grasses

Brief Report

Morphological and Productive Characteristics and Chemical Composition of Grasses in Degraded Areas Subjected to Pasture Recovery Methods

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Abstract: The objective of this study was to evaluate the morphological characteristics, yield and chemical composition of grasses in degraded areas subjected to pasture recovery methods. The randomized block design in a factorial scheme (4 × 5) with four replications (blocks) was used. The first factor was composed of four methods of pasture recovery: Closed pasture (CLP); Weed control (WC); Soil fertilization (SF); and Weed control + Soil fertilization (WC + SF). The second factor was composed of five species used for pasture recovery: *Brachiaria brizantha* cv. Marandu, *Brachiaria brizantha* cv. MG5, *Brachiaria brizantha* cv. MG4, *Andropogon gayanus* cv. Planaltina and *Panicum maximum* cv. Mombaça. The structural characteristics of green biomass yield, dry biomass yield and chemical composition were assessed in those grasses. An effect of the interaction ($p < 0.05$) between forage species and recovery methods on number of clumps, plant height and clump diameter, with superiority for cultivar MG4 in the WC + SF method. The green biomass yield was low in the evaluated grasses because of the advanced stage of the degradation of the pastures. Dry biomass yields increased ($p < 0.05$) when the WC + SF method was adopted, with a good response of grass MG4. There was an interaction ($p < 0.05$) between species and recovery methods on dry matter, mineral matter and neutral detergent fiber contents of the grasses, especially Marandu grass. The different types of grasses responded positively to the methods of pasture recovery with increased biomass and nutritional quality.

Keywords: degraded pasture; nutritive value; tropical grasses

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1. Introduction

The production of roughage presents seasonality due to the irregularity of rainfall. The tropical region of Brazil is characterized by periods of drought that affect the availability and quality of forage, impacting the production of grazing animals [1].

The forage yield and nutritional quality of grasses are guaranteed by the adequate management of pasture (maintenance fertilization) so that the nutritional needs demanded by the animals can be met, allowing at the same time the persistence and production of roughage. The amount of biomass of forage plants results in their growth from the continuous emission of tillers [2], which is a process that maintains the continuation and formation of pastures after animal grazing [3].

The production of roughage and the perenniality of pastures depend on several factors, such as recovery capacity and maintenance of leaf area after defoliation, which reflects negatively on forage production, determining its growth speed, chemical composition and forage accumulation. In the management of cultivated areas, a balance is sought between quality and roughage yield (optimal grazing point), aiming to meet the basic needs of animals [4].

Therefore, it is necessary to have information on how these grasses develop after the adoption of recovery methods for degraded pastures, i.e., if there are changes in their morphogenetic and structural characteristics and chemical composition. Thus, these variables need to be investigated in order to provide good-quality feed for animals, as they are characteristics that vary mainly by age and cultivated species, as well as by the soil and climate conditions and management to which the grass is subjected [5].

Thus, this study aimed to evaluate the morphological, productive and chemical composition characteristics of grasses in degraded areas subjected to different methods of pasture recovery.

2. Materials and Methods

The experiment was carried out at the Experimental Farm Alvorada do Gurguéia which is located in the Professora Cinobelina Elvas Campus of the Federal University of Piauí, in Alvorada do Gurguéia, Piaui, Brazil. According to Köppen the region has a tropical climate with summer rains [6] and two well-defined seasons: the dry season, which extends from May to October, and the rainy season, which extends from November to April (Figure 1), with geographic coordinates 8°23′09.82″ S and 43°50′56.97″ W.

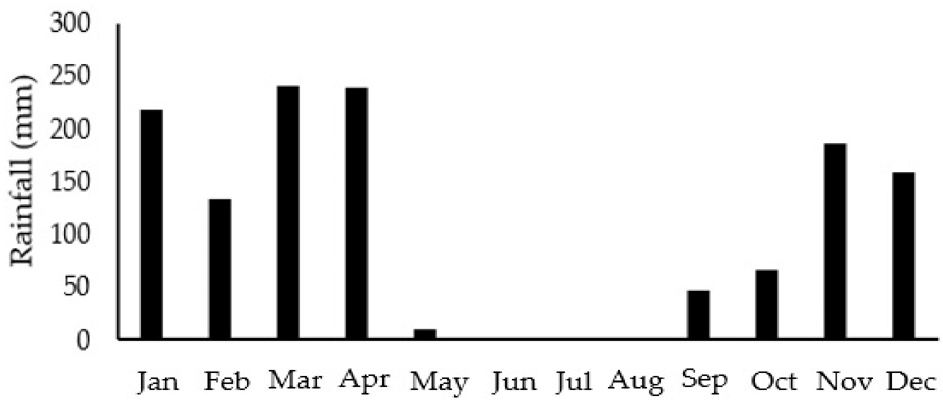


Figure 1. Rainfall (mm) over the experimental year (2014) in Alvorada do Gurgueia, Piauí.

For each grass species, a randomized block design in a factorial scheme (4 × 5) with four replications (blocks) was applied. The first factor consisted of four methods of pasture recovery: closed pasture with no animal grazing (CLP); weed control (WC); soil fertilization (SF); and weed control + soil fertilization (WC + SF), while the second factor was composed of five grass species (*Brachiaria brizantha* cv. Marandu, *Brachiaria brizantha* cv. MG5, *Brachiaria brizantha* cv. MG4, *Andropogon gayanus* cv. Planaltina and *Panicum maximum* cv. Mombaça).

The area used for pasture recovery consisted of pastures implemented in December 2010, with individual sowing of each grass in each area, and with *Brachiaria brizantha* cv. Marandu, *Brachiaria brizantha* cv. MG5, *Brachiaria brizantha* cv. MG4, *Andropogon gayanus* cv. Planaltina and *Panicum maximum* cv. Mombaça with signs of degradation was found in January 2014 with the presence of weeds. Four areas of 200 m^2 each (blocks) were randomly delimited and divided into 4 paddocks (50 m^2) one for each method of pasture recovery (treatment = method). After analyses performed in January 2014, it was observed that there was no need for soil correction (V = 46.8%) according to the species requirement (V = 40 to 45%) [6]. Treatment with fertilization was carried out to increase the recovery of the plant.

The collections were carried out in a square made of pipes (polyvinyl chloride), with dimensions of 1 m × 1 m and an area of 1 m^2. In each plot, the square was thrown four times at random, and four samples were collected. The first analysis of structural characteristics and green biomass yield was performed in March 2014, and the following occurred every 45 days in May and June. The dry biomass was obtained from the green biomass through drying in a forced circulation oven (±60 °C).

The number of clumps (unit/m^2) by manual counting, plant height (m) from the ground to the last expanded leaf using a ruler, clump diameter (m) from the circumference of the clump and number of tillers (unit) by manual count.

To evaluate the yield of green and dry biomass in the pasture, harvests were made at the residual height with scissors, and the samples were weighed and calculated in kilograms per hectare of green biomass and dry biomass of forage per harvest.

Three 500-g samples per plot were randomly collected in each recovery method for chemical composition analysis. These samples were sent to CPCE/UFPI, which were packed in paper bags to proceed to pre-drying in a forced air circulation oven, at 60 ± 5 °C, for 72 h, and then proceeded to grinding in a Willey knife mill (Solab), with a 2-mm sieve, in the Animal Nutrition Laboratory of CPCE/UFPI. Subsequently, analyses of dry matter (DM, No. 934.01), mineral matter (MM, No. 930.05), crude protein (CP, No. 981.10) and ether extract (EE, No. 920.39) were performed according to [7]. To determine the neutral detergent fiber (NDF), the methodology of [8] was adopted with modifications proposed by the manual of the Akon apparatus from Ancon Technology Corporation.

The results of morphological characteristics, productivity and chemical composition were evaluated through analysis of variance and the Scott–Knott test at 5% probability using SISVAR® 5.6 [9]. The statistical model applied was: $Zij = \mu + Ci + Fj + (C \times F)$ is + it, where Z represents the observed value, Ci the fixed effect of the methods of pasture recovery i (i = closed pasture with no animal grazing; weed control; soil fertilization; and weed control + soil fertilization), Fj the fixed effect of the grass species j (*Brachiaria brizantha* cv. Marandu, *Brachiaria brizantha* cv. MG5, *Brachiaria brizantha* cv. MG4, *Andropogon gayanus* cv. Planaltina and *Panicum maximum* cv. Mombaça), and (C × F) is the effect of interaction between methods of pasture recovery and grass species.

3. Results

An interaction ($p < 0.05$) was found on the number of clumps, plant height and clump diameter. Regarding the species, there was an effect ($p < 0.05$) on the number of tillers. The highest number of clumps was found for cultivar MG4 in the WC method (Table 1).

Marandu and Andropogon grasses showed better tillering in comparison to the other studied grasses ($p < 0.05$). The highest plant height was observed for the Andropogon grass pasture in treatment WC + SF.

The forage species that presented the largest clump diameter was Mombaça grass using the WC method. Analyzing the factor recovery method, Marandu and Mombaça grasses showed larger clump diameters with CLP and Mombaça grass with WC and WC + SF methods.

The green biomass was affected by the forage species and recovery methods ($p < 0.05$) (Table 2). The species that obtained the highest green biomass were Marandu, MG4 and Andropogon grass. The most efficient pasture recovery methods were WC + SF, WC and SF, respectively.

Because of the greater green biomass, Marandu grass and the WC + SF method provided a greater dry biomass (Table 3).

In the first harvest, Marandu grass showed a greater dry biomass yield with the CLP method (Figure 2a). Second, using the WC method, GM5 grass showed a greater dry biomass yield (Figure 2e). In the third, Marandu grass again showed a greater dry biomass yield with the CLP method.

In the pasture of Mombaça grass, no dry biomass was observed in the first harvest (Figure 2b). However, it showed a greater dry biomass yield (680 kg/ha) with the recovery method WC + SF in the second harvest. However, in the third harvest, there was a reduction in dry biomass (90 kg/ha) with the WC + SF method.

Table 1. Structural characteristics of grasses under pasture recovery methods.

Species	Number of Clumps (unit/m²)				
	CLP	WC	SF	WC + SF	Species Average
Marandu	4 ^{aC}	3 ^{aC}	7 ^{aB}	8 ^{aB}	5
Mombaça	2 ^{aC}	1 ^{aC}	1 ^{aB}	1,0 ^{aB}	1
Andropogon	2 ^{aC}	3 ^{aC}	3 ^{aB}	2 ^{bA}	2
MG4	21 ^{bA}	27 ^{aA}	14 ^{cA}	14 ^{cA}	19
MG5	13 ^{aB}	10 ^{bB}	17 ^{aA}	5 ^{bB}	11
Method Average	8	9	8	6	
SEM	2.03				
P-Species	0.001 *				
P-Met.	0.119 ^{ns}				
P-Met. × Spe.	0.001 *				
	Number of tillers (unit)				
Marandu	216	177	156	115	166 ^{A}
Mombaça	95	86	25	109	79 ^{B}
Andropogon	98	263	139	256	189 ^{A}
MG4	54	61	85	100	75 ^{B}
MG5	101	124	115	107	112 ^{B}
Method Average	113	142	104	137	
SEM	37.33				
P-Species	0.001 *				
P-Met.	0.310 ^{ns}				
P-Met. × Spe.	0.136 ^{ns}				
	Plant height (m)				
Marandu	0.7 ^{aA}	0.6 ^{aC}	0.7 ^{aB}	0.6 ^{aB}	0.6
Mombaça	0.9 ^{bA}	0.8 ^{aD}	0.6 ^{bB}	0.7 ^{bB}	0.8
Andropogon	0.9 ^{bA}	1.1 ^{bA}	1.0 ^{bA}	1.4 ^{aA}	1.6
MG4	0.2 ^{aB}	0.3 ^{aE}	0.4 ^{aC}	0.4 ^{aC}	0.3
MG5	0.4 ^{aC}	0.6 ^{aB}	0.5 ^{aB}	0.6 ^{aB}	0.5
Method Average	0.6	0.7	0.6	0.8	
SEM	0.03				
P-Species	0.001 *				
P-Met.	0.018 *				
P-Met. × Spe.	0.002 *				
	Clump diameter (m)				
Marandu	1.1 ^{aA}	0.8 ^{aB}	0.9 ^{aA}	0.8 ^{aB}	0.9
Mombaça	1.0 ^{aA}	1.5 ^{aA}	0.7 ^{bA}	1.3 ^{aA}	1.1
Andropogon	0.5 ^{bB}	0.6 ^{bB}	0.5 ^{bA}	1.0 ^{aA}	0.6
MG4	0.3 ^{aB}	0.4 ^{aB}	0.5 ^{bA}	0.6 ^{aB}	0.4
MG5	0.5 ^{aB}	0.7 ^{aB}	0.5 ^{bA}	0.6 ^{aB}	0.6
Method Average	0.7	0.8	0.6	0.8	
SEM	0.121				
P-Species	0.001 *				
P-Met.	0.034 *				
P-Met. × Spe.	0.015 *				

CLP: Closed pasture; WD: Weed control; SF: Soil fertilization; Sp.: Species; SEM: Standard Error of the Mean. ^{a,b,c} Means followed by different lowercase letters in the same row differ according to the Scott–Knott test ($p < 0.05$). ^{A,B,C,D,E} Means followed by different uppercase letters in the same column differ according to the Scott–Knott test ($p < 0.05$). "*"means $p < 0.05$; "ns" not significant $p > 0.05$.

Table 2. Green biomass yield (kg/ha) of grasses under different pasture recovery methods.

Species	Green Biomass (kg/ha)				
	CLP	WC	SF	WC + SF	Species Average
Marandu	2196	2806	2426	2726	2539 [A]
Mombaça	900	1475	640	1690	1176 [B]
Andropogon	826	1200	1446	4800	2068 [A]
MG4	923	2813	2860	2113	2177 [A]
MG5	1113	1893	1846	1573	1606 [B]
Method Average	1192 [b]	2037 [a]	1844 [a]	2580 [a]	
SEM	647				
P-Species	0.004 *				
P-Met.	0.015 *				
P-Met. × Spe.	0.085 [ns]				

CLP: Closed pasture; WC: Weed control; SF: Soil fertilization. [a,b] Means followed by different lowercase letters in the same row differ according to the Scott–Knott test ($p < 0.05$). [A,B] Means followed by different uppercase letters in the same column differ according to the Scott–Knott test ($p < 0.05$). "*"means $p < 0.05$; "ns" not significant $p > 0.05$.

Table 3. Dry biomass yield (kg/ha) of grasses under different pasture recovery methods.

Species	Dry Biomass (kg/ha)				
	CLP	WC	SF	WC + SF	Species Average
Marandu	626	510	623	626	596 [A]
Mombaça	170	235	90	650	286 [B]
Andropogon	150	110	186	546	248 [B]
MG4	150	483	466	500	400 [B]
MG5	240	546	416	466	417 [B]
Method Average	267 [b]	377 [b]	356 [b]	558 [a]	
SEM	140				
P-Species	0.010 *				
P-Met.	0.018 *				
P-Met. × Spe.	0.486 [ns]				

CLP: Closed pasture; WC: Weed control; SF: Soil fertilization. [a,b] Means followed by different lowercase letters in the same row differ according to the Scott–Knott test ($p < 0.05$). [A,B] Means followed by different uppercase letters in the same column differ according to the Scott–Knott test ($p < 0.05$). "*"means $p < 0.05$; "ns" not significant $p > 0.05$.

Andropogon grass obtained a dry biomass yield of 473 kg/ha with the CLP method in the first harvest but expressed no yield in the others (Figure 2c). In the second harvest, it showed greater biomass yield with the CLP method (447 kg/ha), followed by SF and WC + SF (347 and 343 kg/ha) and WC (227 kg/ha). The third harvest of Andropogon showed a high biomass amount with the WC + SF method.

For the pasture of MG4 grass, no dry biomass yield was observed in the first harvest with different recovery methods (Figure 2d). In the second harvest, the method that showed the greatest yield was CLP (447 kg/ha).

In the three harvests performed, the pasture of MG5 grass presented a dry biomass yield for the three recovery methods (Figure 2e). In the first one, the greatest yield was obtained with the SF method (337 kg/ha). In the second step, MG5 grass obtained the greatest dry biomass yield for both treatments. In the third harvest, it showed a low yield when compared to the second harvest.

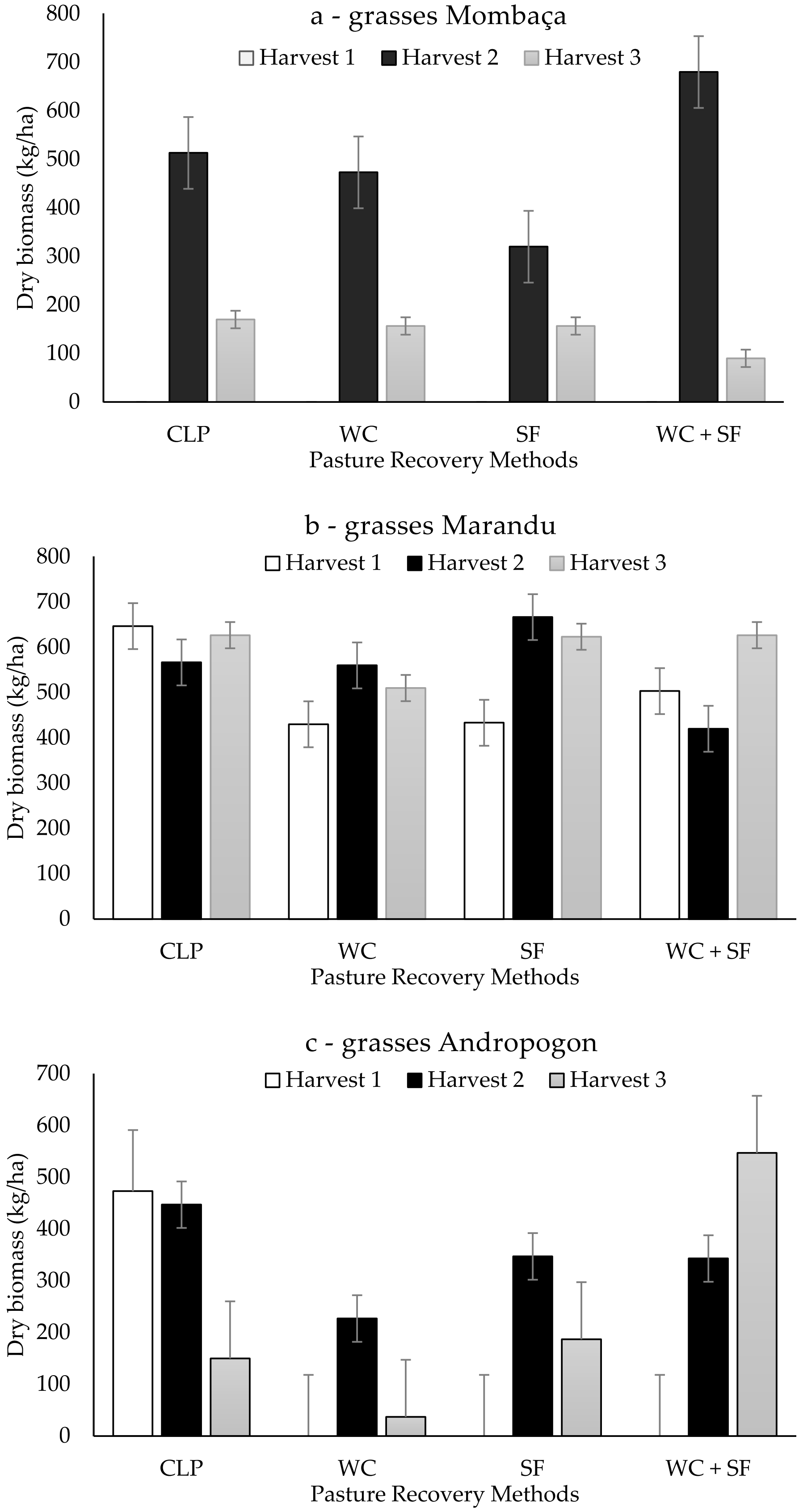
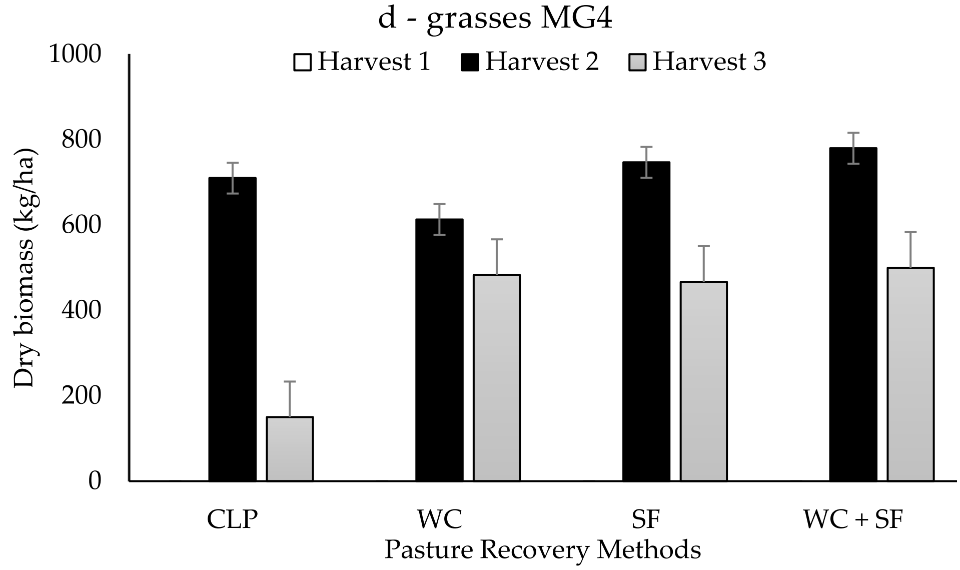


Figure 2. *Cont*.



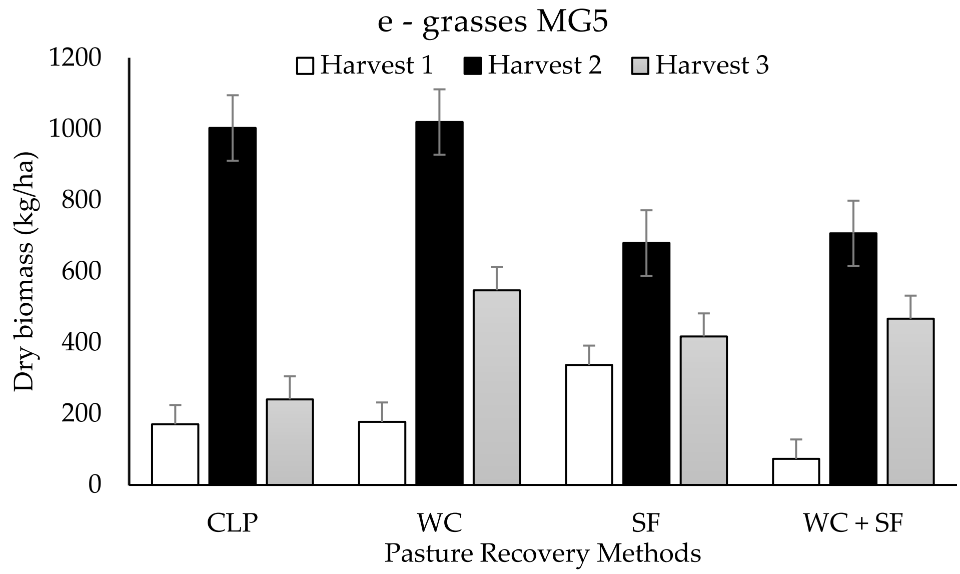


Figure 2. Dry biomass (kg/ha per harvest) of grasses Mombaça, Marandu, Andropogon, MG4 and MG5 under different pasture recovery methods. CLP: Closed pasture; WC: Weed control; SF: Soil fertilization; WC + SF.

The effect of interaction between species and pasture recovery methods ($p < 0.05$) affected the contents of dry matter, mineral matter and neutral detergent fiber. Regarding the species, there was an effect ($p < 0.05$) on the crude protein and ether extract (Table 4).

There was an effect of interaction between species and recovery methods on dry matter, mineral matter and neutral detergent fiber contents of the grasses, with Marandu, Andropogon and MG4 standing out with the intensification of the recovery methods.

The MM contents were higher in the Marandu and Mombaça grasses when subjected to the recovery process. The grasses MG4 and MG5 showed lower contents of NDF with the methods (SF; WC + SF) and (WC, WC + SF), respectively. The crude protein contents were higher in Marandu and Mombaça grasses ($p < 0.005$).

Table 4. Chemical composition of grasses under pasture recovery methods for degraded pastures.

Species	Dry Matter (g kg DM %)				Species Average
	CLP	WC	SF	WC + SF	
Marandu	24.59 ^{aA}	24.68 ^{bA}	24.73 ^{bA}	26.98 ^{aA}	25.24
Mombaça	21.59 ^{aB}	22.09 ^{aB}	24.19 ^{aA}	23.22 ^{aB}	22.77
Andropogon	24.57 ^{aA}	22.11 ^{bB}	25.43 ^{aA}	24.65 ^{aB}	24.19
MG4	23.83 ^{bA}	25.24 ^{aA}	24.95 ^{aA}	24.88 ^{aB}	24.73
MG5	23.07 ^{aB}	22.06 ^{aB}	20.11 ^{aB}	23.06 ^{aB}	22.07
Method Average	23.53	23.23	23.88	24.56	
SEM	0.75				
P-Species	0.00 *				
P-Met.	0.01 *				
P-Met. × Spe.	0.00 *				
Mineral Matter (MM%)					
Marandu	5.99 ^{aA}	5.88 ^{aA}	6.76 ^{aA}	5.45 ^{aA}	6.02
Mombaça	6.64 ^{aA}	6.54 ^{aA}	6.20 ^{aA}	5.96 ^{aA}	6.34
Andropogon	3.66 ^{aB}	3.93 ^{aB}	3.79 ^{aC}	4.66 ^{aB}	4.01
MG4	5.78 ^{aA}	5.47 ^{aA}	5.69 ^{aB}	6.13 ^{aA}	5.77
MG5	6.18 ^{aA}	4.31 ^{bB}	5.30 ^{aB}	4.50 ^{bB}	5.07
Method Average	5.65	5.23	5.55	5.34	
SEM	0.36				
P-Species	0.00 *				
P-Met.	0.23 ^{ns}				
P-Met. × Spe.	0.01 *				
Crude Protein (CP%)					
Marandu	8.31	7.95	8.04	8.03	8.08 ^{A}
Mombaça	8.34	8.42	8.56	8.61	8.48 ^{A}
Andropogon	7.46	6.13	5.71	6.17	6.37 ^{B}
MG4	6.21	5.94	8.29	6.68	6.78 ^{B}
MG5	7.36	6.33	6.76	7.32	6.95 ^{B}
Method Average	7.53	6.95	7.47	7.36	
SEM	0.50				
P-Species	0.00 *				
P-Met.	0.27 ^{ns}				
P-Met. × Spe.	0.11 ^{ns}				
Ether Extract (EE%)					
Marandu	1.35	1.54	1.66	1.28	1.46 ^{B}
Mombaça	1.20	1.54	1.14	1.28	1.29 ^{B}
Andropogon	1.50	2.25	2.21	1.91	1.97 ^{A}
MG4	1.42	1.56	1.46	1.48	1.48 ^{B}
MG5	1.02	1.25	1.16	1.21	1.16 ^{B}
Method Average	1.30	1.43	1.53	1.63	
SEM	0.25				
P-Species	0.00 *				
P-Met.	0.19 ^{ns}				
P-Met. × Spe.	0.96 ^{ns}				
Neutral Detergent Fiber (NDF%)					
Marandu	76.26 ^{aA}	76.64 ^{aA}	71.11 ^{aA}	74.92 ^{aA}	74.73
Mombaça	73.25 ^{aA}	76.63 ^{aA}	72.93 ^{aA}	74.52 ^{aA}	74.33
MG4	72.91 ^{bA}	71.92 ^{bA}	77.46 ^{aA}	75.13 ^{aA}	74.35
MG5	71.15 ^{aB}	73.64 ^{aA}	69.60 ^{bA}	75.96 ^{aA}	72.59
Method Average	73.39	74.71	72.77	75.13	
SEM	1.62				
P-Species	0.25 ^{ns}				
P-Met.	0.15 ^{ns}				
P-Met. × Spe.	0.03 *				

CLP: Closed pasture; WC: Weed control; SF: Soil fertilization. ^{a,b} Means followed by different lowercase letters in the same row differ according to the Scott–Knott test ($p < 0.05$). ^{A,B,C} Means followed by different uppercase letters in the same column differ according to the Scott–Knott test ($p < 0.05$). "*"means $p < 0.05$; "ns" not significant $p > 0.05$.

4. Discussion

The degradation of pastures occurs in many situations due to management failure. One way to identify this failure is to evaluate the number of existing clumps since reducing the number of clumps opens spaces and opportunities for weeds. In this context, it was found that in degraded pastures subjected to weed control, the cultivar MG4 responded better than the other forages evaluated.

Another factor used to evaluate pasture productivity is the number of tillers. This characteristic reflects the ability of the pasture to regrow under certain situations, such as nutritional, environmental and management [10]. It was observed that Marandu and Andropogon grasses showed superior morphogenic responses.

The average number of tillers per plant of the genus *Brachiaria* in this study was similar to the results of previous studies (184 tillers), showing that, even under a certain degree of degradation, there were equivalent numbers of tillers to areas of pasture with productive vigor [2]. Unlike the other grasses studied, Marandu grass was not responsive to recovery methods, presenting a decrease in the number of tillers. Coupled with this, the management season (dry period) was not ideal for such practices due to the negative impact of water stress [11].

Intensive management practices (WC + SF) were important in the development of the Andropogon grass, causing a higher plant height. Height is considered a better parameter than age to evaluate the maturity and production of grass. Andropogon grass reached the highest height in all methods. It is noteworthy that besides presenting low requirements in soil fertility, this grass is tolerant to water deficit, making it a viable option in semi-arid regions. The other grasses did not show satisfactory results for this variable when subjected to recovery methods. This result diverged from previous studies [12–14]; however, it is worth mentioning that the recovery period presented low rainfall, which may have interfered with the capacity for nutrient absorption and plant development [15].

The forage species that presented the largest clump diameter was Mombaça grass using the WC method. Analyzing the recovery method factor, Marandu and Mombaça showed larger clump diameters with CLP, Mombaça grass with WC, Marandu grass with SF and Mombaça and Andropogon WC + SF methods.

For each pasture recovery method, the clump diameter showed different responses, with higher expressiveness of pasture with the WC + SF method. Factors such as the number of young and small tillers, tiller mortality and the degree of degradation are responsible for the low green mass yield [16].

As a consequence of the stage of degradation in which the pasture was and the season (dry season) of application of the recovery methods, the production of green biomass was relatively low for the grasses used (Figure 1), which may have caused low forage production when compared to other studies [17,18]. This same trend was seen in the different harvests for all grasses, regardless of the recovery method.

Once the green biomass production was low, as already expected, the dry biomass of the grasses was reduced. According to [19], fertilization is one of the main methods for increasing dry biomass production, especially when used in degraded pastures. This study showed that the WC + SF method provided a greater dry biomass yield, proving the need for the application of more intensive methods.

Chemical composition is an important factor in evaluating the quality of forage grasses. Its determination is fundamental for the formulation of the diet, and evaluation of intake and animal performance. The highest value of NDF was found in Andropogon grass with the SF method. The five varieties of grasses under study exhibited values above the ideal, and similar to those reported in the literature [20–22] in studies with *Brachiaria brizantha*, *Panicum maximum* and *Andropogon gayanus*, respectively. According to [23], the contents of NDF in tropical grasses are high because of the advanced stage at which they are harvested. According to [24], values higher than 65% of NDF negatively interfere with forage intake, thus compromising animal performance. The protein contents of the different grasses were below what was reported in the literature [25–30]. Protein is the most important nutrient and has the highest cost of the animals' diet. Factors such as plant age, low rainfall, pasture degradation rate and soil degradation rate negatively impact the concentration in the plant.

The application of the methods (CLP, WC, SF and WC + SF) had as a main function the recovery of the pasture, and consequently the improvement of the chemical composition of the forage plants, since other factors are preponderant to recover, establish and offer a pasture of superior quality for animal grazing. Inherent variations in the DM content of different grasses were observed according to the recovery method. However, in tropical and semi-arid regions, which suffer great edaphoclimatic influence, such as rainfall seasonality, it is necessary to adopt correct grazing management practices, respecting the entry and exit height for the animals, that is, using the optimal grazing point of the different grasses so that a good-quality diet can be offered with the promotion of maintenance and forage persistence over the years.

5. Conclusions

The different types of grasses responded positively to pasture recovery methods with increased biomass and nutritional quality.

The method of weed control + soil fertilization promoted better development and chemical composition of grasses.

The cultivation of these forage grasses requires improvements in soil fertility and weed control to maintain adequate growth in the pasture. New research is needed over longer periods, with an assessment of management and practices that increase the permanence of these species in the pasture.

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