Yield and nutritional value of *Cenchrus purpureus* VC Maralfalfa grass

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ABSTRACT

Objective: Characterize the yield traits and nutritional values of Maralfalfa grass (*Pennisetum glaucum* L. × *P. purpureum* Schumacher), under humid tropical conditions.

Design/methodology/approach: The study was carried out in the Germplasm Bank from Rosario Izapa Experimental Unit, plant height, number of tillers, and fresh herbage and dry matter production were evaluated. Crude protein, neutral detergent fiber (NDF), acid detergent fiber (ADF) and *in vitro* dry matter digestibility (IVDMD) of grass samples were determined at 28, 42, 56, 70, 84 and 97 days.

Results: Plant height, number of trillers, and fresh herbage and dry matter production increased as cutting age increased. In relation to the nutritional value, the crude protein content decreased as the cutting age increased, but the NDF and ADF content increased, consequently, the DVDMS decreased.

Limitations of the study/implications: The study was carried out in the humid tropics; the evaluation is required to be carried out under dry tropic conditions.

Findings/conclusions: The appropriate harvest time of Maralfalfa grass in humid tropical conditions is between 42 and 56 days of regrowth, whereas nutritional values decrease over time.

Keywords: forage, feeding, cattle, humid tropics.

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INTRODUCTION

High solar radiation and year-round high temperatures characterize tropical climates; however, rainfall regimes are variable, and water excess or deficiency is the primary limitation for forage production in the tropics (Cardoso *et al.*, 2015). This limitation is reflected in forage production (kg of dry matter day^{-1}) available for grazing livestock (León *et al.*, 2018; Boval and Dixon, 2012). Additionally, grass age influences nutritional quality, with older grasses exhibiting increased proportions of structural carbohydrates in the cell wall and decreased cellular protein content (Verdecia *et al.*, 2011).

The Maralfalfa grass is originally from Colombia and was obtained through hybridization between *Pennisetum glaucum* (L.) R. Br. (syn. *Americanum* (L.) Leeke) and *P. purpureum* Schumacher. It thrives in altitudes ranging from 10 to 2,400 meters on soils with high organic matter content and good drainage. These soils are predominantly loamy-clay and loamy-sandy types, found in relatively dry climates with soil pH ranging from 4.5 to 5.0 (Castrejón *et al.*, 2017).

Maralfalfa has been utilized by livestock farmers in various regions of Chiapas; however, inadequate management has hindered its full production potential. Due to this lack of knowledge, it has not been effectively utilized in feeding systems to enhance meat and milk yields. In a study conducted by Citalán *et al.* (2012) in the Chiapa de Corzo region, production ranged from 9 t ha^{-1} of green matter at 30 days to 65.33 t ha^{-1} at 90 days. In Villaflores, Cárdenas *et al.* (2012) observed increases in total dry matter yield from 4.78 to 20.20 t ha^{-1} defining 60 days as the optimal age for cutting.

Research in other states demonstrates Maralfalfa's yield potential and quality. In Veracruz, Calzada *et al.* (2014) reported yields of 37,297 kg DM ha^{-1}. Ventura *et al.* (2017) achieved yields ranging from 8.2 to 20.2 t DM ha^{-1}. López *et al.* (2020) observed maximum growth rates at 56 days in fertilized plots and a maximum production of 10.4 t ha^{-1}. In Nayarit, Villanueva *et al.* (2022) observed yields of 50.2 t DM ha^{-1}. Gómez *et al.* (2020) concluded that Maralfalfa has superior nutritional value compared to most tropical grasses, with dry matter production of 17.0 t ha^{-1} at 60 days of regrowth. However, Hermitaño *et al.* (2022) mention that the optimal nutritional value based on *in vitro* dry matter digestibility and crude protein content occurs at 45 days of regrowth. In the eastern region of Yucatán, applying nitrogen and phosphorus resulted in the highest dry matter production for Maralfalfa during the rainy season, surpassing varieties such as Taiwan, OM-22, and CT-22 (Ramos *et al.*, 2015).

Maralfalfa is suitable for forage production during the dry season in the tropics, and due to its quality, it yields less than 200 mL g DM^{-1} and less than 50 mL of CH_4 g DM^{-1} (Camacho, 2020). In a study by Vargas and Cruz (2023), the amount of available carbon for Maralfalfa was quantified at 8.28 t of CO_2. Therefore, it is a forage grass with high yield and nutritional quality that, when properly managed, can be used by livestock farmers to transition from traditional livestock farming to alternative production systems with greater economic benefits and high environmental efficiency.

Accordingly, in humid tropical conditions, the cutting age of Maralfalfa grass is crucial for dry matter production and nutritional quality. Therefore, it is considered necessary to estimate the optimal cutting point to harvest the highest nutrient yield per hectare.

MATERIALS AND METHODS

The study was conducted at the Rosario Izapa Experimental Field of INIFAP, located in Tuxtla Chico Municipality, Chiapas, at coordinates 14.961864 latitude, −92.153272 longitude, and an elevation of 398.41 meters above sea level. The climate is warm and humid (INEGI, 2024), with monthly temperatures recorded as follows: average, maximum, and minimum of 26.2, 27.0, and 25.6 °C, respectively. The average annual precipitation is 3,894.6 mm, with the rainy season occurring from June to September. The driest month still receives over 40 mm of rainfall, and the winter rainfall percentage ranges from 5 to 10.2% of the total annual precipitation. The annual total evaporation is 1,384.2 mm, with an average of 115.35 mm, and maximum and minimum values of 155.0 and 111.5 mm, respectively. Solar radiation intensity averages 7 ± 1 hours of sunshine (CONAGUA, 2024). The soil type is classified as Eutric Sideralic Cambisol (Clayic, Humic) (INEGI, 2024), with varying textures among horizons: clayey, clay loam, and clay loam crumbs. The pH ranges from 5.7 to 5.9, organic matter content varies from 9.2 to 1.3%, and total nitrogen content ranges from 0.05 to 0.35% (Gómez *et al.*, 2018).

The grass was established under a randomized complete block design with a split-plot arrangement, comprising three replications. The main plot consisted of Maralfalfa grass, while the subplot treatments were cutting frequencies (Rao, 1998). Cutting frequencies were applied at 28, 42, 56, 70, 84, and 97 days after uniformization cutting. Yield component variables such as plant height (cm), number of tillers per m^2, and green matter yield (GM) in t ha^{-1} were measured. GM yield was determined by weighing the fresh weight of plants harvested from a square meter area cut at 15 cm height. To estimate dry matter yield (DM) in t ha^{-1}, a homogeneous 200 g wet sample was dried to constant weight at 60 °C. The initial weight was subtracted from the final weight, divided by the initial weight, and multiplied by 100. This percentage was then multiplied by the green matter yield to obtain the dry matter yield.

The dried samples were ground using a Wiley mill with a 2 mm sieve and scanned using a Near-Infrared Reflectance Spectrophotometer (NIR) to determine the percentages of crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) (Bonilla *et al.*, 2015; Basurto *et al.*, 2009), percentage of *in vitro* dry matter digestibility (DIVMS), and of rumen degradable protein (PDR) (Hoffman *et al.*, 1999). These analyses were conducted at the National Center for Research in Animal Physiology and Improvement of INIFAP, located in Ajuchitlán, Querétaro.

The data for plant height, number of tillers, green matter yield (GM) in t ha^{-1}, dry matter yield (DM) in t ha^{-1}, percentages of crude protein (CP), rumen degradable protein (%RDP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and *in vitro* dry matter digestibility (%DIVMS) were analyzed using the General Linear Model (Proc GLM) procedure of SAS (2011).

RESULTS AND DISCUSSION

Yield Components of Maralfalfa Grass

The results observed in Figure 1 (A) and (B) demonstrate that Maralfalfa grass has the capability of producing 18 to 42 tillers from 28 to 97 days. Simultaneously, plant height increases from 0.54 to 2.74 m. The tillering capacity of Maralfalfa is influenced by the activation of growth meristems; during the vegetative state, tillering occurs from meristematic centers that produce new plants. Tillers are structural units where new leaves, stems, and roots originate (Buguet and Bavera, 2001).

The green matter yield was 4.55, 9.93, 15.40, 26.25, 29.65, and 40.56 t ha^{-1} at 28, 42, 56, 70, 84, and 97 days of maturity, respectively. Maralfalfa's high capacity to accumulate green matter under tropical climate conditions provides ample availability of green forage to support feeding a larger number of animal units per day. This capability has been observed in various environments by other authors such as Prudencio *et al.* (2020), who reported green matter productions of 98.06 t ha^{-1} at 226 days post-planting. Similarly, Peña *et al.* (2020) achieved green matter yields ranging from 23.89 to 25.23 t ha^{-1} at 90 days of regrowth, using different fertilizer sources and doses. Cuzco *et al.* (2021) observed a green biomass accumulation of 17.4 t ha^{-1} at 45 days after cutting.

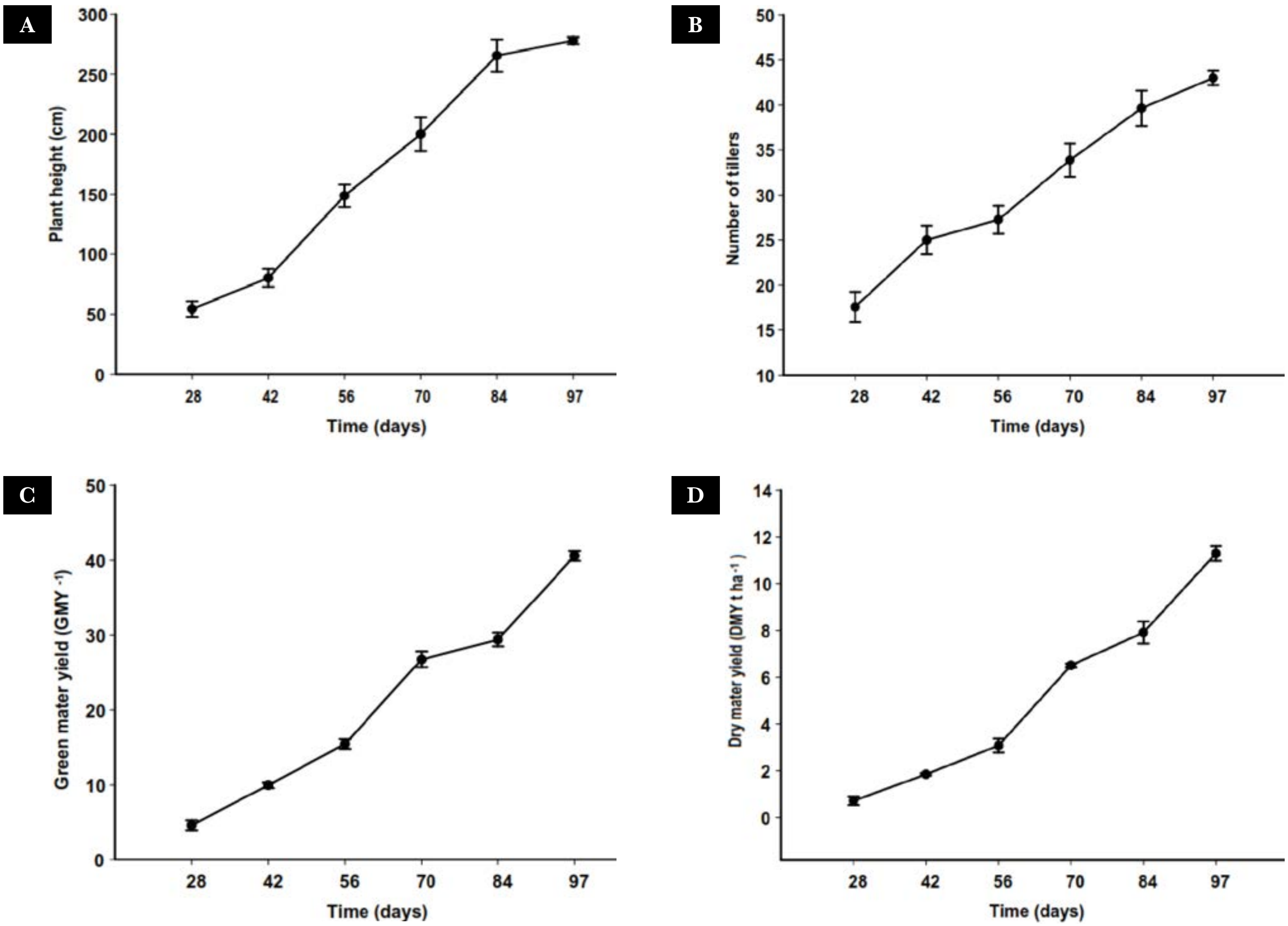

Figure 1. (A) Average number of tillers + SD; (B) Influence of maturity on average height (cm) + SD; (C) Average green matter yield t ha^{-1} + SD; and (D) Average dry matter yield t ha^{-1} + SD of Maralfalfa grass under the climate and soil conditions of Tuxtla Chico, Chiapas.

The dry matter yield of Maralfalfa grass was 0.71, 1.84, 3.18, 7.94, 8.00, and 11.38 t ha^{-1} at 28, 42, 56, 70, 84, and 97 days, respectively. Other studies highlight the yield potential in various environments: Del Aguila *et al.* (2023) achieved 557.8 kg DM ha^{-1} per cutting^{-1} at 49 days of regrowth in the humid tropics of Pucallpa, Peru. Reyes *et al.* (2021) reported 20.9 t DM ha^{-1} at 60 days of regrowth with the application of a complete formula, 30 g per plant of NPK-Mg-S (21-0-28-2-3). Arrieta *et al.* (2024) observed dry matter yields of 67.03 t ha^{-1} in the rainy season, 67.37 t ha^{-1} in the dry season, and an annual yield of 134.41 t ha^{-1}, demonstrating Maralfalfa's genetic capacity to maintain stable production under different environmental conditions. Maldonado *et al.* (2021) assert that the regrowth age of the plant significantly affects dry matter yield.

The chemical and nutritional composition of Maralfalfa grass was affected by maturity. Table 1 shows that the percentage of crude protein (CP) decreased from 16.26% to 7.16% from 28 to 97 days. These findings differ from those observed by Ramos *et al.* (2014), where an increase in plant age at cutting from 40 to 70 days significantly reduced protein content from 19.1% to 10.3%. Conversely, Márquez *et al.* (2007) recorded a protein content of 7.28% at 49 days after cutting. In a separate study, Correa (2006) reported protein values of 21.8% at 56 days and 11.9% at 100 days.

When the CP content of grass decreases, the availability of ruminal ammonia nitrogen also decreases, limiting microbial activity, reducing digestion rate, and slowing digesta transit (Hanigan *et al.*, 2021; Castillo *et al.*, 2014). Additionally, dry matter intake is affected (Mora *et al.*, 2015). In the present study, it was observed that rumen degradable protein (PDR) decreased from 9.95% on day 28 to 3.35% on day 96 after cutting. At the beginning of the growth stage, PDR constitutes 60% of the forage protein, decreasing to less than 50% after day 70.

As the vegetative cycle of the grass progresses, the NDF content increases due to cell wall lignification, which correlates negatively with forage digestibility (Estrada, 2002). To achieve optimal production results, it is recommended to provide forages containing 32 to 60% NDF (Shimada, 2005). Accordingly, Maralfalfa grass would ideally be harvested at a maximum of 28 days of age. However, at this age, its growth and dry matter accumulation are low. Therefore, there needs to be a balance between nutritional value and dry matter production, aiming for maximum production of digestible nutrients per hectare. Nava *et al.* (2021) detected differences in NDF content among regrowth ages, increasing from 67.7% at 72 days to 76.3% at 114 days. Álvarez *et al.* (2021) observed that as the age of the Maralfalfa plant progresses, the NDF content increases. In full plant analysis, they observed 67.06% at 33 days of regrowth, up to 79.06% at day 167, and they suggest that the optimal cutting time may be at 61 days.

The ADF (acid detergent fiber) is the fraction of dry matter that is not digestible, and its content showed a similar trend, increasing from 33.31% to 45.75% as the cutting age increased from 28 to 96 days. Lignification negatively impacts the digestion of cell walls, thereby reducing *in vitro* dry matter digestibility (IVDMD) with increasing ADF content.

In the present study, the IVDMD of Maralfalfa grass decreased as the cutting age increased (Table 1); specifically, it was 78.50% at day 28 and decreased to 64.91% at day 96. Ortíz *et al.* (2018) observed a reduction in true in vitro dry matter digestibility as the sampling period progressed, with values of 79.4% at 39 days of regrowth and 60.7% at 90 days. In another study, Knowles *et al.* (2008) reported an IVDMD of 62.3% at 45 days of regrowth. Sosa *et al.* (2006) obtained an IVDMD of 68.11% at 70 days, while Clavero and Razz (2009) achieved 62.45% after three weeks of growth.

Table 1. Influence of maturity on nutritional quality variables in Maralfalfa grass under the climate and soil conditions of Tuxtla Chico, Chiapas.

Quality variables (%)	Days of maturity at cutting					
	28	42	56	70	84	96
Crude protein	16.26	14.91	9.44	7.54	7.33	7.16
Rumen degradable protein	9.95	8.99	5.70	4.29	3.6	3.35
Neutral detergent fiber	60.47	62.9	71.19	72.2	72.59	73.50
Acid detergent fiber	33.31	36.31	42.42	42.48	43.96	45.75
in vitro dry matter digestibility	78.5	76.56	70.17	66.59	64.69	64.91

The results suggest the importance of considering the optimal cutting age between 42 and 56 days to maximize dry matter yield and maintain a balanced relationship between nutritional quality and forage productivity. The implications of this study highlight the relevance of adjusting Maralfalfa grass management practices according to its maturity to optimize its value as a feed resource for livestock in sustainable livestock production systems in humid tropical climate regions.

CONCLUSIONS

As the cutting age of Maralfalfa grass increases, there is an increment in tiller number, plant height, and both fresh and dry matter yield. However, protein content (PC) and rumen degradable protein (PDR) decrease, while neutral detergent fiber (FDN) and acid detergent fiber (FDA) contents increase, resulting in a reduction in *in vitro* dry matter digestibility (IVDMD). Therefore, the optimal cutting age for Maralfalfa grass ranges between 42 and 56 days of regrowth to maintain a balance between forage productivity and nutritional quality in livestock production systems in humid tropical climate regions.

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