio (Fagundes *et al*., 2006; Nguku *et al*., 2016; Maldonado *et al*., 2020a). In evaluations in Mulato II grass (hybrid *Urochloa*), it is reported that there is a greater population of stems when grazing or cutting is carried out at 15 cm in height, compared to an intensity of 10 cm (Rojas *et al*., 2020), the cobra grass (*Brachiaria* hybrid BR02/1794; Rojas *et al*., 2018) responds in the same way. Maldonado *et al*. (2020b) evaluated three species of *Urochloa* (Piata, Señal and Insurgente) and mention that Insurgente and Señal increased the stem population to a maximum and Piata developed more steadily without rapidly decreasing the population like Insurgente and Señal. The objective of the present study was to evaluate the rate of tissue replacement and dynamics of the population of *Urochloa* stems at different cut stages, in the dry tropics.

Materials and methods

The research was carried out from August to December 2017 in the experimental unit of the Technological Institute of Pinotepa, located at kilometer 26 of the Pinotepa Nacional, Oaxaca-Acapulco highway, south of the locality of San José Estancia Grande, Oaxaca, located at coordinates 16º 22’ and 98º 13’ at 60 masl. According to the Köeppen climate classification, it has an Aw (w) ig climate, corresponding to a warm subhumid climate (García, 2004). The highest rainfall occurred in August, September and October with an accumulated of 854 millimeters, the maximum temperature occurred in August with an average of 34.6 °C, while the minimum was in December with 12.5 °C (Figure 1).

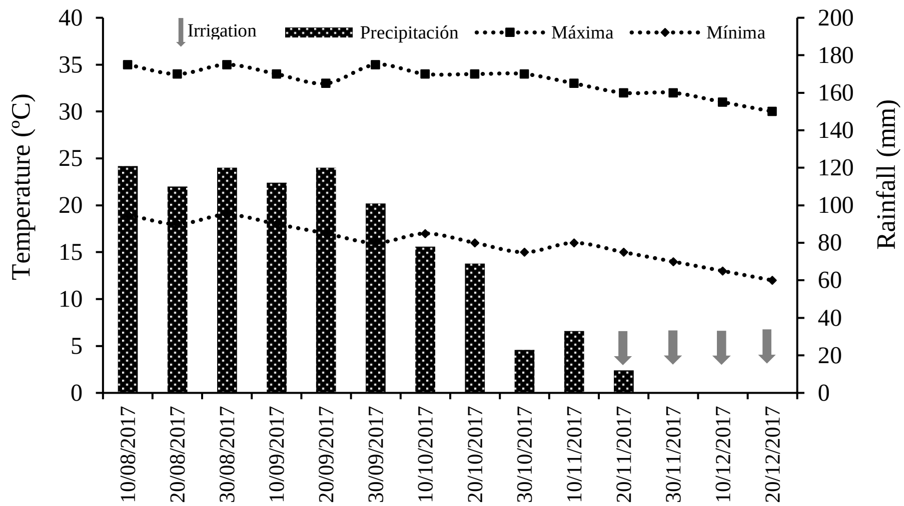

Figure 1. Irrigation, rainfall, maximum and minimum temperature during the study period.

Plot management

Sowing was carried out on August 10, 2017, 8 kg ha^{-1} of viable pure seed of three grasses of the genus *Urochloa*, Mulato II, Convert 330 and Convert 431, were used. The method of sowing was direct at a distance between furrows of 50 cm and continuous lines between plants. Four plots of 10 × 5 m were sown, these plots were divided into eight areas of 2.5 × 2.5 m, in order to evaluate a growth analysis with eight cut stages. The soil had a clay-sandy texture, pH of 4.8 to 5, deficient in organic matter with 1.5%.

Weeds were controlled manually with the help of a hoe, two nitrogen fertilizations were carried out, comprising 100 and 150 kg ha^{-1} with urea (46-00-00) deposited in the soil in strips 3 cm deep and 10 cm away from the plant, being applied at 48 and 67 days after sowing, respectively. Eight days before starting the growth analyses, on October 12, 2017, a homogenization cut was made at a height of 10 cm in all the experimental plots manually with the help of pruning shears. Four irrigations were provided with the drip method in November and December every ten days up to field capacity with a net layer of 200 mm for the good regrowth of the grasses (Figure 1).

Variables evaluated

Stem population dynamics

In this variable of stem density (stems m^{-2}), two PVC rings of 10.4 cm in diameter were placed, which delimited a tiller at the beginning of the experiment, in each experimental unit. All the stems present inside the ring were marked with cable rings of the same color, which were considered as the initial population. Subsequently, every week, for eight weeks, the new stems were marked with rings of different color, a different color was used for each generation, and the dead stems were counted, and the ring was removed.

Tissue replacement

Total growth, net growth and leaf senescence were evaluated in a 2 m long transect, five stems of each grass were randomly selected, which were identified with wire rings of different color. On the stems, the following was measured: the length of the leaf blade, from the base of the ligule to the apex in green leaves or to the base of the chlorotic tissue in senescent leaves. A linear regression equation was obtained, considering the leaf area as the dependent variable and the length of the midrib as the independent variable (Castro *et al*., 2013).

Leaf:stem ratio

The data of the leaf:stem ratio was obtained by weekly cutting two squares of 50 × 50 cm in each experimental plot, leaving 10 cm of leaf area remaining; separating into leaf and stem and it was deposited in a forced air oven at 55 °C until constant weight, recording the weight to estimate the dry matter per hectare at the different stages of cut and finally dividing the leaf by the stem.

Weight per stem

It was recorded weekly one day before the cut, 10 stems of each grass were cut at ground level, dried on a forced air oven at 55 °C until constant weight and their weight was recorded. The average weight per stem was obtained by dividing the total weight by the number of stems harvested.

Dry matter yield

In each grass genotype, every seven days two squares of 50 × 50 cm were cut in each experimental plot at 10 cm in height, randomly selected, then deposited in a forced air oven at 55 °C until constant weight, recording the weight to estimate the dry matter per hectare.

Statistical analysis

The data were analyzed using a completely randomized block design with arrangement in split plots and four repetitions, the procedure used was PROC GLM of SAS (2013), where the effects of cut frequency were considered as fixed. Multiple comparison of the means of the treatments was performed by means of the Tukey test (α= 0.05).

Results and discussion

Stem population dynamics

The highest stem density was recorded from the cut age of day 49 to 56, regardless of the grass, with an average of 410 stems m^{-2} (Figure 2). The Mulato II grass showed the highest stem density at the end of the curve with 540 stems m^{-2}, with continuous and accelerated growth, while the grassland with Convert 330 grass had the lowest stem density throughout the research, with an average of 220 stems m^{-2} and the population trend was slower in time than the other treatments ($p < 0.05$). For its part, the Convert 431 grass was the intermediate with a stem population of 390 stems m^{-2} and a drastic increase in stems in the stage of 21 days, and then it slowly increased as shown in Figure 2.

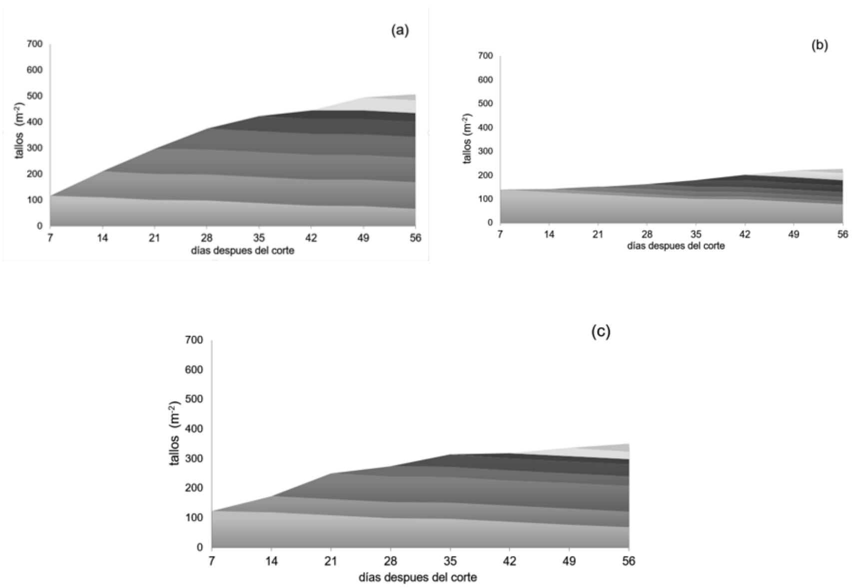

Figure 2. Changes in stem dynamics of three species of the genus *Urochloa.* a) Mulato II; b) Convert 330; and c) Convert 431.

The three grasses had lower stem density at the start of the growth curve (day 7) and it can be attributed to the start of the growth curve since, at the beginning of regrowth, the tillers tend to have a smaller population of stems and increase with the time of establishment of the grassland, greater leaf area and therefore, greater weight as stated by several authors (Ramírez *et al*., 2011; Rueda *et al*., 2020; Maldonado *et al*., 2020a). Another factor was competition since the stems regrowth in a grassland as a usually dense population, where the surrounding vegetation exerts a very strong influence on the inherent characteristics of each species (Matthew *et al*., 1996; Rueda *et al*., 2018).

Studies such as those of Maldonado *et al*. (2020b), in the dry tropics in the population density of *Urochloa* stems, obtained results similar to this study, with an average of 450 stems m^{-2}. Rodolfo *et al*. (2015), when assessing elephant grass (*Pennisetum purpureum*), observed 293 stems m^{-2} in the initial regrowth state, followed by a significant increase and the highest values in the intermediate state of 420 stems m^{-2} and a decrease in the final state with 331 stems m^{-2}. In gamba grass (*Andropogon gayanus* Kunt), Ramírez *et al*. (2020) report an average of 350 stems m^{-2} in a growth curve, results similar to those of this trial. For their part, Maldonado *et al*. (2019), in Cuba 22 grass in the tropics of Mexico, obtained a population smaller than that of this study, with an average of 76 stems m^{-2}, being very variable over time.

Tissue replacement

Figure 3 shows leaf elongation, net growth and senescence by stem of three *Urochloa* grasses, Mulato II, Convert 330 and Convert 431, as the days of cut days vary. The grass that obtained the highest net growth was Convert 330, followed by Mulato II and finally Convert 431, with an average of 169, 133 and 104 cm stem^{-1}, respectively (p< 0.05). The Convert 330 grass showed rapid and higher leaf elongation on all days of cut. Mulato II began to decline from day 41, while Convert 330 and 431 did so from day 49 (p> 0.05). Regarding senescence, in the three grasses it started from the cut stage of 35 days; with Convert 330 showing the highest senescence with 9.2, followed by Mulato II and Convert 431 with 6.2 and 5.6 cm stem^{-1}, respectively (p< 0.05).

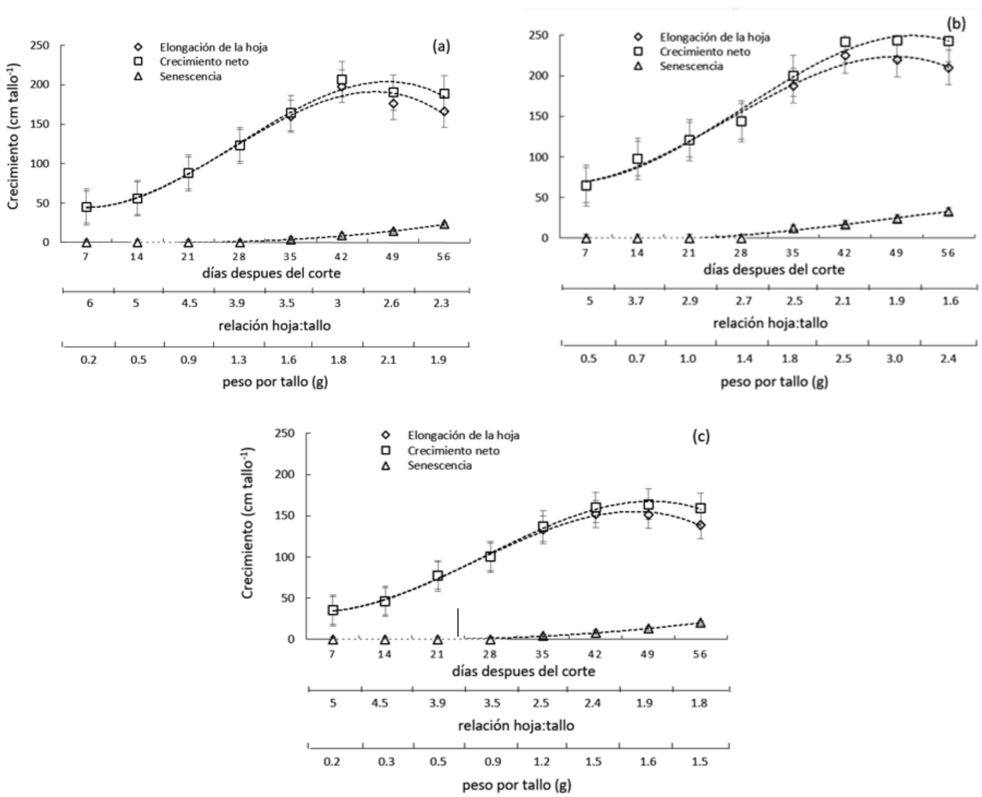

Figure 3. Tissue replacement, leaf:stem ratio and weight per stem (g) of *Urochloa* grasses, Mulato II. a) Convert 330; b) Convert 431; and c) in growth curves.

The greater growth and trend of these *Urochloa* grasses is related to a promotion of cell division and elongation (Taiz and Zeiger, 2002; Wilson *et al*., 2008). In *Urochloa* grasses, Mandonado *et al*. (2020b) mention that at the end of the forage accumulation curve, losses due to senescence increase and therefore, the net accumulation of forage decreases, as in this research. For their part, Rojas *et al*. (2018); Maldonado *et al*. (2019), in tropical grasses, mention that the maximum leaf growth occurs in the cut stage of 49 days, then the growth rates decrease due to a progressive increase of senescent stems and material. After a defoliation, the rate with which a forage recovers depends on the reserve carbohydrates in roots, remaining leaf area and the number of vegetative buds initiated, which increases the photosynthetic capacity of the leaves and greater elongation and net foliar growth (Li *et al*., 2016; Wang *et al*., 2017).

Leaf:stem ratio

The leaf:stem ratio is a measure that represents the quality of the grassland, if it is greater than 1, the leaf will be higher in yield compared to the stem component in the grassland. In the three grasses, the leaf:stem ratio decreased as the cut stage passed ($p < 0.05$). The highest leaf:stem ratio was reported in Mulato II grass in the cut stage of seven days with a value of 6, decreasing until day 56 with 2.3, while the lowest value occurred in Convert 330 grass, starting with a ratio of five in the cut stage of seven days and ending in the cut stage of 56 days with a leaf:stem ratio of 1.6 ($p < 0.05$).

The decrease in the leaf:stem ratio as the cut age increased is related to the decrease in net growth and increase in senescence, as shown in Figure 3. The high leaf-stem ratios and the minimal appearance of foliar senescence can be explained by the habit of tillering and semi-erect growth of *Urochloa* grasses, because it is concentrated in the lower strata of the grassland, in this case, 10 cm of leaf area was left remaining (Rojas *et al*., 2020; Maldonado *et al*., 2020b).

In Mombaza grass (*M. maximum*), Ramírez *et al*. (2009), when evaluating different cut frequencies in the rainy and dry seasons, reported a decrease in the leaf:stem ratio in the dry season (80%) compared to the rainy season; in addition, when the age of regrowth increases, the leaf:stem ratio decreases, they obtained on average 8.4 on day 21, decreasing on day 49 with a leaf:stem ratio of 3.8, trend and results similar to those of this study. In Mulato I (hybrid *U.*), other researchers Cruz *et al*. (2011) report similar results, they mention that the leaf:stem ratio depends on the management given to the grassland, height and cut stages. Maldonado *et al*. (2020b) obtained similar results in grasses of the genus *Urochloa*, having a higher leaf:stem ratio in early phenologies and decreasing as the time and senescence of the plant increase, obtaining a leaf:stem ratio of 8 at the regrowth age of seven days in Piata grass.

Weight per stem

Regardless of the grasses, the weight per stem increased as the evaluation time passed (Figure 3). The highest weight per stem was obtained in the Convert 330 grass at 49 days, with 3 g, followed by Mulato II and Convert 431 with 2.1 and 1.6 g ($p < 0.05$) on that same day. The highest weight per stem was obtained by the Convert 330 grass with 0.5 g in the cut stage of seven days ($p < 0.05$). The weight per stem is closely related to forage yield and stem dynamics since as the weight per stem increases, the dry matter yield increases; however, the population of stems decreases, as is the case of the Convert 330 grass in this research. Several authors record this trend (Rueda *et al*., 2018), due to inter-specific competition for resources such as water, light and nutrients.

In this regard, several researchers mention (Cruz *et al*., 2011) the age of the plant as a factor that determines the increase in weight per stem and senescent material, decreasing the formation of leaves, appearing in the most advanced cut stages. However, it does not only occur due to the age of the plant, but also due to the management given to the grassland and selected species (Maldonado *et al*., 2020b).

Dry matter yield

Table 1 shows the dry matter yield of the grasses Mulato II, Convert 330 and Convert 431 as the days of cut of the grassland vary. In the three grasses, the yield in the first days of growth was slow and then accelerated and then decreased. The highest yield of dry matter, on average, was obtained in the three grasses at 49 days of regrowth with 3 531 kg DM ha^{-1} (p< 0.05). The genotypes obtained the following yield, from highest to lowest: Convert 330 > Convert 431 > Mulato II with 1 845, 1 689 and 1 502 kg DM ha^{-1}, respectively (p< 0.05). On day 49 after cutting, the Convert 330 grass obtained the highest yield with 4 091 kg DM ha^{-1} (p< 0.05).

Table 1. Dry matter yield (kg DM ha^{-1}) of hybrid *Urochloa* grasses: Mulato II, Convert 330 and Convert 431 in growth curves.

Days of cut	Mulato II	Convert 330	Convert 431	Average
7	267 Fc	425 Ga	387 Fb	360 G
14	507 Ec	734 Fa	695 Eb	645 F
21	892 Dc	1 117 Ea	965 Db	991 E
28	1 288 CDc	1 499 Db	1 556 Ca	1 448 D
35	1 564 Cc	1 896 Cb	2 077 BCa	1 846 C
42	2 464 Ba	2 417 Ba	2 437 Ba	2 439 B
49	3 221 Ab	4 091 Aa	3 280 Ab	3 531 A
56	1 816 BCc	2 582 Ba	2 114 Bb	2 171 B
Average	1 502 c	1 845 a	1 689 b	

abc= means with the same lowercase literal in the same row are not different (p< 0.05); ABC= means with the same uppercase literal in the same column are not different (p< 0.05).

Several authors report the same behavior in dry matter yield in the analysis of growth in tropical grasses, an increase in the first days of regrowth to later to begin to decline as the leaves in the lower layers senesced (Maldonado *et al*., 2019; Rueda *et al*., 2020). In grasses of the genus *Urochloa*, Maldonado *et al*. (2020a) report the highest dry matter yield in three grasses, at 49 days of regrowth with 6 732 kg DM ha^{-1} in the Insurgente grass, followed by Piata and the lowest in Señal with 3 320 and 2 675 kg DM ha^{-1}, respectively (p< 0.05), results similar to those of this research. On the other hand, Rojas *et al*. (2018), in Cobra grass (hybrid *Urochloa*), obtained the highest dry matter yield at 56 days at a defoliation intensity of 15 cm with 2 550 kg DM ha^{-1}.

Conclusions

The genotype that obtained the best behavior in the characteristics of the grassland and yield was the Convert 330 grass and harvest it after 49 days of regrowth; nevertheless, longer evaluation time, genotypes and cut intensities with weight gain are recommended.

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